DISTILLERIES

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1.0 SCOPE

This data sheet covers the fire and explosion hazards associated with the production of distilled spirits. It includes recommendations to minimize losses from these hazards.

1.1 Changes

January 2010. Minor editorial changes were made for this revision.

January 2000. This revision of the document has been reorganized to provide a consistent format.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Grain handling, milling and feed preparation facilities should be designed, arranged and safeguarded in accordance with Data Sheet 7-75, *Grain Storage and Milling.*

2.2 Construction and Location

2.2.1 Mashing and Fermenting

2.2.1.1 Mashing and fermenting areas should preferably be of fire-resistive or noncombustible construction.

2.2.2 Distilling

2.2.2.1 Distilling operations should be separated from other buildings by at least 100 ft (30 m). Existing still-buildings that adjoin other buildings should be completely cut off by blank fire walls, parapeted above adjoining buildings. Avoid basements, pipe trenches and other spaces beneath still-buildings.

2.2.2.2 Preferably locate distilling equipment in the open with a minimum of enclosing structure. Any structures should be of damage-limiting construction (see Data Sheet 1-44, *Damage-Limiting Construction*). Load-bearing steel members and exposed steel equipment supports should be fireproofed with a material having a minimum two hours fire-resistance rating. For existing buildings of substantial construction, provide explosion venting capacity through venting windows and roof panels in as high a ratio as practical.

2.2.2.3 Floor cutoffs are advisable at operating levels in high, enclosed buildings. If complete floor cutoffs are not practical, provide solid noncombustible mezzanines with curbs at levels supporting receivers or other equipment containing appreciable quantities of flammable liquids.

2.2.2.4 Unless the maximum possible spill can be extinguished by dilution while confined, provide emergency drainage facilities for the distilling area or building to prevent escaping liquids from exposing other areas or buildings.

2.2.3 Distilled-liquor Handling

2.2.3.1 Distilled-liquor handling areas should preferably be of fire-resistive or noncombustible construction.

2.2.3.2 Distilled-liquor handling areas should be cut off from surrounding occupancies. Vertical cutoffs should be provided in multistory buildings. Cutoffs should have at least a one hour fire-resistance rating.

2.2.3.3 Provide curbs, ramps or trapped floor drains at doorways and other openings to prevent the spread of flammable liquids to other departments. Floor drains in each distilled-liquor handling area should be designed to handle expected sprinkler discharge unless the maximum possible spill can be extinguished by dilution while confined.

2.3 Occupancy

2.3.1 Mashing and Fermenting

2.3.1.1 Grain meal should be discharged to precookers only through tight connections to prevent liberation of dust.

2.3.2 Distilling

2.3.2.1 Pressure vessels should be designed and constructed in accordance with applicable codes, standards, state and local laws and regulations.

2.3.2.2 Stills should be equipped with vacuum and pressure relief devices piped to outdoors. Any condenser vents should also be piped to outdoors. Vents should be sized to discharge the maximum vapor generation possible at zero feed and maximum heating within the pressure limitations of the protected equipment. Vents should terminate at least 20 ft (6.1 m) above the ground and preferably at least 6 ft (1.8 m) above roof level and be so located that vapor will not re-enter the building. Vent terminals should be equipped with flame arresters.

2.3.2.3 Equipment should be designed and maintained to eliminate or at least minimize any liquid and vapor leaks.

2.3.2.4 Where gauges are needed, use Factory Mutual Research Approved[1] gauging devices. If ordinary gauge glasses are used, both connections should be normally kept closed and be provided with weight-operated, quick-closing valves. Protect the glass against mechanical injury. Tail boxes should be replaced with armored rotameters and specific gravity indicators where possible, or with other instrumentation not subject to accidental breakage or leakage.

2.3.2.5 The steam supply for distillation should be thermostatically controlled and interlocked to shut down and sound an audible alarm on cooling-water failure. Alternately, powered standby pumps or gravity supplies of cooling water should be provided.

2.3.2.6 Stills and other large equipment containing flammable liquids should be purged with steam or an inert gas (steam will be most generally available) before opening for inspection or repair. Equipment should be washed with water following steaming.

2.3.2.7 Ventilation designed and installed to ensure air movement throughout the entire structure should be provided to prevent the accumulation of explosive vapor-air concentrations within the building. The stack effect (i.e., natural ventilation) may suffice if the building is high, permanent openings are provided at grade and roof elevations, the equipment can be drained and cleared of vapors during shutdowns, and heat losses from the equipment maintain a temperature above that of the outdoors during all operating periods. If these operating conditions cannot be satisfied, or if block walls or solid floors interfere with natural ventilation, mechanical exhaust ventilation should be designed to provide 1 cfm/ft^2 (0.3 m^3/min/m^2) of floor area. Locate suction intakes near floor level to ensure a sweep of air across the area.

2.3.3 Distilled-liquor Handling

2.3.3.1 Noncombustible, vapor-tight construction should be used for all tanks containing flammable concentrations of alcohol. Tanks should be kept tightly closed except when taking samples.

2.3.3.2 Tanks should be equipped with vents of adequate size terminating outdoors. See Data Sheet 7-88, *Ignitable Liquid Storage Tanks*, for sizing vents using 50% of the recommended area per the Emergency Venting section. Vents should be equipped with Approved flame arresters if the flashpoint of the contents is less than 100°F (38°C).

2.3.3.3 Approved liquid-level gauges should be installed on all tanks. If ordinary gauge glasses must be used, weight-operated, normally closed valves should be installed at both tank connections and the glass protected against physical damage. Wherever possible, top tank connections should be provided and liquids transferred by pumping through the top rather than by gravity flow. If draw-off stations are located in the same area as the supply tank, automatically operated emergency shutoff valves should be provided in gravity-feed lines. Flexible metallic hose should be used on all connections to scale tanks where fire exposure would release the tank contents or expose its vapor space.

2.3.3.4 Mechanical exhaust ventilation should be provided as needed. Ventilation should be arranged with suction near floor level to ensure air movement throughout the building. At dump troughs and similar installations, localized intakes are desirable. Careful attention should be given to below-grade installations,

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*References to "Approved" in this data sheet means the product and services have satisfied the criteria for Factory Mutual Research Approval. Refer to the **Approval Guide** for a complete listing of products and services that are Factory Mutual Research Approved.*

windowless buildings, sumps, pipe trenches and similar installations. Usually, 0.25 cfm of air per ft^2 of floor area (0.075 $m^3/min/m^2$) will be adequate. The use of Approved portable flammable vapor indicators to check the need of adequacy of ventilation is recommended.

2.4 Protection

2.4.1 General

2.4.1.1 Provide automatic sprinkler protection for distilleries in accordance with Table 1.

Table 1. Sprinkler Protection Requirements for Distilleries

Occupancy	*Type of Sprinkler System*	*Sprinkler Temperature Rating°F (°C)*	*Density gpm/ft^2 (mm/min)*	*Area of Demand ft^2 (m^2)*
Mashing and Fermenting[1]	Wet Dry	Any Any	0.15 (6) 0.15 (6)	2500 (232.2) 3500 (325.2)
Still House[2,3]	Wet	212-286 (100-141)	0.30 (12) 1st level, solid intermediate levels and roof 0.15 (6) grated intermediate levels	5000 (464.5) at roof and each level
Tank Rooms[4]	Wet Wet Dry Dry	212-286 (100-141) 160 (71) 212-286 (100-141) 160 (71)	0.25 (10) 0.25 (10) 0.25 (10) 0.25 (10)	3000 (278.7) 4000 (371.6) 5000 (464.5) 6000 (557.4)
Barrel Dumping and Filling Areas	Wet Wet	212-286 (100-141) 160 (71)	0.25 (10) 0.25 (10)	4000 (371.6) 6000 (557.4)
Bottling Areas	Wet Wet Dry	212-286 (100-141) 160 (71) 160 (71)	0.20 (8) 0.20 (8) 0.20 (8)	3000 (278.7) 4000 (371.6) 5000 (464.7)

[1] For combustible construction or equipment only. Automatic sprinkler protection is not needed if both construction and equipment are noncombustible.

[2] Considering the water solubility of ethyl alcohol and the lower flammability compared to hydrocarbons assume that 50% of the sprinklers over the area of demand will open for multi-level facilities.

[3] Provide automatic sprinkler or water spray protection for enclosed still areas in accordance with Data Sheet 7-14, *Fire & Explosion Protection for Flammable Liquid, Flammable Gas & Liquefied Flammable Gas Processing Equipment & Supporting Structures.*

[4] Tanks exceeding 10 ft^2 (0.9 sq m^2) in bottom surface area should have sprinklers provided beneath them. In determining water requirements, include any such sprinklers located within the area of demand specified in Table 1.

2.4.1.2 Sprinkler control valves, dry pipe valves and riser drains should be readily accessible at all times to plant personnel. This is particularly important for areas under direct government supervision that may be locked during non-operating periods.

2.4.1.3 Small hose with combination shutoff nozzles should be provided throughout the distillery in accordance with Data Sheet 4-4N, *Standpipe and Hose Systems (NFPA)*. Hose stream demand is a minimum of 500 gpm (1900 dm/min^3) for at least 60 minutes.

2.4.1.4 Suitable portable fire extinguishers should be provided throughout the distillery in accordance with Data Sheet 4-5, *Portable Extinguishers.*

2.5 Ignition Source Control

2.5.1 Distilling

Electrical equipment, including wiring and lights, should be suitable for Class 1, Group D locations in accordance with Data Sheet 5-1, *Electrical Equipment in Hazardous Locations.* Still-buildings should be considered Division 2 locations.

2.5.2 Distilled-Liquor Handling

Electrical equipment, including wiring and lights, should be suitable for Class 1, Group D locations in accordance with Data Sheet 5-1, *Electrical Equipment in Hazardous Locations.* Tank storage areas should be treated as Division 2 locations. For other distilled-liquor handling areas, follow the guidelines of Figure 1 of Data Sheet 5-1, for determining proper electrical equipment.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

Distilleries are often located in rural districts because large supplies of pure water are needed for process purposes. Remoteness from city water supplies and fire departments places the responsibility for fire protection almost entirely on the facility itself. Safety also depends on good construction, and proper arrangement and safeguards for processes.

Because of the fire and explosion hazards inherent in handling large quantities of flammable liquids, safety depends on supervision by well-trained operators, good maintenance and process equipment safeguards.

Grain handling, milling and feed preparation at distilleries present dust explosion hazards. Although grains and feeds are slow burning, fires in these materials may be deep-seated and difficult to extinguish. Wet grains will heat and sour if not dried promptly.

Process fire and explosion hazards are present during distilling, but are considered negligible during mashing and fermenting. Strict government regulations which require seals on every pipe joint, valve and spigot reduce the probability of flammable liquid or vapor being released during distilling operations.

Flammable liquid hazards are also present in varying degrees in the various distilled-liquor handling areas. The flash and fire points of alcohol/water mixtures are shown in Figure 1.

Because of ethyl alcohol's lower heat of combustion, and radiant heat energy, and its complete miscibility with water, lower sprinkler system demands are required than with other flammable liquids of equivalent flashpoint.

Bottled distillery products vary in alcohol content:

	U.S. Proof	*Alcoholic Content, % by volume*
Whiskeys	80-100	40-50
Gins	80-95	40-47½
Vodkas	80-100	40-50
Rums	80-140	40-70
Brandies	80-140	40-70
Cordials, Liqueurs	40-100	20-50
Cocktails	20-100	10-50
Alcohol (Neutral Spirits)	110-192	55-96

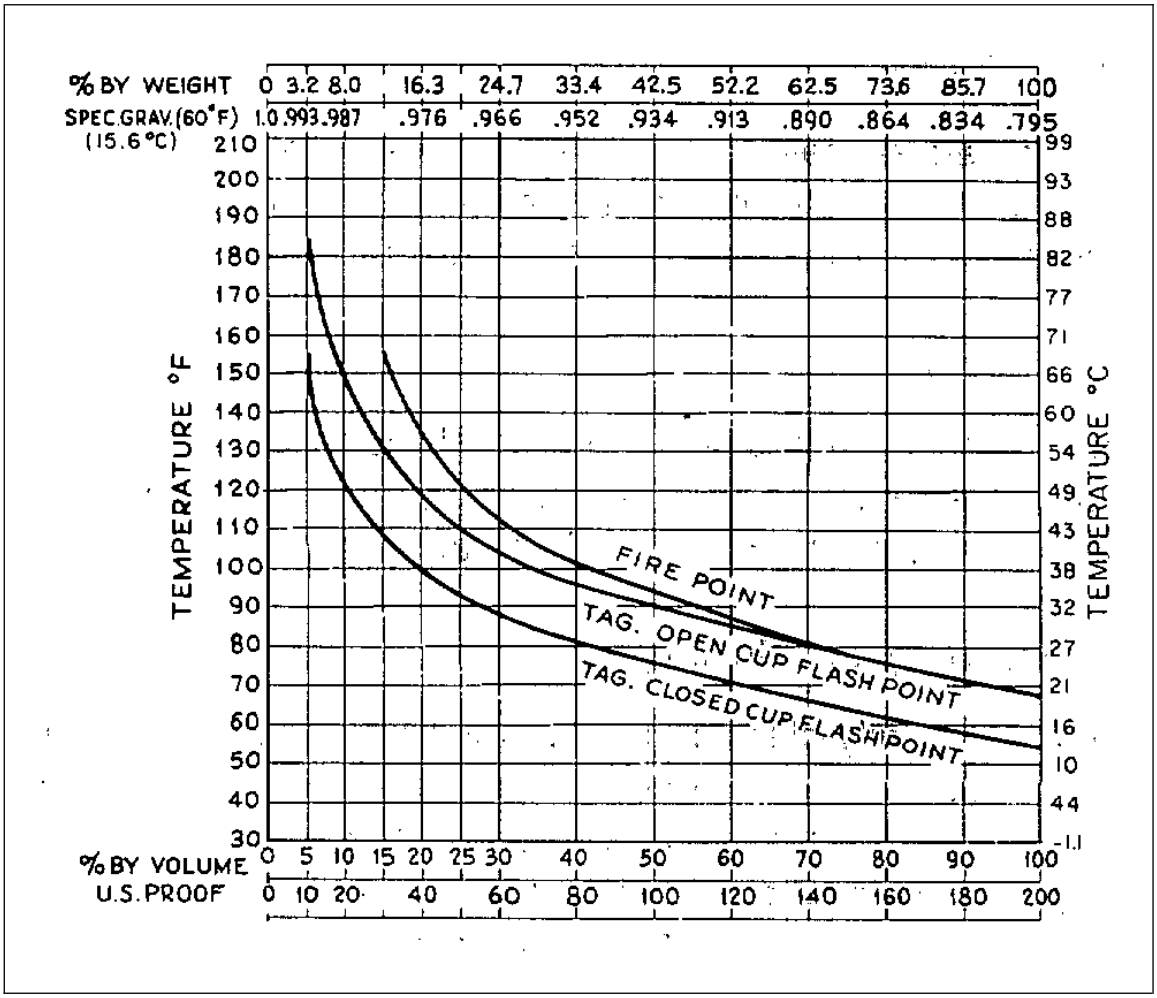

Fig. 1. Flash and fire points of alcohol/water mixtures.

The quantity of water needed to extinguish fires in alcohol-water mixtures depends upon the temperature of the liquid above its fire point and the effectiveness of mixing. The amount of water can be estimated from the following formula, assuming perfect mixing:

$$\text{Volumes of water needed per volume of burning liquids} = \frac{\text{\% alcohol in solution before fire}}{\text{\% alcohol at point of fire extinguishment}} - 1$$

Assume that a solution will be extinguished when the alcohol concentration is reduced to 20%. Applying the formula, a mixture containing 95% alcohol would require 3.75 volumes of water to extinguish each volume of burning liquid. A mixture containing 50% alcohol would require 1.5 volumes.

3.2 Loss History

A survey[2] of distilling industry losses for the years 1933-1981 indicated that approximately 65% of all property damage resulted from fires in 14 unsprinklered distilled spirits warehouses. However, several serious fire and explosion losses occurred in still-buildings and bottling-houses. All of the serious bottling-house fires also occurred in unsprinklered buildings. The most serious losses in still-buildings involved explosions with ensuing fires where sprinkler systems were damaged by the explosion. Several fires also occurred in driers processing dried grains from spent stillage or slops.

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*Appendix G of **Recommended Fire Protection Practices for Distilled Spirits Beverage Facilities-A Suggested Guide**, prepared by the Distilled Spirits Council of the United States, Inc. (DISCUS) dated December, 1981.*

4.0 REFERENCES

4.1 FM

Data Sheet 1-44, *Damage-Limiting Construction.*

Data Sheet 4-4N, *Standpipe and Hose Systems.*

Data Sheet 4-5, *Portable Extinguishers.*

Data Sheet 5-1, *Electrical Equipment in Hazardous Locations.*

Data Sheet 7-14, *Fire & Explosion Protection for Flammable Liquid, Flammable Gas & Liquefied Flammable Gas Processing Equipment & Supporting Structures.*

Data Sheet 7-75, *Grain Storage and Milling.*

Data Sheet 7-88, *Ignitable Liquid Storage Tanks.*

4.2 NFPA Standards

NFPA 30, *Flammable and Combustible Liquids Code*, National Fire Protection Association, Quincy, MA.

APPENDIX A GLOSSARY OF TERMS

Proof: numerical value normally equivalent to two times the alcohol content by volume of a distilled spirit product.

APPENDIX B DOCUMENT REVISION HISTORY

This document does not have any revision history.

APPENDIX C SUPPLEMENTAL INFORMATION

Spirituous-liquor distilleries primarily produce whiskeys, gins, vodkas, rums, brandies and similar beverages. Industrial grain alcohol, denatured alcohol and stock feed are by-products.

Whiskey is obtained by the distillation of a fermented mash of cereal grains such as corn, rye or barley. About 10 bu (352 dm^3) of grain are required to produce a 50 gal (189 dm^3) barrel of 100 proof (50% alcohol) whiskey.

Gins, cordials and liqueurs are obtained by redistillation in contact with flavoring substances, aromatic tinctures and sugar syrups. Another method is to add flavoring and coloring materials directly to neutral alcohol solutions without distillation.

Vodka is obtained by filtering grain neutral spirits through charcoal.

Rum is produced by distilling fermented molasses. Some whiskeys and industrial alcohols are also produced from molasses. Brandies are the product of distillation of wines or fermented fruit juices.

C.1 Process Description

The basic steps in the production of distilled spirits are mashing and fermenting, distilling and distilled-liquor handling.

C.1.1 Mashing and Fermenting

The first step in the production of distilled spirits is the manufacture of beer. The flow diagram for grain preparation and fermentation is shown in Figure 2. Meal from storage bins is weighed, charged with water, and transferred to mash tubs or pressure cookers where the mixture is cooked for several hours. Mash tubs operate at atmospheric pressure and a temperature of about 212°F (100°C). Steam pressure cookers may operate at temperatures in excess of 300°F (149°C) and 50 to 75 psi (3.5 to 5.2 bar) pressure. In a continuous process, mash is heated in a precooker and pumped through the cooker at 350°F (177°C) for three to five minutes.

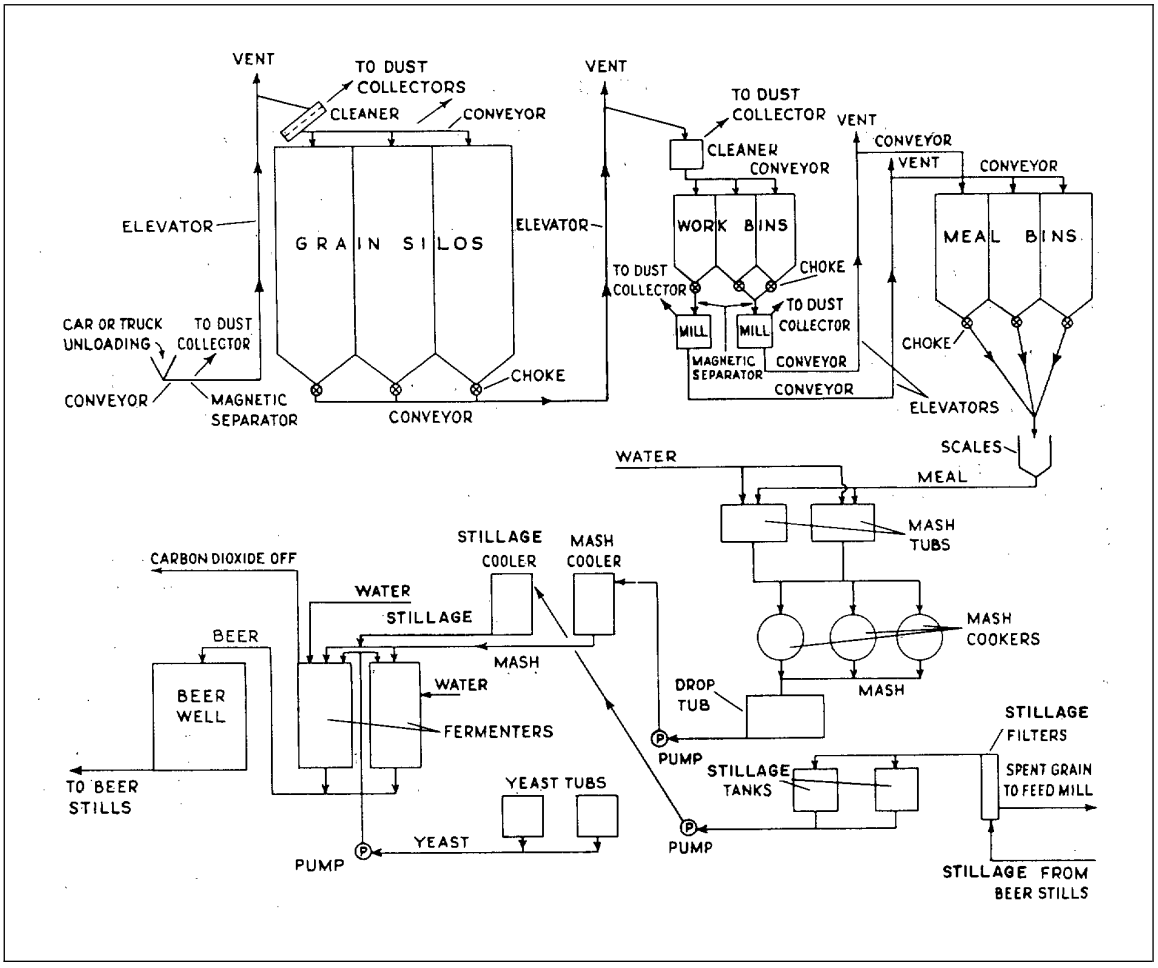

Fig. 2. Flow diagram: grain preparation and fermentation.

Mash passes from the cooker to cooker drop tubs and is then pumped through coolers to fermenters together with thin stillage from the beer stills, water and yeast. After a fermenting period of 72 to 96 hours, the resulting beer, with an alcohol content of 7 to 13% is pumped to a beer well.

Yeast culture is the growth of a selected yeast strain(s) in sterile mash. It is cultivated first in small laboratory quantities and then in successively larger amounts until a quantity sufficiently large to inoculate a fermenter is accumulated. Though the process is nonhazardous, it is essential to the distilling operation. An interruption could cause production losses.

Fermenting tanks may be wood or steel with either closed or open tops, depending on whether they are intended to collect carbon dioxide gases. They may be of various capacities, with 75,000 gallons (284 m^3) tanks not uncommon.

Fermenting houses are usually single-fire area buildings and may be of various types of construction and sizes.

C.1.2 Distilling

The flow diagram for the distilling process is shown in Figure 3. Distillery buildings are usually the equivalent of several stories high and of various types of construction. Newer distilleries are mostly of noncombustible construction. Because of the height of stills and rectifying columns, intermediate floors are usually limited to operating decks and platforms.

Distilling operations are usually continuous, except for some pot-still operations for producing gin and certain types of whiskey, or redistillation of off-grade products. Beer is pumped through preheaters to the top of a

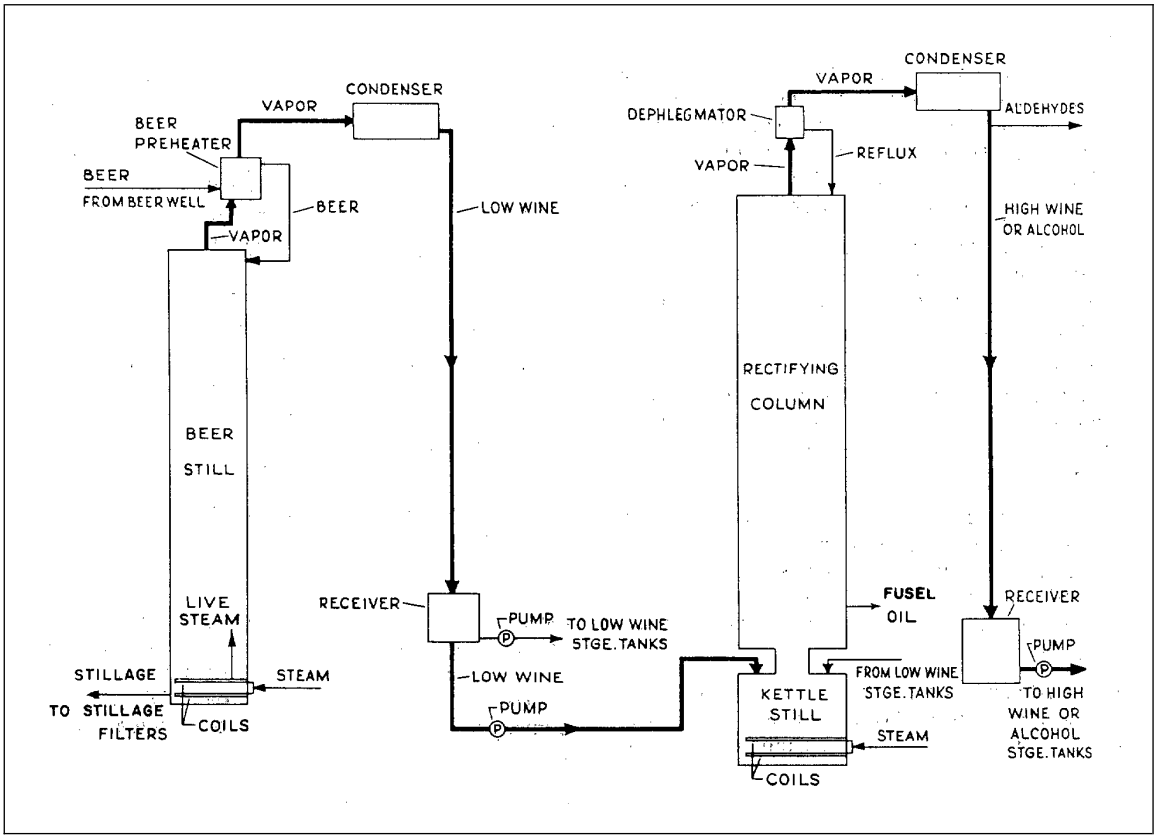

Fig. 3. Simplified flow diagram: distilling.

beer still. It flows over baffles countercurrently to rising alcohol-rich vapors from below. Vapors are condensed and the condensate or ‘‘low wine’’ (40 to 70% alcohol) flows to small receivers. It is then pumped to storage tanks, or directly to steam-heated rectifying columns or doublers for further concentration into ‘‘high wines’’ (55 to 75% alcohol) or commercial alcohol (95% alcohol). High wines (or alcohol) and by-products such as aldehydes and fusel oil are pumped to storage tanks. Residue from the beer still is pumped to spent-stillage or slop tanks for sale or processing as a constituent of stock feed. Stills are steam-heated. Some units involve vacuum distillation at lower temperatures. Vacuum and pressure-relief devices are usually provided; in some older facilities they discharge into the still building proper creating an explosion hazard.

C.1.3 Distilled-Liquor Handling

After distillation, the liquor is usually handled in separate buildings or fire areas. Because of government regulations concerning the handling of distilled liquors, adequate cutoffs are usually provided, particularly in newer distilleries.

C.1.3.1 Wine-Tank Room

Raw spirits from the still buildings are usually stored temporarily in black iron, tin-lined copper, or stainless-steel tanks of varying capacities in the wine-tank room or closed receiver building.

High-wine tanks and weigh tanks are usually of black iron or lightweight tin-lined copper or stainless steel construction. They vary in capacity from a few hundred to several thousand gallons. Although these tanks are under government supervision and have locked covers, sealed valves and fittings, they may not be air tight, particularly in older facilities. Sampling for proof and gauging may be through manholes. Tanks may be equipped with long, unprotected gauge glasses. Many elevated tanks are on wood or unprotected steel supports.

C.1.3.2 Blending or Cistern Room

After quality-control tests, the spirits are pumped to tanks of similar construction (except for black iron) in the cistern room. Proof is reduced to desired barreling strength by adding distilled water, and the final product is put into charred white-oak barrels. Filling is by gravity flow or pumping with a valve arranged to shut off when the barrel is full. Unless the filling equipment is properly maintained, some leakage results.

C.1.3.3 Regauging

After spirits have aged, they are removed from the warehouse and regauged. The federal tax is paid on the number of proof gallons. In the United States a proof gallon is 1 U.S. gallon (3.8 dm^3) of 100 proof alcohol. In Britain and Canada, standard proof spirits or 100 proof is pure ethyl alcohol diluted with an equal amount, by weight, of distilled water (57.06% alcohol by volume) at 60°C (16°C). Older processes required opening, dumping, weighing, and testing each barrel or selected barrels of each lot to determine proof. In newer processes, the contents of all the barrels in a specific lot are dumped into open troughs and pumped to scale tanks. The quantity is determined by weight and a single test is made to determine the proof. Contents of the tanks are agitated prior to testing.

C.1.3.4 Recoopering

When excessive leakage cannot be stopped by calking, the barrel is removed to a recoopering room for repairs or transfer of the contents to another barrel.

C.1.3.5 Blending and Bottling

Spirits are usually blended by dumping barrels of aged spirits into troughs with screened outlets, from which they flow or are pumped to large storage tanks. Alcohol, water, flavorings and color are added to obtain the desired blend. Blends range from 80 to 100 U.S. proof (40 to 50% alcohol). Mixing is usually accomplished by mechanical agitation and sometimes by air. Spirits from blending tanks or bonded storage are usually pumped to elevated, bottle-filling tanks at the bottling plants. Bottles are filled by gravity and vacuum.

Tanks in all of the above processes have varying degrees of vapor tightness. They range in capacity to more than 40,000 gal (151 m^3). Since government regulations call for tanks to be completely emptied and all lines blown free of liquids, bottom connections and centrifugal pumps are generally used.

APPENDIX D NFPA STANDARDS

There is no NFPA standard dealing specifically with distilleries. There are no known conflicts with related NFPA standards except for the tank venting change which previously was consistent with NFPA 30.