Hendrix Covered Conductor

Manual

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Endorsement / Approvals

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Record of revisions

This document contains multiple formatting sections. When it is updated please ensure all section headers and footers have also been updated with correct version numbers and dates.

Revision no.	Date	DM version	Revised by	Description
0	30 Feb 2009	5523521V2	M Oosthuizen	Original issue
1	31 May 2010	5180348V8	R Lategan	Updated tension tables
2	08 August 2013	5180348V10	P. Seiler	Updated Sections 3.6.1, 3.7 & 3.11

Documents referenced in this document

DM#	Title of document
951435	**Overhead Bare Conductor Distribution-Distribution Design Manual Volume 5**
3169978	**Poles 'n' Wires guide**
5107627	**Distribution Standards Construction Handbook (DCSH) Part 4**
4367570	**Distribution Design Catalogue (DDC) Section 1(B)**
1477587	**Policy for Power Line Crossings of Waterways**
2397018	**Code of Practice – Power Line Crossings of Navigable Waterways in Western Australia**
5426076	**Work Practice Manual**
4319958	**Telecommunication equipment located in the vicinity of proposed distribution HV earths**

Other documents that reference this document

DMS#	Title of document
4367570	Distribution Design Catalogue – Hendrix
5107627	Distribution Construction Standards Handbook – Hendrix

Stakeholders

During the process of document updating, the following positions must be consulted:

Position / title
Service Delivery – Distribution Design Engineering
Service Delivery – Technical Services
Customer Services – Network Performance

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Position / title
Service Delivery – Distribution Design Engineering
Service Delivery – Technical Services
Customer Services – Network Performance

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1 Introduction

History

Bill Hendrix, founder of Hendrix Wire & Cable Inc (1951), developed the Covered Conductor System. He had the vision of improving the reliability of the overhead distribution networks implemented by the local utilities at the time. In 1981, Hendrix Wire & Cable was sold and ownership currently belongs to The Marmon Group. Hendrix Wire & Cable is located in Milford, New Hampshire, USA and supplies underground cable, spacer covered conductor, tree wire, insulators, and other overhead accessory products, locally and internationally.

What is the Hendrix Covered Conductor System?

Hendrix Covered Conductor is a messenger wire supported primary distribution system using covered conductors in a closed triangular/delta configuration.

Figure 1-1: Hendrix Covered Conductor System

With reference to Figure 1-1, the messenger wire is tensioned to an initial tension and the three covered phase conductors are suspended from the messenger wire using the specially designed spacer. The messenger wire is the support member and earth of the system because of its high strength and high conductivity. The all aluminium conductors (AAC) are double insulated and have the ability to withstand temporary contact between phases or contact with other objects like falling tree branches, without causing service interruptions. The unique design of the Hendrix system allows the phase conductors to be hung from the messenger wire by means of the spacer which results in virtually no tension on the conductors.

Why is the Hendrix Covered Conductor System Implemented?

The Hendrix Covered Conductor System was introduced to improve the safety and reliability of the HV overhead distribution network in areas where power outages are common due to falling tree or branch contact, as well as in high fire risk areas and at river crossings.

Current methods like using High Voltage Aerial Bundled Conductor (HVABC) and undergrounding conductors in these areas can be impractical and have significant economic implications. The Hendrix system provides a simple, reliable and cost-effective alternative. Hendrix also adds value to the network, requiring very little maintenance during its entire lifespan.

Figure 1-2: Hendrix River Crossing and long spans

Where can the Hendrix Covered Conductor be implemented?

The Hendrix Covered Conductor System is installed in areas where the need for an insulated overhead distribution network is desirable. These areas include, but are not limited to:

- Hilly and mountainous areas

  Network reliability is vulnerable in these areas because of conductor clashing caused during high winds and storms and falling trees and branches. These areas are also more prone to lightning strikes.

- River Crossings

  In 2002, an incident occurred when the mast of a yacht collided with the 22kV bare overhead system strung across the Serpentine River. The mast was energized to dangerous levels resulting in the death of a crew member. This incident called for the modification of existing river crossing methods. The implementation of the Hendrix System at river crossings will significantly improve the level of safety in these areas because of the system insulation, the installation of striker wires as well as the utilization of the messenger wire as the system earth. Refer to 5.8 River Crossing Construction design for more detail.

- Bushfire Danger Areas

  In the unlikely event that conductors clash, for whatever reason, the Hendrix system insulation has the ability to withstand damage and will not produce sparks that can cause bushfires.

How does Hendrix compare to other overhead distribution systems?

Throughout this document comparisons are drawn between the Hendrix system and other overhead distribution systems implemented by Western Power. The greatest advantage Hendrix has over other insulated systems like HVABC and Tree Wire is the larger span lengths that can be achieved. This is because of the high mechanical strength provided by the messenger wire, and the fact that phase conductors are under very little tension. For the results of a complete study undertaken, which draws comparisons between different overhead distribution installations implemented by Western Power, refer to “Review of the 22kV Overhead Conductors in the Hills Area” (DMS#905434).

Advantages of Hendrix Covered Conductor

- Network reliability.

  The covered conductors are individually insulated, resulting in fewer outages caused by events like storms or falling branches. Conductor covering reduces outages from phase to phase and phase to ground contact. Less maintenance is required on the system.

- Strong mechanical configuration.

  Messenger wire provides a high strength physical shield against falling trees and branches and also enables longer spans.

  Protection from lighting by surge arresters and the messenger wire.

  Highly conductive messenger wire earthed every 150m and surge arresters installed at every open point, and also provides adequate protection against lighting strikes and induced voltages. Having an earth wire above the conductors offers an additional shielding benefit from lightning strikes, as opposed to other networks.

- Reduced tree trimming.

  Because the Hendrix Covered Conductor System has a compact design that can tolerate temporary contact, trees can be allowed to grow much closer to the conductors. This greatly reduces the initial tree clearing necessary to install the circuit and the periodic trimming required in order to maintain the circuit.

- Less damage caused by animals

  Wildlife outages are minimized by the very strong conductor covering.

- Lightning protection

  The Hendrix phase conductors are shielded against lightning strikes by having the earthed messenger wire above the phase conductors.

Disadvantages of Hendrix Covered Conductor

- Aesthetics

  Because of the relatively large configuration of the Hendrix System it may appear less aesthetically pleasing than other overhead distribution systems.

- Stripping and jointing

Very tough outer insulation makes stripping and jointing more difficult and time consuming. A special conductor stripping tool is required to remove insulation.

- High start-up costs

  Hendrix is relatively expensive to install and can lead to high start-up costs, but because maintenance and service interruptions are reduced, the long term benefits are attractive.

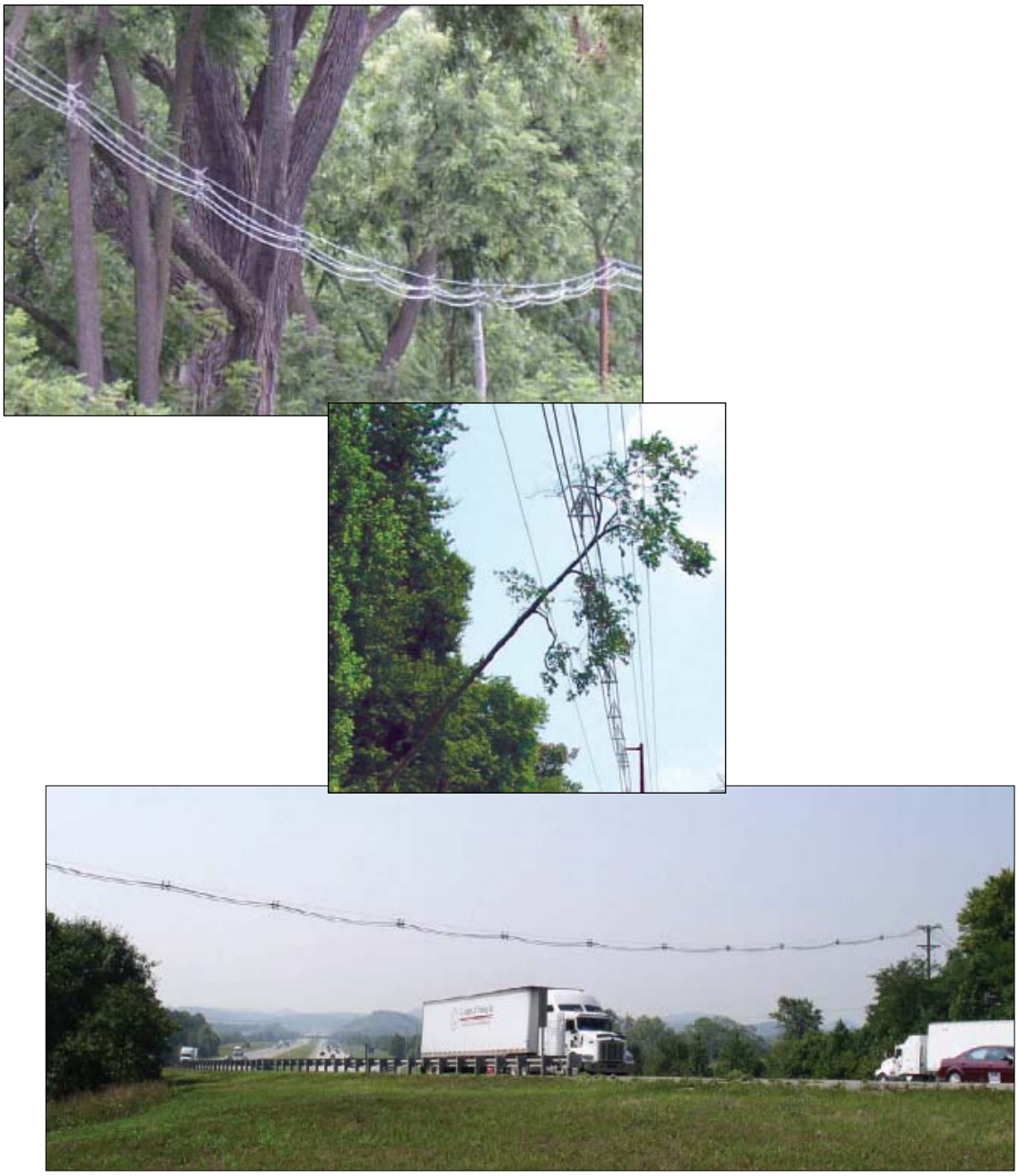


Figure 1-3: Hendrix Applications

2 Scope

This document covers the design, installation and construction details for the implementation of the Hendrix Covered Conductor System. The information contained and referred to in this document was gathered from various sources including the Hendrix Catalogue and existing Western Power documents. It is the intent of this document to supersede all other Hendrix related documents and should be regarded as a current standard.

3 Hendrix Design Philosophy

3.1 Introduction

It is strongly recommended that for Hendrix Covered Conductor designs, the designer has previous HV overhead design experience. It is desirable that the designer has previously done HVABC, LVABC or other covered conductor designs, as the concepts and principles required are transferrable to the Hendrix system.

Hendrix designs differ from bare overhead designs due to the nature of the conductor. Firstly, the insulation on the Hendrix conductors means that issues, such as conductor weight and surge protection, need to be considered. Also of importance, more earths are needed than for a bare overhead system.

Despite these differences, common overhead design philosophies (such as clearances, sags, profiling, etc.) still apply to Hendrix. Refer to the Distribution Design Manual Volume 5 for electrical principles. The issues specific to Hendrix designs on land and for river crossings shall be covered in the following sections.

3.2 Conductor

As described in a previous section, Hendrix Covered Conductor is a type of insulated overhead conductor, referred to as a “covered conductor”. The conductor consists of 4 layers – the conductor[1], a semi-conductive[2] layer, a layer of Low Density Polyethylene[3] (LDPE) and a tougher outer layer of High Density Polyethylene[4] (HDPE).

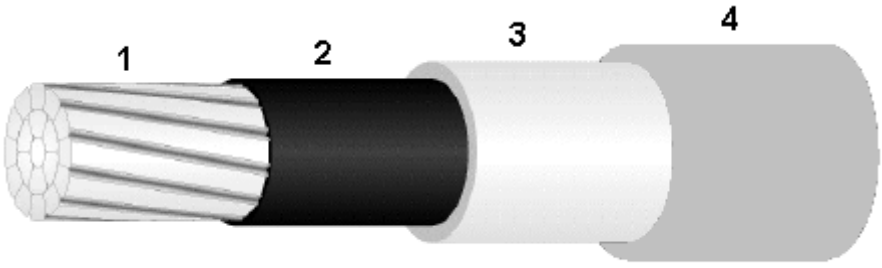


Figure 3-1: Hendrix Insulated Covered Conductor

The conductor is stranded and compacted AAC (all aluminium conductor). The compacted conductor reduces the effect of corona and electrical field stresses. This is because the electrical field stress arising from compacted stranded conductors is much less than normal stranded conductors, which is important in covered conductor systems because these stresses damage the insulation layers over time. To further dissipate these stresses, the conductor has a semi-conductive layer surrounding the aluminium strands.

On the outside the semi-conductive layer is the first insulation layer, LDPE. The outer layer of a Hendrix conductor consists of a hard, grey, HDPE insulation layer. This outer layer is extremely tough, highly resistant to scratching which reduces the risk of bird attack. A special tool is required to remove this layer.

Western Power has standardised the use of Hendrix Covered Conductor to 150mm^2, rated at 25kV and 35kV, and will be using these covered conductors for 22kV and 33kV systems respectively. The properties of this covered conductor are shown below. For more Hendrix conductor electrical data refer to Appendix A**:** Hendrix Conductor Electrical Data.

	150 mm^2	**150mm^2**
	22 kV	**33kV**
Construction		
1 Number of Compact AAC Strands	19	19
2 Semi-conducting Polyethylene (mm)	0.38	0.38
3 Low Density Polyethylene (mm)	3.18	4.44
4 High Density Polyethylene (mm)	3.18	3.18
Diameters		
Nominal Diameter 1 (mm)	14.22	14.48
Nominal Diameter 2 (mm)	14.99	15.24
Nominal Diameter 3 (mm)	21.34	24.13
Nominal Diameter 4 (mm)	27.69	30.48
Conductor Data		
Covered conductor weight (kg/m)	0.855	0.964
Max operating temperature (C^0)	75	75
Current Carrying Capacity (A) – 75^{0}C conductor temp, 25^{0}C Ambient, 0.61 m/s wind with sun.	374	389
Drum Length	1500	1200
Stock Code	EE2555	EE1567

Table 1: Hendrix Covered Conductor Properties

The insulation layers on the Hendrix covered conductor allow each phase of a Hendrix system to be spaced closer than the equivalent bare overhead system. It must be noted, however, that Hendrix covered conductors are not screened and are not touch safe when energised. The insulation on these covered conductors is designed to be sufficient to prevent transient clashes e.g. branches falling on the conductors. This is in contrast with HVABC, which has a non-metallic screen on the outer layer of the conductor, which allows HVABC to be bundled. Despite this, Hendrix covered conductor should be able to withstand most branch falling events (or similar) and result in no power outage, as opposed to a similar event occurring on a bare overhead conductor.

Because Hendrix conductor is a covered conductor, it does not dissipate heat as well as bare overhead conductor of the same conductor size. This is because the insulation layers restrict the effect of air cooling on the conductor. As a result, the current carrying capacity of Hendrix is not as high as the equivalent sized bare conductors.

3.3 Messenger Wire

The messenger wire (also known as the catenary wire) is the supporting wire in the Hendrix Covered Conductor System configuration. It acts as the 'backbone' of the system because it supports the three phase conductors, breaks the fall of tree branches, acts as a lightning shield and the system neutral.

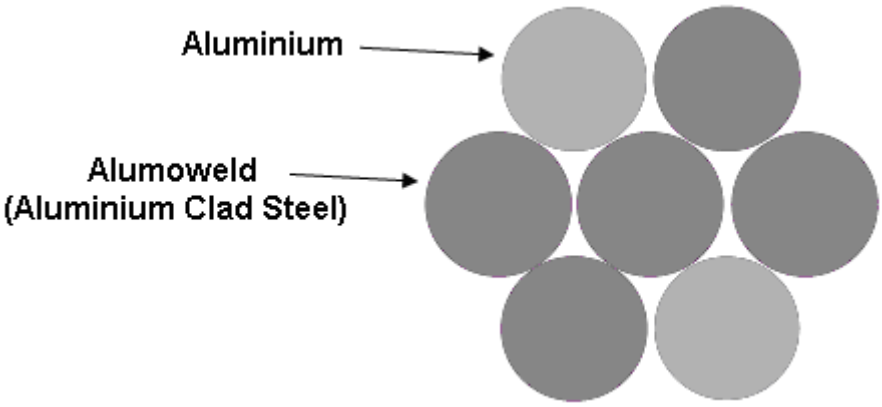


Figure 3-2: 052AWA Messenger Wire

The conductor chosen for the messenger wire is Alumoweld-Aluminium (AWA), due to its high conductivity and strength needed for its role as an earth wire and support wire. The standard 7-strand AWA conductor contains 2 strands of aluminium and 5 strands of Alumoweld (Aluminium Clad Steel). This conductor has a higher tensile strength than AAC due to the Alumoweld strands and is also more conductive than steel wires because of the aluminium strands. The messenger wire properties are listed in Table 2, below.

	052 AWA	**19/2.75 SCGZ**	**19/3.25 SCGZ**
Stranded Wire Diameter	7/4.1	19/2.75	19/3.25
Nominal Diameter (mm)	12.34	13.8	16.3
Cross-Sectional Area (mm^2)	92.42	113	158
Conductor Breaking Load (kN)	76.15	141	196
Young's Modulus (GPa)	166	166	166
Weight (kg/m)	0.515	0.888	1.25
Coeff. of Linear Expansion (/C)	11.5	11.5	11.5
Temp. coeff. of resistance (/C)	0.0036	0.0044	0.0044
DC Resistance (ohms/km)	0.59	1.7	1.2
Stock Code	EE2556	ES0064	ES0050

Table 2: Messenger Wire Properties

During the installation process, the messenger wire is strung at an initial tension first and then the phase conductors and spacers are attached, resulting in a higher final tension on the messenger wire. This will be covered in detail in the following sections.

3.4 Spacers

The key element of the Hendrix system is the spacer. The spacer is made of HDPE, which provides sufficient insulation for the phase separation of the conductors. The spacers hang on and are clamped onto the messenger wire.

Figure 3-3: RTL-46 Spacer

RTL-46 Spacer	
ID	RTL-46
Rated Voltage (kV)	46
Weight (kg)	1.63
Weight (kg/m) (assuming 10m spacing)	0.163
Min. Leakage Distance (mm)	445
Short Circuit Rating (kA)	16
GMD (mm)	292
Stock number	IC0091

Table 3: Spacer Properties

The phase conductors are also held in place by clamps which are secured by simply closing the clamps onto the conductor. Previous experience has however shown that the spacers do move position over time and are affected by strong winds. For this reason an anti-sway bar must be installed on every intermediate structure.

The positioning of the spacers is very important in correctly constructing a Hendrix system. The spacers maintain sufficient clearance between the phases and are designed to maintain

the tensionless system. The spacers are used at intermediate structures and spaced evenly between spans.

The number of spacers required per span length is determined by the following formula:

$$\text{Number of spacers required} = \text{Span Length(m)} / 10 \qquad \text{Eq. 1}$$

The following rules shall be applied to the positioning of the spacers:

- Spacers shall be placed no closer than 12m to termination structures.
- Spacers shall be placed at intermediate structures.
- Spacers shall be placed at a separation distance of 10m. If this cannot be achieved, the separation between spacers can be increased to a maximum of 15m or reduced to 7m

Refer to Section 5.4 Installing the Spacers and Completing the Installation for more detail.

3.5 Configuration of Combined Unit

As stated previously, the insulation layers of Hendrix system allow a smaller phase-phase separation than bare overhead conductors. Hendrix is strung by using the messenger wire to support the three phases. To maintain a consistent phase separation, Hendrix spacers are used at certain intervals. The configuration, phase-phase and phase-earth separation distances as well as the combined system properties are shown in Table 4 and 5 respectively.

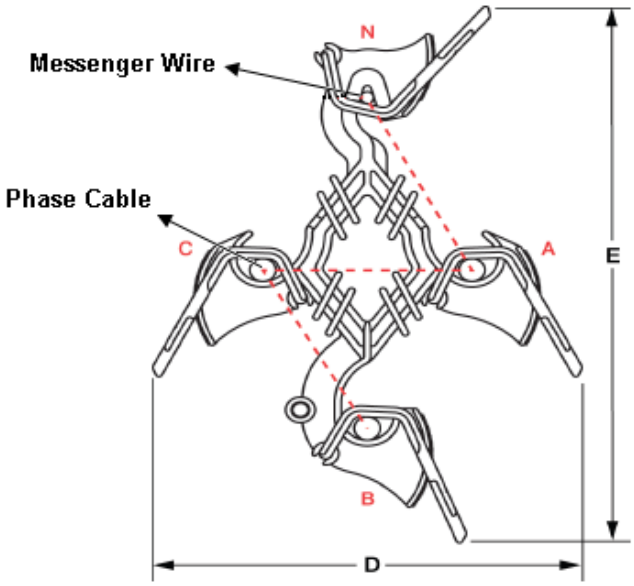


Figure 3-4: Phase Configuration

Conductor Spacing (mm)				Dimensions (mm)	
AN	AC	BC	BN	D	E
305	292	292	535	521	737

Table 4: Combined System Properties

		22kV		33kV	
Phase System	**Messenger wire**	**Total equivalent Weight of Combined System (kg/m)**	**Total equivalent Wind Pressure diameter (mm)**	**Total equivalent Weight of Combined System (kg/m)**	**Total equivalent Wind Pressure diameter (mm)**
3	052 AWA	3.24	101	3.57	109
3	19/2.75	3.62	102	3.94	111
3	19.3.25	3.98	105	4.31	113
1	052 AWA	1.40	43	1.51	46
1	19/2.75	1.78	44	1.89	47
1	19.3.25	2.14	47	2.25	50

Table 5: Total Weight and Wind Pressure Areas for 150mm^2, 22 and 33kV systems

3.6 Hendrix Sag and Tension Principles

3.6.1 Design

Refer to Section 5 Installation Practises for more detail on how the messenger, conductors and spacers are installed.

The main difference, between stringing and tensioning bare overhead conductor and Hendrix covered conductor, is the method of installation.

Bare overhead conductors are strung for a particular ruling span, at a certain initial tension and temperature depending on the physical properties of the conductor. Over time the conductor elongates due to the strands settling-in and conductor creep, which will result in a final tension. This is catered for by applying temperature compensation and tensioning the conductor higher initially to eventually result in the required final tension.

In contrast, when installing Hendrix, the messenger wire is installed first (refer to Section 5.2 and Appendix B: Initial and Final Messenger Wire Stringing Tension Table) at an initial tension (T_1) and then the conductors and spacers are installed onto the messenger, thus effectively increasing the weight per unit length of the messenger wire as a final condition. Messenger wire is a steel conductor, thus conductor creep is regarded as negligible.

The tension and sag for overhead systems (bare and Hendrix) are determined by equations 2 and 3 respectively.

Eq. 2

$$\frac{E \cdot A}{24}\left(\frac{W_1 \cdot L}{T_1}\right)^2 - T_1 + K \cdot E \cdot A\left(t_2 - t_1\right) = \frac{E \cdot A}{24}\left(\frac{W_2 \cdot L}{T_2}\right)^2 - T_2$$

$$S = \frac{\left(W_2 L^2\right)}{8T} \qquad \text{Eq. 3}$$

E Modulus of Elasticity (Pa)
A Cross sectional area of conductor (m^2)
K Coefficient of linear expansion (per ºC)
W_1 Load on conductor at initial conditions per unit length (N/m)
W_2 Load on conductor at final conditions per unit length (N/m)

L Ruling span
t_1 Conductor temperature at initial conditions (ºC)
t_2 Conductor temperature at final conditions (ºC)
T_1 Initial system tension (N)
T_2 Final system tension (N)
S Sag of system (m)

For bare systems the initial and final weight of the conductor are equal, thus $W_1 = W_2$. For the Hendrix system the initial weight (W_1) will be the messenger wire alone and the final weight (W_2) is the messenger wire, covered conductors and spacers combined.

Table 6 presents the maximum allowable span lengths for various messenger wires. This includes the RTL-46 spacer installed every 10m. These values have been calculated so that the final messenger wire tension (no-wind) will not exceed 20% of its CBL for 052AWA and 25% of its CBL for 19/2.75 and 19/3.25 SC/GZ. The limiting factor for these maximum spans is the tension under maximum wind conditions with an applied wind pressure of 925Pa. This tension should not exceed 50% of the messenger's CBL.

Maximum allowable span length (m)				
Hendrix Covered Conductor	052AWA Messenger Wire (20% CBL@ 15°C)			
	Security level I		Security level II	
	Region A 900Pa	Region B 1200Pa	Region A 1000Pa	Region B 1400Pa
22kV - 3 x 150 mm^2	125	70	95	55
33kV - 3 x 150 mm^2	125	70	95	55
Hendrix Covered Conductor	19/2.75 SC/GZ Messenger Wire (25% CBL@ 15°C)			
	Security level I		Security level II	
	Region A 900Pa	Region B 1200Pa	Region A 1000Pa	Region B 1400Pa
22kV - 3 x 150 mm^2	220	140	180	115
33kV - 3 x 150 mm^2	200	120	160	100
Hendrix Covered Conductor	19/3.25 SC/GZ Messenger Wire (25% CBL@ 15°C)			
	Security level I		Security level II	
	Region A 900Pa	Region B 1200Pa	Region A 1000Pa	Region B 1400Pa
22kV - 3 x 150 mm^2	310	190	250	150
33kV - 3 x 150 mm^2	290	180	240	140

Table 6: Maximum Span Lengths (Three Phase)

Note: The values presented in Table 6 are the theoretically calculated values for flat surfaces and constant attachment heights. It is the designer's responsibility to check all clearances and to determine the pole length and strength to ensure a practical and sound engineered design. An additional 0.5kN tip load should be added to the pole loading to cater for the off-centre loading of the conductors.

Hendrix conductor has a steel messenger wire, which does not change tension drastically with a change in temperature and that the maximum temperature this messenger will experience is 50deg, because there is no current involved. Simulations with wind applied show that the difference in longitudinal tension between spans is similar to the urban conductors. A 2:1 maximum adjacent span ratio for Hendrix is recommended.

The 052AWA messenger wire must be tensioned according to the tension data presented in Appendix B. The final combined tension is restricted to a maximum of 20% of the messenger wire CBL at 15º C (creep is ignored).

The simulation of the Hendrix system in sag, tension and profiling software is based on the physical properties of the messenger wire i.e. conductor breaking load, cross sectional area etc. The only difference being that the initial weight is of the messenger wire on its own and the final weight is of the combined system.

3.6.2 River Crossing Designs

The 19/2.75 and 19/3.25 messenger wires are used for river crossings and must be tensioned according to the tension data presented in Appendix D**.** The final combined tension is restricted to a maximum of 25% of the messenger wire CBL at 15º C (creep is ignored).

Transmission structures up to 21.5m with 10kN strength might be needed in order to comply with the waterway crossing policy.

Refer to Section 5.9.4 Stringing and Tensioning across Waterways for details on how stringing across waterways differs from stringing on land.

In order to string the Hendrix system across a waterway, the messenger wire as well as the three phase covered conductors and spacer brackets have to be pulled across the river simultaneously. Once the opposite side of the river has been reached the messenger wire shall be tensioned to no more than the prescribed 25% of its CBL. This means that the initial and final weights at the river crossing will be the same. Refer to Poles ‘n’ Wires guide for simulation.

3.7 Pole Embedment Depth

To determine the pole embedment depth use:
(0.1 x L) + 0.6m for security level I poles where span length is less than 150m and for poles up to 15.5m **and**,

(L/12) + 1.4m or, for security level I poles where span length is less than 150m and for poles from 17m to 21.5m **or**,

Brinch Hansen for security level II poles or bay lengths are equal or greater than 150m.

Pole Length (L)	Embedment depth Security level I	Embedment depth Security level II or >150m
11	1.70	Use Brinch Hansen method
12.5	1.85	
14	2.00	
15.5	2.15	
17	2.8	
18.5	2.9	
20	3.0	
21.5	3.2	

Table 7: Maximum Span Lengths (Three Phase)

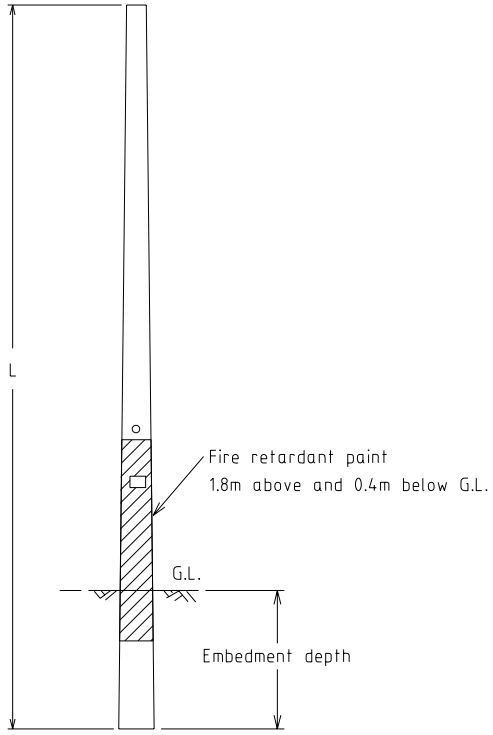


Figure 3-5: Length of pole (L)

3.8 Profiling and line routes

Most of the principles governing conventional overhead designs also apply to Hendrix designs. These include having as many straight spans as possible (i.e. limiting angled locations) and checking for uplift and clearances.

The maximum span lengths for Hendrix systems is dependant on the type of messenger wire used, a range of messenger wires is listed in Table 6. In urban areas where overhead bare networks need to be re-conductored with insulated conductors, spans are typically limited to 55m. This is an advantage over HVABC which requires spans to be limited to about 40m.

Hendrix covered conductor is supplied in 1200m drums. As with most types of conductors, mid-span jointing is also permitted on the Hendrix Systems.

Hendrix covered conductor systems are designed to be a tensionless system, only the messenger wire is under tension. Past experience has shown that too much tension on the phase covered conductors can damage the line post insulator brackets on the angle structures.

3.9 Earthing

The earthing requirements for the Hendrix system are more stringent than on most bare overhead systems, this is in order to prevent damage to the insulation due to floating voltages.

The earthing rules for Hendrix are:

- Down earths to be installed and connected to the messenger wire every 150m (min)
- If river crossing spans exceed 150m, down earths must be installed on the structures at either end of the river.
- Earth resistance for each down earth not to exceed 30Ω.

There are a few more considerations caused by the extra earthing requirements of Hendrix systems. Underground services (e.g. Telstra pits) should be avoided when installing these earths. See Policy in reference section. The issue is compounded when considering the average span lengths in the hills and other areas likely to use Hendrix. Earths may need to be installed on every 3rd or 4th pole. This is tempered by the fact that there are fewer underground services (e.g. Telstra pits) in these areas. It is easier to install earths onto structures that already have existing earths, as this means that there is a lesser likelihood of encountering a Telstra pit or other susceptible underground service nearby.

Adding more earths onto an overhead line requires extra resources and needs to be factored into the estimating process as a result. It should also be noted that the ground in the hilly areas is mainly rock and this makes it difficult to drill and install earths.

3.10 Surge arresters

As with all covered conductor systems, surge arresters are very important. Voltage surges pierce and damage insulation which eliminates the benefit of using covered conductor. Covered conductor systems like Hendrix act as “high capacity wave guides” and the high frequency voltage rise can travel a larger distance in these conductors. As a result, surge arresters must be used at every termination point, open point or tee-off point. See DCSH for more detail.

3.11 Re-conductoring

The Hendrix system is not restricted to short spans as is the case with HVABC and the maximum allowable span lengths depends on the messenger wire used, see Table 6. A Poles ‘n’ Wires simulation must be completed to ensure that the relevant ground clearance and structure loading requirements are met.

3.12 Single Phase Distribution

For single phase distribution, the same design and construction methodology is followed. The only difference is that, a single 150 mm^2 phase conductor and single phase spacer

(photo in Appendix F: Hendrix Construction Components) will be installed. The 052 AWA Messenger wire is utilized as the running earth.

Table 8 presents the maximum span lengths for single phase distribution designs. This includes the RTL-46 spacer installed every 10m. The values have been calculated so that the final messenger wire tension (no-wind) will not exceed 20% of its CBL for 052AWA. The limiting factor for these maximum spans is the tension under maximum wind conditions with an applied wind pressure of 925Pa. This tension should not exceed 50% of the messenger's CBL.

Maximum allowable span length (m)				
Hendrix Covered Conductor	052AWA Messenger Wire (20% CBL@ 15^{0}C)			
	Security level I		Security level II	
	Region A 900Pa	Region B 1200Pa	Region A 1000Pa	Region B 1400Pa
22kV - 1 x 150 mm^2	320	175	245	140
33kV - 1 x 150 mm^2	300	165	230	130

Table 8: Maximum span Lengths (Single Phase)

3.13 River Crossing Designs

3.13.1 Clearances

The height of the aerials is determined by three factors:

- Whether the waterway is navigable
- the distance from the river mouth, which determines if the water body is readily accessible to the ocean
- the voltage of the power line

The height can be obtained from the Policy for Power Line Crossings of Waterways *Table 2 - Water clearance required per voltage level*.

If the waterway is not navigable, the standard 33kV distribution line clearances must be met.

3.13.2 Construction

The same components (messenger wire, spacer, conductor etc.) used for designing standard Hendrix, must be used for River Crossing designs. Refer to Section 5.9 River Crossings Construction details on the construction method and equipment used, as well as the DCSH and DDC for detailed drawings and compatible units used.

3.13.3 Route Surveying

Surveying is to be completed prior to the design (to establish the height of the poles required) and again repeated after the construction (to confirm clearances above the ground and water).

4 Construction

For detailed Hendrix construction drawings refer to the Distribution Constructions Standard Handbook (DCSH). Also refer to the Distribution Design Catalogue (DDC) for drawings and lists of Compatible Units (CU's) available for Hendrix construction.

5 Installation Practice

In this section the general installation practice for stringing Hendrix is presented. This includes a description of the different types of structures available, how the messenger wire and conductors are installed, how to sag the conductors, installation of the spacers etc. Also included are the construction details for Hendrix River Crossings.

5.1 Pole Dressing and Preparation

Western Power makes use of the Roll – By method, which is described in detail later. In order to maximize efficiency, poles are prepared at ground level with all hardware and installation equipment necessary before they are planted. Refer to Appendix E: Installation Equipment and Appendix F: Hendrix Construction Components for photos and descriptions of the required installation equipment and the construction components respectively.

In the figures that follow, the installation equipment marked with an asterisk (*), is only temporarily utilized as part of the installation procedure, and does not form part of the final construction. Refer to DCSH for final construction drawings.

5.1.1 Intermediate Structures - 0^0 to 6^0

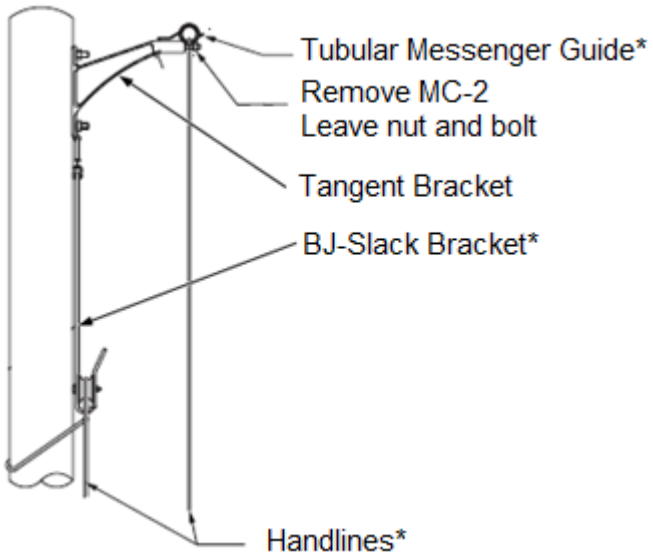


Figure 5-1: Intermediate/Tangent Bracket (0º– 6º)

For Intermediate Structures install:

- Hendrix Tangent Bracket with Tubular Messenger Guide (TMG). In order to install the TMG, the MC-2 which is part of the tangent bracket used to secure the messenger, must be removed but the nut and bolt left in place.
- BJ Slack Bracket.
- Handlines, through TMG and BJ Slack Bracket.
- Do not install the TS-1 Stirrup, used to hold the spacer in its final position at this stage, as it will interfere with conductor installation.

Note: In order to simplify the conductor installation process, the tangent bracket should always be installed facing the same side for the entire pulling section. Refer to Section 5.3 Installing the Conductors.

5.1.2 Angle Structure (7° to 30°)

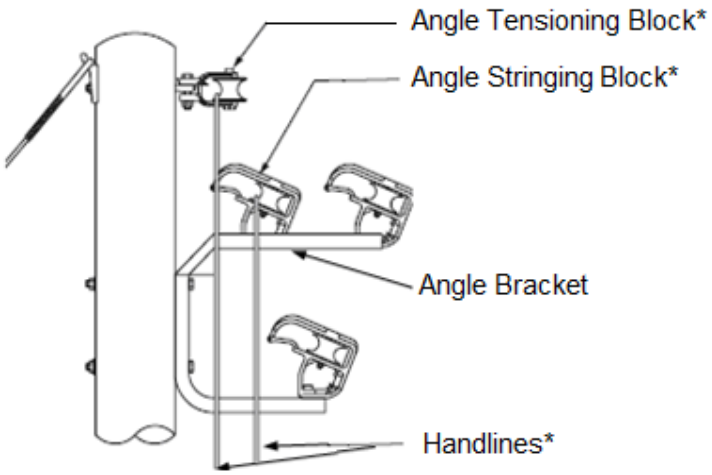


Figure 5-2: Angle Structure (7° – 30°)

For Angles Structures between 7° and 30° install:

- Hendrix Angle Bracket.
- 3 x PAS-1, Angle Stringing Block, one at each insulator position.
- PAT-1, Angle Tensioning Block.
- Handlines through PAT-1 as well as PAS-1, on the inside phase only.

5.1.3 Angle Structure- 31° to 60°

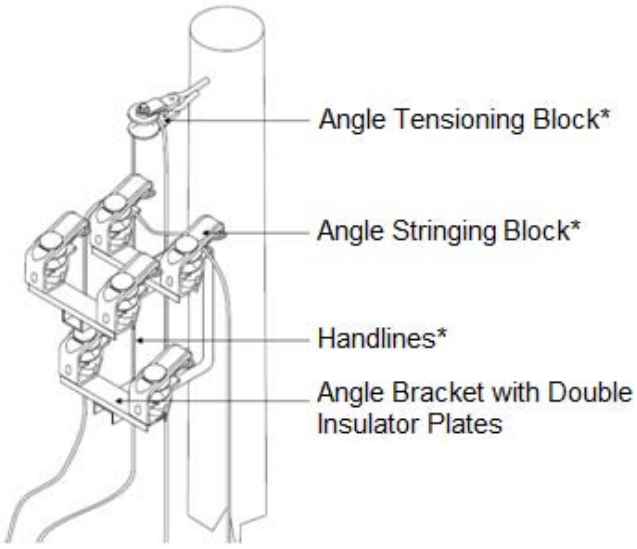


Figure 5-3: Angle Structure (31° – 60°)

For Angles Structures between 31° and 60° install:

- Hendrix angle bracket with double insulator plates.
- 1 x PAT-1, Angle Tensioning Blocks.
- 6 x PAS-1, Angle Stringing Blocks, one at each insulator position.
- Handlines through PAT-1 and both PAS-1's on the inside phase only.

5.1.4 Angle Structure- (61º to 90º)

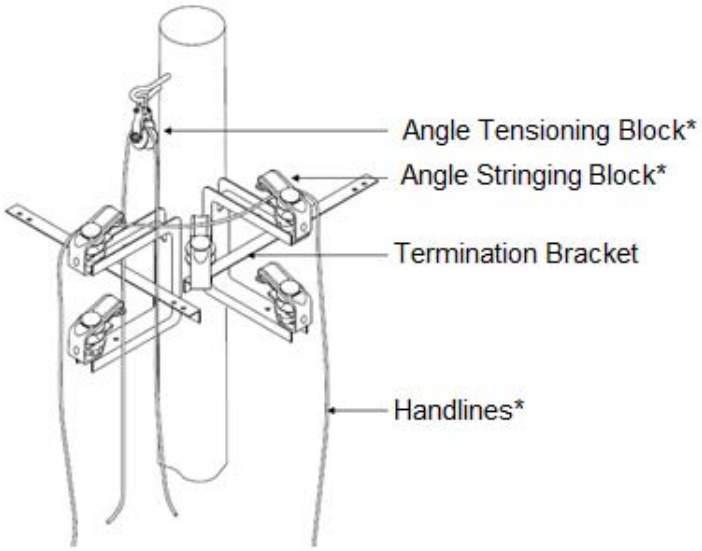


Figure 5-4: Angle Structure (61º – 90º)

For Angles Structures between 61º and 90º install:

- 2 x Hendrix Termination Brackets, positioned at the required angle.
- 5 x PAS-1, Angle Stringing Block, positioned as shown in Figure 5-4. Because of the bracket arrangement the outside phase requires only one PAS-1 for stringing purposes.
- PAT-1, Angle Stringing Block.
- Handlines through PAT-1 and both PAS-1's on the inside phase only.

5.1.5 Termination Structures

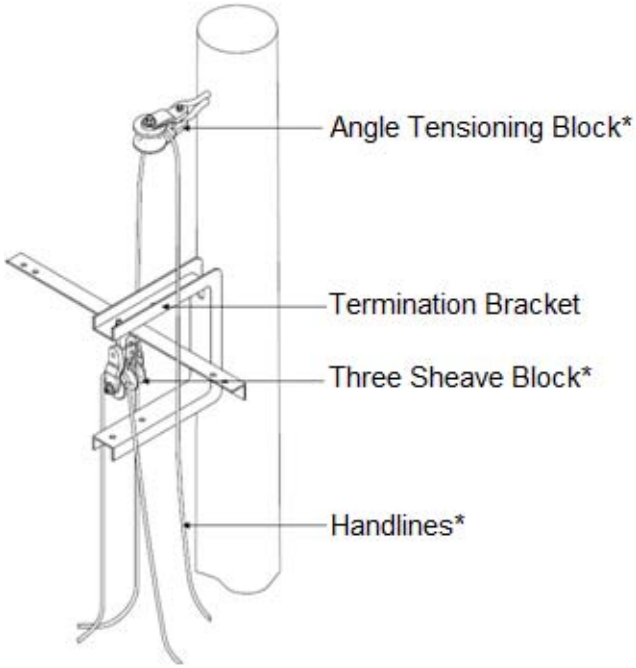


Figure 5-5: Termination Structure

For Termination Structures install:

- Hendrix Termination Bracket.
- PAT-1, Angle Tensioning Block.
- Three Sheave Block. Install single insulator pin and temporarily attach an Eye Nut (CA9050) which will accommodate the attachment of the Three Sheave Block.
- Handlines through PAT-1 and the rollers of the Three Sheave Block.

5.2 Installing the Messenger Wire

The first requirement for installing the messenger wire is to use the handlines installed during pole dressing and preparation to guide a pulling rope through the Angle Tensioning Blocks on the Angle Structures and Termination Structures, and the Tubular Messenger Guide at Intermediate Structures. This is achieved by attaching the pulling rope to one end of the handline and pulling it on the other end, continuing along the circuit until the termination point is reached.

The messenger wire can now be attached to the end of the pulling rope using the correct type of basket and swivel, see Figure 5-6. Pull the messenger wire through the Tubular Messenger Guide and Angle Tensioning Blocks until it reaches the other end. Terminate the messenger wire at the end in order to free the tension on the pulling rope. The pulling rope can then be detached from the messenger wire.

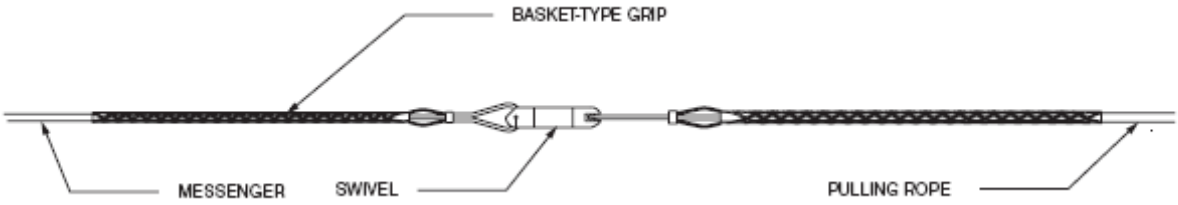


Figure 5-6: Messenger wire Connected to Pulling Rope

On Angle Structures beyond 30º, the messenger wire must be secured on a double termination configuration (Refer to DDC). Each section between messenger wire double terminations must be tensioned separately.

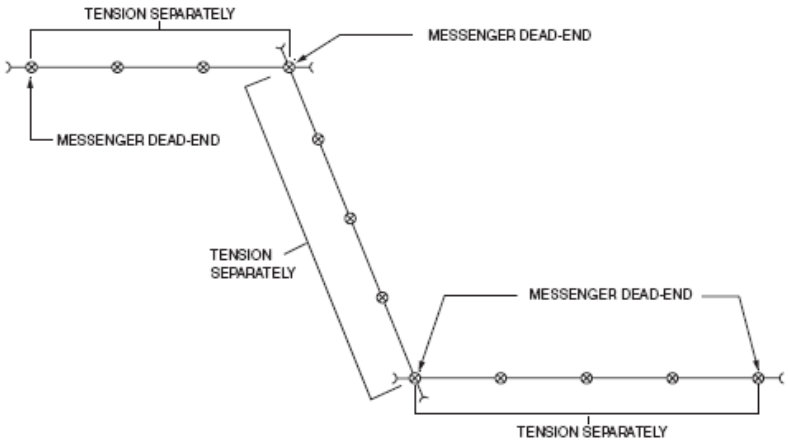


Figure 5-7: Messenger wire Pulling Section

The messenger wire is tensioned, for all lengths between each messenger wire terminations, in accordance with Appendix B: Initial and Final Messenger Wire Stringing

Tension Tables. It is important to note that these values are the initial messenger wire tension values only, prior to attaching spacers and equipment. Tensioning is best achieved by using a dynamometer.

After completing all terminations, install the MC-2 Messenger wire Clamps on all Intermediate Structures and secure the messenger wire in the clamp before removing the Tubular Messenger wire Guide. The procedure is illustrated in Figure 5-8 below. For Angle Structure (6º to 30º) replace PAT-1 with Messenger wire Angle Clamps.

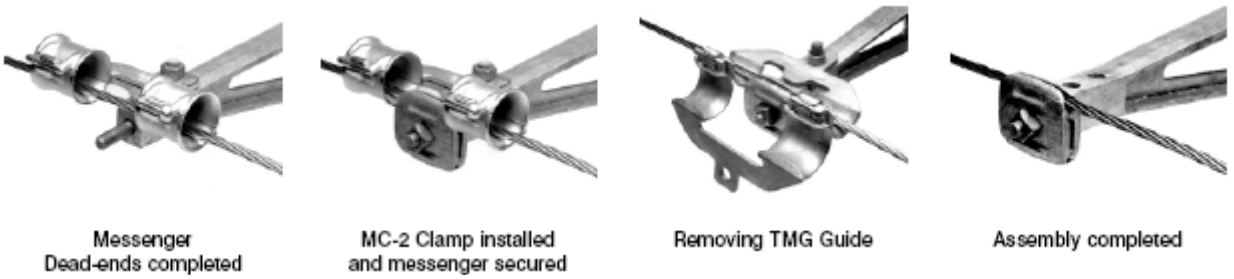


Figure 5-8: Securing the Messenger wire onto Intermediate Bracket

Do not attach the down earth system to the messenger wire and do not install the TS-1 stirrups (see

Figure 5-16) on the tangent brackets as this will interfere with the conductor installation, as the rollers will be unable to run along the messenger wire.

5.3 Installing the Conductors

As with the messenger wire installation, it is necessary to string the pulling rope from the one end of the circuit to the other by utilizing the handlines installed during pole dressing and preparation. The pulling rope will be run through the BJ Slack Brackets on Intermediate Structure, PAS-1 Angle Stringing Blocks on Angle Structures and the Three Sheave Block at Termination Structures.

Unspliced covered conductors can typically be strung through several “pulling sections”, conditions and experience permitting. A “pulling section” is defined as a series of bays where the conductors can be strung through blocks at structures not exceeding angles of 6º. See Figure 5-9

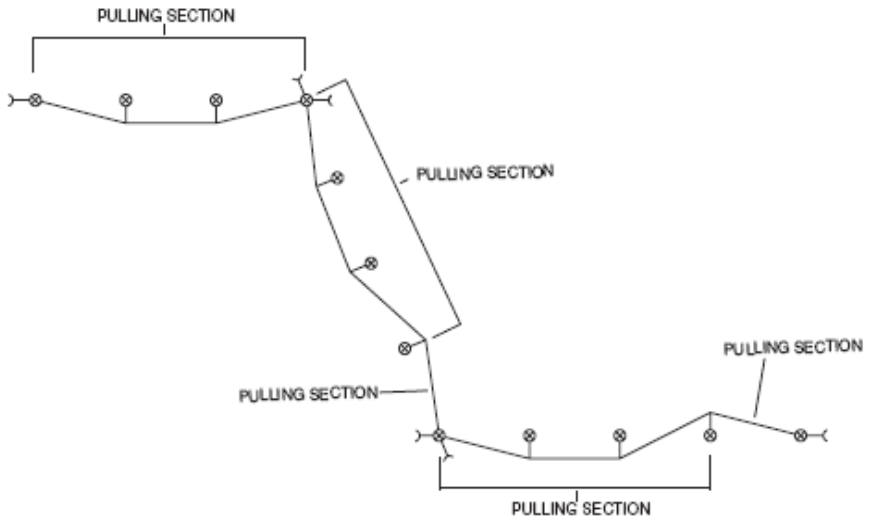


Figure 5-9: Pulling Section

For the first pulling section, arrange the reels so that all three conductors can be pulled together from a location behind the first pole. Attach a Three Sheave Block (not a PBR-3, Roll-By Block) to the first pole, which will allow the conductors to be easily fed into the Roll-By Blocks. See Figure 5-9

Attach the pulling rope and swivel to the lead-end of the TM Messenger wire Trolley and hang the trolley on the messenger wire with the “C” shape of the trolley facing the pole. The conductors are fed from the reels through the Three Sheave Block and connected to the trailing end of Messenger Trolley using the shackle clevis. Conductors should be tied to the shackle clevis using the basket type grips with rotating eye.

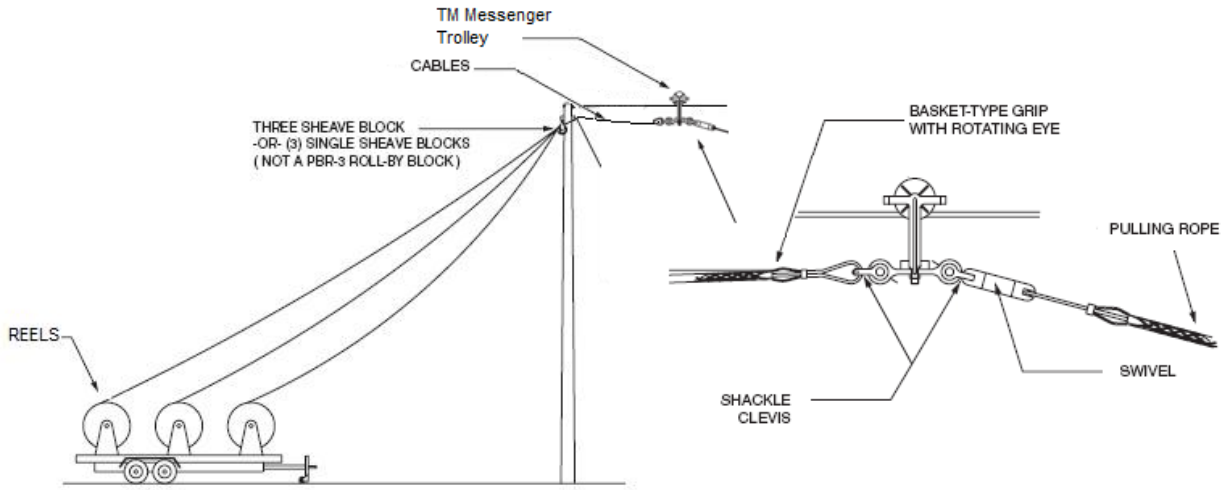


Figure 5-10: Installing the conductors –TM Messenger Wire Trolley

The Roll-By Blocks are installed next. The number of Roll-By Blocks required for a particular pulling section depends on the length of the pulling rope in metres, divided by 10. Roll-By Blocks are tied to each other using the tag lines (10m), in order to maintain a consistent distance of 10 metres from one to another once stretched. Take the first Roll-By Block and secure the three conductors onto the rollers by closing the keeper arm. Hang the Roll-By Block with inserted conductors onto the messenger wire. Continue this process for all Roll-By Blocks for the particular pulling section. See Figure 5-11.

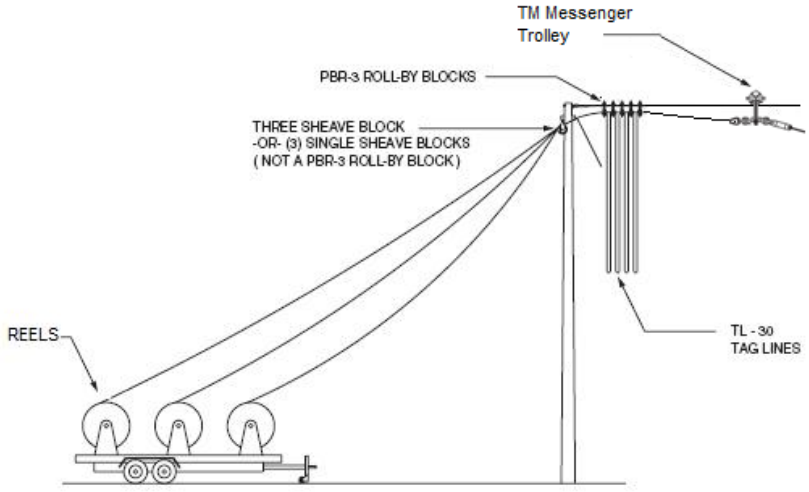


Figure 5-11: Installing the conductors - TL -30 Tag Lines

Start the pulling process slowly. The messenger trolley and Roll-By Blocks are designed to pass over the tangent bracket. Installing the Tangent Brackets on the same side of every pole for the particular pulling section is thus essential. See Figure 5-12.

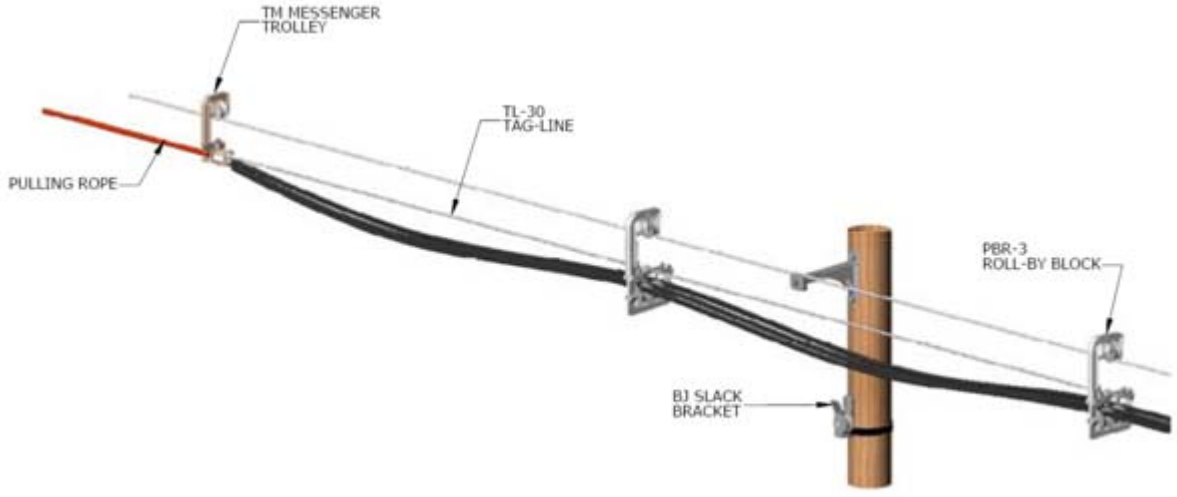


Figure 5-12: Pulling the Messenger wire Guide

Once the Messenger wire Trolley reaches the first angle bracket the first pulling section is complete. Tie-off the first and last tag lines to prevent further movement of the Roll-By Blocks. Reduce the tension on the pulling rope to allow its removal from the inside PAS-1 block. Lift the Messenger Trolley off the messenger wire by hand or using a material handler. Restart the pulling very slowly and guide the Messenger wire Trolley past the angle bracket and replace it onto the next section's messenger wire. Continue pulling until there is enough conductor to allow the individual conductors to be placed in the appropriate PAS-1 Blocks. Reduce pulling tension and place conductors in the PAS-1 Angle Stringing Blocks. See Figure 5-13.

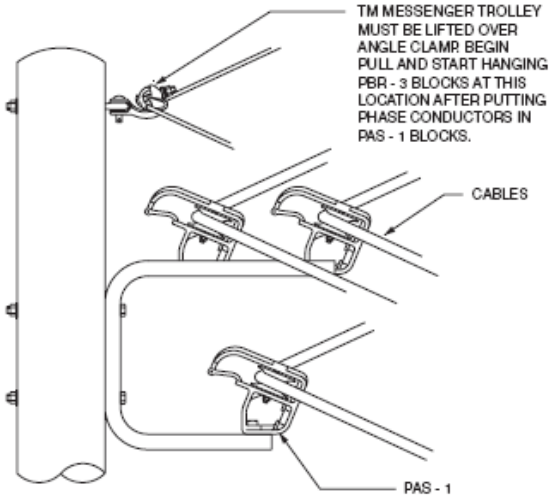


Figure 5-13: Securing the Conductors in Angle Stringing Blocks

Another set of Roll-By Blocks are prepared for the next pulling section, and the process is repeated for all pulling sections.

Generally, conductors cannot be spliced and pulled through PAS-1 blocks. Longer circuits will require the previous run to be completed and terminated at one end, sagged according to the installation temperature and temporarily tied off. An entirely new section is installed, sagged and then spliced into the ends of the completed section.

Sag the conductors between the Roll-By Blocks in accordance with Appendix C: Covered Conductor Sag Tables Table 10. Sagging is very IMPORTANT. The system reliability is compromised if conductors are over tensioned. Note the ambient temperature during the sagging procedure.

Terminate the conductors at the first pole in the circuit (closest to the reel trailer). Use the pulling equipment to adjust the sag between Roll-By Blocks. The sag mid-way between the Roll-By Blocks should be equal to the value from the sag table plus the distance “M”. If the RTL-46 Spacer is used the distance “M” is 535 mm. See Figure 5-14.

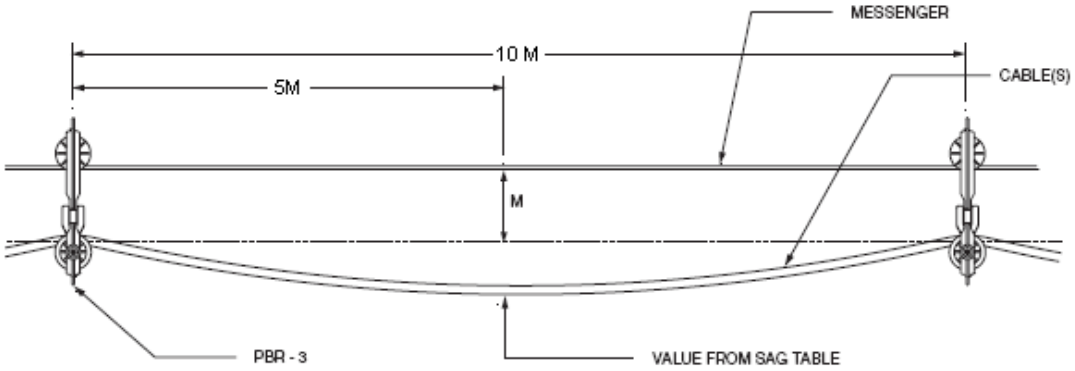


Figure 5-14: Conductor Sag Between Spacers

Sag checks should be made at several locations along the circuit for accuracy and consistency. It is not critical that the sag be exactly the same at each location checked, but any measurement should not be less than the value in the Table 10 plus “M”. A little more sag is better than not enough sag.

5.4 Installing the Spacers and Completing the Installation

Roll-By Blocks can be removed and spacers installed, proceeding through the entire circuit. Spacers are to be installed at approximately 10 metres intervals from one another. If this cannot be achieved spacer separation can be increased to a maximum of 15m or a minimum of 7m. Spacers are to be installed NO LESS than 12 metres from Termination Structures. Installing spacers less than 12 metres from Termination Structure introduces unnecessary tension onto the structure components and conductors. See Figure 5-15. The number of spacers required per span length is determined by the formula:

Number of spacers Required = Span Length(m) / 10

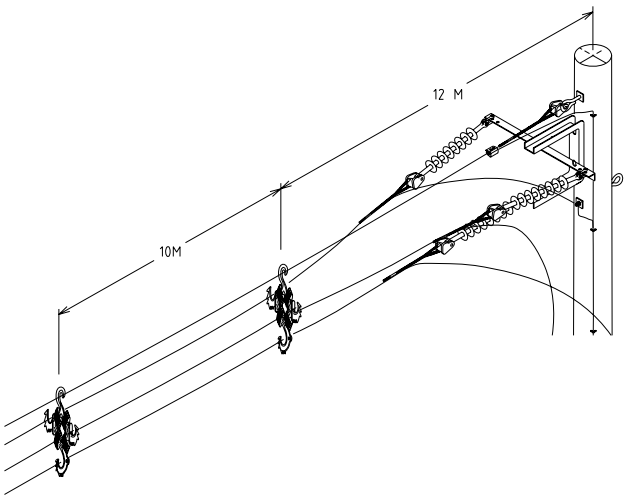


Figure 5-15: Spacer Separation

On Intermediate (Tangent) Structures, attach the TS-1 Stirrup to the Intermediate Structures using the bolt and nut provided (through the hole closest to the Messenger wire Clamp) and then install the spacer on the stirrup. Install an anti-sway bar at the bottom of the spacer and attach it to the pole. See Figure 5-16..

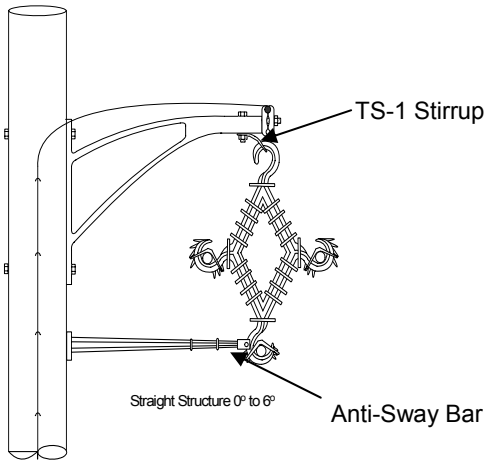


Figure 5-16: Install Stirrup and Anti-Sway Bar

At Angle Structures, replace the PAS-1 Angle Stringing Block with pin type insulators. Conductors are secured to the pin type insulators with covered tie wire. See Figure 5-17.

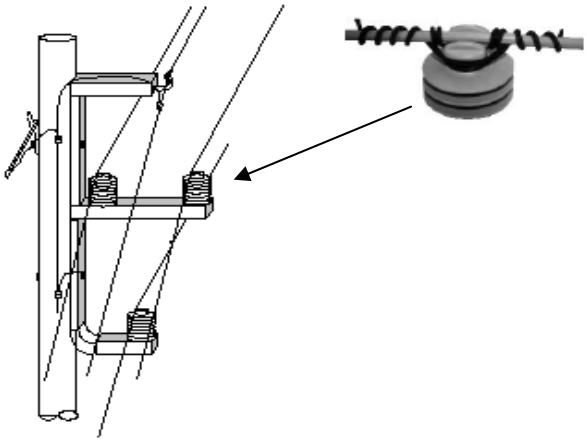


Figure 5-17: Covered Tie Wire

Complete all other work such as stripping the conductors for taps, covering the messenger wire with line duct above the conductor taps and at circuit terminations, installing surge arresters, etc.

5.5 Earthing

The down earth system is installed as per design specifications or at least every 150 metres. The messenger wire is connected to the down earth system at each of these points using the correct hardware. Down earth rods shall not have a resistance higher than 30 ohms.

For maintenance and general works performed on the Hendrix system, the line needs to be earthed at open points at either end of the point of operation. This is achieved by connecting the portable earths to the bus connector earthing stud, situated on structures equipped with surge arresters. Refer to DCSH for more detail.

5.6 Taps and Terminations

5.6.1 Taps

Taps on the Hendrix covered conductors are made by stripping the required length of insulation off the conductors using the stripper. Use the appropriate sized PG-Clamp to connect the tap-off. Finally restore the system insulation by covering the connection with gel-wrap as the Hendrix covered conductors are not water blocked and any water ingress might result in insulation damage and lead to system failure. All taps should have a minimum separation distance of 300mm from earthed points, splices, spacers etc. and a minimum separation distance of 450mm should be maintained between multiple taps. See Figure 5-18 and Figure 5-19 . Line-duct can be used on the messenger wire above a tap or other open points in order to avoid outages caused by wildlife contacts.

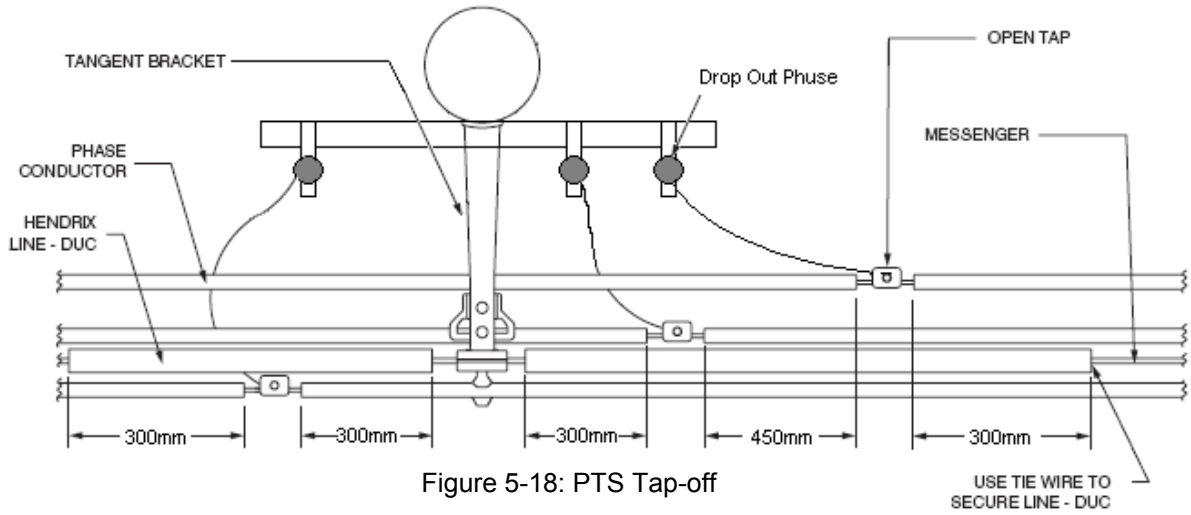


Figure 5-18: PTS Tap-off

Figure 5-19: Gel Wrap

5.6.2 Terminations

The Hendrix Covered Conductor Systems utilize covered phase conductors which do not have external shields. There is therefore no requirement for stress relief at terminations or pot-heads. Terminations may be made in the same manner as open wire construction or in accordance with the termination details.

It is however essential to seal any opening in the cover at termination points to prevent moisture ingress by installing 3M Mastic tape in the gap and overlapping on both sides, onto the lug and over the covered conductor with cold shrink.

5.7 Splices

5.7.1 Messenger Wire Splices

Messenger wire splices shall be rated for the full rated breaking strength of the messenger wire used. Compression or automatic type splices may be used. Care must be taken to

ensure that the Messenger wire Trolley and the Roll-By Blocks will roll over the completed splice.

5.7.2 **Hendrix Covered Conductor Splices**

All phase conductor splices must be full tension splices and must be covered to restore Basic Insulation Level (BIL). Splices can be installed in mid bay and must be staggered to provide a minimum separation of 600 mm, end to end, as shown in the Figure 5-20.

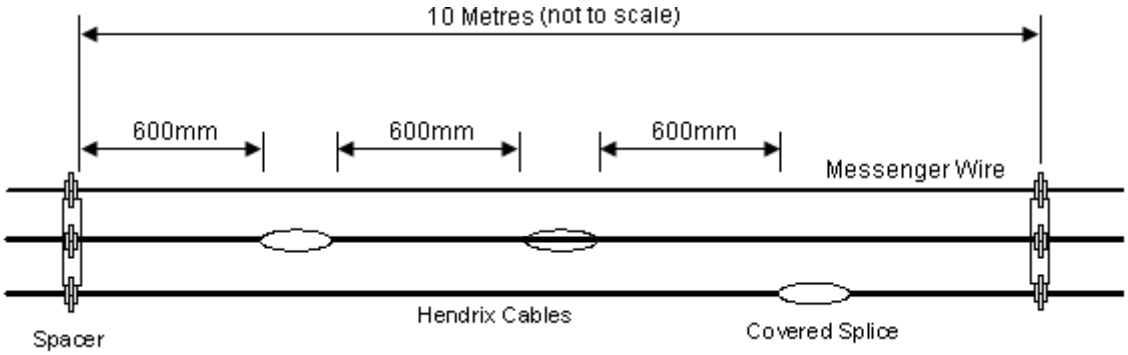


Figure 5-20: Splices

The three different methods of covering splices are: Cold Shrink Splice Cover, Taped Splice Cover, and Heat Shrinkable Tube Splice Cover.

For the Cold Shrink Splice Cover process the following instructions are followed:

1) Clean conductor surface (450 mm of each covered conductor end) using approved cleaning fluid or wipes.
2) Remove covering, including conductor shield (if any), from both ends for a distance equal to one-half of the connector length plus any anticipated growth in length due to crimping. *The maximum allowable connector length is 305mm.* Slip cold shrink tube over one conductor.

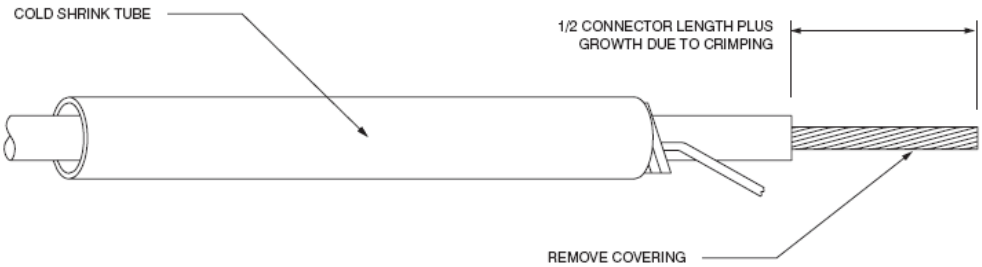


Figure 5-21: Cold Shrink Splice Covering

3) Use chalk or tape wrap to mark on the conductor covering surface 280 mm back from conductor end.

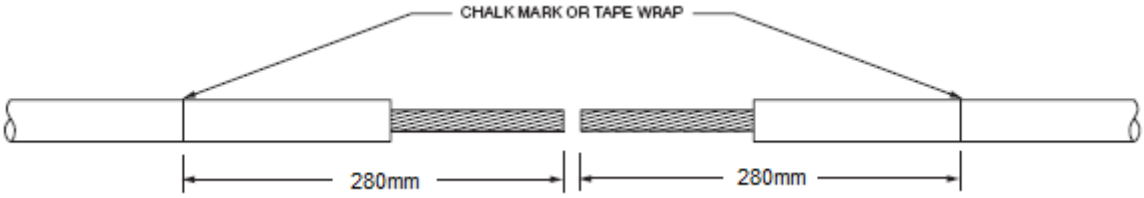


Figure 5-22: Cold Shrink Splice Covering

4) Clean the conductor ends using a wire brush. Install 7/4.75 AAC full tension in-line crimp. Wipe away extruded oxide inhibiting compound.

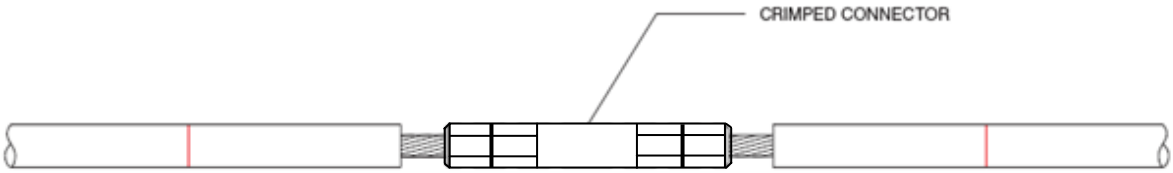


Figure 5-23: Cold Shrink Splice Covering

5) Install one mastic strip on either side of the crimp sleeve to fill the space between the conductor covering and the end of the connector.

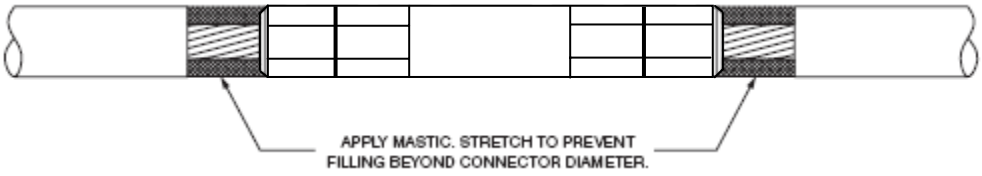


Figure 5-24: Cold Shrink Splice Covering

6) Beginning 15 mm over the conductor covering. Apply a half lapped layer of semi – conducting tape (sticky side down) across the mastic and connector to 15 mm over the conductor covering the other side of the splice. IMPORTANT: Do not extend the semi-conductive tape past the chalk mark or tape wrap marker. Apply sufficient tension to reduce the tape wrap width to 75% of the original width.

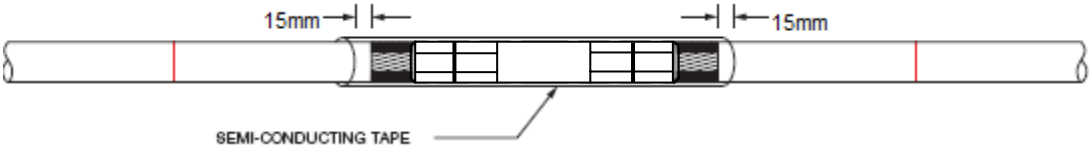


Figure 5-25: Cold Shrink Splice Covering

7) Beginning 15 mm from the chalk mark on the one side of the splice, apply a half-lapped layer of insulating tape (sticky side down) to within 15 mm of the chalk mark on the either side of the splice. A single half-lapped layer is required for 15 kV conductors, two half lapped layers are required for 25 kV conductors and three half lapped layers are required for 35 kV. Be sure to use all the tape provided. Western Power standardised on 33kV systems, it is therefore required to always use three half lapped layers.

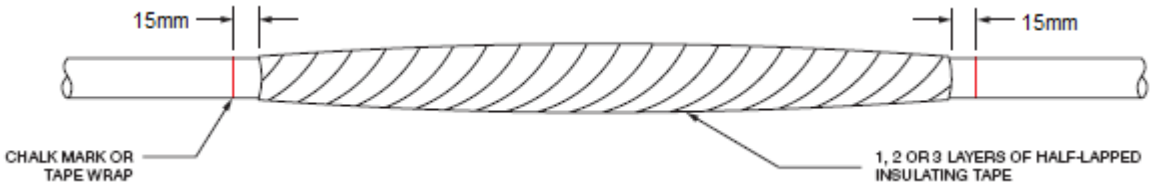
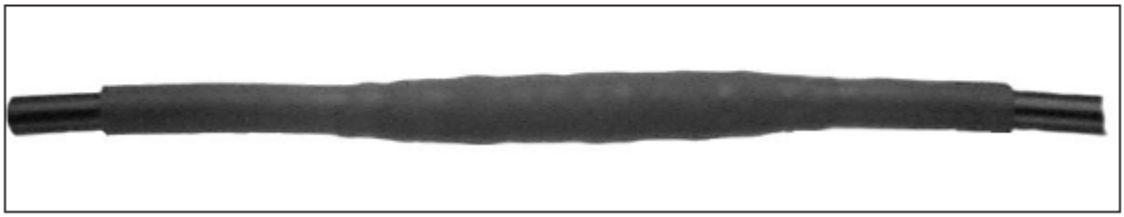


Figure 5-26: Cold Shrink Splice Covering

8) Position the silicon shrink tube over the splice. The end without the core ribbon should be aligned with the chalk mark. Pull the core ribbon while rotating it in a clockwise direction. Tube will shrink around the splice. Overlap and install second tube if required. Note: Do not pull the core ribbon straight out or use a jerking motion as this may cause the core to break.

Removing the core



Completed splice cover

Figure 5-27: Cold Shrink Splice Covering

Important: Automatic type splices shall not be used on Hendrix covered conductors because there is not enough tension in the phase conductors to properly set the jaws for full conductivity.

5.8 Single Phase Distribution

For Single phase distribution, the same design and construction methodology is followed. The only difference is that a single 150 mm^2 phase conductor and single phase spacer (Photo in Appendix F: Hendrix Construction Components) will be installed.

5.9 River Crossing Construction (Long Spans)

5.9.1 General

In January 2003, the Director of Energy Safety issued the “Code of Practice – Power Line Crossings of Navigable Waterways in Western Australia”. The code called for Western Power to modify its existing river crossing, in particular bare wire construction, to a more safe and reliable system that meets the requirements of the code. For this reason the use of the Hendrix Covered Conductor System for river crossings has been introduced.

The method of stringing the Hendrix Conductors across rivers differs from normal Hendrix stringing as the messenger wire, conductors and spacers are winched across the river simultaneously. The reason for this is that river crossing projects usually require longer spans to be strung at greater heights and crew members are only able to work at either end of the river crossing.

5.9.2 Organisation of Construction

- To ensure effective organisation: The co-operation of the *Department of Planning and Infrastructure (DPI) Marine Safety* must be arranged. Their vessel may carry across the river a rope that is used to winch the Hendrix conductors, the messenger wire and the striker wires.
- In a low river traffic area the river traffic can be managed safely by one *DPI Marine Safety* vessel. In the high river traffic areas either a second vessel must be used or a clear marking must be provided on buoys with High Voltage construction warning for the oncoming river traffic from both directions. In high river traffic areas a Timetable of Vessels is to be obtained from the *Marine Operation Centre*.
- Two weeks prior to commencement, the public must be informed about the construction works and the river traffic obstructions. This can be achieved by advertising in The Western Australian and in the local papers.
- The construction site must be marked (eg. with yellow caution tape) to keep the public at bay.
- Clear marking of the dangerous zones around the pole while the cherry picker is operating is essential. Tools and materials of considerable weight that may fall can cause a serious hazard despite the use of Personal Protective Equipment (PPE), i.e. helmets, being worn. See Work Practice Manual.
- Two sets of two-way hand held radios must be used to coordinate construction on both sides of the river and with the *DPI Marine Safety* vessel.
- The Designer's presence at the construction site is highly recommended for the safety, design and organisational reasons.

5.9.3 Pre-construction and Pole Dressing

Pre-construction should commence prior to the switching programme.

When new poles do not have to be installed at the location of the existing structures, they could be installed prior to the actual river crossing construction date. Complete all necessary preparation work that needs to be done on the surrounding network prior to commencement of river crossing works programme. This will enable the main construction to be finished in one or two working days.

During the pre-construction work:

- Install the pole base support biscuits under every pole, 900 mm in diameter, 150mm thick.
- Erect the 10 kN concrete poles and calculate the embedment depth of the pole using the following equation:

$$\text{Pole Embedment Depth} = \left(\frac{\text{Pole Length (m)}}{12} + 1.4 \right) \qquad \text{Eq. 4}$$

- Earth the poles
- Apply blue metal taping to support the poles;
- Install stays and anchors as per structural design
- Refer to the DCSH for Construction Drawing for River Crossings.

Each pole must be dressed in accordance with the approved plans, designs and specifications. The construction is split into two sides viz. a conductor tensioner side and a winch side, see Figure 5-28. For the pole on the conductor tensioner side, a conductor roller for the messenger wire and a three sheave Block for the conductors are attached to the side of the termination bracket. For the pole on the winch side, a conductor roller for the pulling rope is attached to the side of the termination bracket.

5.9.4 Stringing and Tensioning across Waterways

On the winch side, pass the pulling rope through the conductor roller which is attached to the termination bracket. The pulling rope is then transported by boat, to the tensioner side of the river.

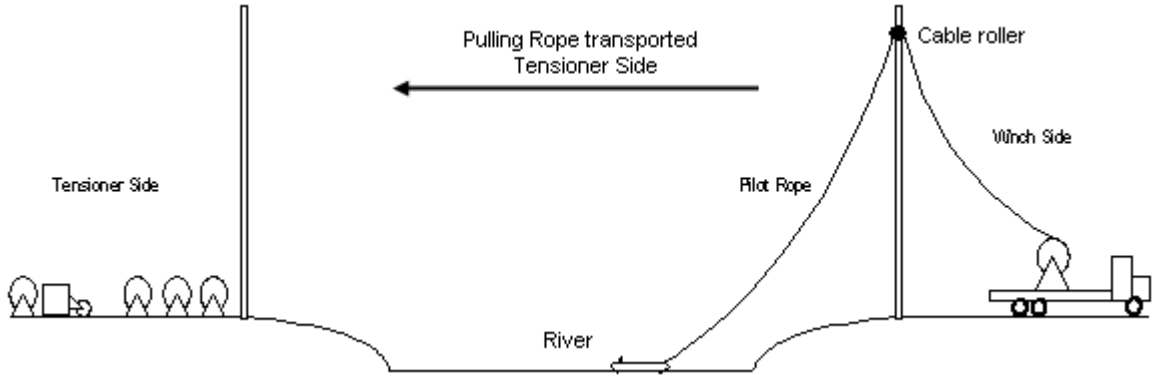


Figure 5-28: Stringing The Pulling Rope

Once across to the tensioner side, the pulling rope is put through the conductor roller and pulled down to ground level. Pass the messenger wire at least four times around the conductor tensioner drum and then connect it to the pulling rope using the correct basket type grip and swivel. The messenger wire is then pulled through the conductor roller before the combination conductor plate is attached.

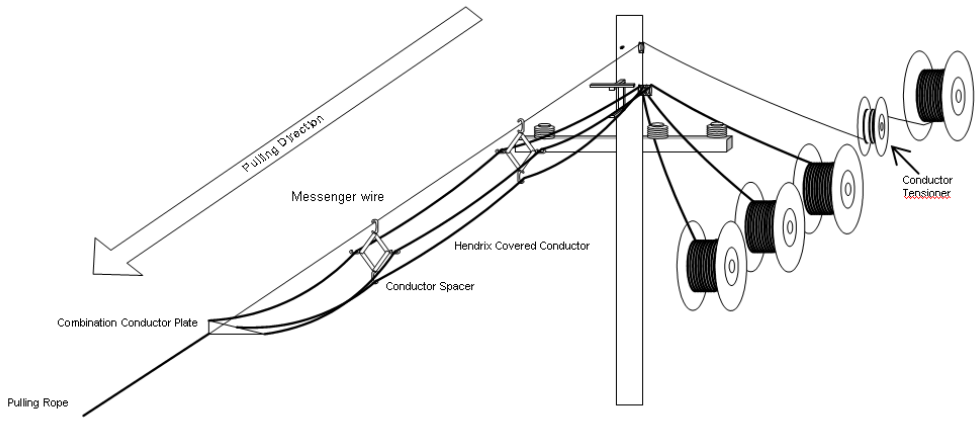


Figure 5-29: Pulling Process

Mark the Hendrix conductor every 10 m whilst it is still on the ground. This enables the linesmen in the cherry picker to know precisely where to place a spacer bracket. Pass the three Hendrix covered conductors through the Three Sheave Block and connect them to the combination conductor plate using the correct preformed dead-ends.

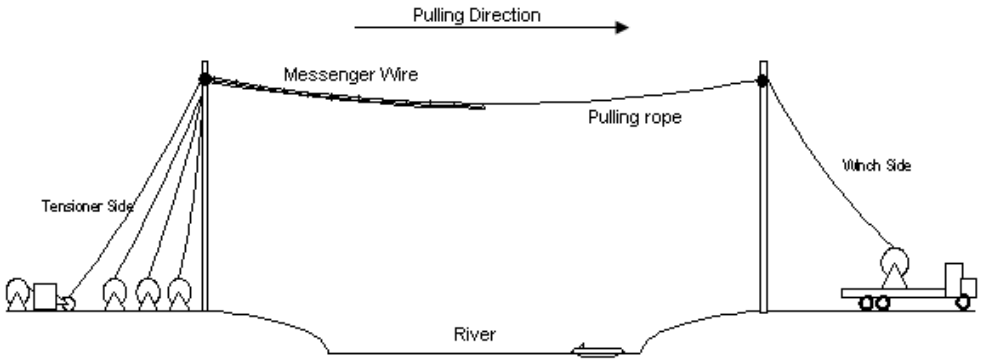


Figure 5-30: Pulling Process

Start pulling the messenger wire and conductors slowly across the river, ensuring that the minimum water to conductor distance (5m during construction) is adhered to by applying sufficient braking on the tensioner side. At intervals of 10m, which have been marked on the conductors before stringing, the pulling process is paused in order to install the spacers, ensuring that the correct sequence of configuration is maintained. Continue this process until the messenger wire, spacers and conductors have reached the termination bracket on the winch side of the river. The winch operator can now be informed to cease conductor pulling, and apply the brake, in order to prevent the messenger wire from moving.

Using the correct preformed dead-ends, terminate the messenger wire and the conductors onto their respective terminations at one end. Release the tension from the winch and remove the pilot rope. The messenger wire shall then be tensioned in accordance with Appendix D: River crossing final tension tables before it is terminated on the other end. Ensure the minimum clearance between waterway and conductor is achieved.

5.9.5 Striker wires

Striker wires are installed on both sides of the Hendrix construction using the same method of installation. The Striker wires are installed as an additional safety precaution, in the event that the mast of a boat/yacht was to collide with the overhead network, the striker wires prevent the mast from contact with the live conductors and from becoming energized in the process. The striker wires are attached to both ends of the steel termination cross arms.

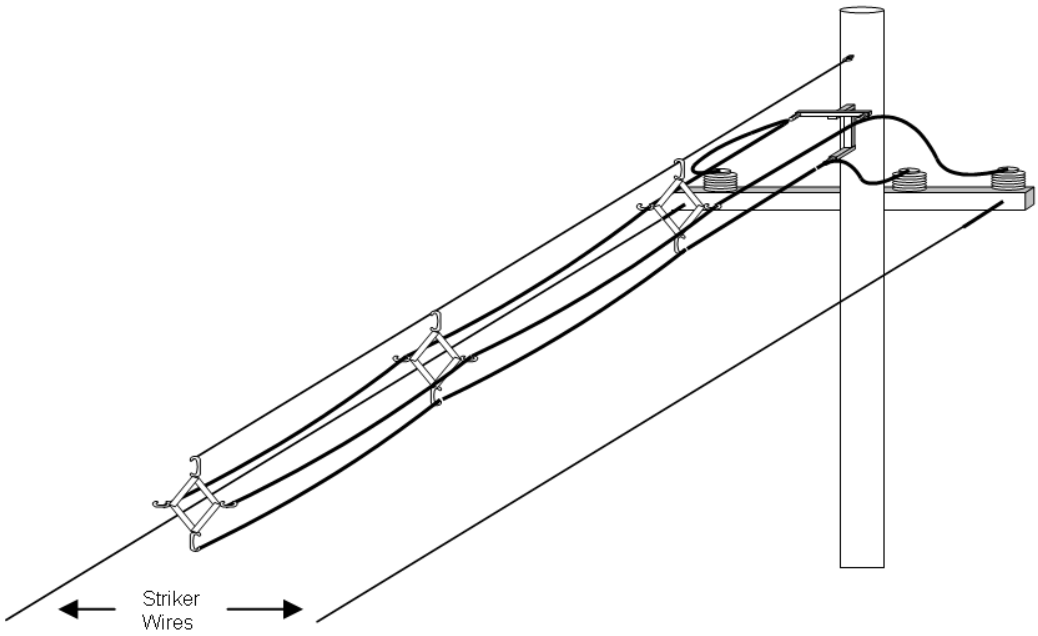


Figure 5-31: Striker Wires

6 Clearances from Vegetation

The basic rule for vegetation in the vicinity of distribution power lines is that vegetation needs to be kept clear (to the side and below) of electricity conductors. Also, generally vegetation should not overhang the conductors. Energy Safety has published Guidelines for the Management of Vegetation near Power Lines.

The Appendix on page 16 of the Guidelines details the minimum vegetation clearances to be maintained around different types of voltages and conductors.

Hendrix conductor should be classified as power line type – insulated unscreened conductor.

Where it is practical to do so, Western Power requires a re-growth space allowance of 1.5 metres for insulated conductors.

Designers should refer to the Western Power document Vegetation Clearances for the Construction of Overhead Power Lines DM# 9288088 for guidance.

7 References

[1] Hendrix Catalogue 'Overhead Cable System, Products and Services' www.hendrix-wc.com

[2] Western Power Document 'DDS –Overhead Conductor Distribution – Distribution Design Manual Volume 5'

[3] Western Power Document 'Prototype River Crossing using Hendrix Cable Report' DMS #2263611

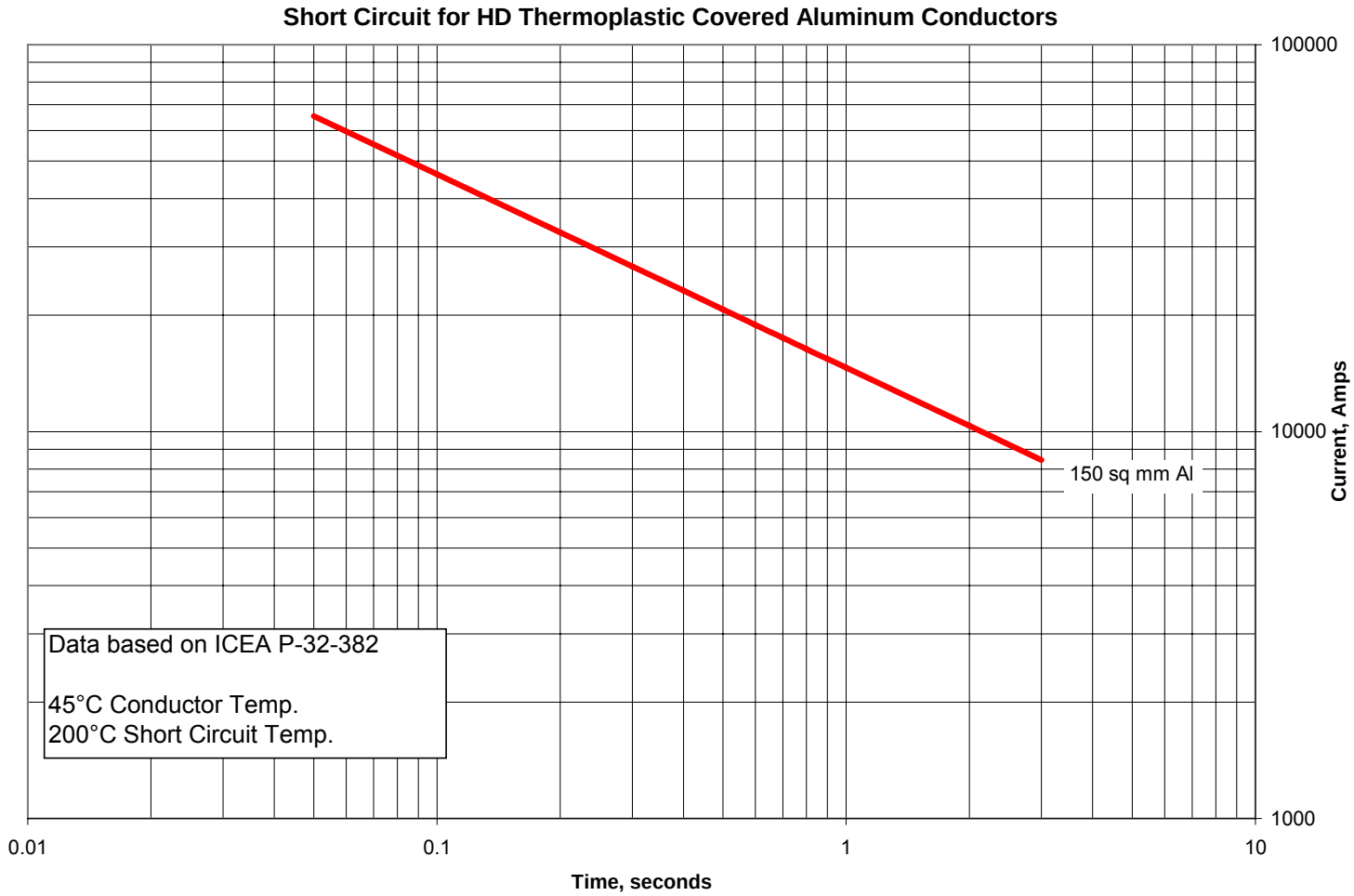
[4] Western Power Document 'Review of 22 KV Overhead Conductors in the Hills Area' DMS #905434

[5] Western Power Document 'Hendrix Cable System-Draft' DMS #3539281

[6] Western Power Document 'River Crossing Design Package' DMS#2257358

Appendix A: Hendrix Conductor Electrical Data

1. Short Circuit Current Rating for Thermoplastic Covered Aluminium Conductor

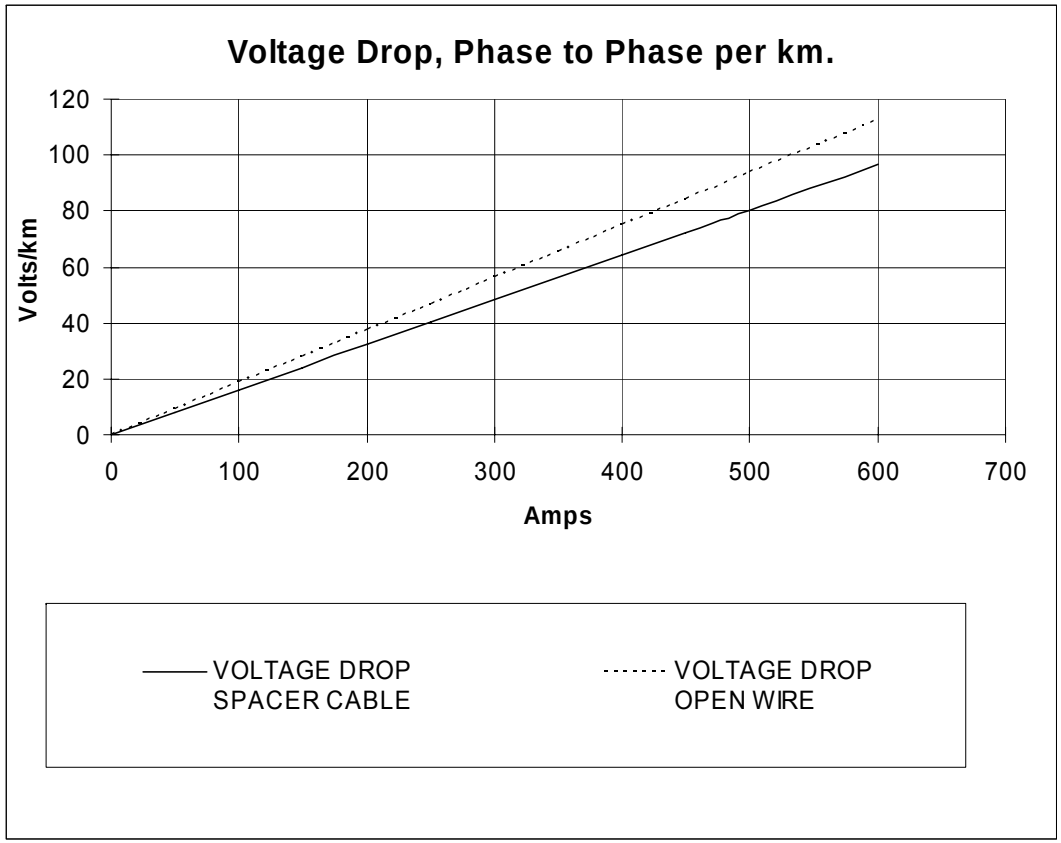


2. Voltage Drop

2.1 Voltage Drop for 150mm^2 Hendrix Covered Conductor

AC RESISTANCE ohm/km @25°C	0.195
GMD OPEN, mm	1344
GMD SPACER, mm	292
GMR, mm	5.639
POWER FACTOR	0.9
REACTANCE OPEN ohm/km	0.41
REACTANCE SPACER ohm/km	0.3

AMPS	VOLTAGE DROP SPACER COVERED CONDUCTOR	VOLTAGE DROP OPEN WIRE	DIFFERENCE
0	0	0	
50	8.05	9.37	14.13%
100	16.09	18.74	14.13%
150	24.14	28.11	14.13%
200	32.19	37.48	14.13%
250	40.23	46.86	14.13%
300	48.28	56.23	14.13%
350	56.33	65.6	14.13%
400	64.37	74.97	14.13%
450	72.42	84.34	14.13%
500	80.47	93.71	14.13%
600	96.56	112.45	14.13%



3. Hendrix Covered Conductor and Spacer Impedance Data

Aluminum Covered Conductor	AC Resistance @ 25 °C ohms/km	AC Resistance @ 75 °C ohms/km	AC Resistance @ 90 °C ohms/km	GMR (mm)	Inductive Reactance ohms/km with RTL-46
150mm^2	0.1945	0.2332	0.2446	5.64	0.2977

Table 9: Covered Conductor and Spacer Impedance Data

Appendix B: Initial and Final Messenger Wire Stringing Tension Tables

22kV Hendrix **Initial** Messenger Tensions (kg)

(Before 3x150sq mm 22kV Hendrix cables are installed)
052AWA messenger wire (20%CBL)

RULING SPAN	CONDUCTOR TEMPERATURE (°C)																		
	5	**7.5**	**10**	**12.5**	**15**	**17.5**	**20**	**22.5**	**25**	**27.5**	**30**	**32.5**	**35**	**37.5**	**40**	**42.5**	**45**	**47.5**	**50**
20	1477	1433	1388	1344	1300	1255	1209	1164	1120	1075	1031	987	942	898	854	810	768	724	680
25	1418	1373	1329	1285	1240	1196	1152	1107	1063	1018	976	932	887	845	801	758	715	674	631
30	1346	1302	1258	1214	1169	1125	1083	1039	995	951	907	864	823	780	738	696	656	616	576
35	1262	1219	1175	1131	1088	1045	1001	958	915	873	831	790	749	707	669	630	591	555	520
40	1167	1123	1082	1039	995	954	910	871	829	788	747	708	670	633	596	562	529	497	467
45	1061	1020	979	937	895	855	815	775	736	699	663	628	593	561	529	498	471	445	421
50	949	909	869	830	791	754	718	681	646	614	582	550	522	494	470	446	425	405	385
55	833	796	758	724	689	656	623	593	565	537	511	486	465	443	424	405	388	373	359
60	721	688	656	625	596	570	543	519	495	475	455	437	419	403	388	375	362	350	339
65	620	594	568	544	521	501	480	461	444	428	413	399	386	373	363	352	343	332	324
70	538	518	499	480	464	448	432	418	406	392	382	371	362	352	344	334	326	320	312
75	476	462	446	433	420	408	398	387	377	367	359	351	343	335	328	321	315	309	304
80	431	420	410	400	389	380	372	364	356	349	341	335	329	323	317	311	306	301	297
85	399	389	381	374	366	359	352	346	339	333	328	323	318	313	308	304	300	295	291
90	374	367	361	355	349	343	337	332	327	322	318	313	309	305	301	297	294	290	286
95	356	350	345	339	334	330	326	321	317	313	309	306	302	299	295	292	288	285	282
100	340	336	332	328	324	320	316	313	309	306	303	299	297	294	291	287	284	281	279
105	329	326	322	319	315	312	309	306	303	300	297	294	292	288	286	283	281	279	276
110	320	317	314	311	308	306	303	300	298	295	293	290	287	285	282	280	278	276	274

22kV Hendrix **Final** Messenger tensions (kg)

(After 3x150sq mm 22kV Hendrix cables are installed)
052AWA messenger wire (20%CBL)

RULING SPAN	CONDUCTOR TEMPERATURE (°C)																		
	5	**7.5**	**10**	**12.5**	**15**	**17.5**	**20**	**22.5**	**25**	**27.5**	**30**	**32.5**	**35**	**37.5**	**40**	**42.5**	**45**	**47.5**	**50**
20	1583	1544	1506	1467	1429	1391	1354	1317	1281	1246	1211	1177	1144	1111	1080	1049	1019	990	961
25	1583	1546	1511	1475	1439	1405	1371	1337	1305	1272	1242	1211	1180	1152	1123	1096	1068	1043	1017
30	1583	1549	1516	1483	1451	1419	1388	1358	1328	1299	1270	1243	1216	1190	1164	1139	1115	1092	1068
35	1583	1552	1522	1491	1462	1433	1405	1377	1350	1323	1298	1273	1249	1224	1202	1179	1157	1136	1115
40	1583	1555	1527	1499	1472	1446	1420	1396	1371	1347	1323	1301	1278	1257	1235	1215	1196	1176	1157
45	1583	1558	1532	1507	1482	1459	1435	1412	1389	1368	1347	1326	1306	1286	1267	1248	1229	1212	1195
50	1583	1560	1536	1514	1491	1470	1449	1427	1407	1387	1368	1349	1330	1312	1295	1277	1261	1245	1228
55	1583	1562	1540	1520	1499	1480	1460	1441	1423	1405	1386	1369	1353	1336	1320	1304	1288	1273	1259
60	1583	1564	1544	1525	1507	1489	1471	1454	1436	1420	1404	1388	1372	1357	1343	1328	1314	1300	1286
65	1583	1566	1547	1531	1514	1497	1481	1465	1450	1434	1419	1405	1390	1376	1363	1350	1336	1323	1311
70	1583	1567	1551	1535	1520	1505	1489	1475	1461	1446	1433	1420	1407	1393	1381	1368	1356	1345	1332
75	1583	1569	1554	1539	1525	1511	1497	1484	1471	1458	1445	1433	1421	1409	1398	1385	1374	1363	1353
80	1583	1570	1557	1543	1530	1517	1505	1492	1480	1468	1457	1445	1434	1423	1412	1401	1390	1380	1370
85	1583	1571	1559	1546	1534	1523	1511	1499	1488	1477	1467	1456	1445	1435	1425	1415	1406	1396	1386
90	1583	1572	1561	1549	1538	1527	1517	1507	1495	1485	1476	1466	1456	1446	1437	1428	1419	1410	1401
95	1583	1573	1563	1551	1541	1532	1522	1512	1503	1493	1483	1474	1466	1457	1448	1439	1430	1422	1414
100	1583	1574	1564	1555	1545	1535	1526	1518	1509	1499	1491	1482	1474	1466	1458	1450	1441	1433	1426
105	1583	1574	1566	1557	1547	1539	1531	1522	1514	1506	1497	1489	1482	1474	1467	1459	1452	1444	1437
110	1583	1575	1567	1559	1550	1542	1534	1527	1519	1512	1504	1496	1489	1482	1474	1468	1461	1454	1446

33kV Hendrix **Initial** Messenger Tensions (kg)

(Before 3x150sq mm 33kV Hendrix cables are installed)
052AWA messenger wire (20%CBL)

RULING SPAN	CONDUCTOR TEMPERATURE (°C)																		
	5	**7.5**	**10**	**12.5**	**15**	**17.5**	**20**	**22.5**	**25**	**27.5**	**30**	**32.5**	**35**	**37.5**	**40**	**42.5**	**45**	**47.5**	**50**
20	1454	1410	1365	1320	1276	1230	1187	1142	1097	1053	1008	963	919	877	832	788	745	700	659
25	1381	1338	1294	1249	1205	1159	1115	1071	1028	984	939	896	852	809	766	724	681	640	597
30	1295	1251	1207	1162	1118	1073	1031	988	944	900	857	814	772	731	690	649	609	571	532
35	1192	1150	1105	1062	1019	976	933	891	848	806	765	724	685	645	608	570	534	501	468
40	1076	1034	992	950	907	865	825	784	745	705	668	630	593	559	525	495	464	437	412
45	951	910	870	829	789	751	714	676	640	604	572	539	510	481	455	430	407	385	367
50	819	781	743	707	672	638	606	574	544	515	489	464	440	419	400	381	365	350	335
55	690	657	627	595	566	539	512	487	466	444	424	407	390	374	360	347	334	323	313
60	577	551	526	504	481	461	442	424	408	393	378	365	354	343	332	322	313	305	297
65	488	470	452	435	420	406	392	379	367	357	347	337	328	320	312	305	297	291	284
70	426	413	400	388	377	367	357	348	339	331	324	317	310	303	298	292	285	280	275
75	382	374	364	356	348	339	332	326	319	313	307	302	297	291	286	281	277	272	269
80	353	346	338	332	326	320	315	309	305	299	295	290	286	281	277	274	270	267	263
85	330	325	320	315	311	306	302	297	293	288	284	281	277	274	271	268	265	262	259
90	314	311	306	302	299	295	291	287	284	280	277	274	271	268	266	263	260	258	255
95	302	299	296	292	288	285	282	279	277	274	271	269	266	264	261	259	257	255	253
100	293	290	286	284	281	278	276	273	271	269	266	264	262	260	258	256	254	252	250
105	284	282	279	277	275	273	270	268	266	264	262	260	259	257	255	253	251	250	248
110	278	276	274	272	270	268	266	264	262	261	259	257	256	254	252	251	249	248	246

33kV Hendrix **Final** Messenger tensions (kg)

(After 3x150sq mm 33kV Hendrix cables are installed)
052AWA messenger wire (20%CBL)

RULING SPAN	CONDUCTOR TEMPERATURE (°C)																		
	5	**7.5**	**10**	**12.5**	**15**	**17.5**	**20**	**22.5**	**25**	**27.5**	**30**	**32.5**	**35**	**37.5**	**40**	**42.5**	**45**	**47.5**	**50**
20	1583	1545	1508	1470	1433	1397	1361	1325	1291	1257	1223	1191	1159	1128	1098	1068	1040	1011	985
25	1583	1548	1514	1479	1445	1412	1379	1348	1317	1286	1256	1227	1199	1171	1144	1118	1093	1068	1044
30	1583	1551	1520	1488	1458	1427	1399	1370	1341	1314	1287	1261	1235	1211	1188	1164	1141	1119	1098
35	1583	1555	1525	1497	1470	1442	1416	1390	1365	1340	1316	1293	1270	1248	1226	1205	1185	1165	1146
40	1583	1557	1531	1506	1480	1456	1432	1409	1386	1364	1343	1321	1301	1280	1261	1243	1223	1206	1189
45	1583	1560	1536	1513	1490	1469	1448	1426	1406	1385	1366	1347	1328	1310	1293	1275	1258	1242	1226
50	1583	1562	1540	1520	1499	1480	1461	1441	1423	1405	1387	1370	1353	1336	1320	1305	1290	1274	1260
55	1583	1564	1545	1526	1508	1490	1472	1455	1438	1422	1406	1390	1375	1360	1345	1330	1316	1303	1290
60	1583	1566	1548	1532	1515	1498	1483	1467	1452	1437	1422	1408	1394	1380	1367	1354	1340	1328	1316
65	1583	1568	1551	1536	1522	1507	1492	1478	1464	1451	1437	1424	1411	1399	1386	1374	1362	1351	1339
70	1583	1569	1555	1541	1527	1514	1501	1487	1475	1463	1451	1438	1426	1415	1404	1392	1381	1371	1360
75	1583	1571	1558	1544	1532	1520	1508	1496	1484	1473	1462	1451	1440	1429	1419	1409	1399	1388	1379
80	1583	1572	1560	1548	1537	1526	1515	1504	1493	1482	1472	1462	1453	1442	1432	1423	1414	1405	1396
85	1583	1573	1562	1551	1541	1530	1521	1511	1501	1491	1481	1472	1463	1454	1445	1436	1427	1419	1411
90	1583	1574	1564	1554	1544	1535	1526	1517	1508	1498	1490	1481	1473	1464	1456	1448	1439	1432	1424
95	1583	1574	1566	1557	1547	1539	1530	1522	1514	1506	1497	1489	1481	1474	1466	1459	1451	1443	1436
100	1583	1575	1567	1559	1550	1542	1534	1527	1519	1512	1504	1496	1489	1482	1475	1468	1461	1454	1448
105	1583	1576	1568	1561	1552	1545	1538	1531	1524	1517	1510	1503	1496	1489	1483	1476	1470	1464	1457
110	1583	1576	1569	1563	1556	1548	1541	1535	1528	1522	1515	1509	1503	1496	1490	1484	1478	1472	1466

Appendix C: Covered Conductor Sag Tables

Final conductor sag tables

1. The values in Table 10 represent the amount of sag allowed between spacers which are separated approximately 10m apart.
2. Regular sag checks need to be done along the installation
3. DO NOT OVER TIGHTEN THE CONDUCTORS.

Ambient temperature during installation, C^0	Sag between Roll-By Blocks at 10 meter intervals (mm)
0	81
15	130
30	160
45	190
50	200

Table 10: Conductor Sag Data

Appendix D: River crossing final tension tables

River Crossing

22kV Hendrix **Final** Messenger tensions (kg)

(Messenger and conductors are installed simultaneously)
19/2.75 SC/GZ messenger wire (25%CBL)

RULING SPAN	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45	47.5	50
110	3680	3643	3608	3572	3537	3503	3468	3434	3401	3367	3334	3302	3270	3239	3207	3176	3146	3116	3087
115	3680	3644	3610	3575	3541	3508	3475	3441	3409	3377	3346	3314	3283	3253	3222	3193	3163	3135	3106
120	3680	3645	3612	3579	3545	3513	3481	3450	3418	3386	3356	3326	3296	3266	3238	3208	3179	3152	3124
125	3680	3646	3614	3582	3550	3519	3487	3457	3426	3397	3367	3337	3308	3279	3252	3223	3196	3169	3142
130	3680	3647	3616	3585	3555	3524	3493	3464	3434	3406	3376	3349	3320	3293	3265	3239	3212	3186	3159
135	3680	3648	3618	3588	3559	3529	3499	3471	3442	3414	3386	3359	3332	3305	3278	3253	3226	3202	3176
140	3680	3649	3620	3591	3562	3533	3506	3477	3450	3423	3396	3369	3344	3317	3292	3266	3242	3217	3193
145	3680	3650	3622	3593	3566	3538	3511	3484	3458	3431	3405	3379	3354	3329	3304	3279	3256	3231	3208
150	3680	3651	3624	3596	3570	3543	3517	3490	3465	3439	3414	3389	3365	3340	3316	3293	3269	3246	3223
155	3680	3652	3626	3599	3573	3547	3522	3496	3472	3446	3422	3399	3374	3351	3328	3305	3282	3260	3238
160	3680	3653	3628	3601	3577	3551	3527	3503	3478	3455	3431	3408	3384	3362	3339	3317	3295	3273	3252
165	3680	3654	3629	3604	3580	3556	3532	3508	3484	3462	3438	3416	3393	3372	3350	3328	3307	3286	3265
170	3680	3655	3631	3607	3583	3560	3536	3514	3491	3469	3446	3425	3403	3381	3361	3339	3319	3299	3278
175	3680	3655	3632	3610	3586	3564	3541	3519	3497	3475	3454	3432	3412	3391	3371	3351	3330	3311	3292
180	3680	3656	3634	3612	3589	3567	3545	3524	3503	3482	3461	3440	3420	3401	3380	3361	3341	3322	3303
185	3680	3657	3635	3614	3592	3571	3549	3529	3509	3488	3468	3449	3428	3409	3389	3371	3352	3333	3315
190	3680	3657	3637	3616	3595	3574	3554	3534	3514	3494	3475	3456	3436	3417	3399	3380	3362	3344	3326
195	3680	3659	3638	3618	3597	3578	3558	3538	3519	3499	3481	3462	3443	3425	3408	3389	3372	3354	3336
200	3680	3660	3639	3620	3600	3581	3562	3542	3524	3506	3487	3469	3451	3433	3416	3399	3381	3364	3348

River Crossing

33kV Hendrix **Final** Messenger tensions (kg)

(Messenger and conductors are installed simultaneously)

19/2.75 SC/GZ messenger wire (25%CBL)

RULING SPAN	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45	47.5	50
110	3666	3631	3597	3565	3532	3499	3467	3435	3405	3373	3343	3313	3282	3253	3224	3196	3167	3139	3111
115	3666	3632	3600	3568	3536	3505	3474	3443	3414	3383	3354	3325	3297	3268	3240	3212	3185	3158	3131
120	3666	3634	3602	3572	3541	3511	3481	3452	3422	3393	3365	3337	3309	3281	3255	3228	3202	3175	3150
125	3666	3635	3604	3575	3545	3516	3487	3459	3431	3403	3375	3349	3322	3296	3269	3244	3218	3193	3168
130	3666	3636	3607	3578	3549	3521	3493	3466	3439	3412	3386	3360	3334	3309	3283	3258	3233	3210	3186
135	3666	3637	3609	3581	3554	3526	3499	3473	3448	3421	3396	3370	3346	3321	3297	3273	3249	3225	3203
140	3666	3638	3611	3584	3558	3531	3506	3480	3455	3430	3406	3381	3357	3333	3310	3286	3264	3241	3218
145	3666	3639	3613	3587	3562	3536	3511	3486	3462	3438	3415	3390	3368	3345	3322	3300	3277	3256	3234
150	3666	3640	3615	3589	3565	3540	3517	3492	3469	3446	3423	3401	3378	3356	3334	3313	3292	3270	3249
155	3666	3640	3617	3592	3569	3545	3522	3498	3476	3454	3431	3410	3388	3367	3346	3325	3304	3283	3263
160	3666	3641	3618	3595	3572	3549	3527	3505	3483	3461	3439	3419	3398	3377	3357	3336	3316	3297	3277
165	3666	3642	3620	3597	3575	3554	3532	3511	3489	3468	3448	3427	3407	3387	3367	3348	3328	3309	3291
170	3666	3643	3621	3599	3578	3558	3536	3516	3495	3475	3455	3435	3416	3397	3377	3359	3339	3321	3303
175	3666	3644	3623	3602	3581	3561	3541	3521	3502	3481	3462	3443	3424	3406	3387	3369	3351	3333	3315
180	3666	3644	3624	3604	3584	3565	3545	3526	3507	3488	3469	3451	3432	3415	3397	3379	3361	3345	3327
185	3666	3645	3626	3607	3587	3568	3549	3530	3512	3493	3476	3458	3440	3423	3406	3388	3371	3355	3338
190	3666	3646	3627	3609	3589	3571	3554	3535	3517	3499	3482	3465	3448	3431	3414	3398	3381	3365	3349

River Crossing

22kV Hendrix **Final** Messenger tensions (kg)

(Messenger and conductors are installed simultaneously)
19/3.25 SC/GZ messenger wire (25%CBL)

RULING SPAN	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45	47.5	50
200	5095	5058	5021	4986	4950	4915	4881	4846	4812	4779	4746	4714	4681	4649	4618	4587	4557	4526	4495
205	5095	5059	5023	4989	4954	4920	4886	4853	4820	4787	4755	4724	4692	4661	4630	4599	4570	4540	4511
210	5095	5060	5025	4992	4958	4925	4892	4859	4827	4795	4764	4733	4702	4672	4642	4613	4583	4555	4526
215	5095	5061	5028	4994	4961	4929	4897	4865	4834	4803	4773	4742	4713	4683	4653	4625	4596	4568	4540
220	5095	5062	5030	4997	4964	4933	4902	4872	4841	4810	4781	4751	4722	4693	4665	4636	4609	4581	4554
225	5095	5062	5031	4999	4968	4938	4907	4877	4847	4818	4789	4759	4731	4703	4676	4648	4621	4594	4568
230	5095	5063	5033	5002	4971	4941	4911	4883	4853	4825	4796	4769	4740	4714	4686	4660	4633	4607	4581
235	5095	5064	5034	5004	4975	4945	4916	4888	4859	4832	4804	4777	4749	4723	4696	4670	4644	4619	4593
240	5095	5065	5036	5006	4978	4949	4920	4893	4865	4838	4811	4784	4758	4732	4706	4681	4655	4630	4606
245	5095	5066	5037	5008	4981	4953	4926	4898	4872	4844	4819	4792	4767	4741	4716	4691	4666	4641	4618
250	5095	5066	5039	5011	4984	4956	4930	4903	4877	4851	4825	4799	4775	4749	4725	4700	4677	4652	4629
255	5095	5067	5040	5013	4986	4960	4934	4907	4882	4856	4832	4807	4782	4758	4734	4710	4687	4664	4640
260	5095	5068	5042	5015	4989	4963	4938	4912	4887	4862	4838	4813	4790	4767	4743	4720	4696	4674	4651
265	5095	5068	5043	5017	4992	4966	4942	4916	4892	4869	4844	4821	4797	4775	4751	4729	4706	4684	4662
270	5095	5069	5044	5019	4994	4969	4945	4922	4897	4874	4850	4828	4804	4782	4759	4737	4716	4694	4672
275	5095	5070	5045	5020	4997	4972	4949	4926	4902	4879	4856	4834	4811	4789	4768	4746	4725	4703	4682
280	5095	5070	5047	5022	4999	4976	4952	4930	4907	4885	4862	4840	4819	4797	4776	4754	4733	4713	4692
285	5095	5071	5048	5024	5001	4979	4956	4934	4911	4890	4867	4846	4825	4804	4783	4762	4742	4722	4701
290	5095	5071	5049	5027	5003	4982	4959	4938	4915	4894	4874	4852	4832	4810	4790	4770	4750	4730	4710

River Crossing

33kV Hendrix **Final** Messenger tensions (kg)

(Messenger and conductors are installed simultaneously)
19/3.25 SC/GZ messenger wire (25%CBL)

RULING SPAN	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45	47.5	50
190	5095	5059	5024	4989	4955	4920	4887	4854	4821	4789	4756	4725	4693	4663	4632	4601	4572	4542	4514
195	5095	5060	5025	4992	4958	4926	4893	4860	4829	4797	4766	4735	4704	4675	4644	4616	4586	4558	4529
200	5095	5061	5028	4995	4962	4931	4898	4867	4836	4805	4775	4745	4716	4686	4657	4628	4600	4572	4544
205	5095	5062	5030	4998	4966	4935	4904	4874	4843	4813	4784	4754	4726	4697	4669	4641	4614	4586	4560
210	5095	5063	5032	5000	4969	4939	4909	4880	4850	4821	4792	4764	4736	4708	4681	4653	4627	4600	4574
215	5095	5064	5034	5003	4973	4944	4914	4886	4857	4829	4800	4773	4745	4719	4692	4666	4639	4614	4588
220	5095	5065	5035	5005	4977	4948	4919	4891	4863	4836	4808	4782	4755	4729	4702	4677	4651	4626	4601
225	5095	5065	5037	5008	4980	4952	4924	4897	4870	4843	4817	4790	4765	4738	4714	4688	4664	4638	4615
230	5095	5066	5039	5010	4983	4955	4929	4902	4876	4849	4824	4798	4773	4748	4724	4699	4675	4650	4627
235	5095	5067	5040	5012	4986	4959	4933	4907	4882	4856	4831	4806	4782	4757	4733	4709	4686	4663	4639
240	5095	5068	5041	5015	4989	4963	4938	4912	4887	4862	4838	4813	4790	4767	4743	4720	4696	4674	4651
245	5095	5068	5043	5017	4992	4966	4942	4917	4893	4869	4845	4822	4798	4775	4752	4729	4706	4685	4663
250	5095	5069	5044	5019	4995	4970	4946	4922	4898	4875	4851	4829	4805	4783	4760	4739	4717	4695	4674
255	5095	5070	5046	5021	4997	4973	4950	4927	4903	4881	4857	4835	4813	4791	4770	4748	4727	4705	4684
260	5095	5070	5047	5023	5000	4977	4953	4931	4908	4886	4863	4842	4821	4799	4778	4756	4736	4716	4695
265	5095	5071	5048	5025	5002	4980	4957	4935	4913	4891	4870	4848	4828	4806	4786	4766	4745	4725	4705
270	5095	5072	5049	5027	5005	4983	4961	4939	4917	4897	4876	4855	4834	4813	4794	4774	4754	4734	4715

Appendix E: Installation Equipment

TM Messenger Trolley

(CZ0403)

PBR-3 Roll-By Block

(CZ0404)

TMG Tubular Messenger Guide

(CB0160)

PAT-1 Angle Tensioning Block

(CZ0406)

PAS-1 Angle Stringing Block

(CZ0405)

BJ Slack Bracket

(CB0161)

Cable Stripper

(NT0448)

TL-30 Tag Line

(OR0055)

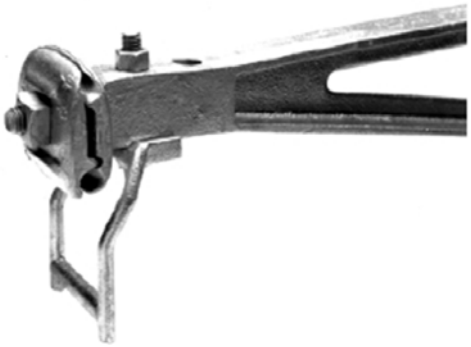
Other Installation Equipment Required:

The following equipment is commonly used for bare wire construction and may also be used to install the Hendrix Covered Conductor System using the Roll-By method.

- Any Standard three reel trailer, crib or jack arrangement which will accommodate the dimensions of the Hendrix conductor reels. Braking is not necessary for the conductor reels under normal conditions on level terrain. A standard 16 mm or 20 mm pulling rope is sufficient.
- A three sheave Block or three single sheave Blocks.
- Swivels.
- Wire mesh pulling grips for messenger wire and covered conductors.
- Parallel jaw pulling grips for tensioning messenger wire and covered conductors.
- ACSR cutters or bolt cutters for cutting messenger wire.
- Conductor splicing sleeves and crimpling tools.
- Dynamometer for measuring messenger wire tension.

Appendix F: Hendrix Construction Components

Tangent Bracket
(IC0094)



TS-1 Stirrup & MC-2
(IC0094)

Angle Bracket
(IC0095, including insulators)

Termination Bracket
(IC0097)

Double Insulator Plate
(IC0096)

Messenger Wire Angle Clamp
(CC0166)

3 Phase Spacer
(IC0091)

Single Phase Spacer

Insulator & Pin
(IC0100) & (IC0099)

Lineduc
(IC0109)

Anti-Sway bracket
(IC0093)

L Bracket
(IC0102)

Cable sock & swivel
(IC0101)

Cable cold shrink
(IC0101)

Covered tie wire
(IC0098)