PRESERVATIVE TREATMENT OF WOOD POLES IN CANADA

G.E. Brudermann, Domtar Chemicals Group, Wood Protection Division

Pointe Claire, Quebec

BACKGROUND

It may not always be realized how significant a role poles play in our daily lives. This may very well be because they have been with us for as long as we can remember and therefore we take them very much for granted. However, it is well recognized that poles are essential in providing us with the standard of living that we are accustomed to, particularly since they facilitate the most efficient distribution of electrical power and function as carriers for communication equipment, such as for telephone lines.

Up to 1945 the majority of pole structures in Canada were made of untreated, durable wood species, such as western red cedar, yellow cedar or eastern white cedar. However, the availability of these species in the desired sizes has always been very limited and, in addition, under severe exposure conditions their performance may not always be adequate. More recently non-durable species that are available in abundance, like the various pine species, have been utilized. Such species require treatment with preservative chemicals to render the wood resistant to the attack and destruction by biodegrading agents, such as fungi and insects.

Up to the early 1950's creosote was virtually the only preservative used for treatment of poles but since then pentachlorophenol-in-oil has almost completely replaced creosote as a pole preservative, and the water-borne arsenical preservatives have been gaining more in importance during the past ten years.

It is estimated that there are about 12.5 million poles installed across Canada, of which several hundred thousand are still untreated cedars. The vast majority of poles are pressure impregnated, although there are a good number that are preserved either full length or at the butt by the thermal process.

When talking about longevity of a pole, a distinction has to be made between physical life, which is from the time of installation to the time it becomes unserviceable due to decay or degradation by other bio-agents, and the actual service life, which is the time from installation to the time the pole is removed from service for any reason, including physical damage because of line up-grading, or relocation. Although the estimation of the physical pole life is difficult and service data are scant, it has been reported that properly preserved poles are likely to have a physical life well in excess of 35 years.

Several requirements have to be met by a pole in order to ensure satisfactory service performance.

Such requirements are:

- Adequate wood strength, as determined by species, dimensions, and allowable defects.

- Preservative treatment, including efficacy of the preservative chemical, the treatment process, and the treatment results.

PRESERVATIVES USED FOR POLE TREATMENTS

As mentioned above, some wood species like cedars contain naturally durable heartwood and only a narrow zone of sapwood which may readily become decomposed through biological activity. However, the majority of pole species native to Canada are non-durable. For such woods durability is imparted by a proper impregnation treatment with preservatives that are effective in preventing biological degradation. An effective preservative must not only be toxic to target organisms, but must also be capable of deeply penetrating wood, it must be resistant to leaching or evaporation from the wood, and must not have any deleterious effects on the wood strength.

The preservatives used for pole treatments in Canada fall into three main categories:

- creosote and creosote solutions
- pentachlorophenol-in-oil solutions
- water-borne arsenical formulations

Creosote is the oldest of these preservatives. It is a distillate of coal tar produced by high temperature carbonization of bituminous coal and consists primarily of liquid and solid aromatic hydrocarbons. The multitude of chemical compounds--more that 160 have been identified--renders creosote highly effective against fungi, insects and marine organisms. Creosote is heavier than water, in which it is nearly insoluble, and apart from its long-term effectiveness against wood destroyers, it also imparts other advantages to wood such as improved mechanical wear and weathering characteristics. It repels water and is an electrical non-conductor. The corrosion of metal fasteners is also retarded in creosote treated wood. Products typically have a dark brown appearance and because of the oil nature of creosote, treated wood cannot readily be painted.

Pentachlorophenol, or penta as it is called for short, is the most widely used oil-borne preservative. It is a crystalline compound formed by the reaction of chlorine and phenol. It has a very low solubility in water, but can be readily dissolved in most high boiling petroleum oils. Treatment solutions of five percent penta in oil are commonly employed. Penta was introduced into Canada during the early 1950's and is now being used for the vast majority of pole treatments (about 75 percent of poles treated annually). The color of penta treated wood may vary with the carrier solvent but it is generally a light brown, which weathers to a pleasant silver. Penta treatments are non-corrosive to metals and because of the use of petroleum carriers penta treated wood is somewhat water-repellant and has a reduced electrical conductivity.

Water-borne preservatives are relatively new. They are inorganic salts with copper and arsenic as the main biologically active ingredients. The water is used as a carrier and the active components become fixed in the wood during the drying process following the pressure treatment. The most widely used water-borne preservative for pole treatments are ammoniacal copper arsenate (ACA) and chromated copper arsenate (CCA). Both preservatives are used in aqueous treating solutions of two to four percent concentration and color wood light green to bluish green. Treated wood is dry to the touch and can be painted.

PRESERVATIVE TREATMENTS

All preservatives mentioned above have been approved by the Canadian Standards Association for use under severe service conditions, such as exist when wood is in ground contact. Standard CSA 080 - "Wood Preservation" specifies preservative properties and explains analytical methods to verify the properties. CSA 080 also stipulates acceptable pole treatments, process conditions and treatment results for a variety of wood species. Quality control methods to verify treatment results are prescribed and recommendations for good practice during storage and handling of treated wood are made. Many pole users either apply these CSA 080 standards directly when purchasing wood or alternatively base their own specifications on the CSA requirements.

The pole species permissible by CSA 080 are:

- Pacific Coast and Interior Douglas-fir
- western larch
- white and red spruce
- jack, white, red, lodgepole, ponderosa, and southern pines
- western red cedar
- western hemlock (full length incised)

All these species may be used for pressure treatments. There are also standards covering full length and butt treatments by thermal process. These standards include species such as western red, northern white and Alaska cedars, and the full length thermal process may also be applied to lodgepole pine poles.

When applying an effective preservative, the success of a treatment, and therefore the degree of protection provided, depends on the amount of preservative deposited in the wood and on its distribution, particularly as it relates to the depth of penetration.

In the biologically vulnerable outer zone of the wood, the concentration of preservative, termed retention, has to be higher than the so-called biological threshold value. This is the level of preservative above which significant biological activity is prevented. Furthermore, the retention has to be high enough so that any leaching, evaporation or migration that may take place during long-term service does not prematurely cause the concentration to fall below the threshold value.

Equally important to the preservative retention in protecting wood is deep preservation penetration. Deep penetration minimizes the chance of decay attack through checks developing after treatment or through exposure of untreated wood that may be caused by abrasion or other physical damage to the wood surface. Treatments, where merely shallow surface layers of the wood are preserved, such as may result from preservative application by brush, spray, or dip treatments, may achieve only very little increase in service life over untreated wood. Consequently, only treatment processes that result in adequate penetration are suitable for the preservation of poles.

The CSA 080 standard permits two basic methods for long-term wood protection. These are the thermal process and the pressure impregnation methods. In Canada about 95 percent of the pole treatments are performed by pressure impregnation.

Thermal Treatments

The thermal process is usually applied to thin sapwood species because deep penetration is not as readily achieved as the pressure processes and close control of the preservative up-take may not always be possible. Thermal treatment facilities may consist of a hot and a cold immersion tank plus a preservative storage tank. A variety of flow lines, controls and valves are also required. Suitable preservatives are creosote and pentachlorophenol-in-oil. During a typical treatment, poles may be immersed in a hot oil bath at a temperature of 190 to 215°F for about six to ten hours. During this heating some air in the wood expands and is expelled. Then the poles are transferred to a cold oil bath of a temperature between 90 and 150°F for two to four hours. The cold bath causes contraction of the air in the wood which facilitates the absorption of preservative under atmospheric pressure.

Pressure Treatments

The most effective way of applying a preservative to wood is by a pressure process. Here treatment conditions can be closely controlled and deep wood penetration can be achieved at metered preservative retentions.

Special equipment is required for pressure treatments. A pressure treating plant would typically be equipped with a horizontal pressure cylinder, also called a retort, that may be six to eight feet in diameter and 75 to 150 feet in length. The treatment system further consists of preservative storage tanks, pressure and vacuum pumps, values, steam generating facilities, and controls to regulate and monitor the treating schedule.

There are three basic pressure processes to choose from, depending on the material to be treated, the preservative to be used, and the treatment results to be achieved.

1. The "full cell" or Bethell process is used with all water-borne treatments and with oil treatments where high retentions are required. In this process, a vacuum is first applied to remove air from the wood cells. The preservative is then admitted into the treating cylinder while maintaining the vacuum. After the cylinder is filled with preservative, pressure and heat are applied until the required absorption is obtained. An expansion bath or final vacuum may be applied after the treatment cycle to remove excess preservative and to render the wood surface free of preservative deposits.

2. The Rueping process, which is an "empty cell process", is commonly used on pine poles. In this process air is forced into the wood before the preservative is admitted. The air pressure is maintained during admission of the preservative, after which the actual impregnation cycle commences. Sufficient pressure is applied to force the preservative deep into the wood against the compressed air. Then, upon release of the treatment pressure, the expanding air in the wood forces excess preservative out of the fibres. The preservative recovered in this manner from the wood is called kick-back or spring-back. The Rueping process is primarily used for products where deep penetration combined with relatively low retentions are required.

3. Similar to the Rueping process, the Lowry process is also an "empty cell" process. In this case, the preservative is admitted at atmospheric pressure. The compression of the natural air in the wood by the preservative aids in expelling excess preservative on release of the pressure at the end of the impregnation cycle. The recovery of preservative is less than in the Rueping process.

Pole Manufacturing Steps

Poles are commonly manufactured to establish size classes, which determine the allowable stresses. In Canada CSA Standard 015 describes suitable species, the allowable natural wood defects and the various strength classes, whereas ANSI 05.1 governs the pole quality requirements in the United States.

After a tree is determined to be suitable as a pole candidate and has been felled, the bark needs to be removed quickly in order to minimize potential attack by fungi or insects and to enhance drying. Peeling is the most common method for removal of the bark.

Poles may then be inspected for any defects such as excessive knots, sweep or spiral grain. In preparation of poles for treatment, some water has to be removed from the wood to make room for the preservative. This can be accomplished by air seasoning, by kiln drying or in the treatment vessel by a conditioning process. Air-seasoning is a well accepted method in areas where the climate permits reasonably fast drying rates. Prolonged storage may lead to fungal infection and loss of wood strength. Efficient storage practices have long been established and are based on allowing good air circulation throughout the pole stacks. Kiln drying of poles is not yet a widely used method due to the high cost involved; however, conditioning processes applied immediately prior to the impregnation process have been gaining an ever increasing importance, and have the added advantage of simultaneously providing a sterilization treatment.

Most utilities have their poles branded and any roofing, boring or other machining and sizing is done prior to treatment. Some difficult-to-treat species, such as hemlock, require incising for better penetration of the preservative.

When a treatment charge is assembled, care is taken in ensuring that poles of similar species, size and moisture condition are included. For treatment the poles in a charge are placed on small rail trams, which are pushed into the treatment cylinders. After closure of the cylinder door, artificial conditioning processes may be applied to remove excess water from the wood to facilitate preservative penetration. In Canada three such processes are employed, namely steam conditioning, boiling-under-vacuum and bathing-in-oil.

Steam conditioning is used on species that are not very heat sensitive including pines. Here steam and pressure are applied (240°F/10 psi) to a charge for several hours to heat the wood. After the steam period a vacuum is applied, which lowers the boiling point of water so that some of the wood moisture can be removed.

Boiling under vacuum or boultonizing, as this process is also called, is used on high moisture content wood in conjunction with creosote or penta-in-oil treatments. Hot preservative is admitted to the cylinder to increase the temperature in the wood. As the wood is being heated, a vacuum is drawn, which lowers the boiling point of water. With this method large amounts of water can be removed from wood and because temperatures are lower (up to 210°F) than during the steam process the possibility of damaging the wood is reduced.

A preservative bath is sometimes applied prior to treatments as a conditioning step. This is similar to the boultonizing processs, except that no vacuum is drawn and the conditioning is limited to the heating of wood. This results in the expulsion of air that expands during heating and also causes small amounts of moisture to be driven off from the wood.

The conditioning cycle is then followed by the impregnation process. A typical penta pressure treatment cycle for pines might employ a Rueping process using an initial air pressure of 30 psi for 15 minutes. After the preservative is admitted under pressure, the pressure is gradually increased to possibly 150 psi and the preservative temperature might be at 190°F. The pressure application is continued until a predetermined gross retention has been achieved, which may take somewhere between one half to two hours. Then the pressure is cut. In order to provide clean pole surfaces an expansion bath might be employed to creosote and penta charges. This would involve the charge being heated to 210 to 215°F for one to two hours. After completion of the bath the preservative solution would be withdrawn from the cylinder and returned to the storage tank. Usually a final vacuum to remove any excess surface oil and to equilibrate wood surface pressure is applied to render poles dry and to minimize the potential for after-bleeding.

After removal of the charge from the cylinder it is inspected for any treatment damage and is then tested for retention and penetration. If the charge fulfills all requirements, creosote and oil-borne preservative treated wood is ready for use, whereas the water-borne preservatives require drying in the open air or in kilns to implement fixation of the chemicals in the wood.

Treatment Results

The quality of the treatment is determined by the amounts and distribution of the preservative in the wood. Consequently, the treatment results are measured as preservative retention in pounds per cubic foot and in inches of penetration depth. The retention can be determined either by measuring the total amount of preservative absorbed by the wood during treatment (called gauge retention) or it can be determined by chemical analysis of the treated wood itself (called the assay retention).

As pointed out before, deep preservative penetration is as important as retention in ensuring long service performance of a pole. Thus, much care is taken in the assessment of penetration. For this purpose, on small poles increment borings are taken from 20 randomly chosen poles in every charge, and in the case of large poles one or two borings, depending on the pole length, are taken from each piece of the charge. Each boring is then split lengthwise in half and the depth of sapwood as well as the depth of preservative penetration is determined using staining reagents.

Precautions during the manufacture of poles include the provisions that all possible machining, sizing and boring is done prior to the pressure treatment so that all exposed surfaces can be properly protected. Nevertheless, in the field it may be unavoidable to bore or otherwise shape wood. Since the entire pole cross section is not normally impregnated, but is more typically provided with a shell or protection, any boring or cutting might expose untreated wood, which may become attacked and destroyed by micro-organisms when conditions are right. To avoid such problems it is necessary to field protect all freshly exposed surfaces with a preservative that is compatible with the original treatment.

CONCLUSIONS

Properly designed and preserved pole structures are able to satisfactorily meet all service requirements and the virtues of treated poles for support of electrical and communication equipment are well recognized. To quote H.N. Day of the New Brunswick Telephone Company, who, I am sure, speaking for the majority of the pole users, says, "We expect overhead construction will be the cheapest and most versatile support structure for power and communications conductors for many years to come".

To be able to meet the demand for pole timbers in the future, longevity of pole structures should be ensured by proper preservative treatments. This will greatly contribute to the efficient use of our pole resource. Equal importance should be placed on providing preventive maintenance for poles in service to obtain an optimum service life and, of course, cooperation between forest management, governments, pole producers, and users is required to develop, to provide and to utilize the pole resources to the fullest.