Appendix F

Industrial Fire Prevention Bulletin Technical Report

SPONTANEOUS COMBUSTION IN DELIMBER RESIDUE PILES

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Residue from delimber operations that are subsequently processed through a chipper or tub grinder is highly susceptible to biological soft heating. Many piles of this material were found to be spontaneously combusting in the Klamath/Lake region as well as the Central Oregon area in 1992 to 1991. This accounted for approximately six fires from twelve hot piles.

Prolonged heating by respiration associated with biological decomposition can result in spontaneous combustion. Also known as Ignition by slow thermal explosion, spontaneous combustion can occur in delimber residue piles within a pile temperature range from So to 170 degrees centigrade (140 to 340 degrees Fahrenheit)

Finely ground delimber material often pushed up into large piles by dozers receives strong inoculations of soil bacteria that combines with its natural ambient bacteria level. Continuing cellular respiration from the recently live residue elevates the pile temperature sufficient for accelerated bacterial metabolism.

The pile temperature rises with those metabolic processes. As water vapor is driven from the solid fuels, through hygrolysis, an inward diffusion of air occurs in the dry porous wood. As the cellulose slowly degrades charcoal and combustion gases (pyrolysis products) are produced.

This reaction combined with gaseous oxygen can trigger slow smoldering combustion. Heat migration through ventilated dry channels within piles can direct ignition to the outride of the pile. Favorable wind conditions can then spread fire to surrounding forest fuels causing an escaped wildfire.

The basic elements of creating a spontaneous combustion risk are; 1) processing live coniferous branch and foliage material; 2) delimbing and subsequently grinding or chipping; 3) pushing up large piles of processed material. Time of year, species composition, or longevity of piles we the subjects of further study.

Ignitions from spontaneous combustion can occur within weeks or a few months from the time a pile is created. Piles allowed to stand indefinitely would remain susceptible. Visible signs of self heating in piles are subtle, i.e. evidence of steam vents, warm pile material, pungent incense odor, etc.

Creation of processed delimber “due piles may be classified as an ignition hazard and, needs to be mitigated in a timely fashion. Dispersing pile material to an average depth of less then two feet or utilization of the material is sufficient to minimize the potential of spontaneous combustion. Caution is given not to simply move the problem to another location.

The Oregon Department of Forestry, USDA Forest Service and Weyerhaeuser Corporation are conducting a cooperative investigation into the spontaneous combustion phenomenon. For more information contact Pete Norkeveck, Oregon Department of Forestry, 2600 State Street, Salem, Oregon 97310 or call at (503) 945-7445.

Spontaneous Combustion in Delimber Piles Theories of Basic Physics

Vegetative State - residue that is in some stage of greenness at the time of delimbing and subsequent grinding or chipping will continue respiration for a period of time sufficient to elevate the internal temperatures within a pile. This elevation of temperature could be a catalyst to accelerating the bacterial metabolism.

Spacial Dimension -- most residue piles are generated on site and grow in size until they interfere with processing operations. Sizes similar to traditional slash piles are ideal for self heating processes to occur.

Piles require sufficient size to insulate themselves from outside effects of temperate and moisture ... subsequently this outside layer or pile covering confines the bacterial and oxidation processes. This insulative effect also minimizes ventilation until strong winds or thermal feedback (discussed below) occurs.

Particle Site - normal particle size from delimber operations makes for a better ventilated pile, not as conducive to self heating and a reduced surface to volume ratio in fuel particles ... subsequent tub grinding or chipping increases the surface to volume ratio on the fuel end enhances compaction. Any cooling value from normal ventilation is then minimized and bacterial metabolism is likely to be more active on substrate that has a higher surface to volume ratio.

Soil Bacteria - natural ambient levels of bacteria in woody vegetation may not be sufficient to maintain metabolism to advanced stages. Scraping or pushing piles allows for strong inoculations of soil bacteria which may be distributed throughout the pile. Combined with respiration, this bacterial metabolism or biological decomposition not only would be more aggressive but would persist longer. The rate and period of the bacterial metabolism is believed to be key in triggering hygrolysis and subsequent oxidation.

Hygrolysis - accelerated bacterial metabolism is believed to be responsible for consuming oxygen from fuel particles as well as driving moisture outward into surrounding air spaces. The fuel may have the appearance of being damp or even wet but the particles themselves remain porous, deficient in moisture content and ambient levels of cellular oxygen.

Oxidation/Pyrolysis - during advanced stages of bacterial metabolism ... theorized as being at the point the bacterial metabolism is subsiding, due to higher internal temperatures arid/or oxygen deprivation from consumption, ambient air oxygen will migrate back into the fuel particles. Not being attached or associated with cellular structure or compounds this process oxidizes the cellulose in the fuel particles. Charcoal like compounds and combustion gases are believed to be the products of pyrolysis.

Ignition - theorized as a slow thermal explosion process, ignition results when ambient atmospheric gases come in contact with concentrations of combustion gases being generated from pyrolysis. The oxidized fuel particles may be sufficient to sustain a slow smoldering combustion that could subsequently advance to a spreading fire.

Atmospheric Stability - further study is needed to measure the effects of general weather conditions on the internal self heating processes. In general it is believed that rain, snow or cool temperatures may only delay or inhibit the process. In addition, it is thought that high temperatures after cool periods, especially if winds are present, stimulate the process or trigger ignition.

Thermal Feedback - piles that are believed to have spontaneously ignited have experienced a brief period (1-3 days) of thermal feedback i.e., strong heating by sun. It is believed this thermal feedback may be responsible for two actions occurring within the pile. The strongest theory supports that this causes the pile to increase its internal temperature creating a negative air pressure within which drafts surrounding outside air suddenly into pockets that may be suitable for reaction. A second theory supports that the thermal feedback accelerates the pyrolysis action so quickly that thermal explosion results. There may be a combination of both of these processes at work to cause ignition.

Ferrous Contaminants - metallic burs or shrapnel from chain flails, tub grinders or chippers may be (as yet have not been proven) a catalyst to the oxidation process. Some believe the ferrous composition accelerates the oxidation stage. Other speculation suggests that super heated metallic brands cause an immediate ignition. Residual live fuel moisture is likely to inhibit ignition from a metallic brand. Ferrous contaminants remain an area to be studied.

Spontaneous Combustion in Delimber Piles Intervention Methods

Foliage Dehydration -allow green foliage to cure before secondary grinding or chipping. This may reduce the initial respiration minimizing the stimulus for bacterial metabolism. Grind or chip residue when discoloration in foliage is apparent i.e., red slash appearance.

Avoid Inoculation - store, pile and process residue on hardened surfaces or consolidate piles with machinery and techniques that minimize the amount of soil mixed into the pile.

Avoid Compaction - do not tread residue piles with machinery as this increases the compaction within the pile. Loose piles will better disperse, host through natural ventilation. If ferrous contaminants can accelerate oxidation (theory not as yet proven)…treading piles with tracked machinery would inoculate the pile.

Minimize Dimension - thought to be the most effect treatment...spread piles to an average depth of approximately 24". It is not known for sure how deep the pile needs to be before self heating occurs. It is believed that the approximate depth of the pile's insulative layer is about 24", hence the recommendation for pile dimension.

Utilization - spontaneous combustion does not suggest instantaneous ignition. If residue piles were utilized as hog fuel or mulch in a more timely fashion, the process may not have sufficient time or conditions favorable enough to result in ignition. Piles that are occasionally turned or disturbed may be less susceptible. Caution is given to avoid simply moving your ignition hazard to a different location unless it is for purposes of providing better fire protection, improved containment capability and isolation from wildland fuels.

Monitoring - it is important to get the word out to all industrial operators on what the risks are and what to look for. Many operators may have innovative ways to mitigate the risk without adding much expense to their operation. Treating situations after the fact may represent missed opportunities and adds cost to the operation. Proactive mitigation is preferred over enforcement

Enforcement - susceptible self heating piles should be classified as ignition hazards and not merely addition fuel hazards. Utilize federal, state and local laws to achieve timely cleanup when recommendations are disregarded. Most fire liability laws would support that failure to act upon written order and exercise due care in mitigating the hazard would equate to "negligence".