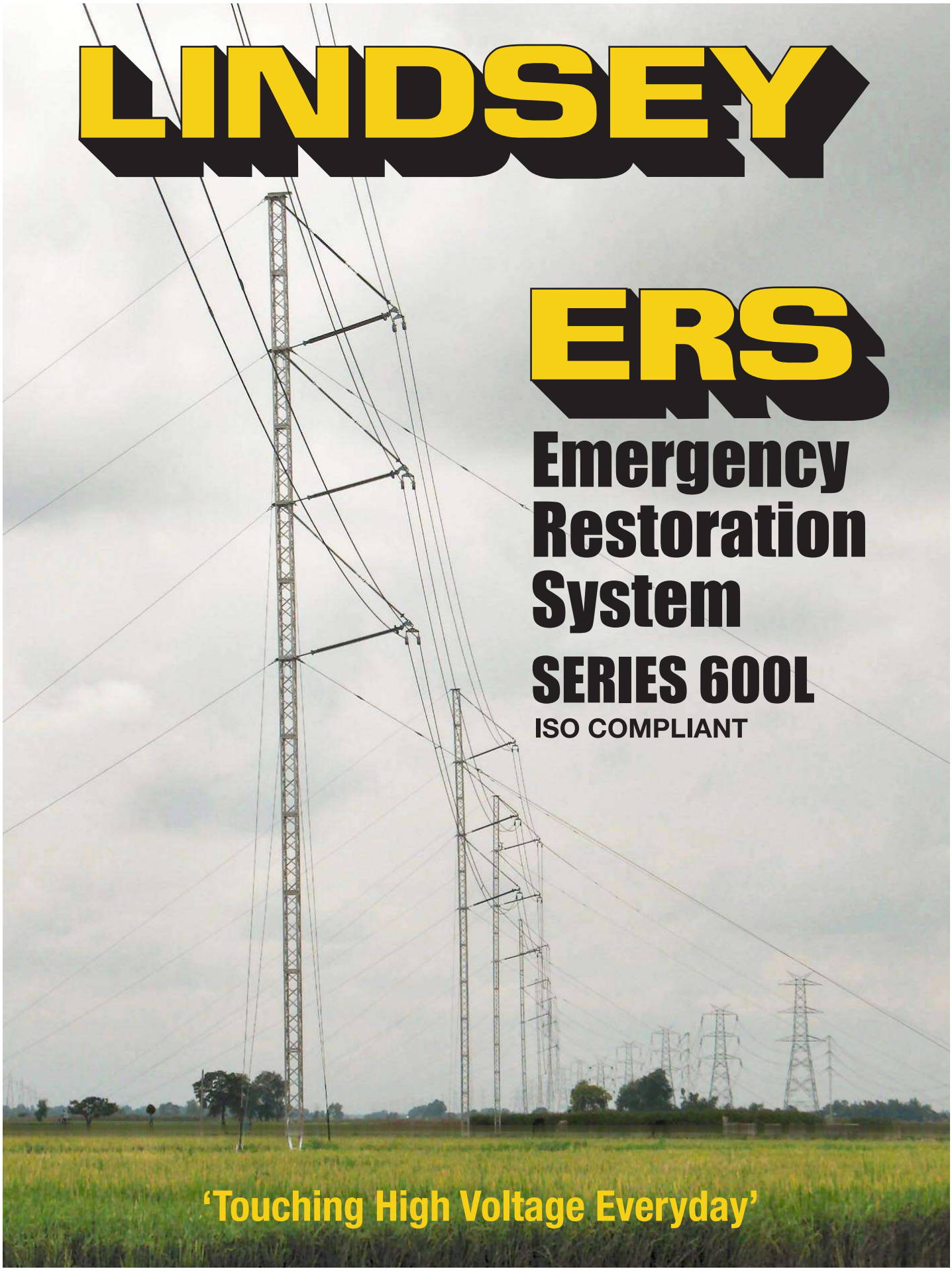


LINDSEY

ERS

Emergency Restoration System

SERIES 600L

ISO COMPLIANT

'Touching High Voltage Everyday'

Sabotage of a critical 500 kV DC transmission line necessitated the erection of this Lindsey Emergency Restoration Structure. ***Total erection time was 5-1/2 hours.***

Why do Transmission Asset Owners Need a Transmission Restoration System (ERS)?

Transmission Line Emergencies Do Occur

Whether caused by exceptional acts of nature or by uncontrollable acts of mankind, transmission lines are vulnerable to mechanical failure.

When critical transmission lines are lost the economic and political costs can be extremely high. More and more, existing electrical transmission lines are working harder. When transmission lines from economical sources are lost, the power that they supplied must be replaced by more expensive sources. These replacement costs, or the cost of lost revenues typically exceeds millions of dollars per day. In some areas, the political consequences of prolonged disruption in the electrical power supply may far exceed the economic costs.

Whether the costs are economic or political, the world's dependence on electrical power makes a transmission Emergency Restoration System a requirement for any transmission asset owner.

Hurricanes and mud slides caused this failure of a 400kV tower.

High winds and flying debris caused failure of this 115kV steel pole line.

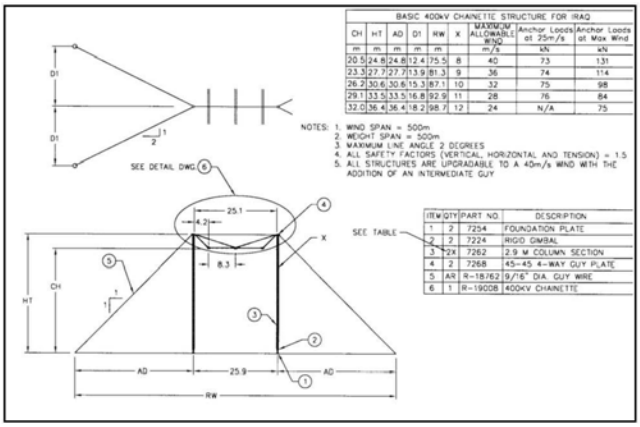
Dynamite charges toppled this 500kV tower. A Lindsey Emergency Restoration Structure was used for a quick solution.

What Makes An Effective Emergency Restoration System?

Universal Modular Restoration Structures

Typically, two of the most difficult requirements for restoration of a damaged transmission line are construction of a new foundation and replacement of damaged tower steel. Tower steel is often stocked; however, predicting the requirements for every possible failure and stocking all the necessary material is difficult and uneconomical.

A more effective and economical solution is the Lindsey Modular Emergency Restoration Structure. This structure requires no special foundation, can be used at any voltage level and for suspension, angle or tension structures, and has standardized components that can be shared between utilities.



BASIC 400kV CHAINETTE STRUCTURE FOR IRAQ

CH	HT	AD	D1	RW	X	MAXIMUM ALLOWABLE WSD	Anchor Loads at 25m/s	Anchor Loads at Max Wind
m	m	m	m	m		m/s	kN	kN
20.5	24.8	24.8	12.4	75.5	8	40	73	131
23.3	27.7	27.7	13.9	81.3	9	36	74	114
26.2	30.6	30.6	15.3	87.1	10	32	75	98
29.1	33.5	33.5	16.8	92.9	11	28	76	84
32.0	36.4	36.4	18.2	98.7	12	24	N/A	75

NOTES:
1. WIND SPAN = 500m
2. WEIGHT SPAN = 500m
3. MAXIMUM LINE ANGLE 2 DEGREES
4. ALL SAFETY FACTORS (VERTICAL, HORIZONTAL AND TENSION) = 1.5
5. ALL STRUCTURES ARE UPGRADABLE TO A 40m/s WIND WITH THE ADDITION OF AN INTERMEDIATE GUY

ITEM	QTY	PART NO.	DESCRIPTION
1	2	7254	FOUNDATION PLATE
2	2	7224	RIGID GIMBAL
3	*2X	7262	2.9 M COLUMN SECTION
4	2	7268	45–45 4–WAY GUY PLATE
5	AR	R–18762	9/16" DIA. GUY WIRE
6	1	R–19008	400kV CHAINETTE

A pre-designated Basic Chainette for 400 kV allows field crews to build a quick sttructure without waiting for additional engineering.

Analysis and Planning

Being prepared for emergencies is a requirement in any restoration system. The asset owner's engineering staff should pre-design restoration structures and be trained to quickly analyze any emergency situation that occurs. The Lindsey Emergency Restoration System (ERS) includes the user-friendly computer program, ProSpot, that can be used to plan the design and placement of the Lindsey Emergency Structures.

This Lindsey Emergency Restoration Structure was used to quickly restore the 400 kV tower destroyed by the hurricane and mud slide shown on page 2.

Field crews practice assembly of the Lindsey Emergency Restoration Structure using a Gin Pole (or Derrick).

Trained Field Personnel

A critical part of any restoration system is the training of field personnel in the erection of emergency structures. The Lindsey Emergency Restoration System includes extensive training in the assembly and erection of Emergency Restoration Structures. Field personnel are trained in various erection techniques using a variety of equipment.

Lindsey works closely with each asset owner, drawing on over three decades of experience in emergency restoration, to develop techniques that are appropriate for each utility's unique situation.

The 600L ERS System

The Lindsey 600L ERS System is a fully integrated solution based on decades of experience in supplying emergency restoration systems, consisting of:

- Series 600L ERS Structural Components
- Accessories
- Integrated Storage
- Structural Analysis Software
- Training

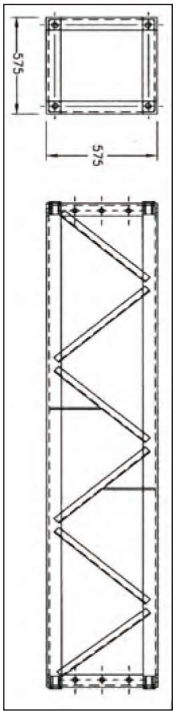
Series 600L ERS Structural Components

All Lindsey Series 600L ERS Structural components have passed the Strength Test Verification requirements of IEEE Std. 1070, IEEE Guide for the Design and Testing of Transmission Modular Restoration Structural Components.

Column Sections

All column sections are fabricated from lightweight, high strength structural aluminum alloy. The all-welded construction insures easy handling and eliminates the loss of small bolted pieces. Column sections are available in 2.90m and 1.45m sections, weighing 80kg and 50kg, respectively. Four high strength M24x3x210 galvanized bolts hold each column section to the next.

Columns are easy to climb and allow up to four linemen to stand at one elevation. Each column section is inspected to insure straightness and reliability.



Precision manufacturing and 100% inspection insure straight columns.

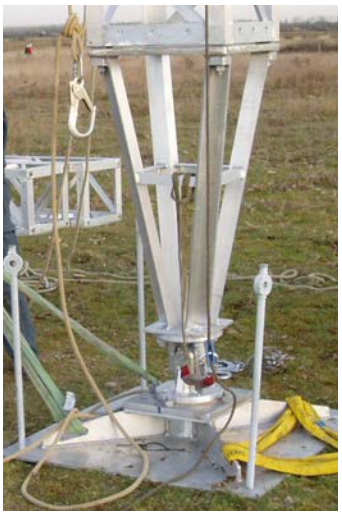
Part No. 7362 is 2.9m long and weighs 80kg.

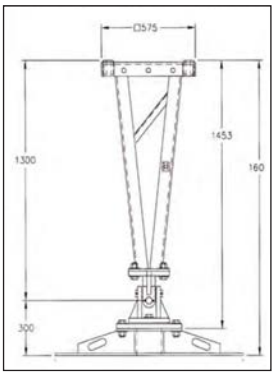
Part No 7363 is 1.45m long.

Foundations and Gimbal Joints

The Foundation (Part Number 7254 weighing 60kg) is made from 1.2m by 1.2m aluminum plate and is designed to be placed directly on the ground to provide bearing support. The design of the Lindsey Foundation allows for several rigging attachment points used for erection of the columns or for raising the conductors.

The Gimbal or articulating joint (Part no. 7224 weighing 77kg) acts as a universal joint eliminating torsion loading of the final structure and allowing the assembled column to be rotated from the horizontal plane to the vertical position from any position.



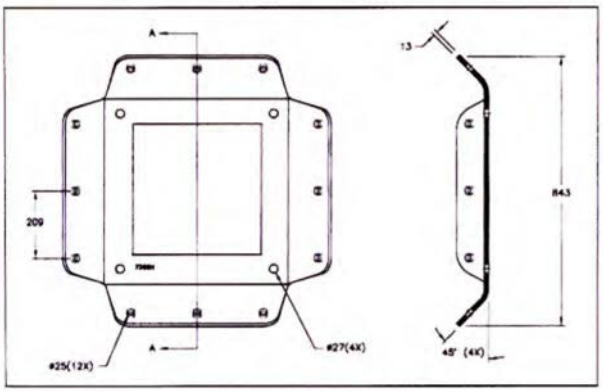


Part No. 7254 Foundation and Part No. 7224 Gimbal Joint.

Series 600L ERS Structural Components

Guy Plates

High Strength Guy Plates are made from structural aluminum plate and directly transfer the insulator loads across the structure and into guy wire loads. Each attachment hole is designed to hold a 134kN load. The Guy Plates are attached to the four (4) holes between or on the top of each column section using high strength M24x3x210 galvanized bolts.



The 45 degree 4-Way Guy Plate (Part No. 7268) is used at all insulator and guy wire attachment locations, weighs 18kg, and allows guying in all four directions. The 0 degree, or straight, Guy Plate (Part No. 7269) is used for in-line tension structures and weighs 16kg.

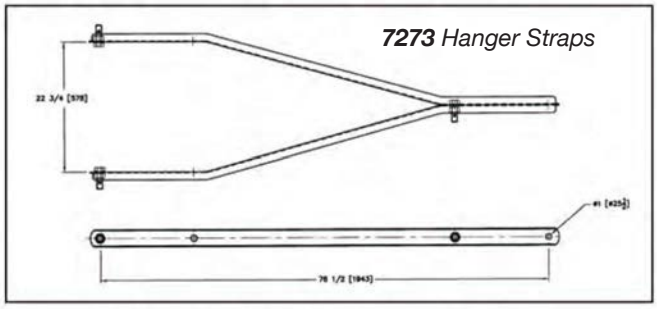
*Part No. **7288** 45 degree 4-way Guy Plate, show left and above, can be located at the top of columns or placed between column sections.*

Post Insulator Supports and Hanger Straps

The post insulator support (Part No. 7267, weighing 10kg) is designed to attach at the joints between column sections. The design of the post insulator support provides a universal pivot point for the post insulator, eliminating bending moments on the post insulator and thus increasing the insulator's buckling strength.

Left, a complete horizontal-vee assembly

*Right, Close-up of the **7267** Post Insulator Support.*

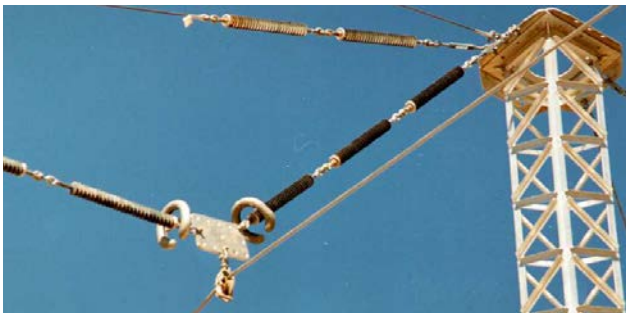


Hanger Straps (Part No. 7273) hold the suspension insulator in a horizontal-vee assembly and provide a restoring moment for the assembly under longitudinal loads. The steel Hanger straps weigh 35kg.

Series 600L ERS Accessories

Insulators and Hardware

Light weight non-ceramic insulators conform to all applicable electrical and mechanical tests as required by ANSI C29.11 and IEC 1109. All suspension insulators are given a routine test load (RTL) of 111 kN and have an ultimate mechanical load of 222 kN. When the Emergency Restoration System is required to restore more that one transmission voltage, multiple insulators are used that can be linked together. The individual post insulators will have a minimum diameter of fiberglass reinforced resin rod required to meet the loading. Two post insulators may be linked together to form a higher voltage insulator.



Lindsey guarantees the fit, strength, coordination, and corona performance of all Hardware Assemblies.

Lindsey guarantees the assembly and fit of all hardware assemblies. A minimum number of different types of hardware will be provided in order to minimize confusion during emergencies, for example, only one size of anchor shackle will be provided. All hardware will have ultimate load ratings to withstand the maximum structure loading. All ferrous materials is galvanized. Routine mechanical pull tests will be applied to all hardware items in accordance with IEEE Std 135.61-1997.

Anchors

Anchoring is a critical element of any guyed Lindsey Emergency Restoration System. Depending on the prevailing soil conditions, a number of different anchoring arrangements can be provided. In general, Lindsey does not recommend temporary anchors for construction, but only the use of the permanent anchors during construction of the structures. For normal soil conditions, hydraulically installed self locking type anchors can be installed in 15-20 minutes. The advantage of these type anchors, besides their speed of installation in normal soils, is that they are proof tested during installation. Anchor installation kits are supplied with these types of anchors.

Anchor installation kit

Cross plate anchors are a very common and universal anchoring method, requiring minimal installation equipment. In normal soils each cross plate anchor will require approximately 4 hours to install by hand.

Left to right, Starting to install, installing and final locking of the normal soil density hydraulically installed self locking anchor.

For normal or low-density soil conditions, i.e. swamp or peat, high strength triple helix screw anchors can be provided

Rock anchors and dead weight anchoring systems can also be supplied to meet specific requirements

Right, Typical triple helix anchor and manual installation procedures in Swamp areas.

Series 600L ERS Accessories

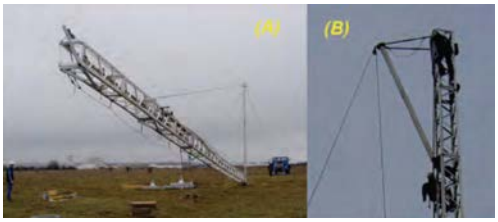
Construction Tools

All necessary construction tools and hand tools can be provided for assembly, erection and lifting of the conductors of a complete emergency restoration structure. A 7271 gin pole made from aluminum alloy can be provided. The 7271 gin pole is supported on one corner of a column section and allows for the lifting of column sections to the top of the structure. All necessary snatch blocks and rigging ropes are supplied with the gin pole. The gin pole has a davit arm to keep loads clear of the structure while being raised by manpower, or a capstan with hydraulic power unit. A 1 ton hydraulic capstan winch with foot pedals can be supplied with each gin pole. This capstan is capable of being powered by the same hydraulic power unit used to install the anchors. A 7280 Erection Jib can be provided for tilting up an entire ERS column. The bottom half of the Jib can be used to lift heavy loads to the top of the column.

7060 Double Roller & Clamp

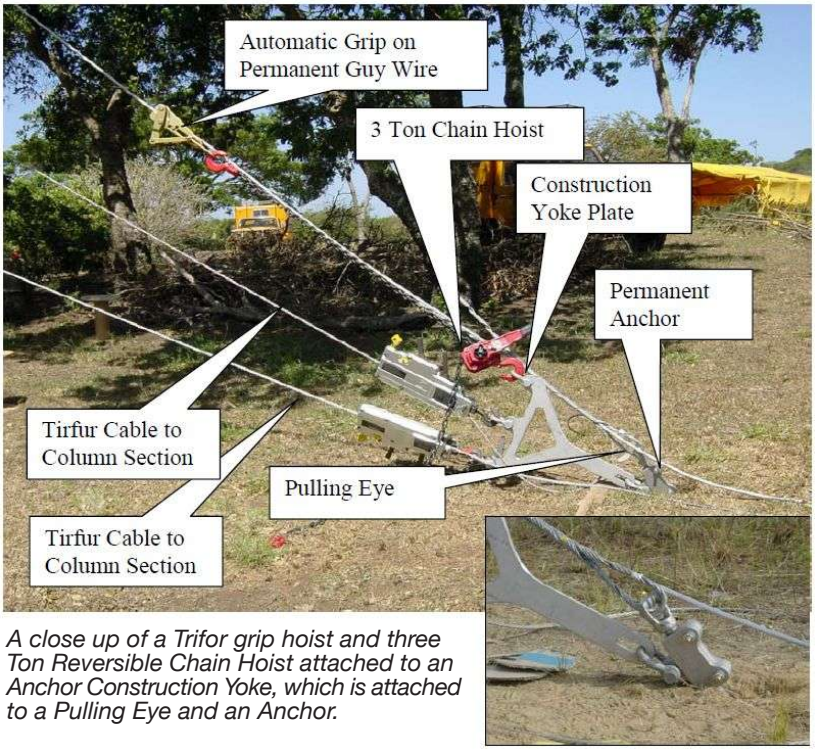
The Lindsey 7271 Gin Pole.

The Lindsey 7004 Capstan and Hydraulic Power Supply.



(A). The 7280 Erection Jib can tilt up an entire ERS column

(B). The bottom half of the Jib can be used to lift heavy loads to the top of the column.



A close up of a Trifor grip hoist and three Ton Reversible Chain Hoist attached to an Anchor Construction Yoke, which is attached to a Pulling Eye and an Anchor.

Storage and Transportation

All Lindsey Series 600L ERS can be shipped in 20 or 40 foot ocean cargo storage containers. Lindsey will package all ERS tower components and their associated insulators and hardware, anchors and guy wire in the containers. It is possible to pack one or more complete ERS structures in one 20 foot container; however, this may not be the most efficient way to store and transport the ERS components. It should be noted, that in some cases the weight of the container is greater than the ERS Structure.

Containers can be transported near the job site and unloaded. From there, the ERS Structures can be taken to the construction site by hand (shown above), small truck or helicopter.

Depending on the total weight of the container and the material handling equipment available in the field, it may be quicker to utilize smaller, all terrain, trucks or helicopters to transport the material to the job site. The Lindsey ERS Structures are made from corrosion resistant high-strength aluminum alloy; therefore, unlike thin galvanized steel structures, they can be stored outside indefinitely, even in marine environments. If the ERS structures are stored outside, the insulators, hardware and tools are usually stored in 20 foot containers or other secure warehouse facility.

Metal side baskets hold all of the heavy equipment.

If the 600L Series ERS is intended to be stored in the 20 foot containers supplied by Lindsey, all of the heavy equipment such as anchors, tools, nuts and bolts will be stored in metal side containers. Nuts and bolts will be stored in plastic containers.

Above right, small helicopters can be effective in moving material to remote construction sites.

A complete 36m tall, 400kV Chainette ERS Structure (including anchors, insulators, guy wires and hardware) is packed in this one 20 foot container.

These Lindsey ERS Structures have been stored in a marine environment for over 20 years.

Small all terrain vehicles can be used to transport ERS Structure and materials directly to the construction site.

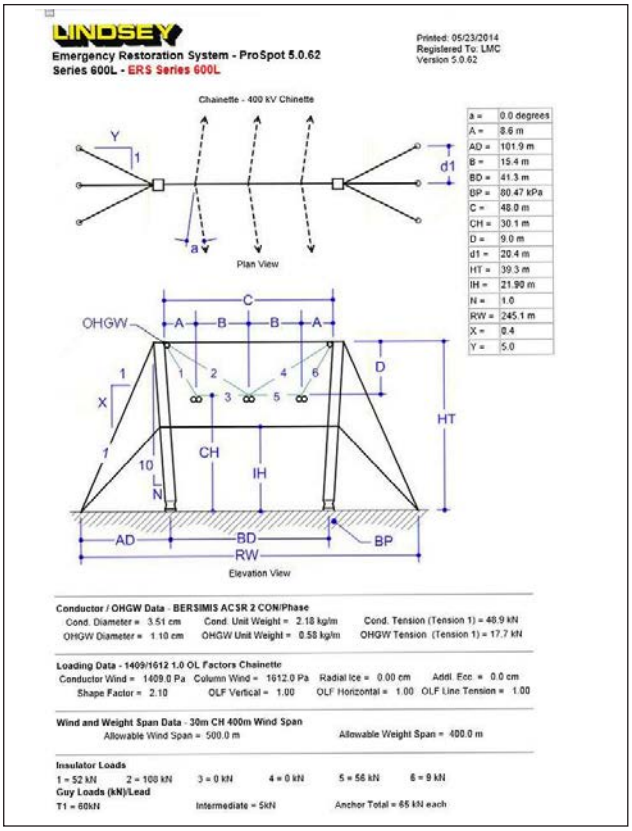
ProSpot® Structural Analysis Software

Another advantage of the Lindsey ERS is our development of the exclusive ProSpot® ERS computer analysis program that allows engineers to rapidly design new restoration structures that were not originally planned when the systems were purchased. This computer program was designed with emergency conditions in mind:

- Easy to learn, and not requiring large amounts of input data, ProSpot® can be used to design a site specific ERS in 5 or 10 minutes.
- Output from ProSpot® can be used to directly construct most ERS structures.
- Provides quick calculations of construction loads.

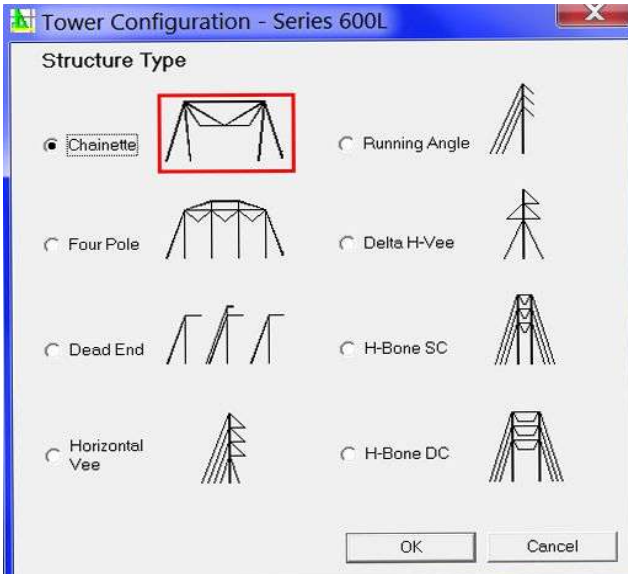
The Lindsey's ProSpot® program can be copied as many times as deemed necessary by the asset owner without incurring additional licensing fees.

The program also includes instruction manuals that explain the theory used as well as a detailed Field Instruction Manual for easy reference.

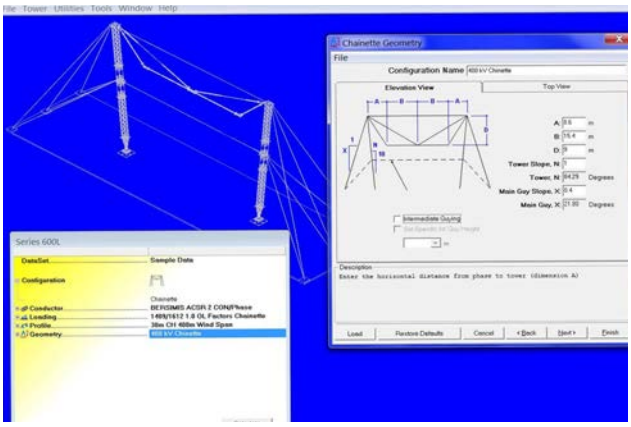


One Page Output

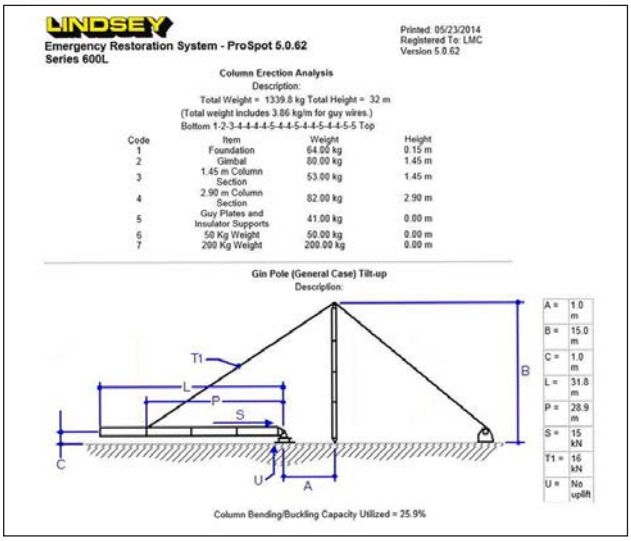
Step 3: *Calculate the results. Shown above is a one page print out of the results. A Plan and Elevation view are shown along with input data. The output shows the insulator loads and required anchor loads. If the structure does not support the required loads, NO OUTPUT is printed. This is a feature only available with the Lindsey ProSpot Program.*



Step 1: *Select the ERS structure to be analyzed*



Step 2: *Select previously stored data or input new data.*



Step 4.Construction Loads
ProSpot® also quickly analyzes a variety of construction loads, as shown in the printout.

Training

The Lindsey Emergency Restoration System also includes extensive training performed by experienced application engineers. Training of the engineering staff will include the use of the ProSpot® computer program.

Field training is another critical area covered by Lindsey. Training of field personnel will take place at the Asset Owner's site, using the normal equipment available to the field personnel, as well as the construction tools provided by Lindsey. The field training will include the actual field construction of a variety of ERS structures using several construction techniques. Special emphasis is given to: anchoring, assembling of modular structures, fixing of foundation plates, erecting of structures on the foundation, guying the tower and stringing of conductor. Specific instructions will be given for installation of ERS using the 7271 Gin Pole, 7280 Erection Jib, as well as crane and helicopter techniques.

Engineering classroom training sessions in the use of the ProSpot® computer program.

Special emphasis is given so as to ensure that the trained personnel aquire proficiency in restoring failed structures so that they can take up this work independently.

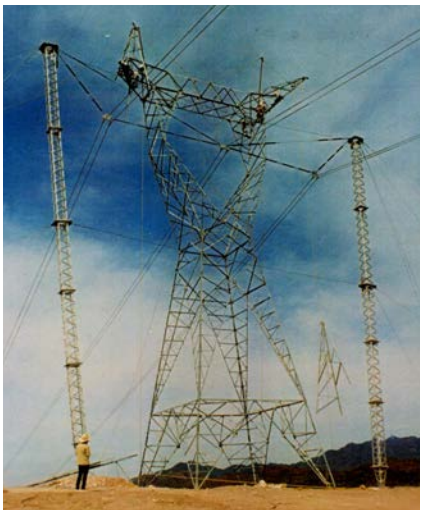
Experience

Lindsey has supplied thousands of Emergency Restorations System structures to dozens of Electric Transmission Asset Owners, in over 20 countries. Our extensive experience in tailoring a complete Emergency Restoration System insures that your specific needs will be met.

LINDSEY

Examples of ERS Structures

Suspension Type



Chainette: *This 400kV ERS is supporting the line while the permanent tower is being built.*

Double Circuit Herringbone: *This double Circuit 230kV ERS was built after a major disaster. The picture at the right shows the same ERS 8 years later.*

Four Column: *These 500kV ERS are supporting the line while a substation is being built below the line.*

Chainette: *These 230kV ERS were built for an emergency bypass and have been in service for over 10 years.*

Examples of ERS Structures

Suspension and Angle type

Four Column: This 400kV ERS was built in One Day to support a line from a nuclear plant. Spans were over 800m on either side.

Single Phase Running Angle: This 500kV ERS was built to restore power after the permanent tower was sabotaged.

DC Chainette: This +/-500kV Direct Current ERS was built in One Day when an airplane destroyed the permanent tower.

Horizontal-Vee: This 345kV ERS is 48m tall and was built to support the line while the permanent tower was moved.

Three Phase Running Angle: This 30 degree ERS was built to restore power after the permanent tower was sabotaged.

Angle Horizontal-Vee This 30 degree, 400kV ERS was built as part of a bypass.

Examples of ERS Structures

Angle and Tension type

Horizontal Full Tension: These 400kV ERS full tenion Dead Ends are under construction as part of a bypass line.

Horizontal 90 Degree Tension: These 400kV, 90 Degree Tension or Dead Ends were built as part of a bypass during construction on the substation.

Vertical Three Phase Tension: This 230kV ERS In-Line tension Dead End was built after a major disaster. The picture above shows the same ERS 8 years later.

Vertical Three Phase Full Tension: This 400kV ERS full tension 3-Phase Dead Ends were built as part of a bypass line. Note there are 4 subconductors per phase.

Construction methods used with Lindsey ERS

Lindsey ERS Systems are compatible with a wide variety of construction methods

(Left) Manpower and Gin Pole:
This 230kV ERS Tension Structure was built by manpower only, in the Himalayas. The 3-Phase Dead End spanned 710m to the structure in red circle.

(Right) Helicopter (1):
Lindsey Series 600L ERS is the lightest weight ERS available. Complete structures can be flown in. A 36.4m Column with foundation, gimbal, 2.9m sections and guy plates weighs 1366kg. With 4 pre attached guy wires 1507kg, as shown.

(Below) Helicopter (2):
A 36.4m Column with foundation, gimbal, 2.9m sections and guy plates can be tilted up. The helicopter only needs to lift 7.7kN including pre-attached guy wires and the helicopters own downwash.

Winch Line and Erection Jib:
A complete ERS Column can be tilted up with a winch line and a small Erection Jib.

Small Crane:
A complete ERS Column can be picked up with a small crane at its center of gravity, and the gimbal "walked" to the foundation.

Ordering an ERS to suit your needs

Contact Lindsey Manufacturing

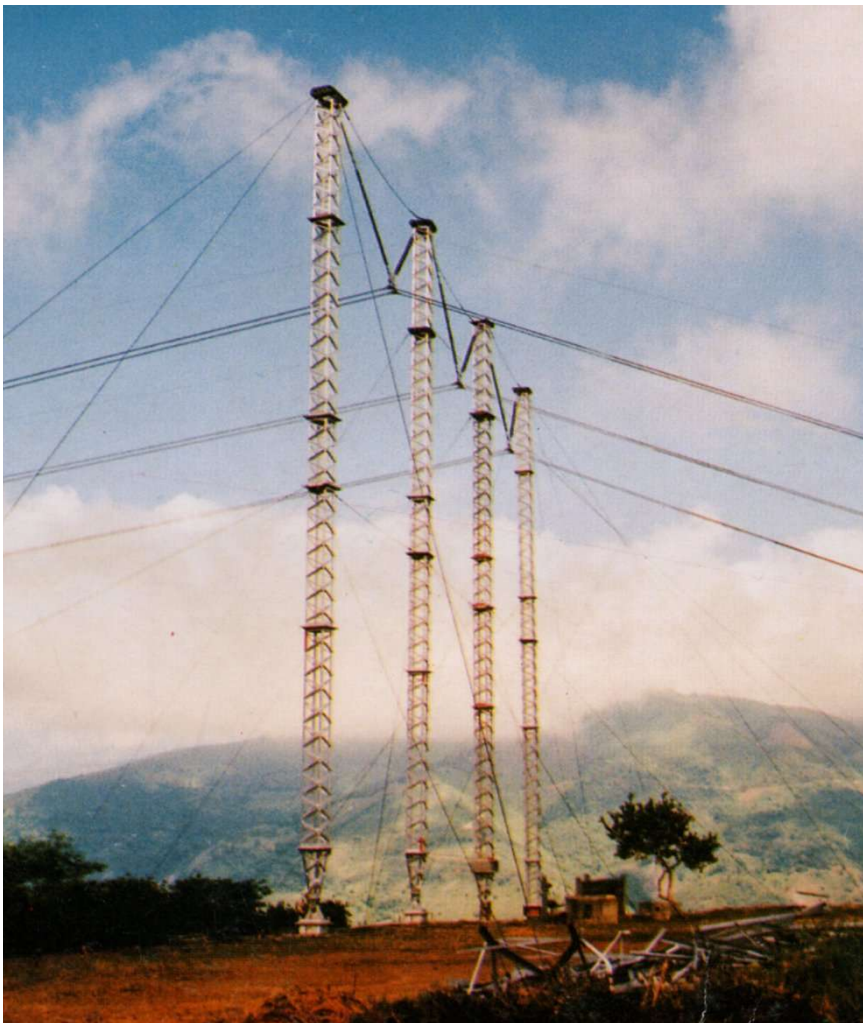
Contact Lindsey Manufacturing Company directly or through one of our representatives. Our in-house application engineers will work with your engineering and operating personnel to determine the most efficient and economical Emergency Restoration System for your application.

In order to prepare an Emergency Restoration System proposal, Lindsey needs to know certain information about your critical transmission lines. Please fill out the ERS Questionnaire available from our web site at www.lindsey-usa.com. Using the ERS Questionnaire, we will provide you with a Technical and Financial Proposal for your consideration.

After your order is placed

Lindsey will fabricate and ship your order. Shortly after arrival of all your ERS materials, training seminars will be scheduled at a mutually agreed upon time for both your engineering and field personnel.

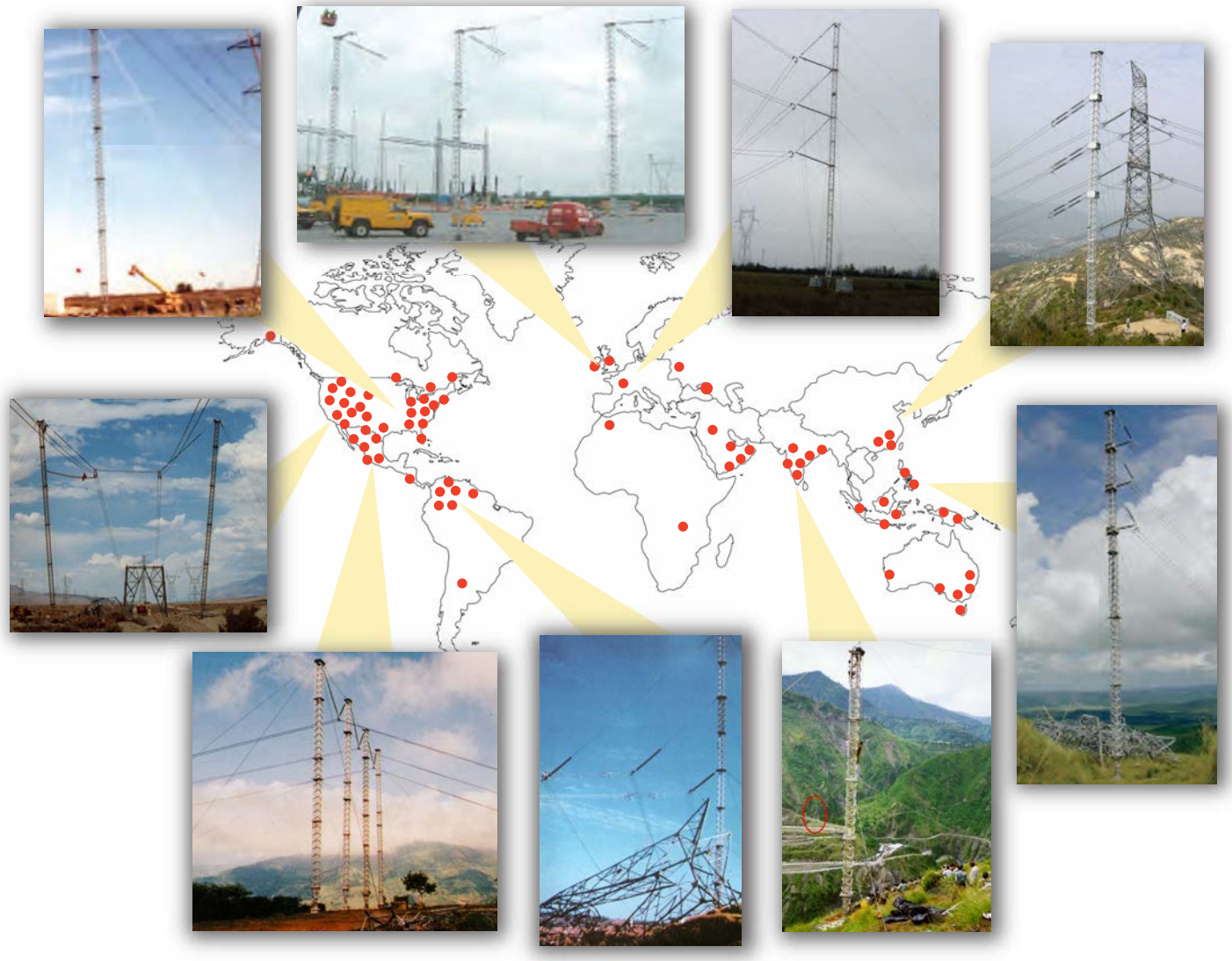
In the future, upgrades in computer software and information on the latest developments will be made available to you. As an owner of a Lindsey Emergency Restoration System, you will be trained to handle almost any emergency that arises. However, should you need us, Lindsey is always available to assist you.



Do you need to restore damaged transmission lines fast?

Lindsey can help you!

We've supplied thousands of Emergency Restoration Systems (ERS) worldwide for natural disasters, sabotage and planned outages. The Lindsey ERS is Fast, Versatile and Proven.



We've got the right ERS for you!

Contact us: Ph. 1-626-969-3471 | Fax 1-626-969-3177
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LINDSEY

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