AGRICULTURAL-RELATED FIRES AND EXPLOSIONS

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Summary

Fires and explosions are well-documented risks associated with all phases of agricultural production throughout the world. Outside of the hazards associated with exposure to agricultural machinery, few hazards result in more loss of life and property on farms and ranches than fires. For example, fires and burns are typically ranked as one of the top three causes of unintentional, fatal injuries involving rural children. The very nature of many agricultural practices contributes to the potential of destructive fires and explosions. This includes the handling of large volumes of highly combustible crop material, use of highly flammable fuels and lubricants, application of controlled burning for land clearing and certain crop processing operations, and the isolation of many agricultural work sites from local fire fighting resources. Furthermore, much of agricultural production is approached with a subsistence management style that frequently de-emphasizes non-productive investments, such as fire and explosion prevention, detection, and suppression technology, that is generally found in other industries. For example, many agricultural facilities and operations are not regulated by local, state or national fire prevention codes and regulations that have been shown to be very effective in other settings. Since, in most cases, producers are not required to comply with existing fire prevention regulations and if they did, are unable to pass the costs along to the consumer of their products, the investments in fire prevention or containment strategies are generally not made. Consequently, the reports of serious burns and injuries, barn and house fires, machinery fires, and seasonal grass and woodlot fires have become the accepted norm rather than viewed as preventable incidences. Fires and explosions on farms and ranches can be prevented, often at low cost. The appropriate use of basic fire prevention techniques and presence of effective

first response procedures, can make a significant difference in whether fire is viewed as a friend or foe by agricultural producers.

1. Introduction

Can a man scoop fire into his lap without his clothes being burned?
Can a man walk on hot coals without his feet being scorched?

Proverbs

Since the first farmers used fire to clear the forest in order to provide more space to produce crops, and used fire to cook, dry or process their crops, they have reaped both the blessings and curses of fire and its related qualities. Fire in a controlled form is a fundamental tool that humankind has used to enhance the quality of life and to complete tasks that would be impossible to perform without the use of sources of heat. On the other hand, fire or combustion out of control has been historically, and continues to be, a significant cause of death, injury and property loss throughout the world. This article will address the fundamentals of fires and explosions, typical characteristics of fires and explosions found in agricultural production operations, and basic detection, suppression and prevention measures.

2. Fundamentals of Fires and Explosions

In order for fire to occur there need to be three elements present: fuel, oxygen and sufficient heat. These components together are often referred to as the basic fire triangle (Figure 1). By adding one more component, containment, a fire can lead to an explosion.

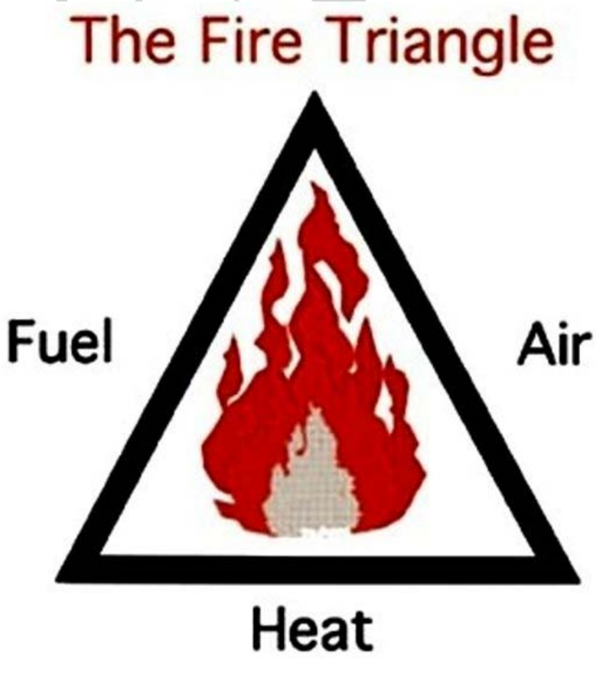

Figure 1. Basic fire triangle.

There are three basic types of fires generally found in agricultural production:

- **Type A or solid fuel fires.** Includes paper, wood, dry grass, crops and crop residue, and fabric. Most agricultural fires are classified as Type A fires and can be extinguished by using water to cool the burning material.
- **Type B or liquid fuel fire.** In most liquid fuel fires, it is actually the vapors of flammable liquids such as gasoline, solvents or oil that are ignited and burn. It is generally not necessary for the ignition source to actually touch the liquid before ignition, and if the vapor is widespread the combustion can be so rapid that the process becomes similar to an explosion.
- **Type C or electrical fires.** Actually, most electrical fires are caused by heat generated by electrical resistance or an electrical short that ignites a nearby solid or liquid fuel. This type of fire can occur in an electrical service box in a farm structure, electrical-powered tools or appliances, on a tractor or combine, or wherever electricity is used. This type of fire is treated differently because using certain extinguishing agents can be hazardous due to their ability to conduct electricity.

Agricultural chemical fires provide an additional sub-category.

Explosions are rare events in agricultural production but can result in deaths, injuries, and catastrophic property losses. The most widely recognized type of explosion in agriculture involves the dust released when handling dry grain. Most grain dust explosions occur in large commercial facilities and can cause tremendous property damage. It is estimated that the explosive nature of dry grain dust in the right mixture with air is 10 to 50 times more explosive then coal dust.

Other more frequent, but less spectacular, types of agricultural-related explosions involve propane or LPG, gasoline, underground natural gas lines damaged by tillage equipment, and even manure storage structures that accumulate explosive methane gas, a by-product of manure decomposition. It should also be noted that basic agricultural inputs such as the fertilizer ammonium nitrate and diesel fuel have been used to fabricate highly explosive devices for criminal purposes such as the bomb used in the infamous Oklahoma City, USA bombing incident.

3. Fires in Stored Agricultural Crops

All harvested crops continue to go through a biological process after harvesting until they reach a point of stability in moisture content or chemical content that allows for long-term storage. This process, caused by either aerobic respiration or anaerobic fermentation, can generate substantial amounts of heat. If this heat is not allowed to escape, the stored material can heat up and eventually reach the combustion point causing damage to the crop or storage structure. The most common examples of this type of combustion include fires that occur in forages or grain stored too wet or forages stored too dry in silos.

The excessive heating process in tightly packed stored forages is referred to as pyrolysis, a chemical reaction that breaks down the plant material and which is capable of sustaining itself for some time in the center of the mass without an external source of oxygen. The fire will smolder, in some cases for weeks, with little external evidence other than a temperature rise in the surrounding material or a noticeable smell. Once the process reaches a source of oxygen, it will then erupt into open burning.

The key to preventing fires and overheating of stored agricultural crops is to achieve appropriate conditioning prior to storage. This involves ensuring that the crop is dried to the correct moisture content (MC) prior to long-term storage. For most grains, the MC should not exceed 15%, and for forages stored in dry bales, the level should not exceed 25%. Crops that are ensiled should be stored at levels higher than 45% MC. (Figure 2). In other words, fires in stored crops can be caused by moisture levels that are either too low or too high due to the different biological characteristics and chemical processes involved. Reference material is available that provides recommendations on appropriate MC levels for safe storage of most crops. There are also chemical additives available that are capable of slowing the fermentation process in some crops thereby reducing the risk of fire.

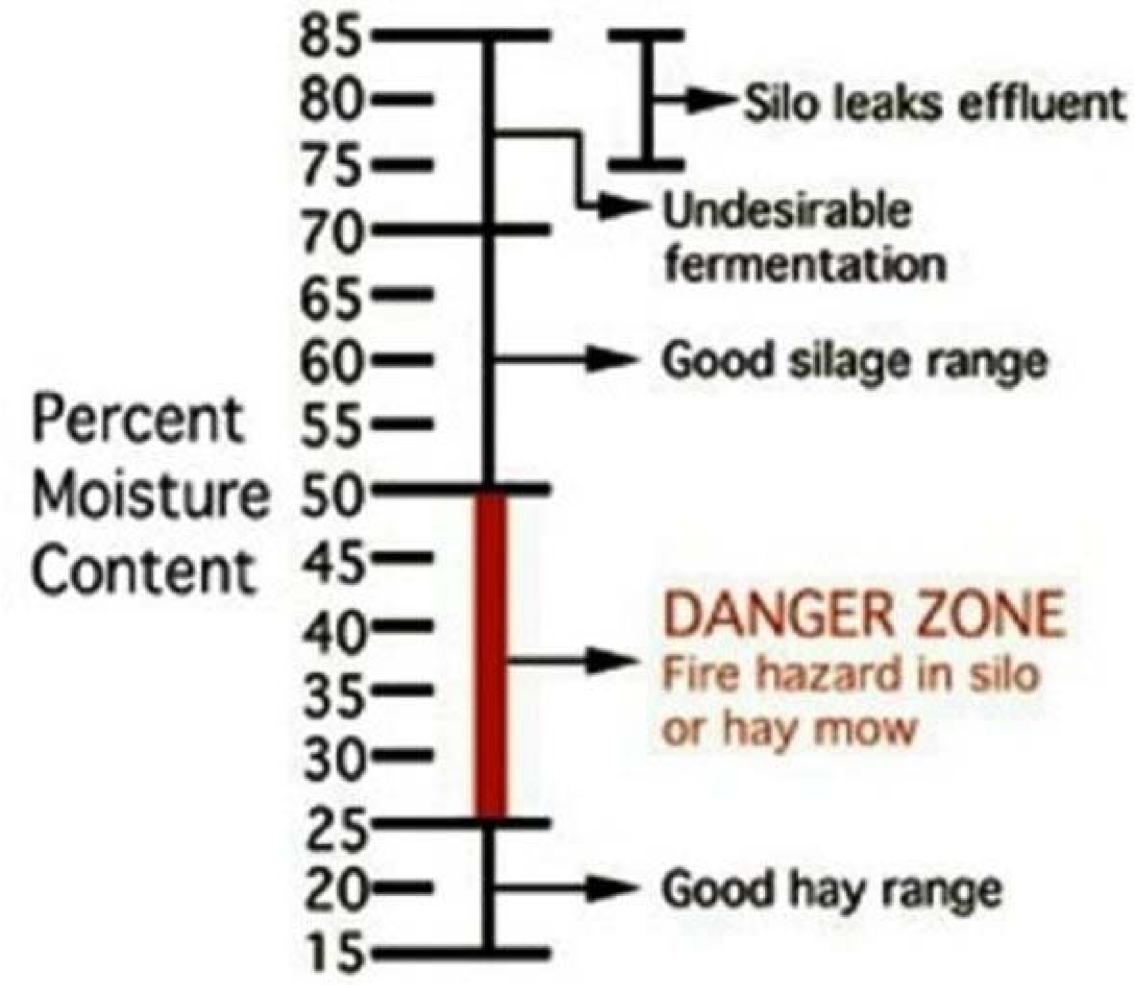

Figure 2. Crop moisture content storage chart.

In addition to achieving the appropriate MC, the stored crop should be protected from re-wetting that can lead to conditions favorable to spontaneous combustion. Precautionary procedures include monitoring ventilation fans that pull in moist air on humid days, preventing roof and hatch leaks, avoiding the introduction of unconditioned grain into dry grain and limiting outside exposed storage.

With the introduction of oxygen-limiting or sealed crop storage structures, the added potential of an explosion is present because the unit provides the final component necessary for an explosion: containment. Because these units are constructed tightly of strong materials, such as concrete or steel, a fire that develops inside can result in a dangerous pressure rise caused by steam and expanding gases. If not allowed to vent, a devastating explosion can occur. In fact more fire fighters have died fighting fires in these structures than other types of crop storage structures.

If a fire or excessive heating above 79 °C (175 °F) does occur in stored crops or a crop storage structure, immediate steps need to be taken to protect nearby structures and salvage as much of the crop as possible. Once the fire has developed, it is unlikely that it will go out on its own accord. In cases of stored hay, the bales surrounding the heated areas should be removed and the hot spots extinguished. Silos present a more complex problem, but if the fire is caught early enough it can be extinguished by injecting water directly into the silage mass using a probe. Again, since substantial damage to the silage is likely, the heated silage should be removed and salvaged if possible. In most cases, overheated forages have lost most of their nutritional value and are not palatable to livestock.

Fires in grain storage bins have been successfully extinguished by injecting large quantities of CO_2 or N_2 into the bottom of the bin, thereby suffocating the fire. Due to the potential for crop damage, the bin should then be emptied to ensure that there are no additional hot spots and to salvage undamaged grain. The use of CO_2 or N_2 has also been successfully used in extinguishing fires in sealed or oxygen limiting structures. In some cases, the manufacturers of these units provide the necessary plumbing at the base of the structure to allow for the injection of gas in the event of a fire. Both CO_2 and N_2 are non-toxic gases and will not contaminate the stored crop. Both are, however, asphyxiants and can present a hazard to anyone entering the structure without self-contained breathing equipment.

There are serious personnel hazards associated with attempts to extinguish fires in crop storage structures. Only properly trained and equipped personnel should be involved. Appropriate first-response procedures include using appropriate personal protective equipment and following confined space entry procedures.

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Bibliography

ASAE Standard (1998a). *ASAE S417.1, Specifications for Alarm Systems Utilized in Agricultural Structures,* 489 pp. ASAE. St. Joseph, MI, USA.

ASAE Standard (1998b). *ASAE S318.13, Safety Agricultural Field Equipment,* 165 pp. ASAE. St. Joseph, MI, USA.

Bellinger P. L. (1994). *Farm and Ranch Safety Management,* 346 pp. Moline, IL: Deere and Company.

Field W. E. (1999). *Farm Rescue-Responding to Incidents and Emergencies in Agricultural Settings*, 76 pp. Ithaca, NY: NRAES.

National Fire Protection Association (1998). *Fire Protection Handbook: Seventeenth Edition.* Quincy, MA, USA.

Shutske J. M., Field W. E., Gaultney L. D., and Parsons S. D. (1990). Agricultural machinery fire losses: a preventative approach. *Applied Engineering in Agriculture* **6**(5), 575–581.

Shutske J. M., Field W. E., and Chaplin J. (1994). Grain combine fires: a loss reduction approach. *Applied Engineering in Agriculture* **10**(3), 175–192.

Biographical Sketch

Professor Field grew up working on a combination dairy-truck farm in Otsego County, New York, and graduated from Cooperstown High School in 1971. He attended State University & Technical College (Farmingdale, NY) then Buffalo State College (Buffalo, NY), where he received a B.S. degree in 1971. His M.S. and Ed.D. degrees were earned at the University of Minnesota (Minneapolis/St. Paul, MN) in 1975 and 1977, respectively.

Professor Field directs Purdue’s Agricultural Safety & Health Program, which incorporates the components of injury prevention, emergency preparedness, and providing rehabilitation services to agricultural workers. A primary focus of his program has been on building collaborative relationships to address agricultural safety/health issues at local, state, and national levels. In 1978, he developed one of the first college-level courses in agricultural safety, which has been completed by over 1,200 students pursuing agriculture careers. He also has supervised over 20 graduate degrees in the agricultural safety/health field and has mentored a number of individuals who are now actively engaged in agricultural safety/health teaching, research, and extension positions.

Dr. Field has published 23 peer-reviewed journal articles, 17 books and book chapters, and nearly 50 Extension publications, audio-visual aids, and educational kits. His endeavors have generated more than $5 million in external support, not including service-in-kind. Included among these sponsors have been NIDRR, DOE/RSA, IOSHA, USDA/CSREES, PVA, Indiana Department of Health, Successful Farming Magazine, and Deere & Company.