Copper Naphthenate: An Update and Status
Report on an Effective
Wood Pole Preservative

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Abstract
This paper reviews the efficacy and field trials of copper naphthenate in various wood species. Included in this discussion are chemical and physical characteristics of copper naphthenate preservative systems, the effect on wood treated with copper naphthenate or copper naphthenate wood preservative systems, a review of the long-term efficacy trials, typical plant handling characteristics of copper naphthenate and its diluted solutions, information relating to conversion of oil-borne pressure treating plants to copper naphthenate and a discussion of early pole failure causes.

Background and history
The use of copper naphthenate as an industrial biocide has been well established since the turn of the century (29). Copper naphthenate is basically the metallic salt of a metal ion reacted with naphthenic acids. Naphthenic acids are by-products of petroleum, typically removed from petroleum fractions by caustic quenching, then resulting acidification. Typical crude petroleum oils contained 0.5 to 2 percent crude naphthenic acid by weight, with the highest concentrations of crude found in South America, western North America, Rumania, Russian, and Central America. The naphthenic acids are typically alicyclic acids. They are broadly classified as acids of the formulae C_{n}H_{2n-2}O_{2} having the typical formulae in Figure 1.

Chemically speaking, these compounds are known as cupric cyclopentane carboxylates or cyclohexane carboxylates. The physical and chemical characteristics of copper naphthenate and naphthenic acids have been described in detail (33) and their use in wood preservation discussed by Hartford et al. (23). Broadly speaking, many naphthenic acids can find their way into wood preservation, since the specifications written for copper naphthenate include a wide variety of acid values, all nap acids of which are known to perform extremely well in ground contact. Trade names for copper naphthenate in commercial use include Perm-E8, Cop-R-Nap, CuNap8, Cunapsol, and Cuprinol. Of these, the most common name is Cuprinol, dating back to the Danish of over a century ago, meaning, “copper in oil” (6). A review of the literature cites many applications for use, including field boxes, beehives, benches, flats, fenceposts, water tanks, canvas, burlap, ropes, nets, greenhouses, utility poles, crossarms, and wooden structures in ground contact and above ground contact (35). Copper naphthenate is known to control many decay fungi, molds, mildew, dry rot, certain marine growths, termites, wood parasites, and bacteria. Recent studies have also proven copper
naphthenate to be effective in preventing the consumption of wood by the aggressive Formosan termite in Hawaiian field tests and lab tests.

Copper naphthenate began its strong leap into the wood preservation business with the need to extend the useful volume of creosote available in the postwar effort. Due to a modification of operating practices of the steel mills, creosote, whose main source is the coking of coal and of petroleum products, was in short supply. The American Wood Preservers' Association (AWPA) began a search for combination biocides that could be added to creosote to effectively extend its service life. Colley et al. determined that copper naphthenate was a likely extender for creosote and did not offer some of the proposed problems that addition of pentachlorophenol (penta) as a phenolic acid would pose in treating plant corrosion.

Resulting papers presented by Minich and Goll (29) included a broad background of the technical aspects of copper naphthenate as a wood preserving chemical, including its solubility in organic solvents, relative vapor pressure, electrical conductivity properties, compatibility with commercially available oils, and the effectiveness of copper naphthenate against wood decay fungi. A specification was proposed to add copper naphthenate to the AWPA Book of Standards. The key issues brought about by the proposal by Minich and Goll included copper naphthenate as a chemical compound of uniform performance, its highly effective nature, and as a permanent wood preservative, its easy application, and its safety in handling to workers.

Copper naphthenate exists in the AWPA Wood Preservative Standards, P-8, with the following specifications:

- The acid used in the manufacture of copper naphthenate shall be naphthenic acid of the group of alicyclic carboxylic acids occurring in petroleum and shall have an acid number of not less than 180 and not more than 250 on an oil-free basis.
- The copper naphthenate concentrate used to prepare wood preserving solutions shall contain not less than 6 percent, nor more than 8 percent, copper in the form of copper naphthenate.
- All of the copper present in the concentrate shall be combined as copper naphthenate.
- The copper naphthenate concentrate shall not contain more than 0.5 percent water.
- The foregoing tests shall be made in accordance with the standard methods of the AWPA Standards A-5.
- Solvents used to prepare solutions of copper naphthenate shall comply with the standards of the AWPA Standard P-9.
- The copper naphthenate concentrate shall not contain more than 2 percent (relative) of the total copper in the concentrate as being water extractable as determined by the analytical method A-14 on Page 248 of the 1987 AWPA Proceedings.

- A gas chromatographic method for determining conformity with part 2.1 and 2.3 will be published in the 1999 AWPA Proceedings as an appendix to the Subcommittee P-5 Report.

These values in the current AWPA Standards vary slightly from the original proposal prepared by Minich and Goll, including an upper limitation of the naphthenic acid value in an attempt to preclude the use of synthetic carboxylic acids in preparing copper carboxylate solutions. Data has been presented to the Association as well as to the International Research Group on Wood Preservation that certain carboxylic acids do not provide adequate protection. Of these, the synthetic carboxylic acids which have the acid numbers in excess of 250 and less than 750, have proven to be highly leachable and insufficient wood preservatives for ground contact. Additionally, the use of low molecular weight acids cause increased water solubility of both the copper and act as a
coupling agent for water/hydrophobic sections of the naphthenate molecule and increase the solutions propensity for the formation of stable emulsions. Copper naphthenate, when produced commercially, consists of an amorphous, glassy solid with the copper content ranging from 9.2 percent to 10.8 percent by weight. When using an acid value number (TAN) for copper naphthenate of approximately 200, the ratio of copper to total copper naphthenate fraction is approximately 1 to 10.

In the United States today, there are approximately 140 million standing utility poles. An excess of .95 percent of these standing utility poles are constructed of wooden materials. Data published by EPRI (1987) indicate that of these poles, approximately 65 percent are treated with penta, 17 percent are treated with creosote, and another 17 percent are treated with inorganic arsenicals. The trendline for these wood commodities indicates that poles treated with oil-borne preservatives, although perceived as easier to climb than poles treated with water-based preservatives, maintain a steady but slowly decreasing market share, probably due to the very reduced cost of water-borne treated wood over that of oil-borne systems. The use of inorganic arsenicals in wood poles is a growing percentage (Micklewright, 1950-1993, 1994-1997). There also appears to be a drop in creosote usage and an increase in the inorganic arsenicals.

Penta, an effective wood preservative, has undergone intensive environmental reviews by the U.S. EPA from 1978 to 1986. The result of this review was the final publication of a RPAR position document IV and a settlement agreement between industry and the EPA. Although penta remains an extremely viable wood preservative, many people concerned over hexachlorobenzene and chlorinated dioxins have begun to specify and user copper naphthenate, due to the bad press received by penta over the last number of years as well as a perceived problem with penta-treated utility poles. Recent data, published by the Electric Power Research Institute, however, indicate that TCLP testing on penta utility poles gave no positive response, indicating the penta-treated wood would not similarly be considered a hazardous waste. The increase in use of copper naphthenate-treated wood and an increasing amount of utility specifications, however, have shown that a gradual increase in copper naphthenate is occurring with expected values for pole purchases in 1999 to exceed 3-4 percent of the total market, or > 1,000,000 poles treated between the dates of 1988 to present.

Copper naphthenate is typically supplied as an 8 percent concentrate dilutable with a wide variety of organic solvents. Typical properties for the 8 percent concentrate and for a 1 percent (copper as metal) solution (RTU - ready to use) when the 8 percent concentrate is diluted with 8.3 parts fuel oil is shown in Figure 10.

One of the principal reasons that copper naphthenate is gaining market acceptance and is being compared to other oil-borne wood preservatives is its low mammalian toxicity. The acute toxicity profile of copper naphthenate (8%) has been well published and documented, including studies conducted by the U.S. Army Industrial Hygiene Group. The current Task Force answering the questions on the U.S. EPA Data Call-In, dated 1985, have reviewed the acute and chronic toxicity package of copper naphthenate and copper naphthenate treating solutions. A typical acute toxicity profile of copper naphthenate concentrate is published in Figure 9 (22,23,26,36). A complete review of the regulatory status by Talereck has been performed and is summarized below in the section entitled Regulatory Status.

**Efficacy of copper naphthenate**

Copper naphthenate exhibits a wide range of efficacy toward most decay fungi (basidiomycetes), termites, and many other wood-destroying insects. Duncan (13-15) performed efficacy trials of copper naphthenate in soil block tests, comparing these to
penta, coal tar creosote, and petroleum fractions. In addition to these data, reports for the AWPA Copper Naphthenate Task Force reviewed the efficacy of copper naphthenate against six decay fungi (white rot and brown rot) and data was reviewed by Morrell to determine effectiveness against copper-tolerant fungi (Poria, Postia). Overall performance of copper naphthenate in various petroleum solvents have indicated that both soil block and agar block techniques were applicable to this preservative system with excellent control over decay organisms tested in the 0.02 to 0.044 lb/ft.\(^3\) copper (as metal) range in southern yellow pine sapwood.

Long-term efficacy trials on 2 by 4s treated by dip, soak, brush-on, and pressure-treating methods have been evaluated by Davidson (11) and Gjovik and Gutzmer (20,21). These data, published in USDA Forest Service Technical Note FPL-02, “Comparison of Wood Preservatives in Stake Tests” (Figure 13), are illustrated graphically in Figures 3 and 4. These data indicate that copper naphthenate dissolved in No. 2 diesel oil gives an average predicted lifespan of 38 to 42 years, comparable to that of either creosote or penta in heavy oil. In addition to these data, USDA Forest Service Publication FPL-01, “Comparison of Wood Preservatives in Post Tests,” indicated that copper naphthenate-treated round stock gives excellent service life when compared to standard preservatives such as CCA, creosote, or penta in P9 Type A oils.

Review of the severity of the tests, including sites at Madison, Wis., Gulfport, Miss., and Dorman, Miss., indicates that the severity of the test plot can alter the service life of wood products when placed in ground contact. However, by placing a standard control preservative into the test plot, the degree of severity of that test plot can be monitored, including the predictability of service life (Fig. 3). These data have been reviewed by Scheffer (1972) and Eslyn (17), including data on utility pole decay and growth temperature relationships of this decay, and by Scheffer in plotting average decay in North America by temperature humidity mapping and ultimately published as part of the REA, now RUS Specifications (decay hazard map), Appendix B, AWPA Committee T-4, 1972). Hunt and Garratt (25) proposed levels of copper in copper naphthenate-treated wood commensurate with those in the current AWPA standards (Figure 12).

In addition to these data, the post farm at Oregon State University continues to have excellent performance of brush-treated, soaked, and pressure-treated Douglas fir posts after greater than three decades of exposure (30). Morrell, Scheffer, and Miller in the "Progress Report have also published these data for the OSU Post Farm Test." Copper naphthenate is also a proven cellulosic fiber preservative. Data reviewed by Curwen (9) has shown that copper naphthenate has a high degree of permanence when used to preserve cellulosics and also has the ability to prevent mildew, rot, and decay from occurring in fiber substrates.

**Copper naphthenate-treated wood**

Copper naphthenate is a standard preservative listed in AWPA Standard P-8. This organometallic preservative system is freely soluble in various organic solvents, including mineral spirits, fuel oil, pole treating oil, and creosote-petroleum mixtures. Currently, the AWPA lists copper naphthenate in over a dozen commodity standards (Figure 14). These standards, approved by both the preservatives committees and/or the treatments committees, indicate that the purchaser and user of copper naphthenate-treated wood commodities can be assured of the expected service life of commodities when properly treated in accordance with these standards.

When copper naphthenate is evaluated for treating utility poles and crossarms, four specific evaluation parameters should always be reviewed: leachability of the preservative system, conductivity of the treated wood commodity, hardness or gaff penetration of the treated wood, and corrosivity of the treating solution when placed in contact with metallic wafers while still in solution.
Leachability

Standard wooden blocks, when treated with copper naphthenate and penta in similar P9 oil, were tested in accordance to AWPA Standard M-11. Results of these tests are shown in Figure 8. Results of this test indicate that the slight leachability of both preservative systems may be one of the primary modes of protection of wood substrates by sterilization of the surrounding soil of the utility pole. Preliminary indications are that copper naphthenate is tightly bound to the wood substrate, which may be both chemical and physical, including copper-lignin bond formation, copper-holocellulose bond formation, and copper-extractives bond formation. Extraction of copper from copper naphthenate treated wood by toluene extraction is almost impossible after only a short wait after treating.

Conductivity

When evaluating preservatives and preservative systems for both wooden utility poles and crossarms, conductivity of the treated wood is of utmost importance. Reduction in the conductivity of the treated wood may be achieved by simple reduction of moisture content of the treated wood commodity by displacing these with non-polar organic solvents or by reducing the overall conductivity of the wood specimen. Review of conductivity testing includes data from Katz and Miller (AWPA Proceedings, 1963). This data indicates that either resistivity or conductivity of treated wood can greatly be affected by grain orientation, moisture content of the piece, temperature, and preservative system employed. Test results published by Asmus et al. (6) have shown that there is no increased conductivity of the treated wood utility pole or cross-arm when treated with copper naphthenate in an oil-borne preservative system. Results are published in Figure 7. Many linemen and engineers are often confused or concerned that a "copper" containing preservative will be very dangerous to climb and be very conductive to electrical current. This is simply not the case with copper naphthenate.

Hardness/gaff penetration

When specifying and using a wood preservative to produce a utility pole, the hardness of the utility pole or the ability to penetrate that utility pole with the standard lineman’s gaff is very important. Hardness of the pole relates to surface hardness as well as the ability to flex under torsion. Many delivery firms typically roll utility poles off the back of either gondolas or flatbed trucks at the destination site, rather than picking these up and moving them with knuckle-boom loaders. The hardness of a utility pole, or its ability to withstand impact, is greatly affected by the preservative system employed. Copper naphthenate-treated poles represent no significant increase in brittleness to a standard utility pole.

When evaluating the gaff penetration of copper naphthenate-treated wood in species such as southern yellow pine or Douglas fir as compared to standard preservative systems, no significant difference was found in gaff penetration between it and penta in similar P9 Type A oils. It is a widely recognized fact that the oil-borne petroleum solutions generally give a certain amount of lubrication for gaff penetration and an ease of penetration to the wood surface. Results of the gaff penetration tests by Pierce, conducted at the testing ground of Arizona Public Service Company, Phoenix, Ariz., are shown in Figure 5 (31).

Corrosivity
The corrosivity of the free oil and copper naphthenate in treated wood offers no significant increase compared to untreated wood or preservative treated wood using other oilborne preservative systems. Tests comparing the corrosivity of the biocide dissolved in either No. 2 fuel oil or medium aromatic treating oil have indicated no significant corrosivity from the treating solution and/or the treated wood specimens (Figure 6).

**Effects of Steaming**

Later work in the development of copper naphthenate as a heavy-duty preservative for poles led to the development of various treating cycles similar to other oilborne systems. Recent work concerning the post treatment steam conditioning of copper naphthenate treated southern pine has determined that some amorphous copper naphthenate is converted to a crystalline cuprous oxide and this was later determined to be less efficacious than copper naphthenate in small laboratory tests. This gave cause to the American Wood Preservers' Association to issue the instruction to the copper naphthenate task force to review, with particular emphasis on the effect of pre and/or post steaming on the efficacy of copper naphthenate preservative systems, including degradation of copper naphthenate. Three papers have reviewed the performance of actual pole diameter stubs placed in a high hazard location containing both termites and potential for early decay attack. Various treating cycles were used to treat the pole stubs in these studies including various post-treatment conditioning methods. Overall, it was found that the use of a post-treatment steam conditioning bath or open steaming cycle did not effect the efficacy or overall performance of large size diameter wood poles in efficacy studies in poles with in-service use ages of 1-12 years after post treatment steaming.

**Treating plant operating conditions**

In evaluations of a new preservative system, the properties of the treated wood are important, but the operating characteristics of that preservative system are also important and should be considered when incorporating the system into an existing treating plant. Currently in the United States, there are 31 operating treating plants using copper naphthenate in various petroleum oils. It is estimated that over 2.5 million pounds of copper naphthenate concentrate are being sold into the wood preservation market into the United States as of this date. This amount of material, based on an 8 percent metallic copper content, indicates that approximately 2 million cubic feet of posts, poles, and lumber are being treated annually. Typical oil-borne preservative plants can be converted over to use copper naphthenate with relative ease. Key issues in operating plant are:

- the tendency for preservatives to be compatible with available treating oils or diluents
- the tendency for preservatives and preservative systems to form emulsions and the resulting separation of these emulsions to allow wastewater discharge
- the propensity of a preservative or preservative system to form sludge within this treating cylinder, treating solution, or on the surface of wood
- typical items necessary to convert an existing operating plant.

**Emulsion formation**

Copper naphthenate solutions, produced from copper naphthenate concentrate and fuel oil, can form stable emulsions, especially when the emulsions contain particulates, wood extractives, wood acids, and wood sugars. These wood components tend to stabilize the emulsions by acting as either thixotropes or surfactants. Investigations into
the tendency of copper naphthenate solutions have been well discussed by Freeman (18) and Accampo (4).

Two single factors play the greatest role in forming emulsions in copper naphthenate treating plants and treating equipment. In every single case investigated where emulsions have formed, insolubles were present in the wood treating solution. This would indicate that the tendency to form emulsions can be greatly reduced by incorporating filtration equipment into the treating plant equipment and filling lines prior to going into either the Boulton tank or the pressure-treating cylinder. In fact, commercial treating plants of large-scale today use multiple canister filters, filter presses/multiple frame plate and framer filters, or multiple bag filters to remove solids from solutions. The incorporation of a filtration unit into a commercial treating plant reduces the amount of emulsions that form and also reduces surface solids deposited onto wood utility poles.

Additionally, the AWPA has issued an instruction to the T-4 Sub-Committee on wood poles to start a task force to "Review, with particular emphasis on the effect, the formation, and the prevention of emulsions in oil-borne treating systems on the performance and treatability of treated wood utility poles, with particular emphasis on Copper Naphthenate". The preliminary findings of this task force to date indicate that the plants have no longer have an emulsion problem in the plants since many of the formulations have changed or exited the market since 1995, and emulsions problems that we occurring then leading to early failures no longer exists, especially after one large copper naphthenate supplier exited the market in 1995. Further work being conducted by this task force in AWPA may lead to the use of a new analytical standard which may place a limit on the emulsibility/water solubility of the RTU treating solution prior to them being introduced into the treating plant.

**Sludging**

Sludging of copper naphthenate has been discussed in various documents such as Wood Treating Chemicals' documents CN-1400 and CN-1500. These documents indicate that the work done by Accampo (4) can be the result of emulsion formation and heating, which would tend to produce sludge within work tanks as well as treating equipment and on wood surfaces. When emulsions form in work tanks, standard industry practice is that the resulting water be driven off with heat. In copper naphthenate treating systems, if the water content exceeds 1 to 2 percent, elevation of the temperature of the work tank solution can cause the formation of black copper oxide. The black copper oxide can then form a “seed;” the resulting emulsion can either grow in size or can precipitate to the bottom of the tank, since copper oxide is not soluble inorganic solvents. This copper oxide increases the amount of xylene insolubles, or sludge, present in the solution. Again, the secret to keeping sludge from forming in copper naphthenate treating equipment is to reduce the water content appreciably, continuously filter the solution, and prevent debris and trash from entering the wood treating equipment.

**Plant conversion**

Plant conversion is very simple when converting from either penta or creosote to copper naphthenate. Adequate cleaning is necessary to meet EPA guidelines if the user does not plan to obtain restricted use pesticide licensing or decontaminating/delisting the facility for use with copper naphthenate only. Incorporation of filtration equipment as well as sludge dewatering equipment is necessary for a copper naphthenate treating plant that would have discharge going to a POTW or water discharge through NPDES permitting. Experience has shown that use of two work tanks, which would allow quiescent settling of solution after agitation and
after removal of debris and water, greatly increases the operating efficiency of the facility and produces the cleanest treated wood. Having two work tanks requires keeping dual inventories of treating solution. A plant may also convert, using simple conversion from either a penta plant or a creosote plant, by simply converting the tanks, removing formerly used preservatives, and incorporating a filtration system into the material flow as well as a sludge dewatering system.

**Early Pole Failures**

Some utility poles treated in the late 1980’s through the early 1990’s have experienced premature failures and resulted in a series of litigation. Some of these poles failed within eighteen months of service, faster even than untreated poles should fail. Legal action proliferated with counter suits between chemical supplier, treaters, inspection companies, and pole suppliers. Several of these suits were settled out of court with the details remaining confidential and not available to the public. Others are pending so it is not possible to cite the relevant data.

To better understand the issues concerning premature failures, Chemical companies have interviewed utility companies, treaters, inspection companies, pole sellers, and industry experts.

What has been learned is that not every case is the same since different situations existed at different times. Based on interviews with industry experts and the expert reports that have been issued, the premature failures are thought to be caused by one or more of the following conditions:

- Pretreatment and Incipient Decay
- Improper Sterilization/Conditioning
- Inadequate copper penetration and retention, including typical Gaussian distribution for low (sub-threshold) treatment
- Improper and insufficient inspections
- Low retention levels in high AWPA hazard zones
- Chemical formulations causing stable water emulsions preventing effective treating
- Treating with too high a water content(emulsions) in the treating solution resulting in the treatment solution water phase penetrating the wood pole and the oil-phase coating the pole exterior surfaces causing an effective "greenhouse-like" effect of keeping a high moisture content in the pole, even if it was effectively dried, and making the exterior surface water repellent to keep the pole interior MC elevated
- Possible use of non-naphthenic synthetic acids that do not conform to AWPA Standard P8 for copper naphthenate causing early decay and contributing to the propensity to form stable emulsions.
- The possible "learning curve" theory where both the treaters and the chemical manufacturer did not know how to effectively handle and use this newer preservative system thinking it would effectively be the same as either penta or creosote in handling and treating characteristics.

No allegation has ever been made that copper naphthenate is not an effective preservative. On the contrary, every case starts with the assumption that poles properly treated with copper naphthenate will meet the industry life expectancy of 35+ years. In fact, with a proper inspection and remedial treatment program, a recent quote at a regional pole conference indicated these oil-borne preservative treated poles may well last > 80 years.
It is unfortunate that failures like this occur, but failures have happened with all preservative treatments. However, steps have been taken to avoid future premature failures with copper naphthenate. Since 1995, the overall quality of the copper naphthenate treated poles has improved as treaters and chemical suppliers have learned to control water emulsions and treatment variables. As of this date, over 1 million poles have been treated with copper naphthenate since 1988, and less than 4000 have been cited as having early decay problems. This 4000 poles out of >1,000,000 poles is certainly less than one might expect (less than 0.5%) as having early failures based on a normal distribution curve, with a mean (median) service life for a wood pole of 35 years.

Regulatory Status

The following summary is a compilation and a review of the regulatory status of Copper Naphthenate by Environmental attorney, Walt Talerek, esq.

Copper Naphthenate is an EPA-registered, non-restricted use (general use) wood preservative. EPA regulations and product labels do not require applicators of copper naphthenate wood preservatives to be certified. (However, some states may require applicator certification for copper naphthenate for the wood-preservatives typical use patterns.) Copper naphthenate wood preservatives are not restricted-use pesticides under 40 CFR section §152.170 because:
- They (CuN wood preservatives) are not Toxicity Category I acute toxicants;
- They do not cause significant subchronic, chronic or delayed toxic effects; and
- They do not pose a serious hazard to man or the environment.

B. Registrants of copper naphthenate wood preservatives are supporting their reregistration.
- Registrants have submitted Phases 2, 3 and 4 reregistration responses to EPA.
- Registrants have submitted toxicity, ecotoxicity, and environmental fate data in response to data call-ins issued by EPA on 1/12/89, 11/18/93 and 5/27/94.
- EPA will issue a Reregistration Eligibility Document ("RED") on the naphthenate salts sometime within the next year or so; and, registrants will respond by developing and submitting additional data and amending their products' labels (Phase 5, which is the last reregistration phase).

C. Copper naphthenate wood preservatives are not the subject of an EPA special review under 40 CFR section 154.7, nor will they be in the future, because:
- They do not pose a risk of serious acute injury to humans or domestic animals; and
- They do not pose a significant risk of inducing oncogenic, heritable genetic, teratogenic, fetotoxic or reproductive effects in humans.

II. Resource Conservation and Recovery Act ("RCRA")
Copper naphthenate wood preservation wastes are not federal hazardous wastes.
- Copper naphthenate wood preservation wastes are neither listed (from specific or non-specific sources) nor characteristic hazardous wastes. See 40 CFR Part 261.
- EPA’s 12/6/90 wood preservative wastes listings rule does not apply.
- Copper and copper naphthenate are not regulated under the Toxicity Characteristic ("TC") and are not Appendix VIII constituents of concern.

B. USEPA has no plans to list or characterize copper naphthenate wood treating wastes as hazardous wastes.
C. Some states, such as California, have TC-type regulations which list copper as a regulated contaminant; and, wastes containing copper above certain specified levels would be considered hazardous wastes.

III. Clean Air Act ("CAA")
A. EPA does not regulate air emissions of copper and copper naphthenate from wood preserving plants.
B. Copper and copper naphthenate are not listed as hazardous air pollutants under the 1990 CAA Amendments. Moreover, EPA has no plans to regulate these emissions.
C. Copper and copper naphthenate are not on EPA’s list of regulated toxic substances for accidental release prevention, at 40 CFR section 68.130.

IV. Occupational Safety and Health Act (“OSHA”)
A. Copper is listed as an air contaminant in Table Z-1 of 29 CFR section 1910.1000. The OSHA-promulgated exposure limits for copper in the workplace are 0.1 mg/m³ as a fume (as Cu) and 1.0 mg/m³ as a dust or mist (as Cu).
B. Copper naphthenate is a hazardous chemical to which OSHA’s hazard communication standard applies. See 29 CFR section 1910.1200. Requirements for material safety data sheets (“MSDS”), labeling and training apply.

V. Clean Water Act (“CWA”)
A. Copper (but not copper naphthenate) is a priority pollutant for which effluent limitations and pretreatment standards have been prescribed for wood treatment plants. See 40 CFR Part 423 Appendix A. (These limitations and standards were based on the use of creosote, pentachlorophenol, ACA and CCA at wood treating plants, however.) The limitations and standards are listed in wood treatment plants’ National Pollutant Discharge Elimination System (“NPDES”) permits, including storm-water, permits.
B. Copper and copper naphthenate are not listed as hazardous substances at 40 CFR section 116.4 and, therefore, spills of these chemicals do not have to be reported.
C. Copper and copper compounds are listed as toxic pollutants. See 40 CFR section 401.15.

VI. Safe Drinking Water Act (“SDWA”)
A. A maximum contaminant level goal of 1.3 mg/l has been prescribed. See 40 CFR section 141.51. However, no numerical primary maximum contaminant level has been promulgated.
B. A secondary maximum contaminant level (protects drinking water quality) of 1mg/l has been prescribed. See 40 CFR section 143.3.

VII. Comprehensive Environmental Reporting, Compensation and Liability Act (“CERCLA” or “Superfund”)
Copper and copper compounds are hazardous substances under 40 CFR section 302.4, but no reportable quantity has been assigned. Releases must be cleaned up; however, releases do not have to be reported to the National Response Center (“NRC”).

VII. Emergency Planning and Community Right-to-Know Act (“EPCRA”)
A. Copper is a toxic chemical for which release reporting (Form R) requirements apply. See 40 CFR section 372.65(a).
B. Copper and copper naphthenate are not extremely hazardous substances for which emergency planning and release notification requirements apply. See 40 CFR Part 355, Appendix A.
C. Copper naphthenate is a hazardous chemical (based on OSHA hazard communication standard criteria) for which material safety data sheet and inventory reporting requirements (Tier I and Tier II) apply.

CONCLUSION: Copper naphthenate is an EPA-registered, non-restricted use, relatively non-toxic, wood preservative. From a regulatory standpoint, copper naphthenate is an attractive wood preservative because EPA imposes minimal requirements on wood preservers who use it. Furthermore, when compared to each restricted-use wood preservative, copper naphthenate enjoys some if not all of the following advantages:

I. EPA does not require applicators of copper naphthenate wood preservatives to be certified;
II. EPA does not regulate copper naphthenate wood preservative wastes as hazardous wastes;
III. EPA does not regulate copper naphthenate emissions from wood-treating plants as hazardous air pollutants, only the solvents that they are diluted with are regulated;
IV. Copper naphthenate is not a regulated toxic substance to which CAA accidental release prevention requirements apply;
V. Copper naphthenate is neither a CWA nor a CERCLA hazardous substance for which spills have to be reported; and
VI. Copper naphthenate is not an EPCRA extremely hazardous substance for which emergency release notification requirements apply.

Currently no treated wood is regulated as hazardous waste. It is simply easier for total compliance for the treater and the user of treated wood to use and specify copper naphthenate when faced with many of the other regulations which further constrain their business and business opportunities.

Summary

Copper naphthenate, in field trials in 3/4 inch stakes, 2 by 4 stakes, and pole-size sections, has proven its effectiveness as a ground-contact wood preservative. Copper naphthenate imposes no significant detrimental properties to treated wood as long as the treatment is in accordance with AWPA guidelines and in accordance with the commodity standards. Copper naphthenate is currently not considered a restricted use pesticide, and wastes containing copper naphthenate are currently not listed as hazardous. Certain wastes that are generated from a copper naphthenate treating plant may be characterized as characteristic hazardous waste, and disposal should only be undertaken after extensive product testing. Copper naphthenate offers a broad spectrum efficacy against termites and decay organisms, while offering a minimal worker exposure to operators handling both the chemical and the resulting treated wood. Plant conversion from an oil-borne system can take place simply. Overall, copper naphthenate can be used as an effective wood pole and wood crossarm preservative, with service life expected to be equal to or exceeding typical creosote or penta treatments at appropriate retentions.

Literature cited

Figure 1. Examples of many of the 1500 + typical Naphthenic acid Structures
Tall Oil Fatty Acids  (Oleic, Linoleic, Palmitic acids)  
TAN ~ 170

2-Ethylhexanoic Acid
TAN ~ 390

Neodecanoic Acid  (+ mixed isomers)  
TAN ~ 320

C$_9$-C$_{13}$ Neo Acids (mixed isomers)  
TAN ~ 360

Rosin acids  (Abietic Acid)  
TAN ~ 160

Figure 2. Typical Non- Naphthenic Acid Structures  
(Synthetic Acids)
Figure 3 - Comparison of copper naphthenate retentions in USDA-FPL Sites in Wisconsin and Mississippi

Figure 4 - Comparison of Wood Preservatives at USDA-FPL Gulfport, MS Test Site
GAFF PENETRATION TEST

Summary of 1/2" Gaff Penetration
Average of Four Gaff Brands

In Pounds

<table>
<thead>
<tr>
<th></th>
<th>Southern Yellow Pine</th>
<th>Douglas Fir</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Range</td>
</tr>
<tr>
<td>Copper Naphthenate-Oil</td>
<td>230</td>
<td>137-317</td>
</tr>
<tr>
<td>Penta-Oil</td>
<td>298</td>
<td>242-340</td>
</tr>
<tr>
<td>Untreated</td>
<td>358</td>
<td>310-404</td>
</tr>
<tr>
<td>CCA-C</td>
<td>405</td>
<td>324-488</td>
</tr>
</tbody>
</table>

Figure 5  Gaff Penetration Test of Various Preservatives in Utility Poles (Pierce).
## CORROSIVITY*

Corrosion Rate of Mild Steel, Mils/Yr.

<table>
<thead>
<tr>
<th>P9A Solvent</th>
<th>1% Copper Naphthenate</th>
<th>7% Pentachlorophenol</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 2 Fuel Oil</td>
<td>&lt;0.5</td>
<td>2.1</td>
</tr>
<tr>
<td>M.A.T.O</td>
<td>&lt;0.5</td>
<td>23.8</td>
</tr>
</tbody>
</table>

*Refluxed at 230-260 F for two weeks in the presence of SYP wood and excess water.

Figure 6  Corrosivity of Copper Naphthenate and Pentachlorophenol Treating Solutions.
## CONDUCTIVITY

<table>
<thead>
<tr>
<th>Preservative</th>
<th>Kilo Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>275</td>
</tr>
<tr>
<td>Copper Naphthenate</td>
<td>315</td>
</tr>
<tr>
<td>CCA Salt Formulations</td>
<td>35</td>
</tr>
</tbody>
</table>

Figure 7. Conductivity of Clear SYP Impregnated with Ground Contact Loadings of Three Wood Preservatives.
## LEACHABILITY*

<table>
<thead>
<tr>
<th>Preservative</th>
<th>Preservative, pcf</th>
<th>% Leached</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Naphthenate</td>
<td>0.134</td>
<td>0.49</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>0.346</td>
<td>11.40</td>
</tr>
</tbody>
</table>

*AWPA Standard Method M-11 was used with toluene dilution / solutions.

Figure 8. Leachability of Oil Borne Wood Preservative Systems.
<table>
<thead>
<tr>
<th>Test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Oral</td>
<td>LD$_{50}$ &gt; 5000 mg/kg</td>
</tr>
<tr>
<td>Acute Dermal</td>
<td>LD$_{50}$ &gt; 2000 mg/kg</td>
</tr>
<tr>
<td>Primary Eye Irritation</td>
<td>Mild Irritant</td>
</tr>
<tr>
<td>Primary Skin Irritation</td>
<td>Moderate Irritation - Temporary</td>
</tr>
</tbody>
</table>

Figure 9. Copper Naphthenate Acute Toxicity Test Results.
**COPPER NAPHTHENATE PROPERTIES**

<table>
<thead>
<tr>
<th></th>
<th>8% Concentrate</th>
<th>RTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Copper</td>
<td>8 ±0.50 %</td>
<td>1±0.50 %</td>
</tr>
<tr>
<td>% Solvent</td>
<td>20</td>
<td>90</td>
</tr>
<tr>
<td>Color</td>
<td>Dark Green</td>
<td>Dark Green</td>
</tr>
<tr>
<td></td>
<td>/Blue Green</td>
<td>/Blue Green</td>
</tr>
<tr>
<td>Freezes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Pour Point, °F</td>
<td>0</td>
<td>-25</td>
</tr>
<tr>
<td>Viscosity, cps at 75° F</td>
<td>2240 ±500</td>
<td>38 ±12</td>
</tr>
<tr>
<td>Viscosity, cps at 180° F</td>
<td>94</td>
<td>14</td>
</tr>
<tr>
<td>Flash point, °F</td>
<td>180 (104)*</td>
<td>170*</td>
</tr>
<tr>
<td>Density, Lb./Gal.</td>
<td>8.5*</td>
<td>7.4*</td>
</tr>
</tbody>
</table>

* DEPENDING ON DILUENT FLASH POINT AND/OR SPECIFIC GRAVITY
Figure 10. Properties of Typical Copper Naphthenate Solutions (Concentrates and Ready-To-Use (Pressure Treating Only, Not Brush or Spray Solutions) Concentrations).
## COPPER NAPHTHENATE TYPICAL TOXICITY PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD$_{50}$</td>
<td>&gt; 5 g/kg</td>
</tr>
<tr>
<td>Dermal Toxicity</td>
<td>None</td>
</tr>
<tr>
<td>Skin Irritation</td>
<td>Temporary moderate skin irritation</td>
</tr>
<tr>
<td>Eye Irritation</td>
<td>None</td>
</tr>
<tr>
<td>Inhalation Toxicity</td>
<td>None</td>
</tr>
<tr>
<td>EPA Label Class</td>
<td>Caution (Class IV)</td>
</tr>
</tbody>
</table>

Figure 11. Acute Toxicity Properties of Copper Naphthenate.
MINIMUM RETENTIONS RECOMMENDATIONS
(Hunt and Garratt, 1967)

Using 0.75% Cu in P9 Oil

Lumber, plywood, timbers

1. For ground contact or fresh water   0.075
2. For not in ground or fresh water   0.045

Piles for fresh water or land         0.090

Utility and building poles

Posts                                 0.045

* 0.033 for Western Red Cedar

0.060 for poles less than 12 inches in diameter and
in moderate service

0.075 for poles over 12 inches in diameter or any
pole in severe service

Figure 12. Proposed Minimum Retention Levels of Copper in Wood Commodities by Hunt and Garratt.
**USDA 2 x 4 SYP STAKE TESTS TESTS (FPL-02)**

A. Mississippi (1942)

<table>
<thead>
<tr>
<th>pcf Cu</th>
<th>Avg. Life, Yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>2</td>
</tr>
<tr>
<td>0.011</td>
<td>16</td>
</tr>
<tr>
<td>0.030</td>
<td>22</td>
</tr>
<tr>
<td>0.060</td>
<td>27</td>
</tr>
<tr>
<td>0.083</td>
<td><strong>8/10 (1981)</strong></td>
</tr>
</tbody>
</table>

**8 removed, 2 left. Estimated Average life - 34 years**

B. Wisconsin (1941)

<table>
<thead>
<tr>
<th>pcf Cu</th>
<th>Avg. Life, Yrs.</th>
<th>Estimated Avg. Life, Yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>5</td>
<td>---</td>
</tr>
<tr>
<td>0.011</td>
<td>26</td>
<td>---</td>
</tr>
<tr>
<td>0.028</td>
<td>*3/5</td>
<td>40</td>
</tr>
<tr>
<td>0.060</td>
<td>*5/8</td>
<td>39</td>
</tr>
<tr>
<td>0.084</td>
<td>*2/6</td>
<td>49</td>
</tr>
</tbody>
</table>

* Removed for decay/total in test (1981)
Solvent = No. 2 Fuel Oil
Figure 13. USDA FPL-02 Data on Copper Naphthenate 2x4's (SYP) in Ground Contact.
### AWPA RETENTION COMPARISONS

Commodity Standard C-4

<table>
<thead>
<tr>
<th></th>
<th>SYP</th>
<th>Douglas Fir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penta</td>
<td>0.38, 0.43, 0.45</td>
<td>0.45, 0.60</td>
</tr>
<tr>
<td>Creosote</td>
<td>6, 7.5, 9</td>
<td>9, 12</td>
</tr>
<tr>
<td>Cu* (as Cu Nap)</td>
<td>0.06, 0.08, 0.13</td>
<td>0.075, 0.095, 0.15</td>
</tr>
</tbody>
</table>

Figure 14. AWPA Retentions for wood poles from Standard C-4-99