**Research Report**
**KTC-94-1**

# BREAKAWAY TIMBER UTILITY POLE INSTALLATIONS IN KENTUCKY

by

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in cooperation with

Kentucky Transportation Cabinet
Commonwealth of Kentucky

Federal Highway Administration
US Department of Transportation

and

Kentucky Utilities Company



January 1994

# METRIC CONVERSION FACTORS

| APPROXIMATE CONVERSIONS TO METRIC UNITS | | | | | APPROXIMATE CONVERSIONS FROM METRIC UNITS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Symbol | When You Know | Multiply By | To Find | Symbol | Symbol | When You Know | Multiply By | To Find | Symbol |
| | | **LENGTH** | | | | | **LENGTH** | | |
| in. | inches | 25.40000 | millimetres | mm | mm | millimetres | 0.03937 | inches | in. |
| ft | feet | 0.30480 | metres | m | m | metres | 3.28084 | feet | ft |
| yd | yards | 0.91440 | metres | m | m | metres | 1.09361 | yards | yd |
| mi | miles | 1.60934 | kilometres | km | km | kilometres | 0.62137 | miles | mi |
| | | **AREA** | | | | | **AREA** | | |
| $in.^2$ | square inches | 645.16000 | millimetres squared | $mm^2$ | $mm^2$ | millimetres squared | 0.00155 | square inches | $in.^2$ |
| $ft^2$ | square feet | 0.09290 | metres squared | $m^2$ | $m^2$ | metres squared | 10.76392 | square feet | $ft^2$ |
| $yd^2$ | square yards | 0.83613 | metres squared | $m^2$ | $m^2$ | metres squared | 1.19599 | square yards | $yd^2$ |
| ac | acres | 0.40469 | hectares | ha | ha | hectares | 2.47103 | acres | ac |
| $mi^2$ | square miles | 2.58999 | kilometres squared | $km^2$ | $km^2$ | kilometres squared | 0.38610 | square miles | $mi^2$ |
| | | **FORCE** | | | | | **FORCE** | | |
| kip | pound-force | 4.44822 | kilonewton | kN | kN | kilonewton | 0.22481 | pound-force | kip |
| | | **VOLUME** | | | | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57353 | millilitres | ml | ml | millilitres | 0.03381 | fluid ounces | fl oz |
| gal. | gallons | 3.78541 | litres | l | l | litres | 0.26417 | gallons | gal. |
| $ft^3$ | cubic feet | 0.02832 | metres cubed | $m^3$ | $m^3$ | metres cubed | 35.31448 | cubic feet | $ft^3$ |
| $yd^3$ | cubic yards | 0.76455 | metres cubed | $m^3$ | $m^3$ | metres cubed | 1.30795 | cubic yards | $yd^3$ |
| | | **PRESSURE** | | | | | **PRESSURE** | | |
| psi | pound-force per square inch | 6.89476 | kilopascal | kPa | kPa | kilopascal | 0.14504 | pound-force per square inch | psi |
| | | **MASS** | | | | | **MASS** | | |
| oz | ounces | 28.34952 | grams | g | g | grams | 0.03527 | ounces | oz |
| lb | pounds | 0.45359 | kilograms | kg | kg | kilograms | 2.20462 | pounds | lb |
| T | short tons (2000 lb) | 0.90718 | megagrams | Mg | Mg | megagrams | 1.10231 | short tons (2000 lb) | T |
| | | **TEMPERATURE (exact)** | | | | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | (°F-32)/1.8 | Celsius temperature | °C | °C | Celsius temperature | (1.8C) + 32 | Fahrenheit temperature | °F |

Technical Report Documentation Page

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| KTC 94-1 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Breakaway Timber Utility Pole Installations in Kentucky | January 1994 |
| | 6. Performing Organization Code |
| 7. Author(s)<br>Ronald D. Hughes | 8. Performing Organization Report No.6<br>KTC-94-1 |
| 9. Performing Organization Name and Address<br>Kentucky Transportation Center<br>College of Engineering<br>University of Kentucky<br>Lexington, Ky 40506-0043 | 10. Work Unit No. (TRAIS)<br><br>11. Contract or Grant No.<br>DTFH61-86-C-0032 |
| 12. Sponsoring Agency Name and Address<br>Kentucky Transportation Cabinet<br>State Office Building<br>Frankfort, KY 40622 | 13. Type of Report and Period Covered<br>Final<br><br>14. Sponsoring Agency Code |

15. Supplementary Notes

Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

This report describes the installation of ten breakaway timber utility poles in Lexington, Kentucky. Installations were made by Kentucky Utilities Company personnel and monitoring has been performed by Kentucky Transportation Center investigators. Retrofit hardware is described and locations of modified poles are detailed.

Modified poles have not been struck by vehicles during the monitoring period.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Breakaway<br>Utility<br>Pole<br>Safety | Unlimited with the approval of the Kentucky Transportation Cabinet |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 22 | |

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## Executive Summary

This report describes the installation of ten breakaway timber utility poles in Lexington, Kentucky. Installations were made by Kentucky Utilities Company personnel and monitoring has been performed by Kentucky Transportation Center investigators. Retrofit hardware is described and locations of modified poles are detailed.

Modified poles have not been struck by vehicles from the time of the first installation in 1988 through the end of the monitoring period in December 1993.

## Introduction

There are approximately 3.9 million miles of public roads and streets within the United States. It has been estimated there are as many as 88 million utility poles located within the rights of way of those roads and streets. Vehicles colliding with fixed objects adjacent to the roadways account for 4.3 percent of all accidents and 9.3 percent of all accidents involving a fatality. Vehicles colliding with fixed objects adjacent to roadways are 2.2 times more likely to lead to a fatality than other first harmful events. Approximately 1,475 persons are fatally injured each year as a result of vehicles impacting utility poles. Vehicle-utility pole accidents account for approximately 110,000 other types of injuries yearly. Approximately 85 percent of pole accidents occur within urban areas. Utility poles are second only to trees as the most frequently struck obstacles in fatal accidents.

Countermeasures to minimize vehicle-utility pole collision problems include: a.) place utility lines underground, b.) place poles further from the roadway, c.) reduce pole density, d.) shield poles, and e.) use breakaway poles. All of the options would be relatively expensive for use in correcting existing hazardous situations. The options should be considered for new or relocated installations.

Breakaway installations were first considered for use in the late 1950's by personnel in the Ministry of Transport in England. A slip base concept was conceived by D. L. Hawkins, Texas Department of Highways, and tests on sign supports were conducted in 1963. Breakaway designs were developed and employed for most man-made obstacles, except utility poles, encountered in the roadside environment. Those developments took place during the 1960's and 70's.

Breakaway timber utility poles were first considered for use in the late 1960's. Much of the work on application of the breakaway technology, as applicable to timber utility poles, was conducted by Southwest Research Institute personnel between 1974 and 1982. Conceptual designs evolved during a study sponsored by the Federal Highway Administration (FHWA). Additional work was performed by investigators at the Texas Transportation Institute (TTI), by contract with FHWA. The primary objective of that work was to produce an effective breakaway shear connection at ground level and to overcome problems of pole detachment, conductor failure, and entanglement.

TTI investigators made efforts to meet the requirements of NCHRP Report 230 and overcome factors that had caused reservations on the part of FHWA and industry officials toward selective implementation. Those efforts proved fruitful and successful tests were performed.

FHWA officials forwarded a prospectus to personnel in each state in October 1983 and requested responses relative to expressions of interest in participating in field trial installations. Kentucky Transportation Cabinet (KyTC) officials notified FHWA personnel of a willingness to install and evaluate several breakaway utility poles. FHWA personnel granted permission for KyTC to participate in the field trials to be evaluated by Kentucky Transportation Center (KTC) investigators.

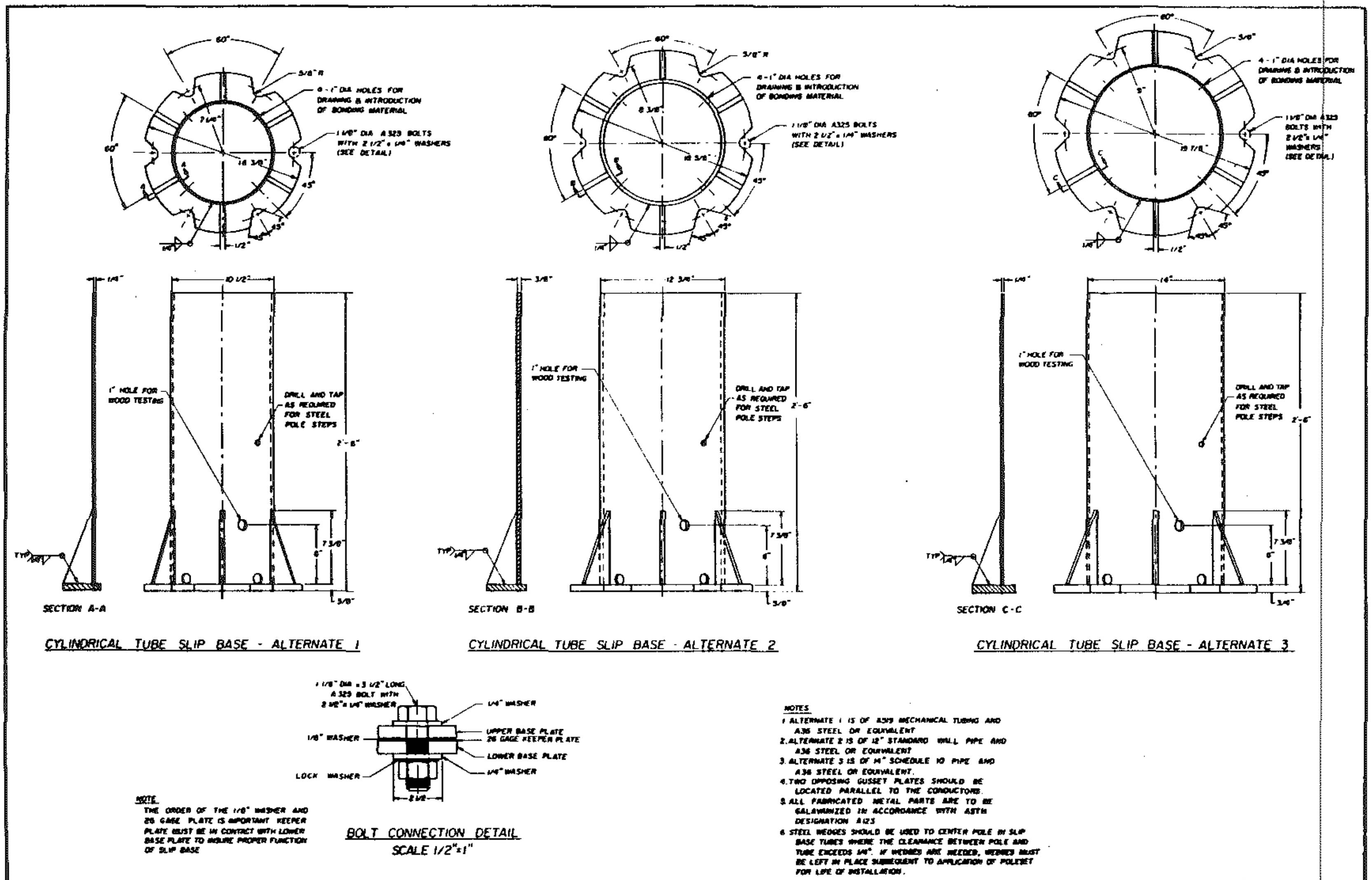


Figure 1 - Slip Base Connections

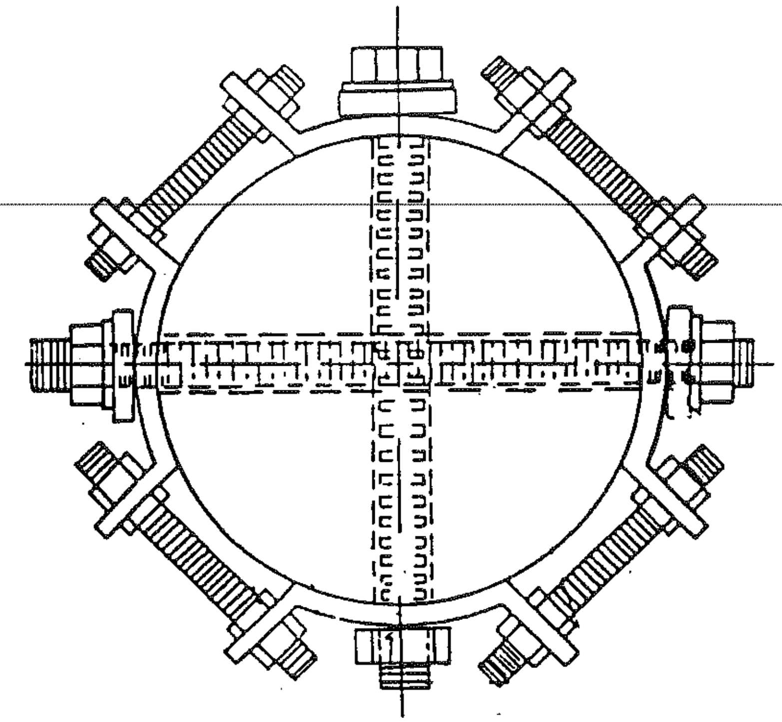

Figure 2 - Pole Band Assembly

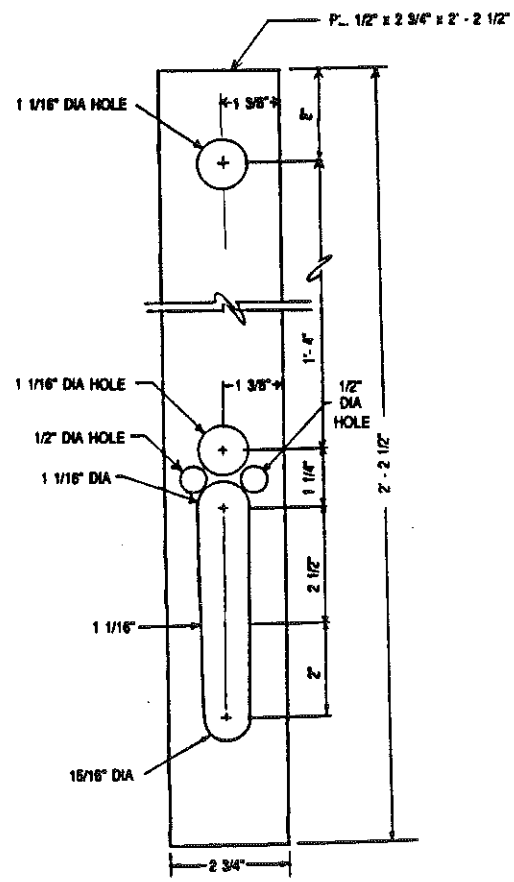


Figure 3 - Steel Strap Detail

KyTC officials were notified of further developments in the breakaway design and testing program. Field installations in Kentucky were delayed to allow for crash tests on modified designs. A contract for Federal Task Order DTFH61-86-C-00032 was executed by FHWA and KyTC officials in August 1986. That task order provided $75,000 for installations and evaluation of the breakaway utility poles. An agreement for KTC investigators to perform the evaluation was finalized in September 1986. Negotiations for installations by Kentucky Utilities Company (KU) (Lexington, Kentucky) crews were formalized in December 1986. The agreements provided for funding limits of $32,500 for KTC evaluation and reporting and $42,500 for Kentucky Utilities Company retrofit hardware purchases and installations.

KU officials placed an order for sufficient hardware to retrofit ten poles in August 1987 and hardware was received in December. Retrofits were made beginning in January 1988. Ten poles were retrofitted by October 23, 1989. This report documents those installations and performances through the end of December 1993.

## Breakaway Design and Hardware

The breakaway concept reported herein was developed for and tested on 40-ft, class 4 timber utility poles. The modifications for new or in-place poles consist of a slip base lower connection, hinged upper connection, and two overhead guys or upper support cables. The slip base is designed to withstand moments imposed by wind loads.

The lower shear plane is created by sawing through the pole perpendicular to the long axis at an elevation that is or will be 3 in. above the groundline. The shear plane consists of two 5/8-in. or two 3/4-in. thick base plates separated by a 0.0179-in. keeper plate and serves to maintain a fixed diameter circle for six 1 1/8-in. diameter bolts which are used to connect the 5/8-in. or 3/4-in. plates.

Each base plate is welded to 30-in. long steel pipe or mechanical tubing and is braced by six stiffeners welded to the base plate and pipe or tubing. A 1/4-in. thick washer is used under each bolt head and under each nut. Bolts are 3 1/2-in. in length and are torqued to 200 ft-lb. Pipe or tubing diameter and wall thickness for use are governed by the pole diameter near the groundline. Lower connection details are shown in Figure 1.

A moment-sensitive upper connection is created by sawing through the pole perpendicular to the long axis at an elevation that is or will be approximately 20 ft above the groundline. The connection consists of two four-part pole bands for installation above and below the cut and four steel straps. The pole bands and steel straps are depicted in Figures 2 and 3, respectively.

One pole-band assembly is placed above the upper cut and one assembly is placed below the upper cut. The assemblies are to be positioned equal distances above and below the cut so that the center to center distance between assemblies is 16 in. A minimum torque of 100 ft-lb is to be applied to each bolt. A hole is drilled through the pole 8 in. above the cut to accommodate a 1-in. diameter, all-thread bolt to affix the upper pole-band assembly and two opposite straps to the pole. The upper pole-band assembly and other two opposite straps are then affixed to the pole by use of a second 1-in. diameter, all-thread bolt placed 90 degrees and below the first bolt. The pole-band assembly and portions of straps below the cut are affixed to the pole in the same manner used for the upper assembly.

Steel support cables are placed immediately above the upper connection and near the crossarm. The cables are attached to adjacent poles on each side of the breakaway pole. The lower cable serves as a pivot point for the lower pole segment when the pole is impacted by a vehicle. The upper cable is intended to stabilize the upper pole segment and to minimize damage to the power lines.

The breakaway timber utility pole is designed to activate when struck by a vehicle travelling at speeds ranging from 20 to 60 mph. It is expected that most of the hardware used for the retrofit would be reusable after an accident. The keeper plate would not be a reusable item. It is possible that all four straps would need to be replaced after an accident.

Upon impact, slip base bolts shear the keeper plate and the pole slips along the lower cut plane. The pole rotates and one or more strap holes shear to allow for relative movement of the bolt and strap slot within the area of the pole band assembly below the upper cut. It is intended that the pole will rotate sufficiently so that the pole clears the vehicle's hood, windshield, and roof and allows the vehicle to pass under the pole without injury to vehicle occupants. It is expected that the pole would be partially supported by the steel cables and the conducting lines should remain in service. The sequence of events for the concept is depicted in Figure 4.

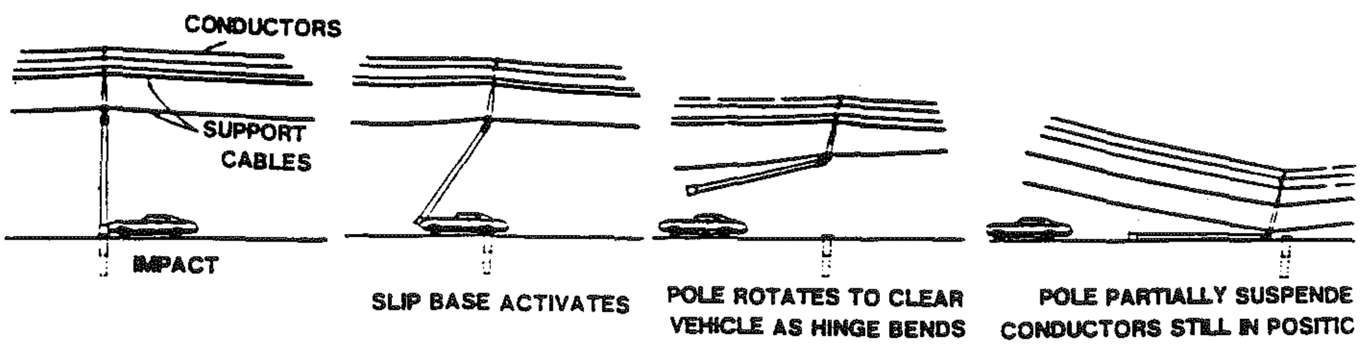


Figure 4 - Breakaway Sequence

The current design does not provide for retrofits on poles having tap lines that would create side tension. Poles should not be located in a sharp curve and the breakaway pole should not contain transformers, reclosers, or other units that could cause eccentric loading on the pole. There should be a clear zone to allow the pole to swing free of fixed objects.

## Kentucky Installations

The breakaway timber utility pole hardware may be used to retrofit existing conventional poles, or it may be used on a new pole which could be used for a new installation, or to replace an existing pole. KU officials choose to retrofit existing poles for all installations.

Sufficient hardware to retrofit ten poles was ordered from Robert F. Shepherd, Timber Products Consultant, Box 162-A, Rindge, NH 03461. Retrofit hardware cost $1,263 per pole in January 1988, labor and equipment costs were approximately $1,447 per pole. This resulted in a total per pole cost of about $2,710 per pole.

KU Construction Department personnel considered several items when selecting poles for retrofit installations. An attempt was made to identify poles which had been replaced due to vehicular accidents. Those poles were considered as first candidates for retrofits and then additional poles were chosen to fulfill the ten-pole requirement. Items considered during the selection process included:

a) previously replaced due to accident,
b) Lexington area,
c) close to road,
d) speed limit greater than 35 miles per hour,
e) high volume of traffic,
f) possibly near a hill or in a curve,
g) intersections (increase in likelihood of accident),
h) straight line pole (no angles),
i) no tap lines off of pole,
j) clear zone behind the pole to allow for pole to swing free, and
k) no heavy equipment on pole (no transformers, reclosers).

The same construction crew supervisor coordinated each installation. The crew was composed of a Supervisor A, two Line Technician A, a Line Technician B, and a General Laborer. Vehicles used during installations included a digger derrick, a double bucket truck, and a flatbed truck. An arrow-board trailer was pulled by the flatbed truck and that vehicle was primarily used for traffic control. The general construction sequence for installation of the retrofit hardware follows.

Traffic control elements, in accordance with the Manual on Uniform Traffic Control Devices, were placed and electrical lines were covered with insulating pads. Two support cables were affixed to the pole to be retrofitted and were then attached to each adjacent pole. The pole ground wire at the base was removed. A collar to support the upper portion of the pole was placed around the pole within six to eight ft of the top of the pole and the collar was attached near the end of the boom of the digger derrick. Soil was removed at the pole base. The pole was sawed horizontally 3 in. above groundline and two grooves were sawed in the stub near the ground-pole surface to provide channels for distribution of Poleset, a two-component thermo setting material. Wood preservative was applied to the upper cut surface. The lower base-plate assembly was placed on the in-ground pole section. Poleset or a similar compound was poured through a hole in the center of the base plate to fill all voids between the pole and base-plate assembly.

The upper base-plate assembly was placed at the base of the out-of-ground pole section. The assembly was positioned concentrically around the pole with three set screws. The pole and upper assembly were positioned above the in-ground section and the keeper plate and six washers were positioned between the base plates. The setscrews were loosened and the upper base-plate assembly was rotated to align bolt slots and then the setscrews were tightened to provide equal space between the pole and pipe or tube circumferentially. Poleset or its equivalent was placed to fill the void between the upper base-plate assembly and pole. The six sets of bolts, washers, and nuts connecting the lower and upper base plate assemblies were placed and bolts were torqued to 200 ft-lb.

Holes to attach pole bands and straps were drilled through the pole. The pole was cut horizontally approximately 20 ft above the groundline. The pole section above that cut was raised and wood preservative was applied to the cut surfaces. The pre-assembled pole bands were placed above and below the cut. The upper band was positioned and bolts were partially tightened. The lower band was positioned and bolts were partially tightened. The all-thread bolt was inserted and a washer and nut were placed at each end to affix the upper band and two opposing straps to the pole. The other all-thread bolt and remaining two straps were placed on the pole.

Bolt holes in opposing straps were used to position the lower band and to affix the lower band and straps to the pole. Bolts were torqued to 100 ft-lb to complete the installation. The pole grounding wire at the base was replaced. The installation steps are shown in Ffigures 5 through 18. An installation could be completed within six to eight hours.

## Locations of Breakaway Installations

Ten poles retrofitted within Lexington were at the following locations.

1. Press Avenue and Virginia Avenue
2. Richmond Road and East Fairway
3. Richmond Road and West Fairway
4. Richmond Road and Lincoln Avenue
5. Tates Creek Pike and McMeekin Place
6. Tates Creek Pike and Albany Road
7. Viley Road and Parterre' Place
8. South Pin Oak Drive (GTE Switching Complex)
9. 811 West High Street
10. 1081 South Broadway

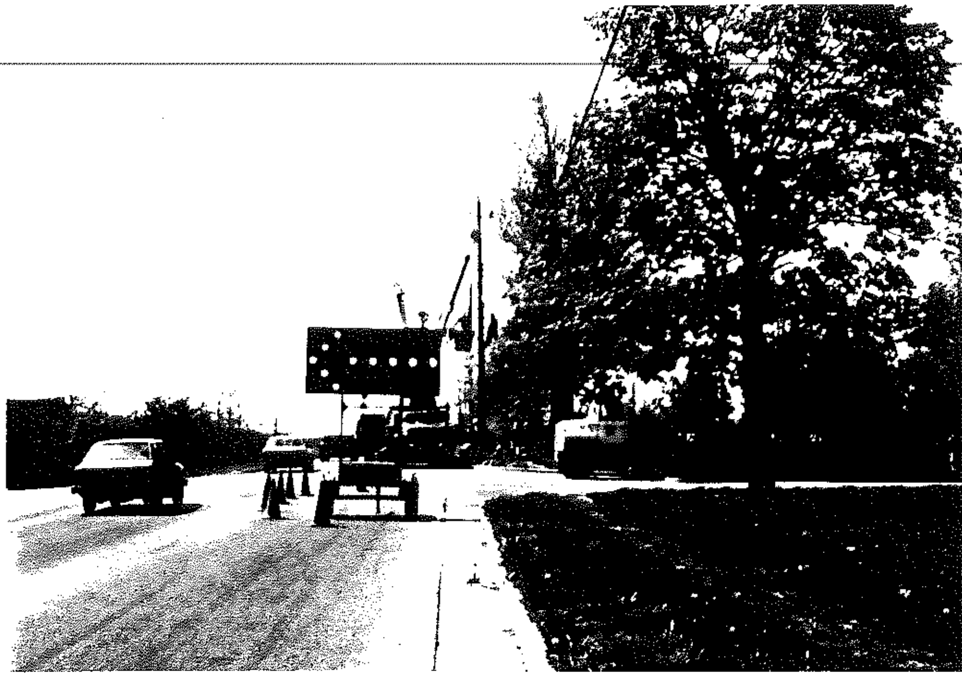

Figure 5 - Traffic Control

Figure 6 - Insulate Lines

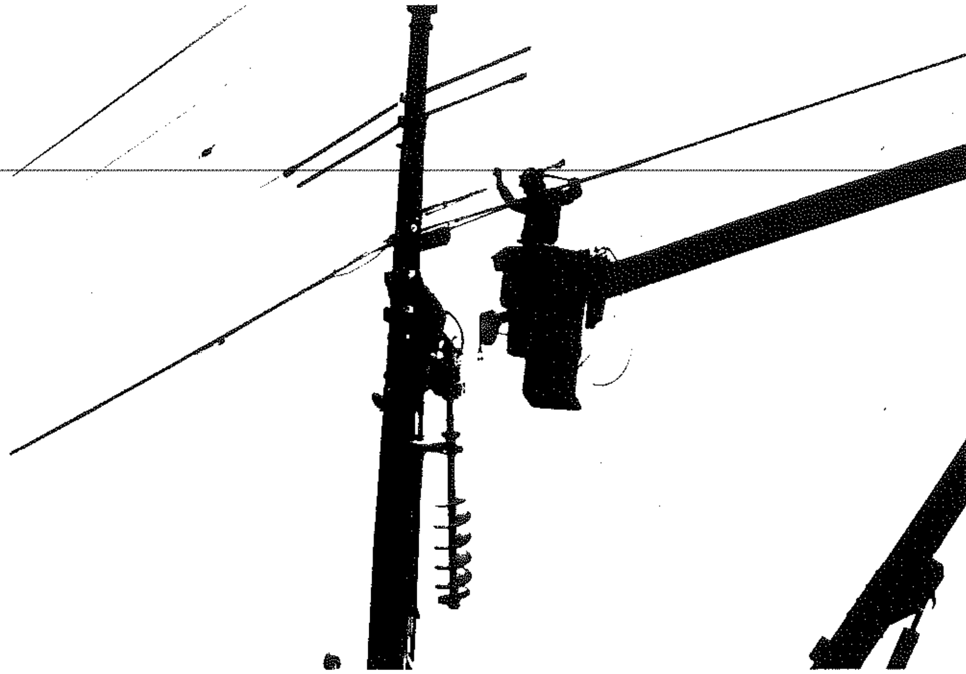

Figure 7 - Install Support Cables

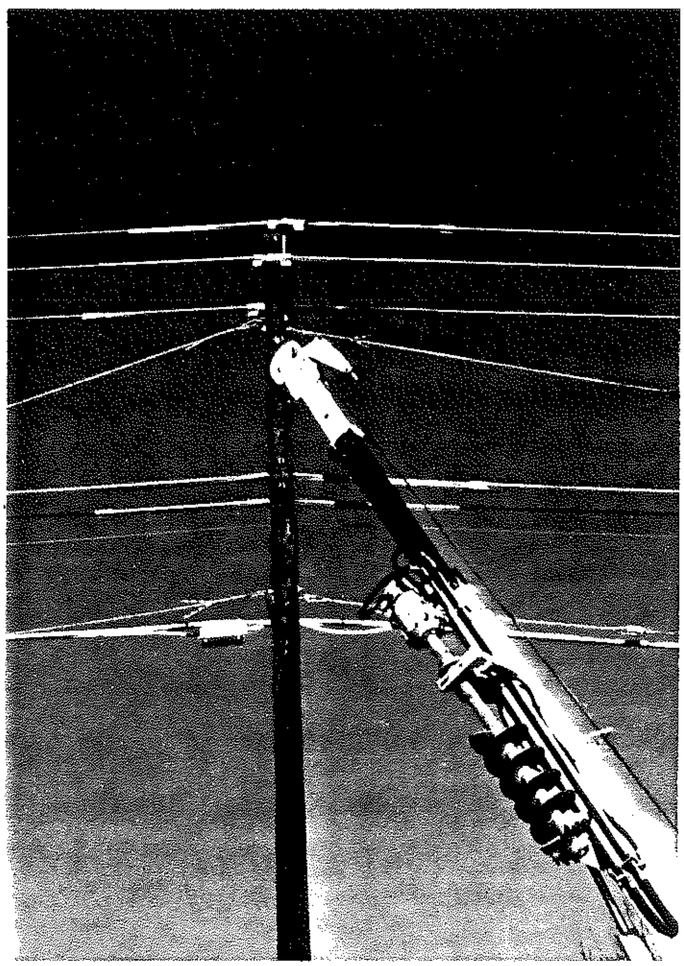

Figure 8 - Affix Collar

Figure 9 - Remove Soil, Base Cut, Groove, Use Preservative on Both Cut Surfaces

Figure 10 - Install Lower Tube with Base

Figure 11 - Place Filler

Figure 12 - Install Upper Tube with Base

Figure 13 - Add Slip Plate, Bolts, Washers, Nuts, and Torque to 200 Ft-Lb

Figure 14 - Place Filler

Figure 15 - Drill through Pole

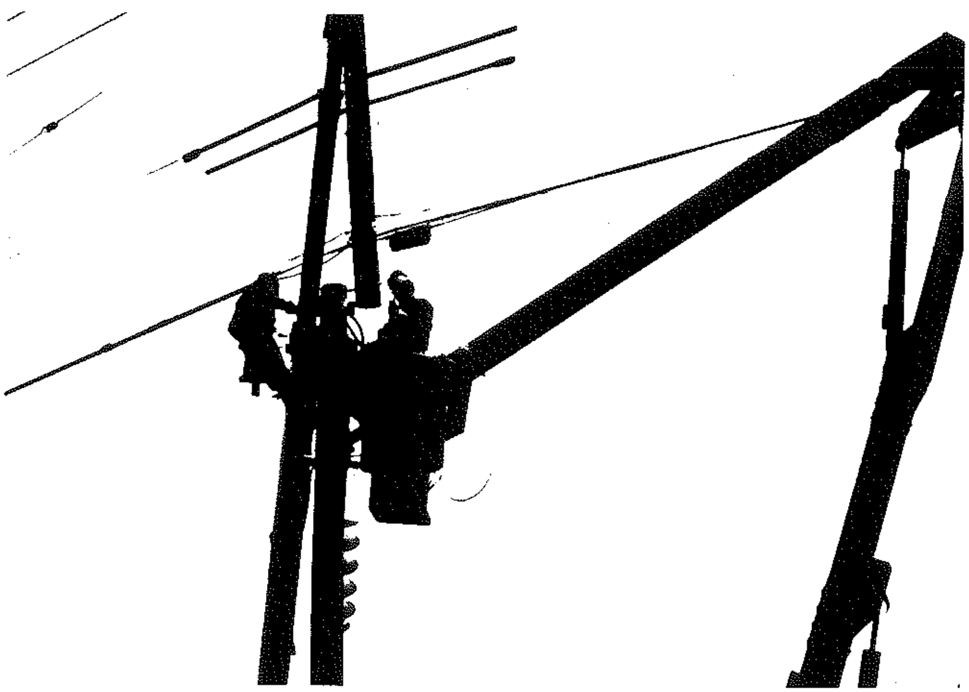

Figure 16 - Cut Top

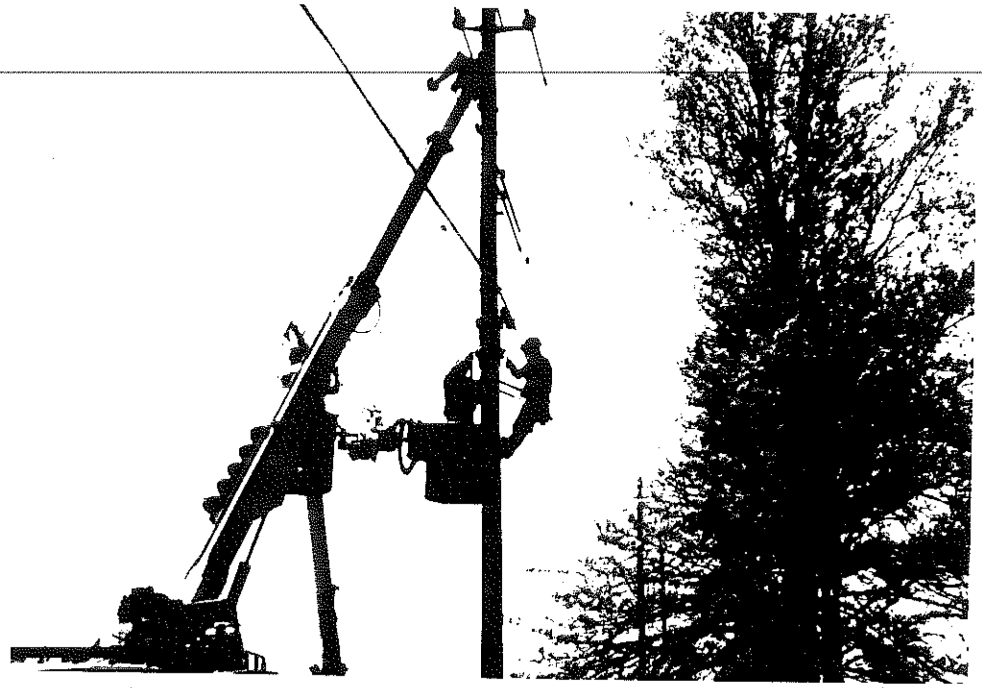

Figure 17 - Apply Preservative and Pole Bands

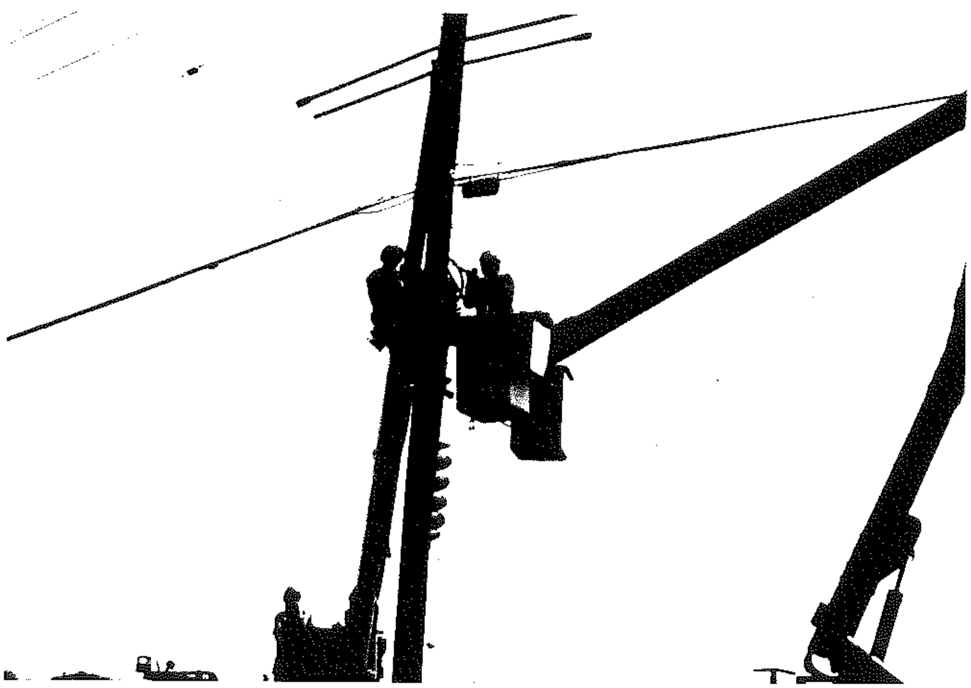

Figure 18 - Install Straps and Torgue Bolts to 100 Ft-Lb

## Summary

Ten poles were retrofitted between January 1988 and October 20, 1989.

Retrofitted poles have been inspected quarterly since the first installation and no indications of problems have been observed. No severe weather conditions have occurred since the first installation and none of the retrofitted poles have been hit by a vehicle.

The pole at 811 West High Street was retrofitted during January, 1989. At approximately 11:18 pm on March 28, a car hit a steel guard post adjacent to a timber utility pole at 833 West High Street. The retrofitted pole was two poles east of the accident location. Two persons died as a result of the accident. Reports indicated excessive speed and alcohol were contributing factors. The retrofitted pole was not a factor in the accident.

Table 1 - Pole and Location Details

| Pole No. | Pole Height- (Above Ground) ft | Upper Cut to Ground-ft | Curb to Pole-ft | Curb Height-ft | Distance to Support Poles-ft N or W | S or E | ADT 1989 | ADT 1993 | Posted Speed (MPH) | Number of Lanes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 39 | 19.5 | 0 | 0 | 100 | 106 | 10,195 | 12,400 | 35 | 2 |
| 2 | 35 | 21.1 | 0.5 | 0.1 | 102 | 138 | 29,800 | 32,400 | 35 | 4 (divided) |
| 3 | 35 | 20.2 | 0.5 | 0.1 | 150 | 113 | 29,800 | 32,400 | 35 | 4 (divided) |
| 4 | 38 | 18.8 | 1.0 | 0.5 | 146 | 112 | 24,800 | 32,400 | 35 | 4 (divided) |
| 5 | 39 | 22.2 | 2.3 | 0.5 | 233 | 124 | 24,000 | 24,900 | 45 | 4 (divided) |
| 6 | 35 | 19.5 | 2.2 | 0.5 | 251 | 173 | 26,100 | 33,050 | 45 | 4 (divided) |
| 7 | 35 | 20.5 | 5.0 | 0 | 149 | 144 | 3,260 | 3,450 | 35 | 2 |
| 8 | 28 | 17.5 | 0.5 | 0.3 | 84 | 52 | 4,240 | 4,890 | 35 | 2 |
| 9 | 28 | 17.5 | 0.5 | 0.3 | 74 | 47 | 11,800 | 16,500 | 35 | 2 (one way) |
| 10 | 30 | 20.5 | 0.5 | 0.2 | 63 | 60 | 31,500 | 36,800 | 35 | 4 |