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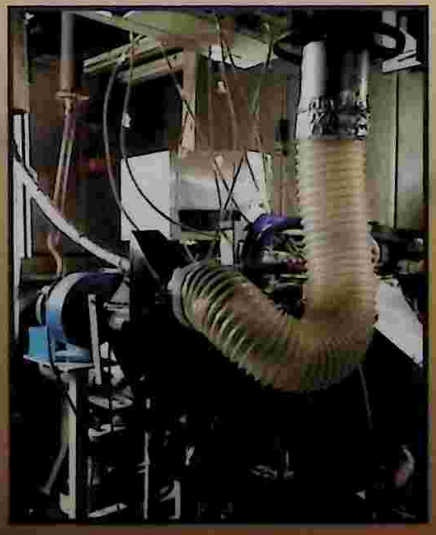
SECOND EDITION



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25

Food-Grade Lubricants and the Food Processing Industry

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25.1 Introduction

The food processing industry presents unique challenges to lubricant formulation engineers, lubricant marketers, plant lubrication engineers, equipment designers, and builders. While it is never desirable for lubricants to be allowed to contaminate raw materials, work-in-progress, or finished product, the consequences of a lubricant contaminated product is rarely more acute than in the food processing industry. As such, lubricants used in this industry have requirements, protocols, and performance expectations that go well beyond typical industrial lubricants.

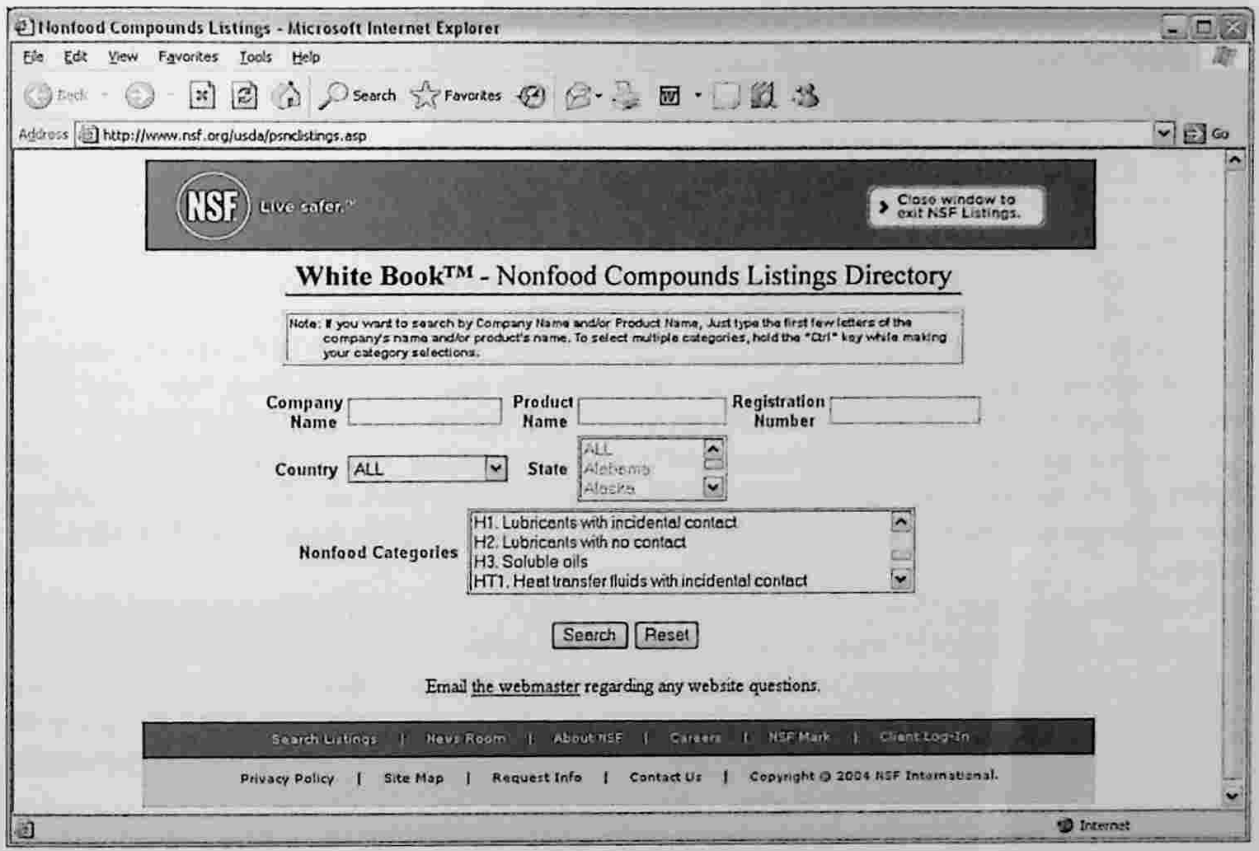

FIGURE 25.1 NSF's search engine of approved lubricants in H1, H2, and H3 applications.

25.3.3 Third-Party Certifications

In response to the change in the approval process, several commercial organizations developed external certification programs. Three such organizations were the National Sanitation Foundation (NSF), Underwriters Laboratory (UL), and a joint effort by three recognized industry professional associations: The National Lubricating Grease Institute (NLGI), The European Lubricating Grease Institute (ELGI), and the European Hygienic Equipment Design Group (EHEDG).

NSF has developed a lubricant evaluation program that essentially mirrors the FSIS program by evaluating the candidate lubricant formulations to verify compliance with the various FDA CFR guidelines. Each component in the formulation is submitted to NSF by the lubricant manufacturer along with other supporting documentation. This is then reviewed to verify it is within the FDA list of permitted substances [4]. NSF's website provides food processing manufacturers with a continually updated list of approved lubricants at www.nsfwhitebook.org (Figure 25.1).

Underwriters Laboratory is another organization that began third-party certification of food-grade lubricants but no longer is doing so. While they have not been as active as NSF in the area of food-grade lubricants, in the past, UL has organized several informational meetings inviting lubricant and chemical manufacturers to attend [5].

The NLGI/ELGI/EHEDG Joint Food-grade Lubricants Working Group has been active in drafting an authorization program for food-grade lubricants. This group's program is also based on the former USDA/FSIS authorization program and CFR policies. Their plan is to develop a DIN (the German Institute for Standardization) standard in Germany and use the DIN standard to later develop an ISO (International Organization for Standardization) standard [5].

Not all countries use third-party certifications. Canada, New Zealand, Australia, and Japan are some of the countries that federally regulate food-grade lubricants [1]. However, the Canadian Food Inspection Agency (CFIA) is working on a food-grade lubricants approval system, and NSF will help with the

CFIA review process. Also, the Australian Quarantine Inspection Service has approved approximately 50 food-grade lubricants based on NSF registration [6].

25.4 Challenges Facing Food-Grade Lubricants

Agricultural and animal substances go through a number of processes in a manufacturing plant such as cleansing, sterilizing, blending, mixing, cooking, freezing, cutting, packaging, canning, and bottling. Large-scale food processing requires machinery such as pumps, mixers, tanks, hoses, and pipes, chain drives, and conveyor belts. Machinery used in food processing facilities face many of the same tribological and lubrication challenges found in other nonfood processing plants. In that sense, lubricants must offer similar protection of internal surfaces to control friction, wear, corrosion, heat, and deposits. They must also offer good pumpability, oxidation stability, hydrolytic stability, and thermal stability where the application so requires. Many of the raw materials used to formulate lubricants that effectively address these challenges in conventional industrial applications are not permissible in food applications for safety reasons.

In addition, certain applications within the food and drug manufacturing facilities demand that lubricants resist degradation and impaired performance when in contact with food products, certain process chemicals, water (including steam), and bacteria. They must also exhibit neutral behavior toward plastics and elastomers and have the ability to dissolve sugars. In general, these lubricants must comply with food/health and safety regulations, as well as be physiologically inert, tasteless, odorless, and internationally approved [7].

Lubricants in many food processing plants can be subjected to ingression and contend with an assortment of environmental contaminants. For instance, a corn-milling environment generates significant dust. Although not as hard as silica-based terrain dust, it still presents a problem for filtration. A meat plant requires stringent steam cleaning at all times, so the risk of water contamination is high. Water contamination in gear oils routinely exceeds 15% in some plants.

Another aspect of lubrication contamination that poses unique risk to food-grade lubricants is the growth of microorganisms such as bacteria, yeast, and fungi. While these can also be challenging to conventional industrial lubricants, the opportunity for microbial contamination in the food-production industry is considerably greater.

25.5 Food-Grade Lubricants Defined by Category

Food-grade lubricants are either compounded or uncompounded products acceptable for use in meat, poultry, and other food processing equipment, applications, and plants. The lubricant types in food-grade applications are broken into categories based on the likelihood that they will contact food. The original food-grade designations H1, H2, and H3 were created by the USDA. The approval and registration of a new lubricant into one of these categories depends on the ingredients used in the formulation. The three designations are described here [2].

H1 lubricants are food-grade lubricants used in food-processing environments where there is some possibility of incidental food contact. Lubricant formulations must be composed of one or more approved basestocks, additives, and thickeners (if grease) listed in 21 CFR 178.3750. Only the minimum amount of lubricant required should be used on the equipment.

H2 lubricants are lubricants used on equipment and machine parts in locations where there is no possibility that the lubricant or lubricated surface contacts food. Because there is not risk of contacting food, H2 lubricants do not have a defined list of acceptable ingredients. They cannot, however, contain intentionally heavy metals such as antimony, arsenic, cadmium, lead, mercury or selenium. Also, the ingredients must not include substances that are carcinogens, mutagens, teratogens, or mineral acids [4].

TABLE 25.1 H-3 Soluble Oil Approved Lubricants

Lubricant type	Regulations they must meet
Edible oils (corn oils, cottonseed oil, soybean oil)	21 CFR 172.860
Certain mineral oils	21 CFR 172.878
Generally recognized as safe (GRAS)	21 CFR 182 or 21 CFR 184

H3 lubricants, also known as soluble or edible oil, are used to clean and prevent rust on hooks, trolleys, and similar equipment. Equipment applied with H3 lubricants should be cleaned by washing or wiping the surface before putting the equipment in service. These lubricants can only consist of ingredients as shown in Table 25.1 [4].

Deciding whether there is a possibility of contact is tough, and many have erred on the side of safety with respect to selecting H1 over H2.

25.6 Approved Lubricant Formulations in H1 Lubricants

As previously mentioned, the USDA/FSIS approvals are based on the various FDA Codes in Title 21 that dictate approval for ingredients used in lubricants that may have incidental contact with food. These are mentioned as follows:

- 21.CFR 178.3570 — allowed ingredients for the manufacture of H1 lubricants
- 21.CFR 178.3620 — white mineral oil as a component of nonfood articles intended for use in contact with food
- 21.CFR 172.878 — USP mineral oil for direct contact with food
- 21 CFR 172.882 — synthetic isoparaffinic hydrocarbons
- 21.CFR 182 — substances generally recognized as safe

Based on the Title 21 FDA regulations noted, the following is paragraphs discuss the allowable basestocks, additives, and thickeners in food-grade lubricants.

25.6.1 Acceptable Food-Grade Basestocks

Depending on whether the food-grade lubricant is H1 or H2, the list of approved basestocks will vary. H2 lubricant basestock guidelines are less restrictive and consequently allow a broader variety of basestocks. Many products used in industrial (nonfood) plants are also used in food plants for H2 applications. H1 lubricants are much more limited since they are designed to allow for accidental exposure with the processed foods. The approved H1 lubricant basestocks can be either mineral or synthetic.

25.6.1.1 Petroleum-Based Lubricants

Mineral oils used in H1 food-grade lubricants are either technical white mineral or USP-type white mineral oils. White oils start as normal paraffinic petroleum stocks and are processed into pure branched paraffin stocks, stripped free of the majority of aromatic hydrocarbons, sulfur, and nitrogen contaminants. They are highly refined and are colorless, tasteless, odorless, and nonstaining. Technical white oils meet the regulations specified in 21 CFR 178.3620. Based on the American Society for Testing Materials (ASTM) method D156-82, "Standard Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)," the Saybolt color must be a minimum of 20 to be considered a technical white oil [8]. USP mineral oils are the purest of all white mineral oils, and are the most oxidatively stable [5].

Historically, white mineral oils were first listed in the United States Pharmacopoeia (USP) in 1926. Later, a paper on the general principles of white oil manufacturing was written in 1935 followed by other papers [1].

TABLE 25.2 Approved Substance for H1 Lubricants per 21CFR 178.3570

Substance	Limitations
Aluminum stearoyl benzoyl hydroxide	For use only as a thickening agent in mineral oil lubricants at a level not to exceed 10% by weight of the mineral oil
N, *N*-*bis*(2-ethylhexyl)-ar-methyl-1H-benzotriazole-1-methanamine (CAS Reg. No.94270-86-7)	For use as a copper deactivator at a level not to exceed 0.1% by weight of the lubricant
BHA BHT	
[alpha]-Butyl-omega- hydroxypoly(oxyethylene) poly(oxypropylene) produced by random condensation of a 1 : 1 mixture by weight of ethylene oxide and propylene oxide with butanol; minimum mol wt 1500; Chemical Abstracts Service Registry No. 9038-95-3	Addition to food not to exceed 10 ppm
[alpha]-Butyl-omega- hydroxypoly (oxypropylene); minimum mol wt 1,500; Chemical Abstracts Service Registry No. 9003-13-8	Addition to food not to exceed 10 ppm
Castor oil	Addition to food not to exceed 10 ppm
Castor oil, dehydrated	Addition to food not to exceed 10 ppm
Castor oil, partially dehydrated	Addition to food not to exceed 10 ppm
Dialkyldimethylammonium aluminum silicate (CAS Reg. No. 68953-58-2), weight 1, 6-hexanediol (CAS Reg. No. by weight of the mineral oil. 629-11-8), where the alkyl groups are derived from hydrogenated tallow fatty acids (C_{14}–C_{18}) and where the aluminum silicate is derived from bentonite	For use only as a gelling agent in mineral oil lubricants at a which may contain up to 7% by level not to exceed 15%
Dimethylpolysiloxane (viscosity greater than 300 cSt)	Addition to food not to exceed 1 ppm
Di (n-octyl) phosphite (CAS Reg. No. 1809-14-9)	For use only as an extreme pressure-antiwear adjuvant at a level not to exceed 0.5% by weight of the lubricant
Disodium decanedioate (CAS Reg. No. 17265-14-4)	For use only: 1. As a corrosion inhibitor or rust preventative in mineral oil–bentonite lubricants at a level not to exceed 2% by weight of the grease 2. As a corrosion inhibitor or rust preventative only in greases at a level not to exceed 2% by weight of the grease
Disodium EDTA (CAS Reg. No. 139-33-3)	For use only as a chelating agent and sequestrant at a level not to exceed 0.06% by weight of lubricant at final use dilution

TABLE 25.2 Continued

Substance	Limitations
Ethoxylated resin phosphate ester mixture consisting of the following compounds: 1. Poly(methylene-p-tert-butyl phenoxy)poly-(oxyethylene) mixture of dihydrogen phosphate and monohydrogen phosphate esters (0 to 40% of the mixture). The resin is formed by condensation of 1 mol of p-tert-butylphenol with 2 to 4 mols of formaldehyde and subsequent ethoxylation with 4 to 12 mols of ethylene oxide 2. Poly(methylene-p-nonylphenoxy) poly(oxyethylene) mixture of dihydrogen phosphate and monohydrogen phosphate esters (0 to 40% of the mixture). The resin is formed by condensation of 1 mol of p-nonylphenol with 2 to 4 mols of formaldehyde and subsequent ethoxylation with 4 to 12 mols of ethylene oxide 3. n-Tridecyl alcohol mixture of dihydrogen phosphate and monohydrogen phosphate esters (40 to 80% of the mixture; CAS Reg. No. 56831-62-0)	For use only as a surfactant to improve lubricity in lubricating fluids complying with this section at a level not to exceed 5% by weight of the lubricating fluid
Fatty acids derived from animal or vegetable sources and the hydrogenated forms of such fatty acids	
2-(8-Heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethanol (CAS Reg. No. 95-38-5)	For use at levels not to exceed 0.5% by weight of the lubricant
Hexamethylenebis(3,5-di-tert-butyl-4-hydroxy hydrocinnamate) (CAS Reg. No.35074-77-2)	For use as an antioxidant at levels not to exceed 0.5% by weight of the lubricant
[alpha]-Hydro-omega-hydroxypoly (oxyethylene) poly(oxypropylene) produced by random condensation of mixtures of ethylene oxide and propylene oxide containing 25 to 75% by weight of ethylene oxide; minimum mol wt 1,500; Chemical Abstracts Service Registry No. 9003-11-6	Addition to food not to exceed 10 ppm
12-Hydroxystearic acid	
Isopropyloleate	For use only as an adjuvant (to improve lubricity) in mineral oil lubricants
Magnesium ricinoleate	For use only as an adjuvant in mineral oil lubricants at a level not to exceed 10% by weight of the mineral oil
Mineral oil	Addition to food not to exceed 10 ppm
N-Methyl-N-(1-oxo-9-octadecenyl) glycine (CAS Reg. No. 110-25-8)	For use as a corrosion inhibitor at levels not to exceed 0.5% by weight of the lubricant
N-phenylbenzenamine, reaction products with 2, 4, 4-trimethylpentene (CAS Reg. No. 68411-46-1)	For use only as an antioxidant at levels not to exceed 0.5% by weight of the lubricant
Petrolatum	Complying with Sec. 178.3700. Addition to food not to exceed 10 ppm
Phenyl-[alpha]-and/or phenyl [beta]-naphthylamine	For use only, singly or in combination, as antioxidant in mineral oil lubricants at a level not to exceed a total of 1% by weight of the mineral oil

(*Continued*)

TABLE 25.2 Continued

Substance	Limitations
Phosphoric acid, monohexyl and dihexyl esters, compounds with tetramethylnonylamines and C_{11-14} alkylamines	For use only as an adjuvant at levels not to exceed 0.5% by weight of the lubricant
Phosphoric acid, monoisooctyl and diisooctyl esters, reacted with tert-alkyl and (C_{12}–C_{14}) primary amines (CAS Reg. No.68187-67-7)	For use only as a corrosion inhibitor or rust preventative in lubricants at a level not to exceed 0.5% by weight of the lubricant
Phosphorothioic acid, O, O, O-triphenyl ester, tert-butyl derivatives (CAS Reg. No. 192268-65-8)	For use only as an extreme pressure-antiwear adjuvant at a level not to exceed 0.5% by weight of the lubricant
Polyurea, having a nitrogen content of 9 to 14% based on the dry polyurea weight, produced by reacting tolylene diisocyanate with tall oil fatty acid(C_{16} and C_{18}) amine and ethylene diamine in a 2 : 2 : 1 molar ratio	For use only as an adjuvant in percent level not to exceed 10 mineral oil lubricants at a by weight of the mineral oil
Polybutene (minimum average mol wt 80,000)	Addition to food not to exceed 10 ppm
Polybutene, hydrogenated; complying with the identity prescribed under Sec. 178.3740	Addition to food not to exceed 10 ppm
Polyethylene	Addition to food not to exceed 10 ppm
Polyisobutylene (average mol wt 35,000–140,000 (Flory))	For use only as a thickening agent in mineral oil lubricants
Sodium nitrite	Use only as a rust preventive in mineral oil lubricants at a level not to exceed 3% by weight of the mineral oil
Tetrakis[methylene(3,5-di-tert-butyl-4-hydroxyhydro-cinnamate)] methane (CAS Reg. No. 6683-19-8)	For use only as an antioxidant in lubricants at a level not to exceed 0.5% by weight of the lubricant
Thiodiethylenebis (3,5-di-tert-butyl-4- hydroxyhydrocinnamate) (CAS Reg. No. 41484-35-9)	For use as an antioxidant at levels not to exceed 0.5% by weight of the lubricant
Tri[2(or 4)-C_{9--10}-branched alkylphenyl] phosphorothioate (CAS Reg. No. 126019-82-7)	For use only as an extreme pressure-antiwear adjuvant at levels not to exceed 0.5% by weight of the lubricant
Triphenyl phosphorothionate (CAS Reg. No. 597-82-0)	For use as an adjuvant in lubricants herein listed at a level not to exceed 0.5% by weight of the lubricant
Tris(2,4-di-tert-butylphenyl)phosphite (CAS Reg. NO. 31570-04-4)	For use only as a stabilizer at levels not to exceed 0.5% by weight of the lubricant
Thiodiethylenebis(3,5-di-tert-butyl-4-hydroxy-hydro-cinnamate) (CAS Reg. No. 41484-35-9)	For use as an antioxidant at levels not to exceed 0.5% by weight of the lubricant
Zinc sulfide	For use at levels not to exceed 10% by weight of the lubricant

Source: 21 CFR 3570 — Lubricants with incidental food contact. Retrieved online at www.access.gpo.gov/nara/cfr.index.asp.

25.6.1.2 Synthetic Lubricants

Synthetic H1 lubricants are mainly polyalphaolefins (PAO). They were first introduced in 1981 by Gulf Research and Development Company [1]. Compared to white mineral oils, they have significantly greater oxidation stability and greater range of operating temperatures. Another H1 synthetic lubricant used is Polyalkylene glycols (PAG). These lubricants are more increasingly used in high temperature applications.

TABLE 25.3 Bakery and Confectionery Products

Flour pumps/blowers/fluidizers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Blanchers — initial cooking	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Dough mixers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Sifters/separators	
Greased bearings	NLGI No. 2 Grease
Chains	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Dividers/portioners	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pan-tray washers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray or ISO 100 R&O or AW Oil
Pan-tray stackers/unstackers	
Greased bearings	NLGI No. 2 Grease
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Air Line Lube	ISO 46 R&O or AW Oil
Liquor mills	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Depositors/applicators	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 46 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Extruders	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 46 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Slicers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Blenders	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Shapers/rounders/moulders/elongators	
Geared bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Panners/depanners	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Proofers/coolers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Ovens/fryer/roasters/cookers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Baggers/packagers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 46 R&O or AW Oil
Open gears	NLGI No. 2 Grease Spray
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Wrappers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 46 R&O or AW Oil
Open gears	NLGI No. 2 Grease Spray
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Dust collectors	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil
Conveyers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pumps	
Greased bearings	NLGI No. 2 Grease

Source: Food Processing Industry brochure. Lubrication Engineers, Inc. With permission.

TABLE 25.4 Beverages

Depalletizers/palletizers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Air Line Lubes	ISO 46 R&O or AW Oil
Bottle-can washers/rinsers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Open gears	NLGI No. 2 Grease Spray
Bottle-can fillers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Bottle cappers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Thread roller	ISO 100 R&O or AW Oil
Can closers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Open gears	NLGI No. 2 Grease Spray
Bottle labelers	
Greased bearings/cams	NLGI No 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Chains	NLGI No. 2 Grease Spray
Open gears	NLGI No. 2 Grease Spray
Enclosed gears	ISO 220 Gear Oil
Bottle-can uncaser/packer/case wrapper	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Syrup mixers/pumps/fillers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Open gears	NLGI No. 2 Grease Spray
Pasteurizers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Hydraulics	ISO 46 R&O or AW Oil
Chains	NLGI No. 2 Grease Spray
Conveyors	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pumps	
Greased bearings	NLGI No. 2 Grease

Source: Food Processing Industry brochure. Lubrication Engineers, Inc. With permission.

Dimethylpolysiloxane (silicones) with a viscosity greater than 300 cSt [9] is also permitted for H1 lubricants. Sanction letters for the use of silicone fluids as defoaming agents show up as early as 1953. Silicones were not approved until soon after a petition filed by General Electric in 1965 [1]. Silicones have even higher thermal and oxidation stability than PAO and PAG base oils.

25.6.1.3 Differences Among Basestocks

Although synthetics are more expensive than mineral oils, tests performed on H1 PAO and white mineral oils on drive chains show that the useful life of PAOs is almost twice that of white oils. Testing has shown PAG base oils have a service life five times longer than white mineral oils [7]. In addition to longer service life, there is evidence that synthetic H1 oils do a better job of protecting metal surfaces from corrosion and wear and withstand greater temperature extremes required around freezers or ovens.

25.6.2 Acceptable Food-Grade Additives and Thickeners

Often basestocks are not able to meet the severe demands required in food processing work environments. To improve the performance characteristics of base oils, additives are blended into the formulation. The types of antioxidants, corrosion inhibitors, antiwear, extreme pressure additives, and concentration are limited by 21 CFR 178.3570.

TABLE 25.5 Canned, Preserved, and Frozen Fruits and Vegetables

Peelers/pitters/huskers	
Greased bearings/slides	NLGI No. 2 Grease
Oiled bearings	ISO 46 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Snippers	
Greased bearings/slides	NLGI No. 2 Grease
Oiled bearings	ISO 46 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Graders/food washers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Blanchers — initial cooking	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Grinders/blenders/finishers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hammer mill	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil
Baggers/sealers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Air Line Lubes	ISO 100 R&O or AW Oil
Depalletizers/palletizers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Air Line Lubes	ISO 46 R&O or AW Oil
Can-jar washers	
Greased bearings	
Enclosed gears	
Chains/open gears	
Can-jar filters	
Greased bearings/valves	NLGI No. 2 Grease
Oiled bearings/valves	ISO 100 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Centrifuges	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 100 R&O or AW Oil
Chains	NLGI No. 2 Grease Spray
Presses	
Geared bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Cookers/coolers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil
Chains	NLGI No. 2 Grease Spray
Freezing tunnels	
Greased bearings	NLGI No. 2 Grease
Hydraulics	ISO 46 R&O or AW Oil
Chains	NLGI No. 2 Grease Spray
Vacuum filters/evaporators	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Homogenizers/pasteurizers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil or ISO 460 Gear Oil
Fluid drive	ISO 46 R&O or AW Oil
Hydraulics	ISO 68 R&O or AW Oil
Can closers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Labelers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Can-jar packers/casers/uncasers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Conveyers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray

(*Continued*)

TABLE 25.5 Continued

Can-jar coolers		*Pumps*	
Greased bearings	NLGI No. 2 Grease	Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil		
Chains/open gears	NLGI No. 2 Grease Spray		
Jar cappers			
Greased bearings	NLGI No. 2 Grease		
Enclosed gears	ISO 220 Gear Oil		
Chains	NLGI No. 2 Grease Spray		

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Greases are lubricating oils that have a thickening agent added to the formulation. Approved grease thickeners include aluminum stearate, aluminum complex, organo clay, and polyurea [10]. Aluminum complex is the most common H1 food-grade grease thickener. They can withstand high temperatures and are water resistant, which are important properties for food processing applications. Greases with calcium sulfonate thickeners have not been explored for approval by the USDA or FDA, but has been approved in Canada for incidental contact [11].

The list of approved base oils, additives, and thickeners for H1 incidental contact with food is available in Table 25.2.

25.7 Selecting What Machines Require Food-Grade Lubricants

Selecting whether to use an H1 or H2 lubricant can be challenging. As previously mentioned, H1 lubricants are permitted where incidental contact might be possible, whereas an H2 lubricant is only permitted where there is no possible contact with the food product. For example, a lubricant used on a conveyor system running over a food line must be an H1 category oil, while a conveyor system running underneath a food line may use either an H1 or H2 lubricant. Because H1 lubricants are limited by types of additives and in the past only used mineral oil basestocks, H1 lubricants in certain instances provided less protection and shorter lubricant life. Now that synthetics are used, some H1 lubricant performance can exceed nonfood-grade lubricants. This is highly significant in allowing consolidation and avoiding accidental cross-contamination of H1 and H2 oils, and contamination of H2 oils with food [7].

Tables 25.3 through 25.9 are designed as a quick reference for some food processing applications generic for several types of industries [12]. The specific application should be checked to verify the lubricant grade or viscosity. The tables do not identify whether to use an H1 or H2 lubricant. It is ultimately the food-processing plant's decision to determine whether an H1 is required or if an H2 lubricant is allowable.

25.8 Selecting an H1 Food-Grade Supplier [13]

Finding the right lubricant supplier is as important as selecting the right lubricant. It is important to find a food-grade lubricant supplier that understands specific applications and requirements. Also, a supplier can serve as a part of the maintenance department, to help educate staff on lubrication maintenance and provide training to get the most performance and service life possible out of the lubricant. Other important qualities of a lubricant supplier are product consolidation, oil analysis, on-time delivery, speedy response to questions, and ability to tailor products to client needs.

TABLE 25.6 Dairy Products

Separators/clarifiers	
Enclosed gears	ISO 100 R&O or AW Oil or ISO 220 Gear Oil
Homogenizers/pasteurizers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil or ISO 220 Gear Oil
Hydraulics	ISO 46 R&O or AW Oil
Tank-vat agitators	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Fillers/cappers	
Geared bearings	NLGI No. 0 or 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Packagers	
Geared bearings	NLGI No. 0 or 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Dryers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Powder baggers/bag closers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Mixers/hammers/mills/vibrators	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil
Dust collectors	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 100 R&O or AW Oil
Liquifiers	
Greased bearings	NLGI No. 2 Grease
Thermutators	
Greased bearings	NLGI No. 2 Grease
Labelers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Casers/packers/stackers/destackers	
Geared bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Guides	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Air Line Lube	ISO 46 R&O or AW Oil
Cheese fillers/presses	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Slides	ISO 100 R&O or AW Oil
Cams	NLGI No. 2 Grease Spray
Butter churns/boats	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Hydraulics	ISO 46 R&O or AW Oil
Rear leg	ISO 68 Turbine Oil
Centrifuges	
Oiled bearings	ISO 100 R&O or AW Oil
Fruit feeders	
Hydraulics	ISO 46 R&O or AW Oil
Ice cream freezer	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Valves	ISO 46 R&O or AW Oil
Ice cream fillers	
Greased bearings	NLGI No. 2 Grease
Slides	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Clutches	ISO 68 Turbine Oil
Conveyers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pumps	
Greased bearings	NLGI No. 2 Grease

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TABLE 25.7 Fat and Oil Products

Expellers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Bean cleaners/shakers/dehullers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Dryers/condensers/coolers/toasters	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chain/open gears	NLGI No. 2 Grease Spray
Crackers/grinders/hammer mills	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Flakers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Solvent extractors	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Centrifuges	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Mixers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Dust collectors	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Conveyors	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pumps	
Greased bearings	NLGI No. 2 Grease

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25.9 Global Trends [2]

USDA H1 and H2 still stand as a recognized approval for food and drug suitability. In fact, many lubricant manufacturers still aspire to the USDA H1 and H2 categories and approval process, and supply certification from their boards of directors to guarantee that claim.

However, efforts chaired by Klüber Lubricants of Germany led to the creation of a new standard, DIN V 0010517, 2000-08 (Food-grade Lubricants — Definitions and Requirements). This standard has since been approved at a higher DIN level.

This German standard has been submitted by DIN as a draft to ISO in Geneva. It may take several years from the date the application is accepted for an international standard to be released.

NSF has evolved globally to succeed the USDA. NSF International, The Public Health and Safety Company™ , has been committed to public health, safety, and protection of the environment for more than 55 years. NSF has earned the Collaborating Center designations by the World Health Organization (WHO) for both food safety and for drinking water safety and treatment. It is conceived and administered as a public service organization serving as an independent and neutral body to resolve issues between regulatory bodies, business, industry, and the public.

The DIN standard V 0010517, 2000-08 has also been adopted by ELGI and NLGI as their guideline.

TABLE 25.8 Grain Mill Products

Milling separatos/degerminators	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Shakers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Washers/cleaners	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Dryers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Evaporators	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Ovens/cookers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Package fillers/baggers/bag closers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 46 R&O or AW Oil
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Mixers/blenders	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pellet mills — feed processing	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 100 R&O or AW Oil ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Coolers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Tempering bins	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Grinding mills/hammer mills/comminuters/crumblizers	
Geared bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Adjusting screws	NLGI No. 2 Grease Spray
Sifters	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Loaf molders/extruders	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Dough mixers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Centrifuges/filters/oil extractors	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil or ISO 220 Gear Oil
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Dust collectors	
Greased bearings	NLGI No. 2 Grease
Conveyors	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pumps	
Greased bearings	NLGI No. 2 Grease

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TABLE 25.9 Meat, Seafood, and Poultry

Parts washers/scalders	
Greased bearings	NLGI No. 2 Grease
Feather pickers	
Greased bearings	NLGI No. 2 Grease
Smoke houses/ovens	
Greased bearings	NLGI No. 2 Grease
Linkage	NLGI No. 2 Grease Spray
Open gears	NLGI No. 2 Grease Spray
Cookers	
Greased bearings	NLGI No. 2 Grease
Linkage	NLGI No. 2 Grease Spray
Open gears	NLGI No. 2 Grease Spray
Grinders/disintegrators	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Pickling injectors	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Can washers, fillers and closers/labelers/packers/wrappers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Air Line Lube	ISO 46 R&O or AW Oil
Rehangers/neck breakers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Hydraulics	ISO 46 R&O or AW Oil
Eviscerators/remove entrails	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Hydraulics	ISO 46 R&O or AW Oil
Mixers/mincers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains/open gears	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Meat saws/meat and bacon slicers/peelers/skinners/chippers/venters	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Air Line Lube	ISO 46 R&O or AW Oil
Sausage linkers/frank machines/patty machines	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 100 R&O or AW oil or 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Stuffers	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 100 R&O or AW Oil or 220 or 460 Gear Oil
Chains	NLGI No. 2 Grease Spray
Centrifuges/separators/dryers/filters	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Air Line Lube	ISO 46 R&O or AW Oil
Graders/deboners	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Freezers	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Hydraulics	ISO 46 R&O or AW Oil
Conveyors	
Greased bearings	NLGI No. 2 Grease
Oiled bearings	ISO 100 R&O or AW Oil
Enclosed gears	ISO 220 Gear Oil
Chains	NLGI No. 2 Grease Spray
Pumps	
Greased bearings	NLGI No. 2 Grease

TABLE 25.9 Continued

Gizzard machines/lung pullers/neck skin cutters/venters	
Greased bearings	NLGI No. 2 Grease
Enclosed gears	ISO 220 or 460 Gear Oil
Hydraulics	ISO 46 R&O or AW Oil

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25.10 Religious Organizations Influence in Food-Grade Lubricants

The Muslim and Jewish religions further restrict the formulation of food-grade lubricants. Today, there are approximately 14 million Jews and 1.3 billion Muslims worldwide [14]. Both religions have rules covering aspects of food processing.

"Kosher for Pareve," or Kosher, is the term used to describe Jewish dietary laws. Kosher law is approved by several rabbinic orders. In the United States, the Orthodox Union and the Organized Kashrus Laboratories are major approval organizations active in the approval of food-grade lubricants. Kosher law outlaws the use of pork and pork by-products. Kosher law also prohibits any mixing of meats and dairy and eggs. Any equipment must be properly cleaned and left idle for 24 h before and after making kosher foods [1].

Under Islamic law, "Halal," meaning lawful or permitted in Arabic, laws are imposed on their food products. In the United States, the Islamic Food and Nutrition Council of America issues Halal Certificates. Similar to Kosher laws, Halal foods exclude the use of pork and pork by-products. Also, Halal excludes the use of alcohol in its products, which potentially limits some of the additives used in food-grade lubricants [1].

25.11 Conclusions

The food and beverage processing industries with respect to food-grade lubricants has changed dramatically within the last five years. Understanding the differences between H1, H2, and H3 lubricants and making the proper lubricant selection is critical to food safety and machine reliability. As an additional source, NSF's website provides lubricant requirements for food-grade products and gives a free access listing of certified food-grade lubricants on their website at www.nsfwhitebook.org.

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