

Safety: Producing and Using Ethanol

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The energy crunch and increasing fuel costs have stimulated interest in fuel alcohol. However, along with these developments comes a number of new and old safety problems. Before attempting to produce or use fuel ethanol, familiarize yourself, your family and employees with potential hazards and the safety precautions that should be taken to prevent accidents.

Characteristics of gasoline and ethanol

Ethyl-alcohol and gasoline have many of the same physical characteristics. The same safety precautions and considerations that apply to gasoline also apply to the production and use of alcohol. Ethanol has about two-thirds the explosive potential of gasoline.

The National Fire Protection Association (NFPA) classifies gasoline and ethanol as Class 1B Flammable Liquids — flash point less than 73 degrees F and boiling point at or above 100 degrees F (see Table 1).

Table 1. Flammable characteristics.

	Ethanol	Gasoline
Flash point	55 degrees F	-44 degrees F
Ignition temperature	689 degrees F	536 degrees F
Flammable limits (percent fuel by volume)	3.3 - 19	1.4 - 7.6
Specific gravity (water = 1)	0.8	0.8
Vapor density (air = 1)	1.6	3.4
Boiling point (vaporization)	172 degrees F	100 - 400 degrees F
Btu/gal	83,000	125,000

The flash point is the lowest temperature at which a liquid gives off sufficient vapors to form an ignitable mixture with air near the surface of the liquid or within the container.

The flash points of alcohol-water mixtures vary depending on the proof (Figure 1). Eighty proof ethanol (60 percent water) has a flash point of 80 degrees F, compared with 160 proof ethanol (20 percent water) that has a flash point of 62 degrees F.

Ethanol has much wider flammable limits than does gasoline (see Table 1). The flammable limits are minimum and maximum concentrations of vapors in air, below or above which the fuel will not ignite and burn or explode.

For example, a gasoline vapor-air mixture with less than approximately 1.0 percent of gasoline vapor is too lean to ignite and burn. Similarly, if there is more than approximately 8 percent of gasoline vapor, the mixture will be too rich to ignite and burn.

Safety guidelines — codes and standards

Your first safety consideration should be during distilling plant design and construction. Adhere to the codes and standards of the industry. However, building and/or fire codes are not mandatory in most Missouri areas. Good management practice dictates that construction and operation meet or exceed codes or standard recommendations.

NFPA codes and standards

Fire is one of the major safety hazards of ethanol production. Give special consideration to comply with National Fire Codes and Standards of the NFPA. Copies of the standards should be available from your local library, fire department or building inspector. Some of the NFPA standards are:

No. 30 — Flammable and Combustible Liquids Code

No. 321 — Classification of Flammable Liquids

No. 385 — Tank Vehicles for Flammable and Combustible Liquids

No. 70 — National Electrical Code

No. 78 — Lightning Protection

No. 61B — Grain Elevators. Bulk Handling Facilities

No. 68 — Explosion Venting

No. 69 — Explosion Prevention System

No. 101 — Life Safety Code

No. 395 — Farm Storage of Flammable Liquids

No. 497 — Classification of Class I Hazardous Locations

ASME Code

In addition to the fire codes, the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code provides safety guidelines on the installation and operation of a boiler system.

OSHA Standards

If you hire persons to work in a distillation facility, you must comply with appropriate Occupational Safety and Health Act (OSHA) Standards. Refer to MU publication [G1961](#), *Agriculture and the Occupational Safety and Health Act*, available at your local University Extension center.

Other considerations

Separation of the distillation facility from other farm facilities is very important to help prevent fire from spreading. The minimum recommended separation between farm buildings is 50 feet. Fuel storage structures should be situated at least 100 feet from other buildings. Consider a greater distance when buildings align with prevailing winds.

In addition to building location, consider the possible spread of fire in the building once it starts. Slowing the spread within the building may reduce the loss. Fire walls and fire stops in a building can slow or halt the movement of flames, heat and hot gases. For additional information on improving the fire resistance of farm buildings, review MU publication [G1910](#), *Improving Fire Resistance of Farm Buildings*, and the Fire Protection Handbook of NFPA.

Availability of water may be a problem with fighting a fire in a rural area. Provide a supplementary supply to be used by the fire department in case of a fire.

Production considerations

As already noted, the production of ethanol poses several specific safety hazards. Some of special note are:

- Dust accumulation
- Contact with moving parts — grinding
- Ignition of ethanol leaks and/or fumes
- Over-pressurization
- Scalding from steam gasket leaks
- Contact burns from steam lines
- Handling chemicals
- Suffocation

Grain grinding process

Two hazards associated with grinding are accumulation of grain dust and the operator coming into contact with moving parts.

The dust resulting from the grinding and/or cracking of grain, if allowed to accumulate, could result in an explosive mixture. The prevention and control of the dust generation and accumulation is the key to the prevention of a potential dust explosion. If the grinding operation is located inside the building, the National Electric Code would classify the areas as a Class 11 location and all electrical components and/or heating components must be explosion-proof.

All moving parts (pulleys, power take-offs, belts, etc.) should be guarded to meet OSHA and the American Society of Agricultural Engineers (ASAE) requirements for machinery guarding. OSHA requirements are described in MU publication [G1961](#), *Agriculture and the Occupational Safety and Health Act*, and OSHA publication 2256, *Guarding of Farm Field and Farmstead Equipment and Cotton Gins*. Both of these publications are available through your County University of Missouri Extension Center.

Ignition of ethanol leaks and/or fumes

Ethanol is very flammable, so be careful to eliminate all potential sources of ignition, fuel leaks or possible areas of vapor build-up. Locate the distillation columns, condensers and storage tanks outside of the building in a well ventilated area away from the boiler and other ignition sources. There should not be an opening into the building within 10 feet of the distillation column. All electrical components within 10 feet of the distillation column and any transfer areas must be explosion proof; meeting the requirements of a "Class 1, Division II" location in accordance with the National Electrical Code.

Electrical equipment, motors, switches should be explosion-proof. In addition, the entire system should be properly grounded to prevent the build-up of static electricity.

Metal grinders, cutting torches, welders, etc., should not be used around any area of the system or equipment that contains or has contained ethanol.

If you must use such equipment, follow procedures in Bulletin A 6.0-65, *Safety in Welding and Cutting*. Other materials on the subject you should review are:

NFPA Standard 51B — Fire Prevention in Use of Cutting and Welding Processes
NFPA Standard 327 — Cleaning or Safeguarding Small Tanks and Containers

- Data Sheet #432 (National Safety Council) — Cleaning Small Containers That Have Held Combustibles

The entire ethanol production area should be posted with "No Smoking" signs. This is especially important around the storage area, distillation columns and condenser. The building should be well ventilated to prevent the build-up of vapors.

Over-pressurization

Most boilers used in producing ethanol will be low-pressure units — below 20 psi. However, care should be taken to ensure that pressure relief valves are properly installed and maintained. Also make sure the correct valve is selected and installed to relieve the maximum pressure for which the system is designed.

If you install a system that operates above 20 psi (most operate between 5 and 15 psi), you must acquire a ASME (American Society of Mechanical Engineers) boiler certification (check with insurance company). One certification requirement is that a certified operator be in attendance when the boiler is in operation.

Contact with steam lines

Two problems associated with steam lines are the possibility of burns from direct contact and scalding from gasket leaks. These two problems can be controlled or eliminated by:

- Insulating steam lines to protect against contact.
- Wearing heat-resistant gloves or mitts that protect hands and arms from the high temperatures.
- Placing baffles around flanges to direct steam jets away from the work area. Another solution would be to weld all joints, but from an economical standpoint this is probably not practical.

Chemicals

Special care should be taken when handling chemicals. Precautions include:

- Never breathe fumes from concentrated bases or acids.
- Slowly mix or dilute acids or bases to allow the heat generated from the chemical reaction to dissipate. To control chemical reaction pour an acid into water for dilution, not the reverse.
- Immediately flush exposed body area with large quantities of water.
- Always wear chemical splash goggles, rubber gloves and a heavy duty apron when handling a concentrated chemical.
- Always store chemicals in a fire proof, **locked** facility.

Suffocation

Never enter the fermenters, beer wells or stillage tank unless they are properly ventilated and purged of all inert and toxic gases (e.g. carbon monoxide). Force ventilate (with fan or blower) the tanks for at least 30 minutes before entering. There may not be enough oxygen available to support life. When a person enters a tank for any reason always have another person present and attach a lifeline to the person entering the tank. If you feel faint, get to fresh air immediately. **Caution: A rescue person should not enter a tank to aid a worker overcome by fumes or lack of oxygen unless the rescuer is wearing self-contained breathing equipment.**

Fire extinguishment

Every area should be equipped with an approved and properly maintained multi-purpose dry chemical extinguisher (minimum one 10-pound multi-purpose extinguisher). Foam extinguishers that are charged with an alcohol foam are effective (other foams can be broken down by ethanol).

The local fire department should be contacted to make them aware that an alcohol production facility is located in their fire district. This will allow them to pre-plan for a fire and to make certain that they have adequate extinguishing agents available for that type of fire.

OSHA

Employers of one or more persons have the legal responsibility to ensure safe and healthful working conditions under the William-Steiger Occupational Safety and Health Act (OSHA). To assist you in complying with the Act, review MU publication [G1961](#), *Agriculture and the Occupational Safety and Health Act (OSHA)*, available from your University of Missouri Extension Center.

Two areas of the Act specific to ethanol production are the guarding and training requirement of the Agricultural Machinery Guarding Standard and the General Duty Clause.

Insurance coverage

Before you install or start up your system, check with your insurance company to make sure that you have coverage in case of an accident. Most standard fire policies carry the following exclusions:

- Loss is not covered, except by proper endorsement, when the hazard is increased by any means within the control and knowledge of the insured.

- When this endorsement is attached to a policy, the company is not liable for loss — by explosion of steam boilers, steam pipes, steam turbines or steam engines, if owned by, leased by or operated under the control of the insured; or by rupture or bursting of rotating or moving parts of machinery by centrifugal force or mechanical breakdown.

Most insurance companies offer additional coverage on distillation equipment and facilities.

Usage

Fuel storage facilities should meet requirements of NFPA 395, *Standard for the Storage of Flammable and Combustible Liquids on Farms and Isolated Construction Projects*. This standard applies to liquids having a flash point below 200 degrees F (ethanol flash point 55-70 degrees F).

Safety considerations when handling ethanol should be the same as with gasoline. However, according to the National Safety Council, at fuel temperatures of 150 degrees F, vapor pressure generated by alcohol may be twice that of gasoline (see Table 1). For this reason, be sure fuel caps are clean and in good repair. Also check the fuel cap vent to make sure it's not plugged with dirt, oil, grease, etc. Always remove the fuel cap slowly to assure the slow release of pressure and to prevent fuel from spraying over you and possibly catching your clothes on fire.

Always remember to follow the basic safety rules when working with any flammable liquid:

- Always tighten the fuel cap securely.
- Never take the cap off or refuel when the engine is running or hot.
- Don't smoke while refueling or anywhere near gasoline.
- When you are filling your tank, maintain control of the nozzle.
- Don't fill your tank to capacity allow room for expansion.
- Wipe up any spills immediately.
- Keep your equipment properly maintained.
- Keep your equipment clean — free of trash and oil. Don't drive your equipment near open fires.
- Never use gasoline for cleaning parts.
- Make sure everyone operating your equipment follows all the safety rules in the operator's manual. If you don't have an operator's manual, contact your local dealer.

Ethanol (ethyl alcohol) is a solvent and can deteriorate fuel system components. Copper, magnesium, aluminum and terne metal commonly used in a fuel system may be affected. Some gaskets and plastics can also be affected.

Establish a preventive maintenance program. It will help increase fuel economy, reduce break-downs, preserve the value of equipment, and ensure your safety. Preventive maintenance includes the following:

- Check exhaust system for broken manifolds, loose exhaust pipes, broken mufflers, leaking gaskets.
- Check for fuel leaks at connections of lines, sediment bowls, fuel cap gaskets and carburetors.
- Check electrical wiring for frayed or cracked insulation and loose connections.
- Be sure fuel tank heat shields are in place.
- Use only the correct fuel cap and be sure it's in good condition.

References

National Fire Protection Association. *Flammable and Combustible Liquid Code*, Pamphlet No. 30. 470 Atlantic Ave., Boston, MA 02210.

American National Standard Institute. *Safety in Welding and Cutting*, Standard 249.1. 1430 Broadway, New York, New York 10018.

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