10.8 Wood Preserving[1-3]

Wood preservation is the pressure or thermal impregnation of chemicals into wood to provide effective long-term resistance to attack by fungi, bacteria, insects, and marine borers. By extending the service life of timber products, wood preservation reduces the need for harvest of already stressed forestry resources, reduces operating costs in industries such as utilities and railroads, and ensures safe working conditions where timbers are used as support structures.

Seventy-five percent of the wood treatment plants in the United States are concentrated in two distinct regions. One of these regions extends from east Texas to Maryland, corresponding roughly to the natural range of southern pines, which is the major species utilized. The second, smaller region is along the Pacific coast, where Douglas fir and western red cedar are the predominant species. The remaining 25 percent of wood treatment plants are scattered throughout the United States.

10.8.1 Process Description[2-9]

10.8.1.1 Preservatives -

There are two general classes of wood preservatives: oils, such as creosote and petroleum solutions of pentachlorophenol; and waterborne salts that are applied as water solutions. The effectiveness of the preservatives varies greatly and can depend not only upon its composition, but also upon the quantity injected into the wood, the depth of penetration, and the conditions to which the treated material is exposed in service.

10.8.1.2 Conditioning -

With most wood treating methods, significant amounts of free water in the wood cell cavities may slow or prevent the entrance of the preservative chemical. Therefore, wood moisture content must be reduced prior to treatment. Moisture reduction can be accomplished by using artificial conditioning treatments or by air-seasoning (i.e., storing the untreated wood outdoors in piles). Unseasoned wood that is exposed to the open air generally dries slowly until it comes into approximate equilibrium with the relative humidity of the air. However, some wood species will rot before the air drying is complete.

Because certain wood species will rot before air drying can be completed in some climates, wood is artificially conditioned by one of three primary methods: (1) steaming-and-vacuum, (2) boiling-under-vacuum (commonly referred to as the Boulton process), and (3) kiln drying. Vapor drying also has been used but currently is used rarely, if ever. These conditioning treatments remove a substantial amount of moisture from the wood and also heat the wood to a more favorable treating temperature. Steaming and Boultonizing have the added effect of disinfecting the wood. In segregated systems, conditioning is performed in separate “clean” cylinders that do not contain preservative.

The steaming and vacuum method of conditioning is used primarily for treating southern pine poles. Steaming and vacuum may be performed in a dedicated cylinder or in the same cylinder used for treating the wood. In this process, the wood charge is heated with live steam. Then, a vacuum is drawn.

The Boulton process is used primarily for Douglas fir and hardwoods. The Boulton process usually is performed in the same cylinder used to treat the wood. In this process, the cylinder is charged with wood, and heated preservative is used to heat the wood charge for 1 to 24 hours. At that point, a vacuum is drawn. Finally, the preservative is returned to the work tank. This step is referred to as “blow back” from the practice of using compressed air to blow the preservative back into the work tank. However, many treatment systems use pumps to withdraw preservative from the treatment cylinder and return it to the work tank. Although such systems do not actually blow back the preservative, the term still is used to refer to this step of the process.

10.8.1.3 Treating -

Most wood-preserving methods may be classified as either pressure processes, in which the wood is placed in a treating cylinder or retort and impregnated with preservative under considerable force, and nonpressure processes, which do not involve the use of induced pressure. Nonpressure processes can be classified as thermal processes, in which heat is applied, and nonthermal processes, such as brushing, spraying, dipping, and soaking. Nonpressure processes generally are used only with oilborne preservatives. Because the majority of wood treated annually is impregnated by pressure methods in closed cylinders, only pressure processes are discussed in the following sections.

Pressure processes operate on the same general principle, though they may differ in the specifics of the process. The treatment is carried out in steel cylinders or retorts. Most units conform to size limits of 2 to 3 meters (m) (6 to 9 feet [ft]) in diameter and up to 46 m (150 ft) or more in length, and are built to withstand working pressures up to 1,720 kilopascals (kPa) (250 pounds per square inch [psi]). The wood is loaded on special tram cars and moved into the retort, which is then closed and filled with preservative. Applied pressure forces preservatives into the wood until the desired amount has been absorbed. Three processes, the full-cell, modified full-cell, and empty-cell, are in common use. These processes are distinguished by the sequence in which vacuum and pressure are applied to the retort. The terms “empty” and “full” refer to the level of preservative retained in the wood cells. The full-cell process achieves a high level of retention of preservative in the wood cells, but less penetration than the empty-cell process, and the empty-cell process achieves relatively deep penetration with less preservative retention than does the full- cell process.

Full-Cell Process -

The full-cell (Bethel) process is used when maximum preservative retention levels are desired, such as when treating timbers with creosote for protection against marine borers. Figure 10.8-1 presents a flow diagram for the full-cell pressure treating process. In addition to creosote, the full-cell process also is used primarily with waterborne preservatives. The full-cell process steps are listed below:

1. The charge of wood is sealed in the treating cylinder, and an initial vacuum is applied for approximately half an hour to remove as much air as possible from the wood and from the cylinder;

2. The preservative, either heated or at ambient temperature depending on the system, enters the cylinder without breaking the vacuum;

3. After the cylinder is filled, the cylinder is pressurized until no more preservative will enter the wood or until the desired preservative retention is obtained;

4. At the end of the pressure period, the pressure is released, and the preservative is removed from the cylinder; and

5. A final vacuum may be applied to remove the excess preservative that would otherwise drip from the wood.

If the wood is steam-conditioned, the preservative is introduced after the vacuum period following steaming. In segregated systems, the steam conditioning and preservative application steps are conducted in separate cylinders. The final steps in the process are the unloading of the retort and storage of the treated wood.

Modified Full-Cell Process -

The modified full-cell process generally is used for the application of waterborne preservatives. This method is similar to the full-cell process except for the initial vacuum levels. The modified full-cell process uses less vacuum than the full cell; the vacuum levels are determined by the wood species being treated and the preservative retention levels desired. The flow diagram shown in Figure 10.8-1 also characterizes the modified full-cell pressure treating process.

Empty-Cell Process -

The empty-cell process obtains deep preservative penetration with a relatively low net preservative retention level. If oil preservatives are used, the empty-cell process most likely will be used, provided it will yield the desired retention level. The Rueping process and the Lowry process are the two most commonly used empty-cell processes. Both use compressed air to drive out a portion of the preservative absorbed during the pressure period. Figure 10.8-2 presents a flow diagram for the empty-cell pressure treating process.

In the Rueping process, compressed air is forced into the treating cylinder containing the charge of wood to fill the wood cells with air prior to preservative injection. Pressurization times vary with wood species. For some species only a few minutes of pressurization are required, while more resistant species may require pressure periods of from 30 minutes to 1 hour. Air pressures used typically range from 172 to 690 kPa (25 to 100 psi) depending on the net preservative retention desired and the resistance of the wood.

After the initial pressurization period, preservative is pumped into the cylinder. As the preservative enters the treating cylinder, the air escapes into an equalizing or Rueping tank at a rate which maintains the pressure within the cylinder. When the treating cylinder is filled with preservative, the pressure is raised above that of the initial air and maintained until the wood will take no more preservative or until enough has been absorbed to leave the desired preservative retention level after the final vacuum.

After the pressure period, the preservative is removed from the cylinder and surplus preservative is removed from the wood with a final vacuum. This final vacuum may recover from 20 to 60 percent of the gross amount of preservative injected. The retort then is unloaded, and the treated wood stored.

The Lowry process is an empty-cell process without the initial air pressure Preservative is pumped into the treating cylinder without either an initial air pressurization or vacuum, trapping the air that is already in the wood. After the cylinder is filled with the preservative, pressure is applied and the remainder of the process is identical to the Rueping process.

The advantage of the Lowry process is that full-cell equipment can be used without the accessories required by the Rueping process, such as an air compressor, an extra tank for the preservative, or a pump to force the preservative into the cylinder against the air pressure. However, both processes are used widely and successfully.

10.8.2 Emissions[2-3,6,9-17]

For waterborne preservatives, emissions from wood preserving processes generally are not significant. For oilborne preservatives, the primary sources of emissions from wood preservation processes are (1) the treated charge immediately after removal from the treating cylinder, (2) the vacuum system (conditioning cycle and final vacuum cycle), and (3) displaced air from working tank blow backs. The two process emission points are the work tank vent and the vacuum system. Figures 10.8-1 and 10.8-2 identify which process steps are associated with emissions from these two process emission points. Table 10.8-1 presents emission factors for organic pollutant emissions from creosote wood preserving. Table 10.8-2 presents emission factors for inorganic pollutant emissions from chromated copper arsenate wood preserving.

The elevated temperature of the treated charge when it is pulled from the cylinder causes some of the lower boiling point organic compounds to volatilize as aerosols, forming a white emission plume that typically dissipates within a few minutes.

Volatile organic compound emissions include those organic compounds present in the wood that are released when heated during conditioning and treatment, and the polycyclic aromatic hydrocarbons (PAHs) that are evaporated from the creosote solution and removed from the retort through the vacuum system during the Boulton (boiling-under-vacuum) process and during the final vacuum applied during the Rueping process. Creosote emissions can be estimated as the sum of the emissions of the PAHs. Polycyclic aromatic hydrocarbons are included in the class of compounds referred to as polycyclic organic matter (POM), which is listed as a hazardous air pollutant in the Clean Air Act.

The emission point for the steaming and vacuum method of conditioning is the vacuum pump system vent. Vacuum systems include condensers, which are considered part of the process equipment and not separate emission control devices. The emission points for the Boulton process are the vacuum pump vent during the vacuum stage of the conditioning process and the work tank vent during the blow back or preservative withdrawal stage of the conditioning process.

Working tank blow backs also occur at the end of a preservative treatment cycle when the treating solution is returned to the work tank. The air displaced by the returning solution is vented via a control device to the atmosphere. In some systems, the displaced air in the work tank is vented back into the treatment cylinder to fill the head space created as the preservative is withdrawn from the cylinder. In such systems, there are no emissions associated with blow backs. A problem may arise when the quantity of preservative being blown back is not monitored closely and air begins to blow up through the work tank. Volatile compounds are picked up by the air as it bubbles up through the treating solution and are carried out through the tank vent.

Fugitive emissions of various preservative constituents may occur after the treated wood is removed from the retort. The fugitive emission rate is a function of the vapor pressure, which is driven by temperature. Emission rates are greatest immediately after the wood is removed from the retort and generally decline afterward. Reference 16 describes a method for estimating fugitive emissions from creosote-treated wood storage as a function of time, temperature, and the effective surface area of the treated wood. Additional information and a discussion of that method can be found in Reference 17, which is the background report for this AP-42 section. However, in the absence of a reliable method for estimating the effective surface area, that method is not presented in this AP-42 section.

In addition to the three primary process emission sources, emissions are generated from waste water treatment and organic liquid storage tanks. Oilborne wood treatment plants frequently have onsite waste water treatment facilities designed to separate organic materials from the waste water generated during the treating process. This wastewater treatment is a potential source of VOC and HAP emissions. Emission factors for waste water treatment sources are presented in AP-42 Section 4.3, Waste Water Collection, Treatment And Storage.

Liquid storage tanks for the various preservatives are also sources of VOC and HAPs. Emissions from these storage tanks are covered in AP-42 Chapter 7, Liquid Storage Tanks.

10.8.3 Controls[2,10-12]

There are few options for controlling fugitive emission losses from treated charges. Constructing a ventilation hood to collect VOC emanating from the freshly treated charge is economically infeasible due to the size of the hood needed for covering the cylinder end and drip pad. The effectiveness of controlling emissions by using water to cool freshly treated wood by spraying or quenching is questionable. A primary drawback to water quench systems is that the contaminant is merely transferred to water, resulting in the need for an effluent treatment system. In addition, water quench systems generate significant amounts of waste water, which include listed hazardous substances, and, thus, is not desirable.

A 1993 survey of 97 wood preserving facilities found that at least eight facilities used wet scrubbers for controlling emissions from creosote wood preserving; use of both venturi scrubbers and packed-bed scrubbers was reported. One facility also reported using a packed-bed scrubber to control VOC emissions from a PCP wood preserving process. At least two creosote facilities used condensers and one facility used an incinerator to control VOC emissions from creosote wood preserving. The results of one emissions test on the incinerator-controlled facility indicated a VOC control efficiency of more than 99 percent for the Boulton process and first blowback. None of the wood preserving facilities currently in operation use incineration for emission control. A few facilities control emissions from creosote wood preserving processes by means of a knock-out tank followed by a venturi scrubber. The results of an emission test on such a system indicated a VOC control efficiency of 75 percent.

Odorous emissions from the steam jet vacuum system suggest that a single-pass water-cooled condenser may not condense all of the organics in the exhaust. One option for correcting this problem is to install a larger condenser capable of further reducing the organic content in the vapor. A properly sized condenser with adequate cooling water will condense virtually all of the organics in the exhaust stream Another option is to modify the vacuum system to include two steam jet ejectors in series with a barometric (direct contact) intercondenser between them. In this system, the barometric intercondensers condense the oily vapors in the steam and remove them with the intercondensed water. A third option is to replace the steam jet ejectors with a vacuum pump and duct the exhaust vapors to an activated carbon adsorption system or to an afterburner. Both are efficient means for removing organic compounds from the exhaust gas.

Working tank blow back vapors can be controlled by bubbling the vapors through water or through a water spray before venting to the atmosphere. However, the effectiveness of these systems will deteriorate if the water is allowed to reach saturation and is not changed periodically. Another option for controlling these vapors is to incinerate them in an afterburner along with the vacuum system exhaust. However, incinerators are not in use currently at any domestic wood preserving facilities.

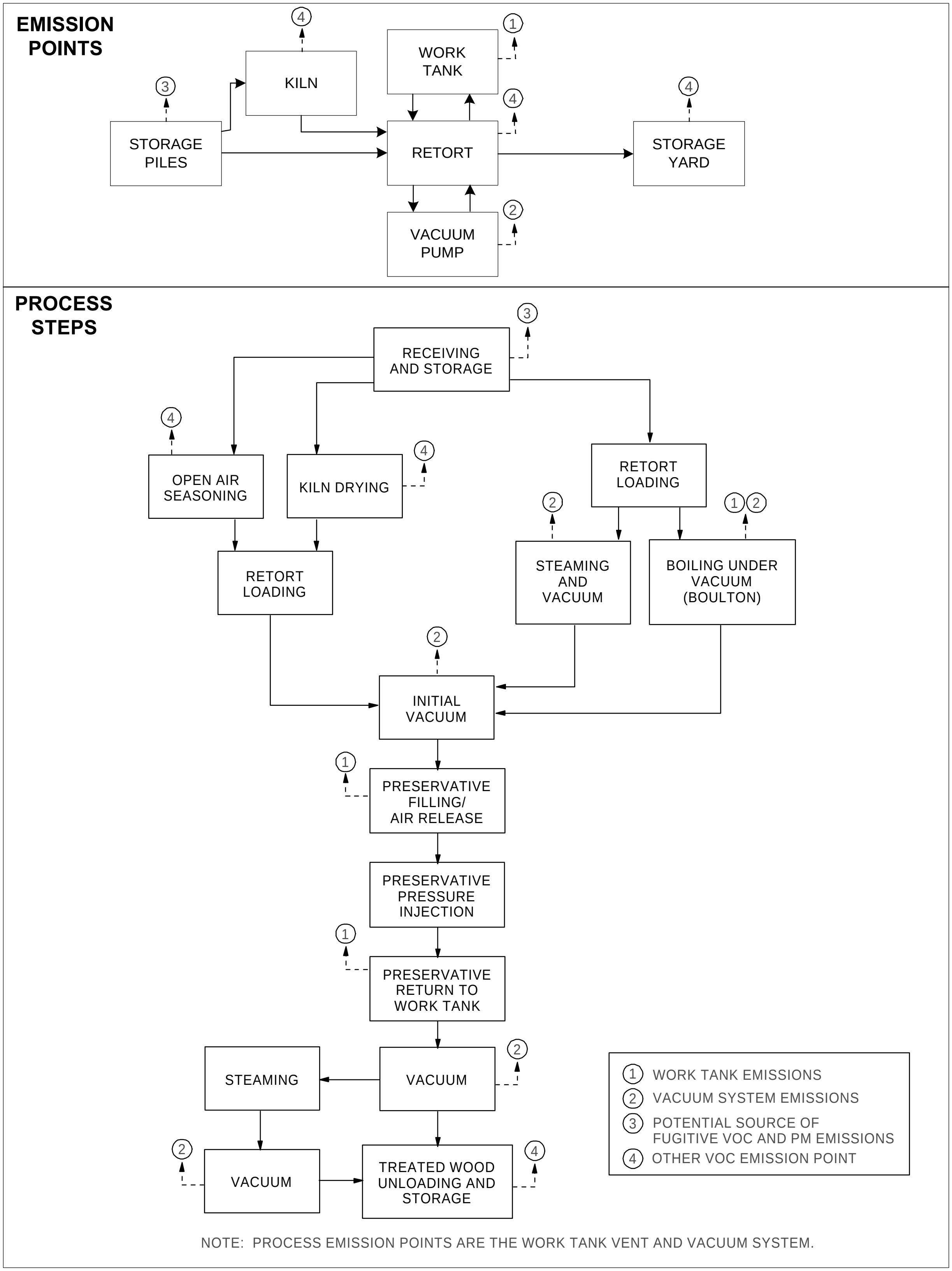

Figure 10.8-1. Flow diagram of the full-cell and modified full-cell pressure treating processes.

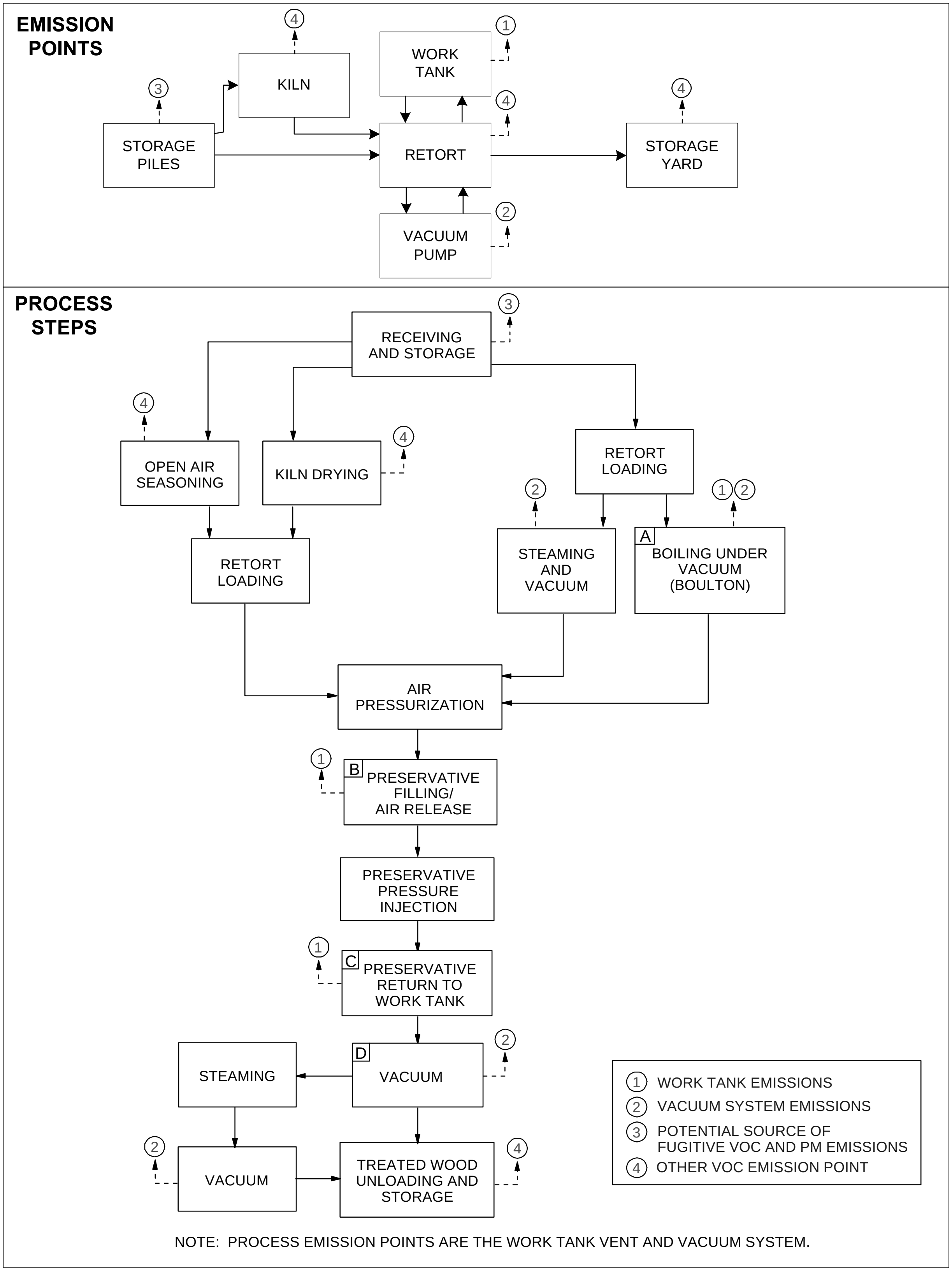

Figure 10.8-2. Flow diagram for the empty-cell pressure treating process.

TABLE 10.8.-1. EMISSION FACTORS FOR CREOSOTE EMPTY-CELL WOOD PRESERVING[a]

EMISSION FACTOR RATING: E

Process	CASRN	Pollutant	Emission Factor
Treatment cycle without conditioning, uncontrolled emissions (SCC: 3-07-005-30) (Includes steps B, C, and D shown in Figure 10.8-2)		VOC[b]	7.4 x 10^{-4}
	83-32-9	Acenaphthene	6.3 x 10^{-7}
	208-96-8	Acenaphthylene	1.7 x 10^{-6}
	120-12-7	Anthracene	1.6 x 10^{-8}
	56-55-3	Benzo(a)anthracene	1.7 x 10^{-8}
	205-99-2	Benzo(b)fluoranthene	1.6 x 10^{-8}
	207-08-9	Benzo(k)fluoranthene	6.0 x 10^{-9}
	50-32-8	Benzo(a)pyrene	8.2 x 10^{-9}
	86-74-8	Carbazole	3.6 x 10^{-7}
	218-01-9	Chrysene	8.4 x 10^{-9}
	132-64-9	Dibenzofuran	1.8 x 10^{-6}
	206-44-0	Fluoranthene	8.6 x 10^{-8}
	86-73-7	Fluorene	7.8 x 10^{-8}
	91-20-3	Naphthalene	4.6 x 10^{-6}
	85-01-8	Phenanthrene	2.8 x 10^{-7}
	129-00-0	Pyrene	7.3 x 10^{-8}
Treatment cycle with conditioning by Boulton process, uncontrolled emissions (SCC: 3-07-005-40) (Includes steps A, B, C, and D shown in Figure 10.8-2)		VOC[b]	5.8 x 10^{-3}
	83-32-9	Acenaphthene	9.9 x 10^{-6}
	208-96-8	Acenaphthylene	2.8 x 10^{-5}
	120-12-7	Anthracene	1.3 x 10^{-7}
	56-55-3	Benzo(a)anthracene	1.3 x 10^{-7}
	205-99-2	Benzo(b)fluoranthene	1.3 x 10^{-7}
	207-08-9	Benzo(k)fluoranthene	4.8 x 10^{-8}
	50-32-8	Benzo(a)pyrene	6.5 x 10^{-8}
	86-74-8	Carbazole	2.9 x 10^{-6}
	218-01-9	Chrysene	6.7 x 10^{-8}
	132-64-9	Dibenzofuran	3.5 x 10^{-5}
	204-44-0	Fluoranthene	6.8 x 10^{-7}
	86-73-7	Fluorene	3.9 x 10^{-6}
	91-20-3	Naphthalene	7.9 x 10^{-5}
	85-01-8	Phenanthrene	1.9 x 10^{-6}
	129-00-0	Pyrene	5.8 x 10^{-7}

Table 10.8-1 (cont.).

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[a] References 12 and 16, except where noted. Factors are in units of pounds per cubic foot (lb/ft^3) of wood treated. To convert to kilograms per cubic meter (kg/m^3), multiply by 16. CASRN = Chemical Abstract Services Registry Number. SCC = source classification code.

[b] References 10 and 16. Volatile organic compounds as propane, based on Method 25A test results.

Table 10.8-2. EMISSION FACTORS FOR INORGANIC POLLUTANT EMISSIONS FROM CHROMATED COPPER ARSENATE EMPTY-CELL WOOD PRESERVING[a]

EMISSION FACTOR RATING: E

Source	CASRN	Name	Emission Factor
Treatment cycle with conditioning, uncontrolled emissions (SCC 3-07-005-43)	7440-47-3 7440-50-8	Chromium Copper	1.4×10^{-9} 1.9×10^{-9}

[a] Reference 11. Includes emission from artificial conditioning cycle and final vacuum only. Factors represent uncontrolled emissions. Emission factor units are pounds per cubic foot (lb/ft^3) of wood treated. To convert to kilograms per cubic meter (kg/m^3), multiply by 16. CASRN = Chemical Abstract Services Registry Number. SCC = Source Classification Code.

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