



Waukesha

ALL

SERVICE BULLETIN

TOPIC: Lubrication System
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SUBJECT: Waukesha® Oil Recommendations

MODELS AFFECTED: All Waukesha Engines

SUMMARY

Use this service bulletin to identify the oil needs and specifications of all Waukesha engines. Listing is by current production model and fuel type.

This bulletin revision provides Waukesha's current lubricating oil recommendations as a guideline.

TABLE OF CONTENTS

TOPIC	PAGE
Information And Instructions	1
Lubricating Oil Performance	1
Oil Designations.....	2
Oil Additives	2
Oil Recommendations.....	2
Catalyst Contaminants.....	2
Oil Filtration Requirements	2
Extended Oil Drain Intervals	3
Waukesha Cogeneration Installations	3
Waukesha APG 220GL Installations.....	3
Sour Gas, Digester Gas, And Landfill Gas Recommendations.....	4
Recommended Oil For Landfill Gas Applications	4
Recommendations For Fuel Gas Filtration Of Solids And Liquids	5
Used Oil Testing And Condemnation Limits Table	7
Oil Condemning Limits.....	8
Oil Viscosity Selection.....	9
Multi-Viscosity Oils.....	9
Synthetic Oils.....	9
Low Ambient Temperature Operation.....	9
For 220GL Applications	9
Oil Consumption Guidelines	10
Recommended Oil Change Intervals	10
Oil Change Interval Tables	11-12
Duty Cycle Definitions.....	12
Formulas For Determining Oil Consumption Rates	12

INFORMATION AND INSTRUCTIONS

Waukesha engines are heavy duty industrial type engines and require heavy duty lubrication oils. The basic requirements are high lubricating quality, high thermal stability, and good control of contaminants.

Waukesha's engine product line consists of industrial engines, from the VSG™ through the 16V-AT27GL spark ignited gas engines. With this wide product line, the lubrication oil requirements and systems change greatly between each model and fuel type.

LUBRICATING OIL PERFORMANCE

 **CAUTION** The performance of a lubricant, like that of any manufactured product, is the responsibility of the refiner and supplier.

Waukesha Engine strongly recommends monitoring the condition of the oil through the use of a good oil analysis program.

There are hundreds of commercial crankcase oils marketed today. Engine manufacturers or users cannot completely evaluate the numerous commercial oils. The current edition of the *EMA Engine Fluids Data Book* is available for purchase from:

Engine Manufacturers' Association
Two North LaSalle Street
Chicago, IL 60602
Phone: (312) 827-8700
Fax: (312) 827-8737
Email: ema@enginemanufacturers.org
www.enginemanufacturers.org

This document provides a tabulation of global lubricant producers and marketers, together with the performance classification for which the producers have indicated their products are qualified.

The Waukesha Engine Warranty is limited to the repair or replacement of parts that fail due to defective material or workmanship during the warranty period. The Waukesha Warranty does not include responsibility for lubricating oil performance.

With the exception of cogeneration, the 220GL products, and special or prototype installations, Waukesha Engine has made it a practice not to recommend oil by brand name.

OIL DESIGNATIONS

Oil is designated in several ways: American Petroleum Institute (API), Society of Automotive Engineers (SAE), American Society for Testing and Materials (ASTM) performance classifications and Military Designation. Since no gas engine industry oil performance designations exist, it is the responsibility of the engine operator to verify with their oil supplier, that the oil they select has proven field performance in their specific engine make and model. This oil must also meet the minimum requirements specified by Waukesha as listed in Table 1.

OIL ADDITIVES

Quality oils formulated specifically for natural gas engines have sufficient additives to meet requirements. Waukesha does not recommend the addition of oil additives to these quality oils.

OIL RECOMMENDATIONS

Waukesha recommends the use of oil formulated specifically for gas engines and meeting minimum ash requirements based on engine makes and models (see Table 1). The ash forming constituents in oil formulations provide detergency, corrosion protection, and anti-wear protection. In addition, the ash produced during combustion of these additives will provide protection against valve face and seat recession.



CAUTION Waukesha engines use specifically formulated gas engine oils. Waukesha Engine does not recommend gasoline or diesel oil formulations for use with its engines. Use of gasoline or diesel oil formulations may cause severe engine damage.

CATALYST CONTAMINANTS

The following contaminants are known catalyst deactivators and should be avoided when selecting lubricating oils for installations with catalysts since they contribute to shortened catalyst life: heavy and base metals such as lead, mercury, arsenic, antimony, zinc, copper, tin, iron, nickel, chrome, sulfur, and phosphorus. These individual elements should not exceed 1 ppm or collectively exceed 5 ppm at the catalyst inlet. Specific exceptions: phosphorus or silicon compounds at the catalyst inlet are not to exceed 1 ppm and sulfur compounds at the catalyst inlet are not to exceed 100 ppm.

Do not confuse the concentration of these elements *AT THE CATALYST INLET* with the concentration of these elements in the oil itself.

Table 1. Oil Recommendations By Engine Model

MODEL	SULFATED ASH% ^(1, 2, 3)
VSG SERIES GAS ENGINES	
VSG F11 G, GSI, GSID	0.35 – 1.0
VGF SERIES GAS ENGINES	
VGF F18, H24, L36, P48 G, GL, GLD/GLD/2	0.45 – 0.75
VGF F18, H24, L36, P48 GSI, GSID	0.35 – 0.50
VHP SERIES GAS ENGINES	
VHP F2895, F3521, L5790, L7042, P9390 G, GSI, GL	0.35 – 1.0
VHP F3524, L5794, L7044, GSI, L5774, LT	0.45 - 0.75
AT25/27GL SERIES GAS ENGINES	
8L, 12V, 16V, GL	0.35 – 1.0
APG SERIES GAS ENGINES	
16V150LTD, 12V220GL, 18V220GL	0.4 – 0.5

NOTES: (1) Oils must be specifically formulated for gas engines using highly refined mineral oil base stocks. The ash requirements are a percentage by weight with both metallic and ashless additive systems. A maximum of 0.10% zinc is recommended.
(2) Oil with 0.35% ash or less may be used in naturally aspirated and catalyst equipped naturally aspirated or turbocharged engines with the understanding that valve recession may occur, thus shortening the normally expected valve and seat life.
(3) Use 1.0% ash oil for the VHP and AT engines only if needed due to higher than normal valve recession rates.

OIL FILTRATION REQUIREMENTS

The quality of oil filtration will directly affect engine component life.

Waukesha's basic filtration requirement is 90% efficient at 15 microns for all full flow sock and paper elements, and 98% efficient at 25 microns for fiberglass disposable and cleanable full flow metal mesh elements. **Mesh or screen sizes larger than 25 microns are not acceptable.**

Oil filter elements should be changed when the oil is changed or when the pressure drop across the oil filter exceeds values stated in the specific engine maintenance manuals.

Waukesha's complete oil filter performance specification is shown in Waukesha specification sheets S08486 and S08486-1.

EXTENDED OIL DRAIN INTERVALS

Extended oil drain intervals are not recommended unless a Waukesha Microspin centrifuge as well as Waukesha-supplied oil filtration components are installed. The Microspin centrifuge, in conjunction with Waukesha-supplied oil filtration components, will remove by-products of combustion, allowing an increase in scheduled oil drain and oil filter element change intervals. See Table 11 and Table 12 for the maximum number of hours between normal and extended oil drain and oil filter element change intervals.

It is recommended that oil analysis be used to determine oil change intervals, when condemning limits are reached (see Table 5). Follow the oil change interval recommendations and engine oil hours in Table 11 if oil analysis cannot be used.

WAUKESHA COGENERATION INSTALLATIONS

Waukesha Engine does not ordinarily recommend oils by brand name. However, based on actual field experience, the oils listed in Table 2 are specified for cogeneration installations with forced hot water cooling systems 212 – 265° F (100 – 129° C) or ebullient cooling 250° F (121° C).

It is especially important that the engine oil used in cogeneration applications utilize base stocks with good thermal stability. The products listed in Table 2 have a minimum of 4000+ hours of experience, and will perform satisfactory in high temperature cooling system applications.

Additional engine oils may be added to the above list provided they meet the following criteria:

- Used in similar applications 212° F (100° C) to 265° F (129° C) jacket water temperatures.
- Minimum of 6 months operation. Documented with engine inspection data.
- No signs of oil degradation or lacquering problems (based on normal oil change interval, the engine should be clean).

Table 2. Recommended Oils For Cogeneration Applications (Using Pipeline Quality Gas)

BRAND	TYPE	PERCENT OF SULFATED ASH
Chevron HDAX Low Ash	SAE 40	0.50
Estor Super Exxon Co. USA Exxon Co. International	SAE 40	0.45
Estor Elite (Synthetic) Exxon Imperial Oil Exxon Co. USA	SAE 20W40	0.45
Estor Select 40 Esso Imperial Oil Exxon Co. USA	SAE 40	0.95
Mobil Pegasus 1 (Synthetic)	SAE 15 W40	0.51
Mobil Pegasus 905	SAE 40	0.54
Mobil Pegasus 805	SAE 40	0.54
Mobil Pegasus 710 (89)	SAE 40	0.94
Petro Canada, CG40	SAE 40	0.73
Q8 Mahler HA (Europe only)	SAE 40	0.90
Q8 Mahler MA (Europe Only)	SAE 40	0.55
Shell Mysella MA SIPC (Outside USA only)	SAE 40	0.90
Petro Canada Sentron LD5000	SAE 40	0.57
Shell Mysella XL	SAE 40	0.50
Repsol YPF Vectis LA-540	SAE 40	0.50

WAUKESHA APG 220GL INSTALLATIONS

Waukesha Engine does not ordinarily recommend lube oils by brand name for specific products. However, based on actual field experience, the oils listed in Table 3 are specified for all 220GL installations.

Table 3. Recommended Oils For All 220GL Applications (Using Pipeline Quality Gas)

BRAND	TYPE	SULFATED ASH (%w) ASTM D874
Total Nateria MH 40	SAE 40	0.45
Total Nateria P 405	SAE 40	0.42
Total Nateria X 405 (Synthetic)	SAE 15W40	0.45
Mobil Pegasus 705	SAE 40	0.49
Mobil Pegasus 805	SAE 40	0.54
Mobil Pegasus 905	SAE 40	0.54
Mobil Pegasus 1 (Synthetic)	SAE 15W40	0.51
Shell Mysella LA	SAE 40	0.45
Texaco Geotex LA	SAE 40	0.45

It is especially important that the engine oil used in APG 220GL applications utilize virgin base stocks with good thermal stability. The products listed in Table 3 are known to give satisfactory performance in high temperature cooling system applications.

Contact Waukesha Engine for potential additions to the list of approved 220GL oils.

SOUR GAS, DIGESTER GAS, AND LANDFILL GAS RECOMMENDATIONS

 WARNING

Waukesha Engine assumes no liability or responsibility for damage to the environment or severe personal injury caused by using landfill gases or sour gases. It is the customer's sole responsibility to carefully analyze any gases they choose to use. Use of these gases is at the customer's own risk and could result in severe personal injury or death.

Alternate fuel sources are attracting increasing interest today as a low cost fuel or because of environmental concerns. Waukesha, being the leader in developing engine systems to accommodate these alternate fuels, is aware of problems due to sulfur compounds (H₂S, etc.), siloxanes, and halide constituents in these fuels. Hydrogen sulfide (H₂S), siloxanes, and total organic halide as chloride (TOH/CI) bring with them totally different problems to the engine and lubricating oils.

Waukesha has limited fuel trace gases to the following:

- Sulfur bearing compounds (H₂S, etc.) content in fuel gas to 0.1%, (1000 ppm) by volume. However, it is not unusual to encounter biomass gas or field gas with much higher percentages of sulfur bearing compounds (H₂S, etc.). Gas exceeding 0.1% sulfur bearing compounds must be treated.
- Maximum organic halide content, expressed as chloride, (TOH/CI) in landfill gas is limited to 150 micrograms per liter (µg/l).
- Maximum liquid fuel hydrocarbons at the coldest expected engine mounted regulator fuel outlet temperature are limited to 2% total by gaseous volume.
- Maximum permissible free hydrogen content is 12% by volume.
- Maximum total siloxanes for engine models is 25µg/l. If greater than 25µg/l total siloxanes are present, fuel treatment is required.
- Liquid water and glycol are not permitted in the fuel gas.

When dealing with halogens or halogen compounds in landfill gas, the subject becomes far too complicated to address here as it relates to the selection of a lubricating oil, used oil analysis, and drain interval. It follows that those customers operating on landfill gas review Waukesha Engine's Fuel Specification S7884-7 (or current revision) to fully understand the ramifications of operating an engine on landfill gas. This document (as well as Service Bulletin 9-2701 or latest revision) prescribes specific fuel gas sampling techniques, fuel gas analysis, handling of abrasive fuel constituents, and limitations on total organic halide as chloride, to achieve reasonable engine life. Lubricating oil requirements change as the TOH/CI increases.

RECOMMENDED OIL FOR LANDFILL GAS APPLICATIONS

Table 4. Recommended Oils for Landfill Gas Applications

BRAND	TYPE	PERCENT OF SULFATED ASH
Mobil Pegasus 610 (446)	SAE 40	0.98
Mobil Pegasus 605 (426)	SAE 40	0.48
Chevron HDAX LFG	SAE 40	0.71

Waukesha recommends lubricating oils specifically formulated for landfill gas. However, care must be taken that oils formulated for a particular fuel type not be used beyond their recommendations. When used outside of their recommendations, some landfill gas formulated oils can cause excessive build-up of abnormal ash deposits in the combustion chamber. These recommended engine oils (see Table 4) should only be used with engines using landfill gas and never with engines using digester gas.

The best approach would be to filter or absorb corrosives in the fuel gas before they reach the engine. There are increasing claims for filtration and absorption by various companies manufacturing and promoting these types of products. Waukesha makes no endorsement of these products or service. Their performance is solely the responsibility of the manufacturers.

RECOMMENDATIONS FOR FUEL GAS FILTRATION OF SOLIDS AND LIQUIDS

Solid Particulate Removal:

Coalescer shall have an absolute rating of 5 microns (0.3 microns for landfill applications) for solid particulate removal.

Liquid And Aerosol Removal From Fuel Gas:

Coalescer shall remove entrained liquid and aerosol contaminants of 0.3 μm (micron) or larger.

- Fuel gas compressor lubricating oil carryover must be removed from the fuel stream. A coalescing filter with a 0.3 micron rating is adequate in most cases. Even though this oil is hydrocarbon based and combustible, it contains an additive package with calcium and other undesirable elements and compounds. Failure to remove this carryover oil can lead to fuel regulator problems, excessive spark plug and combustion chamber deposits, cylinder varnish, ring sticking, and other problems.
- Liquid water is not allowed in the fuel because it frequently results in fouling and corrosion. Particular attention must be paid to landfill and digester gases since these gases are commonly received saturated with water. Due to extremely small clearances in the admission and check valves, absolutely no water can be tolerated in a prechamber fuel system. To insure that no liquid water forms in the fuel system, Waukesha specifies that the dew point of the fuel gas should be at least 20° F (11° C) below the measured temperature of the gas before all engine mounted regulators and engine remote regulator pilot valves (if so equipped). On engines without prechamber fuel systems, saturated, (100% relative humidity) fuel gas at the carburetor inlet is acceptable. A 0.3 micron coalescing filter will remove any liquid water droplets being carried along with the fuel stream. The water content of the gas can then be reduced to an acceptable level by several methods.
 - Condensation of excess moisture by refrigerating the fuel gas to no higher than 40° F (4° C) followed by filtering to remove the liquids and reheating of the gas to 85 – 95° F (29 – 35° C). This process will also remove significant amounts of halogenated and heavy hydrocarbons and volatile siloxanes.
 - Selective stripping with a chemical process, such as Selexol™.

C. By heating: If the gas is 30° F (17° C) or more **above** the ambient temperature, it can be cooled by passing it through a heat exchanger or refrigeration system, then reheated, in a manner similar to Step A. If the gas is 20° F (11° C) or more below the ambient temperature, it can be heated. In both cases, the fuel system after the heating operation should be insulated. Heating of the fuel gas is limited to the maximum allowable temperature of 140° F (60° C).

- Glycol is not permitted in fuel gas because it can affect the engine in adverse ways. The lubricating qualities of the oil may be reduced, resulting in bearing failure, piston ring sticking, excessive wear, and other problems. A 0.3 micron rated coalescing filter will remove liquid glycol from the fuel stream.

Design Criteria:

A Coalescer Filter Housing is to be of the cylindrical type, vertically mounted. The housing shall contain two sump chambers, such that the lower sump collects heavier liquid dropouts immediately downstream of the gas inlet, while the upper sump collects liquids draining off the coalescer cartridge(s).

The coalescer design shall use an inside to outside gas flow path through the coalescer cartridge.

Recommended Coalescing Filter:

Pall Process Filtration Company
Model CC3LG7A

The following recommendations will minimize corrosion problems normally encountered with fuel gas containing H_2S and TOH/Cl:

Recommendation #1

Select a gas engine lubricating oil with a high alkalinity reserve, 7 to 13 TBN (Total Base Number). Alkalinity reserve in the oil is measured in TBN. The higher the TBN, the more reserve.

Contact your oil supplier or consult the *EMA Engine Fluids Data Book* for an appropriate choice. Also follow the appropriate ash content percent by weight for the specific engine model.

Recommendation #2

Analyzing “used” oil is mandatory for alternate fuel applications. Oil change periods are determined by TBN, TAN (Total Acid Number), oxidation, and nitration level in the used oil samples. The user must change the oil when the TBN level falls to 30% of the new oil value or TAN increases by 2.5 – 3.0 above the new oil value. The method of measuring TBN in used oil is shown in Table 5.

DEXSIL® Corporation has developed the Q2000 field test kit. This kit is used to determine the chlorine contamination of engine oil exposed to chlorine containing fuels, as in landfill gas. This field test kit is highly accurate and allows the operator to obtain timely test results in the field. The oil must be sampled every 50 hours, in order to establish a “trend.” Waukesha has experienced good results with this kit. Order information may be obtained from DEXSIL® Corporation, One Hamden Park Drive, Hamden, CT 06517.



CAUTION TOH/CI does not affect TBN levels the same as sulfur compounds. Therefore, the 30% TBN depletion (50% TBN depletion on 220GL engines) as an indicator of a change interval only applies to the applications where fuel gas does not contain halides. Disregarding this information could result in product damage and or personal injury.

Recommendation #3

Increase the jacket water temperature to 210° – 235° F (99° – 113° C) and oil temperatures to 185° – 200° F (85° – 93° C). The AT series engines are limited to a maximum of 180° F (82° C) oil temperature. The 220GL series engines are limited to a maximum of 212° F (100° C) jacket water outlet temperature, and 167° F (75° C) oil inlet temperature. Increased temperatures will reduce condensation, which will reduce the concentration of acids within the crankcase. High temperature thermostats are available for most models.

If you have any question on lubricants to be used with alternate fuel gases, contact the Field Service Department or Sales Engineering Department prior to selecting a lubricating oil.

Table 5. Used Oil Testing And Condemnation Limits

ANALYSIS METRICS	STANDARD TEST METHOD USED	CONDEMNING LIMITS	
		APG 220GL	ALL OTHER WAUKESHA ENGINES (And non specified APG220GL)
WEAR METALS:			
Iron (Fe)	ASTM D5185	30 ppm max	Wear Metals By Trend Analysis [Investigate source(s) of rising wear metal(s). Change oil based upon analysis report recommendations.]
Aluminum (Al)		10 ppm max	
Copper (Cu)		15 ppm max	
Lead (Pb)		20 ppm max	
Tin (Sn)		10 ppm max	
Chromium (Cr)			
Nickel (Ni)			
Silver (Ag)			
Titanium (Ti)			
CONTAMINANTS:			
Silicon (Si)	ASTM D5185	20 ppm max	By Analysis Report Recommendations
Sodium (Na)			Any detectable amount as coolant leak indicators
Potassium (K)			
Chlorine (Cl)		900 ppm	
MULTI-SOURCE:			
Boron (B)	ASTM D5185		Multi-source by Analysis Report Recommendations (if contaminant)
Molybdenum (Mo)			
Antimony (Sb)			
Manganese (Mn)			
ADDITIVES:			
Magnesium (Mg)	ASTM D5185		Additive levels are information only
Calcium (Ca)			
Barium (Ba)			
Phosphorous (P)			
Zinc (Zn)			
Soot	FTIR		Above 2.5% by vol.
Water %	ASTM D1744 Karl Fish	Above 0.3% wt.	Above 0.1% by wt.
Glycol (pos/neg)	ASTM D2982		Any detectable amount
Viscosity (40° C)	ASTM D445	+50% change	-20 / +30% change
Viscosity (100° C)		+25% change	
TAN	ASTM D664	2.5 rise over new oil (See <i>Note 1</i> on next page)	3.0 rise over new oil (See <i>Note 1</i> on next page)
TBN	ASTM D2896 (new oil)	Drop to 50% of new oil TBN (See <i>Note 1</i> on next page)	Drop to 30% of new oil TBN (See <i>Note 1</i> on next page)
	ASTM D4739 (used oil)		Not applicable to TOHCL
Oxidation	40 Abs/cm Peak Height Method		
Nitration			
Oxidation	ASTM E2412 (FTIR) (no fresh oil ref. needed)	25 Abs @ 1700 cm ⁻¹	25 Abs @ 1735 cm ⁻¹ Peak Area Method
Nitration		20 Abs @ 1625 cm ⁻¹	25 Abs @ 1625 cm ⁻¹ Peak Area Method
Flash Point	ASTM D92 (Cleveland Open Cup)		356° F (180° C)
Particle Counts:			Maximum Monitored Levels (See <i>Note 2</i> on next page)
ISO Code	ISO 4406		25/24/20
4 micron	ISO 11500		160,000 particles/ml
6 micron			80,000
10 micron			30,000
14 micron			5,000
21 micron			1,000
38 micron			100
70 micron			12
100 micron			8

With natural gas fuels engine oil samples should be taken based on trend experience or @ 500 hours maximum.

Note 1: Sweeten the oil sump by adding new oil when TBN level falls below TAN level so the oil can continue to neutralize acids. Resample sweetened oil to verify proper TAN/TBN levels. If TAN/TBN condemning limits are reached and sump sweetening is not done, the oil must be changed to re-establish proper oil alkalinity protection from acid formation.

Note 2: Do not condemn the oil based solely on particle count levels unless a severe rise in any micron level occurs in the 500 hour oil sample analysis. Inspect the engine filtration system (improperly seated elements, holes in elements, a stuck open filter bypass valve, a non functional centrifuge, etc.) if an early hour excessive rise is seen in particle counts. Longer term, consider other oil condemning units with rising particle counts in the decision to change oil and filters.

OIL CONDEMNING LIMITS

WARNING

Engine oil is extremely hot and is under pressure. Use caution when sampling engine oil for analysis. Failure to follow proper procedures could cause severe personal injury or death.

Lubricating oil condemning limits are established by the engine manufacturer's experience and/or used oil testing.

Laboratory testing will determine the used oil's suitability for continued use. Used oil testing should cover the data shown in Table 5.

The engine oil sample should be drawn before the full flow oil filters with the oil at operating temperature. Insure the sample valve outlet is clean before the sample is drawn. This insures the oil sample is not contaminated by debris of the sample valve outlet.

CAUTION

Actual oil change intervals to be determined by engine inspection and oil analysis in conjunction with the condemning limits. Disregarding this information could result in product damage.

In the interest of developing a reasonable life expectancy for Waukesha engines operating on fuel gas laden with some level of halogens, our experience dictates the following:

- To achieve the life expectancy of an engine operating on pipeline quality natural gas, remove all halogen compounds and abrasives from the fuel gas.
- Reasonable life can be expected if Total Organic Halide as Chloride Concentration (TOH/Cl) of the fuel does not exceed 150 micrograms per liter ($\mu\text{g/l}$). Total Organic Halide as Chloride (TOH/Cl) equals the sum of all halogenated compounds expressed as chloride in micrograms/litre ($\mu\text{Cl/L}$) at Standard Temperature and Pressure (STP). Reasonable life can also be expected with increased maintenance and operating adjustments to the engine.

- Typical changes in maintenance and operation at this level are:

- Decreased oil change interval (150 hours to start).
- Condemn oil when 900 ppm chlorine is reached. This will aid in establishing an oil change interval.
- Oil analysis every 50 hours maximum.
- Elevated jacket water temperature 212 – 235° F (100 – 113° C).
- Elevated oil temperature to 185 – 200° F (85 – 93° C). 180° F (82° C) maximum for AT models, and 167° F (75° C) for 220GL models.
- Use of high TBN oil (7.0 – 13.0).
- Bypass lubrication oil filtration. Waukesha Engine has introduced the Microspin cleanable oil filtering system. The Microspin system uses the cleaning capabilities of a centrifuge, coupled with cleanable filter elements. The Microspin system uses Waukesha's current oil filtration canister for the cleanable elements. The centrifuge is installed as a bypass system, working in conjunction with the cleanable filter elements. The Microspin centrifuge can also be used with standard filter elements.

- TOH/Cl above 150 micrograms chloride/litre require pre-treatment of the fuel in order to make it suitable for use in a reciprocating engine.

DEXSIL® Corporation has developed the Q2000 field test kit, as a test for chlorine contamination of engine oil exposed to chlorine containing fuels, as in landfill gas. This field test kit is highly accurate and allows the operator to obtain timely test results in the field. The oil must be sampled every 50 hours, in order to establish a "trend." Waukesha has experienced good results with this kit. Order information may be obtained from DEXSIL® Corporation, One Hamden Park Drive, Hamden, CT 06517.

OIL VISCOSITY SELECTION

The operating temperature of the oil in the sump or header is the best guide for selecting the proper SAE grade of oil. When the oil temperature is unknown, add 120° F (67° C) to the ambient temperature to obtain the estimated sump oil temperature.

Table 6. VSG Sump Temperature And SAE Number

SUMP TEMPERATURE	SAE
210 – 250° F (99 – 121° C)	40
160 – 210° F (71 – 99° C)	30

Table 7. VGF/VHP Sump And Header Temperatures And SAE Number

SUMP TEMPERATURES	HEADER TEMPERATURE	SAE NUMBER
160 - 230° F (71 - 110° C)	160 - 195° F (71 - 91° C)	40
Below 160° F (71° C)	Below 160° F (71° C)	30

Table 8. ATGL Sump And Header Temperatures And SAE Number

SUMP TEMPERATURES	HEADER TEMPERATURE	SAE NUMBER
160 - 230° F (71 - 110° C)	160 - 180° F (71 - 82° C)	40

Table 9. 220GL Sump And Header Temperatures And SAE Number

SUMP TEMPERATURES	HEADER TEMPERATURE	SAE NUMBER
172 - 194° F (78 - 90° C)	145 - 167° F (63 - 75° C)	40

NOTE: Do not operate engines with an oil header temperature below 140° F (60° C). Engines that exceed 195° F (91° C) header temperature or 215° F (102° C) sump temperature should have reduced oil change intervals based upon lube oil analysis (see Table 5).

MULTI-VISCOSITY OILS

Use multi-viscosity oils only for engines in cold starting applications. Multi-viscosity oil may deteriorate in continuous operation, allowing the oil to lose viscosity through shearing. In this state, the oil may not supply sufficient lubricating films and/or pressure. Therefore, use an oil analysis program to determine the oil change intervals.

SYNTHETIC OILS

Based on developments by oil manufacturers and the release of their synthetic lubricating oils, Waukesha Engine now recognizes these products as being suitable for all Waukesha stoichiometric ("rich burn") and lean burn gas engines. Table 2 and Table 3 lists the synthetic oils available.

When synthetic lubricating oils are selected, it is suggested contacting Waukesha Engine's Product Support or Sales Engineering Department for oil change interval recommendations if oil analysis is not done, however oil analysis is recommended by Waukesha Engine. Typically, synthetic oil change intervals are 3 to 5 times longer than those of mineral oils. Actual change intervals must be established through oil analysis and visual inspection of engine components. Typical areas to look for oil breakdown are: exhaust valve stems, piston ring area, and piston undercrown. Oil filter change intervals remain per the respective engine maintenance manual recommendations.

Synthetic oils are not recommended for digester or landfill gas application without prior approval by Waukesha Engine.

LOW AMBIENT TEMPERATURE OPERATION

At low ambient temperatures, use an oil that will provide proper lubrication when the engine is hot and working. For engines of 1000 cu. in. (16.4 L) and above, operating at ambients below 50° F (10° C), oil and jacket water heaters are required to warm oil and water for fast starting and loading of engines. Waukesha Engine will supply information on these starting devices upon request.

FOR 220GL APPLICATIONS

To avoid any troubles when starting under cold ambient conditions, and because of the extra pressure drop involved by the external circuit, it is mandatory that oil temperature in the external circuit does not fall down below 68° F (20° C).

This minimum temperature can be achieved by two different means:

- Either the external circuit (piping, control valve, and cooler) is located in a warm area where temperature never falls below 68° F (20° C), such as inside engine a building rather than outside.
- Or the external circuit is fitted with a warming system (electrical resistance or preheaters and circulation) which regulate lube oil temperature to a minimum of 68° F (20° C).

OIL CONSUMPTION GUIDELINES

Typical oil consumption rates have been updated for all Waukesha engines.

Table 10. Typical Gross Oil Consumption Rate

MODEL	LBS/HP-HR	GRAMS/HP-HR	GRAMS/KWB-HR
ALL	0.0002 – 0.002	0.091 – 0.910	0.121 – 1.22

NOTE: Oil consumption rates given above are a general guide and not meant to be used for condemning limits or determining overhaul requirements. Oil treatment, losses, and changes not included.

RECOMMENDED OIL CHANGE INTERVALS

Table 11 on page 11 is provided as a guide to engine oil change intervals when oil analysis is extremely difficult to obtain by customers/end users of Waukesha engines.

**CAUTION**

The use of some types of oil, as well as dusty environment, marginal installation, internal engine condition and/or operating the engine with malfunctioning carburetion equipment may require more frequent oil changes. Waukesha Engine recommends that the lubricating oil be monitored with a professional oil analysis program. Extended oil change intervals may cause varnish deposits, oil oxidation, or sludge conditions to appear in the engine, which an oil analysis cannot detect. Disregarding this information could result in engine damage. Contact your local Waukesha Distributor for periodic engine maintenance.

Table 11. Recommended Oil Change Intervals For Engines Receiving Normal Maintenance

ENGINE MODEL	ISO STANDARD OR CONTINUOUS POWER RATING	ENGINES OPERATED IN EXCESS OF ISO STD POWER OR PEAK SHAVING	EBULLIENT COOLED OR HOT WATER SYSTEM WITH ENGINE WATER TEMPERATURE 211° F (99° C) OR ABOVE	STANDBY DUTY
FOR ENGINES OPERATING WITH OIL SUMP TEMPERATURE OF 230° F (110° C) OR ABOVE				
VSG Series F11 Natural Gas and HD-5 Propane	Normal 720 hours ¹	300 hours	N/A	300 hours or annually
FOR ENGINES OPERATING WITH OIL SUMP TEMPERATURE OF 195° F (91° C) OR BELOW				
VGF G, GL, GLD/GLD/2 Low Capacity Natural Gas and HD-5 Propane	Normal 1000 hours (Extended 1250 hours ²)	500 hours	500 hours	500 hours or annually
VGF G, GL, GLD/GLD/2 High Capacity Natural Gas and HD-5 Propane	Normal 2100 hours (Extended 2350 hours ²)	1000 hours	1000 hours	500 hours or annually
VGF GSID, GSI Low Capacity Natural Gas and HD-5 Propane	Normal 720 hours (Extended 900 hours ²)	500 hours	500 hours	500 hours or annually
VGF GSID, GSI High Capacity Natural Gas and HD-5 Propane	Normal 1500 hours (Extended 1750 hours ²)	720 hours	720 hours	500 hours or annually
VHP SERIES Natural Gas, HD- 5 Propane	Normal 1000 hours (Extended 1500 hours ²)	500 hours	500 hours	500 hours or annually
ATGL Series Natural Gas	Normal 3000 hours (Extended 4000 hours ²) or sooner by analysis. Sample every 720 hours.		See Table 5 for condemning limits.	
APG SERIES				
16V150LTD Natural Gas	Normal 1500 hours ⁴			500 hours or annually
220GL Natural Gas	1500 hours filter 3000 hours oil ^{3,4}			500 hours or annually

NOTES: Change oil filter elements whenever oil is changed.

¹ Attainable with 15.5:1 air/fuel ratio (carburetor adjusted to 1.15% CO in the exhaust). If best economy carburetor setting, 17.0:1 – 17.7:1 air/fuel ratio (1.4 – 2.1% O₂ in the exhaust), is used, oil change hours should be reduced to 300 operating hours.

² Extended oil drain intervals listed are acceptable if a Microspin centrifuge in conjunction with a Waukesha supplied oil filtration system is utilized and an oil analysis program is followed (See Table 5), with visual inspection of power cylinder components at 4000 hrs. after start of test to determine the extended oil change interval. Part deposit inspection pass/fail criteria must hinge on acceptable industry standards of deposit evaluation of varnish, lacquer and carbon on valve stems, piston ring grooves and piston undercrown. Oil filter change intervals remain per the respective engines' maintenance manual recommendations. The extended drain interval hours shown in Table 11 above **may be exceeded** if all oil analysis metrics published in Table 5 remain within specification limits using engine oil analysis.

³ Up to 6,000 hour oil change with synthetic oil on 220GL models is possible, but only based upon lube oil analysis. Filter change intervals remain at 1,500 hours.

⁴ No overload allowed on APG engine models.

Service Bulletin No. 12-1880AB

Table 12. Recommended Oil Change Intervals for engines receiving normal maintenance and using gaseous fuel containing H₂S @ 0.1% by volume (1000 ppm) or less based upon lube oil analysis (See Table 5). An oil change is required at the TBN/TAN crossover point.

ENGINE MODEL	ISO STANDARD OR PRIME POWER RATING	ENGINES OPERATED IN EXCESS OF ISO STD POWER OR PEAK SHAVING	EBULLIENT COOLED OR HOT WATER SYSTEM WITH ENGINE WATER TEMPERATURE 211° F (99° C) OR ABOVE	STANDBY DUTY
FOR ENGINES OPERATING WITH ELEVATED OIL SUMP TEMPERATURE				
VSG SERIES	360 hours*	250 hours	N/A	250 hours or annually
VGF SERIES	360 hours*	250 hours	360 hours	250 hours or annually
VHP SERIES	360 hours*	250 hours	360 hours	250 hours or annually
NOTE: AT series engines are limited to a maximum oil temperature of 180° F (82° C)				
ATGL Series Natural Gas	500 hours or sooner by oil analysis. Sample every 100 hours.		See Table 5 for condemning limits.	

NOTES: Change oil filter elements whenever oil is changed.

*Attainable with 15.5:1 air/fuel ratio (carburetor adjusted to 1.15% CO in the exhaust). If best economy carburetor setting, 17.0:1 – 17.7:1 air/fuel ratio (1.4 – 2.1% O₂ in the exhaust), is used, oil change hours should be reduced to 300 operating hours.

Table 13. Duty Cycle Definitions

ISO STANDARD OR CONTINUOUS POWER RATING:	The highest load and speed that can be applied 24 hours a day, 7 days a week, 365 days per year, except for normal maintenance. It is permissible to operate the engine at up to 10% overload or maximum load indicated by the intermittent rating, whichever is lower, for two hours in each 24 hour period.
GENERATOR STANDBY POWER RATING:	In a system used as a backup or secondary source of electrical power, this rating is the output the engine will produce continuously (no overload), 24 hours per day, for the duration of the prime power source outage.
INTERMITTENT POWER RATING:	This rating is the highest load and speed that can be applied in variable speed mechanical system application only. Operation at this rating is limited to a maximum of 3500 hours per year.
GENERATOR PEAK SHAVING:	Peak shaving is operation of an engine for a limited time to meet short term peak power requirements. Speed, loading, and hours per year of operation will affect the recommended oil change interval.

FORMULAS FOR DETERMINING OIL CONSUMPTION RATES

The following formulas may be useful in determining whether the oil consumption rate of the engine is normal.

$$\frac{\text{LBS}}{\text{HP} - \text{HR}} = \frac{7.3 \times \text{Number of Gallons of Oil Used}}{\text{HP} \times \text{Hours of Operation}}$$

$$\frac{\text{LBS}}{\text{HP} - \text{HR}} = \frac{1.82 \times \text{Number of Quarts of Oil Used}}{\text{HP} \times \text{Hours of Operation}}$$

$$\frac{\text{Grams}}{\text{HP} - \text{HR}} = \frac{875 \times \text{Number of Litres of Oil Used}}{\text{HP} \times \text{Hours of Operation}}$$

$$\frac{\text{Grams}}{\text{kW}_b - \text{HR}} = \frac{875 \times \text{Number of Litres of Oil Used}}{\text{kW}_b (\text{corrected}) \times \text{Hours of Operation}}$$