Lubricating Australia for Over Eighty Five Years

Penrite is a 100% family owned private Australian oil company and has been in continuous operation for over 85 years. Its premium lubricants are developed and manufactured in Australia in Melbourne and Brisbane and in Bream in England – they are exported to Europe, North America, Asia and New Zealand. By maintaining constant liaison with suppliers and international partners the latest technological developments are adapted to Australian conditions, and are continually applied to Penrite products globally.

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PENRITE

A Better Class of Oil

Guide to Oils and Greases

PROUDLY AUSTRALIAN
FAMILY OWNED
SINCE 1926

2011 Edition

About Penrite

Les Mecoles made his first blend of oil as a teenager on the stove in his mother's kitchen in 1926. Les was a young man of initiative and ability and he was soon making larger and larger quantities of oil, eventually purchasing his first factory in Hoddle Street, Melbourne.

Initially, Les imported base oil from Pennsylvania – recognised at the time as the best base oils available. The finished product was supplied to workshops and garages in 44 gallon drums and due to the quality of the product and the service supplied by Penrite to their customers, the Company flourished forcing Les to move to larger premises at 3 Cross Street Brunswick, Melbourne in the early 70's.

By 1979 ill health meant Les was no longer able to run the business and he offered it for sale to John Dymond who, as the Australian Sales Manager for Lubrizol, an American Petro Chemical company, had been a supplier to Penrite for many years and had developed a firm relationship with Les and a mutual respect for the way lubricants should be produced. John, a mechanical engineer by trade and a car enthusiast at heart, eagerly accepted the offer.

John immediately began to expand the Penrite range, introducing products such as the now famous HPR 30 and HPR 50, as well as a range of lubricants specifically formulated for vintage, veteran and classic vehicles.

John's technical background and commitment to quality ensured that Penrite produced the best possible product for every application – from the highest performing vehicles to lawn mowers, from heavy-duty diesel engines to industrial gears. While the range of Penrite products continues to expand as technology advances, this philosophy implemented by John in 1979 continues with the Company to this day.

Penrite's expansion continued steadily to now see blending plants in Melbourne, Brisbane and the UK, and offices or warehouses in all capital cities and major regional centres across Australia and New Zealand.

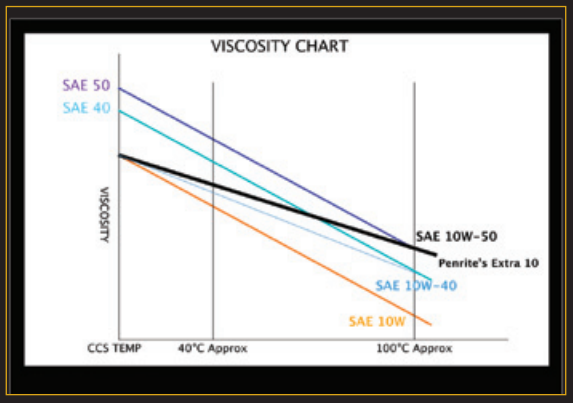
Penrite Oil Company remains proudly Australian and family owned. The Company's continual growth in Australia and expansion into New Zealand, the United Kingdom, Europe, USA and Asia can be attributed to the passion of its employees to maintain the commitment to quality of product and service that first began back in 1926.

What is Extra 10

Penrite make a Better Class of Oil. Their premium engine oils always go the Extra 10 above the industry benchmark. So if the industry recommends a 10W-30 for example, Penrite make a 10W-40. That's just another part of their commitment to making the best oil for your car.

The W number on the front of the pack tells you the viscosity of the oil at start up temperature, while the second number describes the oil's viscosity at its operating temperature. All oils thin out as they get hotter. The higher the second number, the less the oil will thin out. The thicker the oil at operating temperature, the greater the protection for your engine. Which means less wear and greater oil flow which is good news for you and your car.

Penrite make a higher rated oil for all applications, which is why they are known for their innovation and commitment to creating superior lubricants.



Oil Viscosity

SAE 10W-40

- 10W is the oil's thickness at cold. All oils of a similar number are the same base thickness or level of pumpability.
- All liquids, including oil thin out as temperature increases.
- The second number (40) is a measure of the oil's viscosity at operating temperature.
- The higher the second number, the less the oil thins out as temperature increases.
- The higher the second number, the better the level of protection provided at operating temperature.

PENRITE

A Better Class of Oil

This booklet is designed to help you understand a little more about oils and greases, their specifications and how they work. The level of detail has been kept fairly basic and can be used as a simple reference.

CONTENTS

Also included, is a large amount of technical data on Penrite products. While correct at the date of printing, it is subject to change as formulations progress. The changes do not impact on the performance of the product.

Penrite do not skimp on quality. We choose the best additives we can to do all the above. Our choices result in Penrite-only additives being used for many products in our range. When you buy Penrite, you are buying an uniquely Australian product, not only from a physical perspective but potentially a chemical one. Our viscosity modifiers are chosen to minimise shear losses, to help keep the fluid film as thick as possible for the life of the drain.

So what does this mean for Penrite Products?

We recognise that different engine designs required a range of oils to properly lubricate and protect the engine while preserving the fuel economy or power of the engine. Hence we first look at what the original oil requirement is for start up viscosity at typical Australian ambient conditions. We then apply the most appropriate oil grade in our range that would also ensure good protection at operating temperature. This is one of the reasons why Penrite petrol engine oils have some of the widest multigrade ranges of any oil company.

Penrite now has top line oils to cover all engines from 1970s technology to 21st Century technology. There are also special oils (not covered here) to handle Vintage, Veteran and Classic era vehicles.

Our ATFs are chosen to give the best performance in an automatic transmission. We would rather not recommend an oil than recommend one that may cause problems in the transmission.

Our MTFs use specialised additives to ensure a smooth shift – they are not simple downtreats of hypoid oils, which is quite often the case for some companies.

PENRITE

A Better Class of Oil

OIL FUNCTIONS

To properly lubricate, an oil or grease must:

Lubricate Parts and Prevent Wear

This is the basic function of all oils. Keeping the moving parts separated. In general the thicker the oil film, the better the wear protection, but the oil additives also play an important role. Modern additives often allow an oil of slightly lesser viscosity to be used and still provide the same level of protection.

Reduce Friction

The film of oil reduces friction simply because there is no metal-to-metal contact. The heavier the oil though, the greater the drag and hence more heat may be generated. Correct oil selection is therefore a balance of what is needed to protect the component without generating excessive drag.

Protect Against Rust and Corrosion

As oils degrade they form corrosive by-products so the oil contains anti-corrosion and acid neutralising additives to protect components.

Keep Components Clean

Oils need to be very stable under heat and not cause system deposits. Different oils will last different lengths of time in a given application.

Be Compatible with Seals

The oil must lubricate and not cause deterioration of seals.

Prevent Foam

Foam reduces the lubrication properties of the oil, therefore industrial oils must be resistant to foaming or be able to 'release' any foam quickly.

SPECIAL PROPERTIES FOR ENGINE OILS

Permit Easy Starting

Most wear occurs in an engine at start up. Therefore, the oil must have the correct low temperature viscosity to flow quickly to the bearings and valve train to prevent wear. Some engines require low viscosity oils to start at all, especially some of the new diesel engines found in four wheel drives, where the oil is used to operate the pump to prime the fuel injectors.

Cool the Engine

At least 40% of the engine is cooled by the oil, not the radiator system. This means the oil is always under heat stress (oxidation) as it transfers heat from hot spots back to the sump. This includes main and big end bearings, the crankshaft, rods, other bearings plus timing gear and pistons.

Reduce Combustion Chamber Deposits

Some oil will always reach the combustion chamber – either via the cylinder walls or via the valves. It is then burned off with the fuel. So it must burn clean enough that it does not build up on valve seats or pistons tops which can cause problems.

SPECIAL PROPERTIES FOR AUTOMATIC TRANSMISSION FLUIDS

- They are a power transmission medium for the torque converter.
- Act as a hydraulic fluid for the hydraulic (and electronic) control systems.
- They must transmit sliding friction energy in bands and clutches. This property varies between transmission makes, and is why there are so many ATFs on the market. Friction is the key.
- They transmit this energy in such a way that the shift is always smooth.

SPECIAL PROPERTIES FOR MANUAL TRANSMISSION FLUIDS

- Be capable of providing an easy gearshift for the life of the oil drain. This is a function of both friction modifiers and viscosity.
- Maintain long clutch life and prevent seal leaks.

SPECIAL PROPERTIES FOR GEAR AND DIFFERENTIAL OILS

- Must protect against pitting, spalling, scoring and scuffing caused by the large shear loads placed on the oil by the gear set.
- Protect against copper corrosion. Older technologies were not kind to copper alloys and used to turn them black via chemical attack. Most modern hypoid oils do not tend to do this due to advances in technologies.
- Limited slip oils must enable the cone or clutch to work properly when distributing power to the drive wheels. As such, they contain a special friction modifier to achieve this. It should be noted that oils designed for use in limited slip differentials can be used in standard hypoid differentials.

ADDITIVES

There are many types of oils and greases and they use many of the same types of ingredients. However, these are put together a little differently. Not all of these are found in every oil or grease.

Firstly you have base oils, made from either crude oil at a refinery or man-made (synthetics). To achieve the functions required by finished lubricants, you must then put additives in the oil. These all do different things.

Detergents

Any oil with an API engine rating of SC or above has a level of detergency. This detergency level is not necessarily related to all of the quoted API ratings of the oil, as some high detergent diesel oils may only meet lower petrol engine oil specifications. It is a balance. Detergents are usually metallic compounds and they control deposits and keep engines clean. They can clean up dirty engines depending on the product.

Dispersants

These are usually ashless (non metallic) organic chemicals. They keep contaminants and by-products dispersed in the oil helping to prevent deposits from forming. They are highly effective in controlling low temperature contaminants. They can keep them so fine in suspension, they pass through the oil filter with the oil additives!

Extreme Pressure Additives

API GL-2 and up oils, all contain extreme pressure (EP) additives of some description. They tend to be sulphur-phosphorus based although chlorine is also used. Some types are also found in compressor and hydraulic oils, and especially in slideway oils and chain lubricants.

Friction Modifiers

These reduce friction and vary in chemical nature depending on the type of oil.

Friction Modifiers - Engine Oils

Used to reduce internal engine friction and are common in low viscosity oils where fuel economy is important. They are also effective anti-wear agents. Current technologies do not cause the same problems with bore glazing as in the past.

Friction Modifiers - Transmission and Gear

The most important part of an ATF and a purpose designed MTF is the friction modifier. These enable the transmission to function correctly so the end user has smooth gear changes. In limited slip differentials, these prevent chatter and squawk and ensure the differential works as it should. They are all different types of chemistry.

Oxidation Inhibitors

Reduce oxygen attack on the oil, reducing oil thickening, especially at high temperatures.

Rust and Corrosion Inhibitors

Prevent rust and attack on metal surfaces from acids.

Anti-Wear Agents

Prevent wear due to seizure or scuffing of rubbing surfaces. They are normally zinc, phosphorus or other organo-metallic types.

Foam Depressants/Air Release Agents

Prevent foam from forming, thereby maintaining a lubrication film and the ability of the oil to be pumped at the required rate.

Pour Point Depressants

Reduce the oils tendency to crystallise at low temperatures, ie it's ability to pour.

Viscosity Index Improvers (VII)

These change the oil's rate of thinning out (the VI) as temperatures increase – ie make multigrade oils. They are polymers that expand as temperature increases – think of them as like a slowly uncoiling spring. VIIs change the Viscosity Index (VI) of a product – the higher this number is, the less the oil viscosity will change with temperature. There are many different types and those used in engine oils are very different to those in gear oils, as an example.

BASE OILS

All oils must contain base oils! They go with the additives mentioned previously. Not all base oils are created equally however. The API classifies these into 6 main groups.

Group	Sulphur %	Saturates %	VI	Manufacturing Method
I	>0.03	<90	80-119	Solvent Refined
II	<0.03	>90	80-119	Hydro-processed
III	<0.03	>90	120 +	Severely hydro-processed
IV	Poly alpha olefins (PAOs)			Oligomerization (man made)
V	All Others (including esters)			Various
VI	Poly internal olefins (PIOs)			Oligomerization (man made)

Group III, IV and VI oils are 100% synthetic. Some very high quality Group II oils (called Group II Plus) are also accepted as having synthetic performance. When looking at the table, think of saturate (relates to aromatics and other hydrocarbon molecules) and sulphur levels as the degree of purity of the oil. The Group III products used by Penrite are over 99% pure, and hence as good as the man made PAO products. Group III products have many marketing names such as XHVI (Shell) and VHVI (Petro-Canada). These synthetic base oils are used for two main reasons – greater oxidation stability (for longer oil life) and low volatility (to decrease oil consumption) In order to meet the ACEA specifications on oil volatility, many lighter engine oil viscosity grades must use a percentage of these products, especially if Group I base oils are used.

Note that Group V contains synthetic esters (among others) but it also contains other products such as mineral aromatic and naphthentic base oils and even vegetable oils.

From a Penrite perspective, we choose the combination of the above base oils to ensure maximum performance for a given oil.

For more on base oils, refer to the appendix at the end of this book.

INDUSTRY OIL CLASSIFICATIONS

There are many oil industry classifications covering viscosity and other performance criteria. Just a few are quoted in the following pages, and some you will recognise.

SAE Viscosity

SAE stands for Society of Automotive Engineers. The SAE developed a classification system to define the viscosity, or thickness, of the oil. This system has been progressively modified over the years.

It defines "operating" engine oil viscosities for different grades and contains specifications for "cranking" viscosity and pumpability at start up, the "W" grades or winter. A multigrade oil is one that meets both a "W" low temperature viscosity requirement and a 100°C "operating temperature" requirement. For engine oils there is a specification that must be met at 150°C, known as a High Temperature/High Shear (HT/HS) viscosity. This is to simulate what happens in high stress areas of the engine eg bearings. Centipoise (cP) and Centistokes (cSt) are the units each is measured in.

In addition, gear oils require a KRL test. This is a severe oil shear test, and the oil must stay in grade or within a nominated range after shear. Its severity is the main reason why 75W-x gear oils are expensive as these are difficult to make.

SAE Viscosity has little relevance to industrial oils but some compressor oils are stated as meeting SAE 30 for example.

SAE J300 - Engine Oils					
SAE Grade	Cold Cranking MAX Viscosity cP@Temp, °C	Pumpability Max Viscosity cP@ Temp, °C	Viscosity @100 °C		HT/HS@ 150 °C Min cP
			Min cSt	Max cSt	
0W	6200 @ -35	60,000 @ -40	3.8	NA	NA
5W	6600 @ -30	60,000 @ -35	3.8	NA	NA
10W	7000 @ -25	60,000 @ -30	4.1	NA	NA
15W	7000 @ -20	60,000 @ -25	5.6	NA	NA
20W	9500 @ -15	60,000 @ -20	5.6	NA	NA
25W	13000 @ -10	60,000 @ -15	9.3	NA	NA
20	NA	NA	5.6	<9.3	2.6
30	NA	NA	9.3	<12.5	2.9
40	NA	NA	12.5	<16.3	See note
50	NA	NA	16.3	<21.9	3.7
60	NA	NA	21.9	<26.1	3.7

Note: 2.9cP for 0W-40, 5W-40 and 10W-40 grades, 3.7cP for 15W-40, 20W-40, 25W-40 and 40 grades. Penrite define "70" engine oils as above 26.1cSt at 100°C and "30W" as less than 13,000cP at -5°C.

SAE J306 (Jun 2005) Gear Oils			
SAE Grade	Max Temperature for a Viscosity of 150,000cP	Viscosity @100 °C	
		Min cSt	Max cSt
70W	-55	4.1	NA
75W	-40	4.1	NA
80W	-26	7.0	NA
85W	-12	11.0	NA
80	NA	7.0	<11.0
85	NA	11.0	<13.5
90	NA	13.5	<18.5
110	NA	18.5	<24.0
140	NA	24.0	<32.5
190	NA	32.5	<41.0
250	NA	41.0	NA

Note: Limit must also be met after testing in 20 hour KRL Shear Stability Test (CEC-L45-T-93 Method C).

ISO VISCOSITY

This is the defining category for industrial oils. The following table shows the kinematic viscosity limits for each ISO Viscosity Grade. Each viscosity grade is 50% higher in viscosity than the preceding viscosity grade. These limits are set at a 10 percent tolerance level above and below the mid-point of a grade. Any product with a viscosity outside these tolerance levels is not a recognized ISO Viscosity Grade.

ISO-Viscosity System for industrial lubricants					
ISO Viscosity Grade	Mid Point cSt @ 40°C	Kinematic Viscosity Limits			
		Minimum		Maximum	
		cSt	S.U.S.	cSt	S.U.S.
2	2.2	1.98	32.0	2.42	34.0
3	3.2	2.88	35.5	3.52	37.5
5	4.6	4.14	39.5	5.06	42.5
7	6.8	6.12	46.0	7.48	50.5
10	10	9.00	55.5	11.0	62.5
15	15	13.5	71.5	16.5	83.5
22	22	19.8	97.0	24.2	116
32	32	28.8	136	35.2	165
46	46	41.4	193	50.6	235
68	68	61.2	284	74.8	347
100	100	90.0	417	110	510
150	150	135	625	165	764
220	220	198	917	242	1121
320	320	288	1334	352	1631
460	460	414	1918	506	2344
680	680	612	2835	748	3465
1000	1000	900	4169	1100	5095
1500	1500	1350	6253	1650	7643

AGMA VISCOSITY NUMBERS

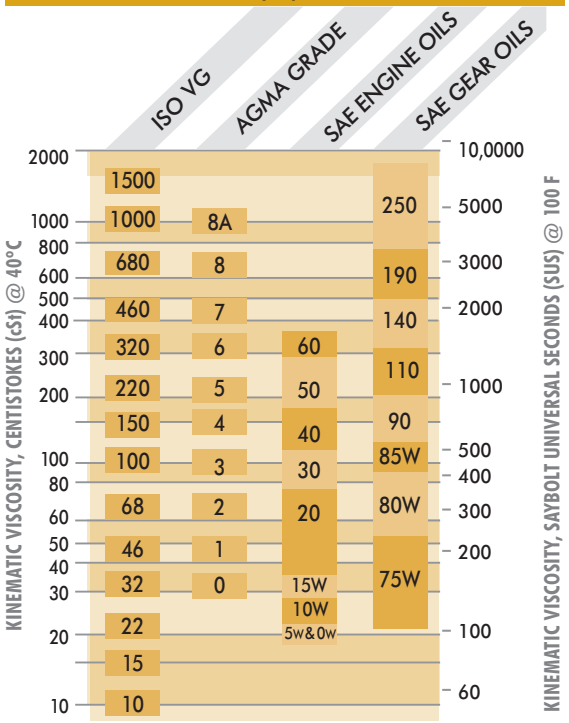
The American Gear Manufacturers Association (AGMA) has set up a numbering system to define gear oil viscosities required for various industrial gear boxes and applications. These AGMA Lubricant Numbers are normally stamped on the manufacturer's metal name plate.

Viscosity Ranges for AGMA Lubricants (ANSI/AGMA 9005-D94)

Rust & oxidation inhibited gear oils	Extreme Pressure Gear Lubricants	Synthetic Gear Oils	Viscosity Range cSt @ 40°c	Equivalent ISO grade
AGMA Lubricant No.	AGMA Lubricant No.			
0	-	0S	28.8-35.2	32
1	-	1S	41.4-50.6	46
2	2EP	2S	61.2-74.8	68
3	3EP	3S	90-110	100
4	4EP	4S	135-165	150
5	5EP	5S	198-242	220
6	6EP	6S	288-352	320
7.7 Comp	7EP	7S	414-506	460
8.8 Comp	8EP	8S	612-748	680
8A Comp	8AEP	-	900-1100	1000
9	9EP	9S	1350-1650	1500
10	10EP	10S	2880-3520	-
11	11EP	11S	4140-5060	-
12	12EP	12EP	6120-7480	-
13	13EP	13S	190-220 cSt @ 100°C	-

So there are three systems of viscosity measurement. However, all is not lost. The next chart shows how you convert from one grade to another.

Viscosity Equivalents



NOTE:

- Read across horizontally
- Assumes 100 VI Single grade oils
- Equivalence is in terms of viscosity at 40°C only
- Viscosity limits are approximate: for precise data consult ISO, AGMA and SAE specifications.
- W grades are represented only in terms of approximate 40°C viscosity. For low temperature limits consult SAE specifications.
- Penrite Technical Bulletin No 32 has a large version of this chart.

API SERVICE CLASSIFICATIONS

API stands for American Petroleum Institute. In 1970 along with the SAE and ASTM (American Society for Testing and Materials), they established the API Service Classification System to define the performance level of a given oil, unrelated in the main, to oil viscosity.

The API requirements "S" for Spark Ignition (petrol) and "C" for Compression Ignition (diesel) can be briefly described as follows.

Designation and Description

SA	Oil without additive
SB	Some antioxidant and anti scuff properties
SC	Meets 1964-1967 requirements of Automotive manufacturers
SD	Meets 1968-1971 requirements of Automotive manufacturers
SE	Meets 1972-1979 requirements of Automotive manufacturers
SF	Meets 1980-1988 requirements of Automotive manufacturers
SG	Meets 1989-1993 requirements of Automotive manufacturers
SH	Meets 1994-1997 requirements of Automotive manufacturers
SJ	Meets 1998-2000 requirements of Automotive manufacturers
SL	Meets 2001-2004 on requirements of Automotive manufacturers
SM	Meets 2004-on requirements of automotive manufacturers. XW-20 and XW-30 grades have chemical limits
SN	Meets MY2010 requirements of automotive manufacturers. XW-20 and XW-30 grades have chemical limits

SA to SJ are obsolete.

CA	Light duty, high quality fuel, for MIL-L-2104A, 1954
CB	Moderate duty, lower quality (high sulphur) fuel
CC	Moderate to severe duty diesel and gasoline service MIL-L-2104B, 1964
CD	Severe duty diesel, including turbo, Caterpillar Series 3, MIL-L-2104C
CD-II	API CD plus Detroit Diesel 6V53T approval for two stroke engines
CE	Turbo/Supercharged heavy duty diesels from 1983
CF	Off road indirect injection diesel engines and others using a broad range of fuel types including high sulphur. May be used to replace API CD oils
CF-2	Severe duty two stroke diesel engine service from 1994
CF-4	Severe Duty four stroke diesel engine service for lower emission diesel engines (from 1988)
CG-4	Severe Duty four stroke engines meeting 1994 emission standards (less than 0.5% fuel sulphur)
CH-4	High speed four stroke engines meeting 1998 emission standards (less than 0.5% fuel sulphur).
CI-4	High speed four stroke engines fitted with cooled EGR (released Dec 2001) and using low-sulphur fuel.
CI-4 PLUS	As per CI-4 but with further restrictions on after shear viscosity and performance. (released September 2004). Aust. 2008.
CJ-4	Released in 2006 for 15ppm maximum fuel sulphur. Enhanced wear, protection 1.0% ash maximum. US EPA '07.

CA to CG-4 are obsolete.

HISTORY OF API SPECIFICATIONS

Originally it used an "M" and "D" system but in the 1960s, this changed to the one we are familiar with today. Specifications exist for petrol and "heavy duty" diesel engines only.

CURRENT	OLD OR YEAR OF RELEASE
SA	ML
SB	MM
SC	MS (1964) and AMA ASTM G IV
SD	MS (1968) and AMA ASTM G IV
SE	MS (1972) and AMA ASTM G IV
CA	DG (1954, MIL-L-2104A)
CB	DM
CC	DM (1964, MIL-L-2104B)
CD	DS (MIL-L-45199/2104C Caterpillar Series 3)

ACEA ENGINE SERVICE CLASSIFICATIONS

ACEA stands for Association des Constructuers Europeens de l'Automobile. This classification system is the European equivalent of the API classification system, but is stricter and has more severe requirements. Hence an oil that meets both API and ACEA specifications uses a better additive package than one that is designed to meet only API specifications. Unlike the API, ACEA has three main groups – "A/B" for gasoline and light duty (passenger car, 4WD etc) diesel engines, "C" for light duty three way catalyst (TWC) and diesel particulate filter (DPF) compatible oils and "E" for heavy duty diesel engines. These can be defined as follows.

Designation and Description

A1/B1 For use in gasoline and light duty diesel engines capable of using low friction, low viscosity, and low HT/HS shear (2.9 to 3.5cP) oils. A fuel economy specification, this oil may not be able to be used in all engines.

A3/B3 Stable, stay in grade oil intended for use in high performance gasoline and diesel engines or extended drain intervals.

A3/B4 For use in direct injection diesel engines where special oils may be required, but also suitable for applications described under A3/B3.

A5/B5 Similar to A3/B3 but for engines capable of using low friction, low viscosity and low HT/HS oils. May be unsuitable for use in some engines.

C1 Stable, stay in grade oil of A5/B5 performance level and a phosphorus limit of 0.05% (low SAPS). These oils cannot meet API SM/SN.

C2 Stable, stay in grade oil of A5/B5 performance and mid-SAPs (Phosphorus 0.08%).

C3 Stable, stay in grade oil with mid-SAPs (phosphorus 0.08%). These oils may also meet A3/B4* and API SN. HT/HS >3.5cP

C4 Stable, stay in grade oil similar to C1 but with tighter volatility limits and no lower limit on phosphorus.

E2 General purpose oil for naturally aspirated and turbocharged diesel engines, medium to heavy duty service and mostly normal drain intervals. (Obsolete by 2010)

E4 Stable, stay in grade oil more severe than E7, for significantly extended oil drain intervals. Usually synthetic or predominantly synthetic. Also for Euro 3 and Euro 4 engines.

E6 As for E4 but with chemical limits to allow use in engines with particulate filters and SCR NOx reduction systems. Only for diesel fuel with<50ppm sulphur. 1.0% ash, 0.08% phosphorus. Euro 4 and 5.

E7 Designed for use in Euro 1, Euro 2 and Euro 3 emission diesel engines in severe heavy duty service and extended drain intervals where allowed. More severe than E2/E3 but not as severe as E4.

E9 Designed for Euro 5 engines with DPFs. SAPS limits line up with API CJ-4 and 7BN minimum.

ACEA specification oils have tighter shear stability and oil volatility requirements than equivalent API specification oils

*ACEA 2010 specification oils can no longer meet both C3 and A3/B4.

HISTORY OF EUROPEAN SPECIFICATIONS

Prior to ACEA, the CCMC was the issuing body for Europe up until 1990's. A rough comparison is shown below

ACEA	Old CCMC (not in absolute terms, a guide only)
A2	G1, G2
A3	G4, G5
B2	PD1
B3/B4	PD2
E2	D4
E3	D5

ILSAC ENGINE SERVICE CLASSIFICATIONS

ILSAC (International Lubricants Standardisation and Approval Committee) includes the major automobile manufacturers that manufacture vehicles in the USA. This includes the Japanese manufacturers. Effectively, ILSAC specifications are the fuel economy version of the API specifications.

GF-1 is obsolete

GF-2 is equivalent to API SJ

GF-3 is equivalent to API SL

GF-4 is equivalent to API SM

GF-5 is equivalent to API SN

ILSAC grades only apply to viscosities XW-20 and XW-30. GF-4 has introduced a phosphorus limit of 0.08% maximum and a sulphur limit of 0.2% maximum, GF-5 is similar, but it introduced new requirements relating to phosphorus volatility and compatibility with ethanol fuels.

ILSAC, API and ACEA specifications require a large range of engine tests and laboratory tests on the oil. Parameters such as high and low temperature wear, oxidation, soot control, oil thickening, deposit control, volatility, stay in grade performance, fuel economy, chemical composition and many others are tested against limits and rated.

In the case of the API, the oil specifications become more severe as the letters climb the alphabet, eg SL is more severe than SJ. This is not necessarily the case with ACEA as their specifications are more application specific.

GLOBAL SPECIFICATIONS

Developed by ACEA, API and JAMA for diesel oils with different limits to the 'donor' categories.

Heavy Duty: DHD-1 = E7/CI–4 + JASO tests

Light Duty: DLD-1 = B2 + JASO tests

DLD-2 = B1 + JASO tests

DLD-3 = B3 + JASO tests

OTHER FOUR STROKE CLASSIFICATIONS

JASO DL-1 Similar to ACEA CI for light duty diesel engines.

JASO DH-1 Heavy duty diesel, higher ash formulation with performance superior to API CF-4. Has additional valve train wear and piston cleanliness requirements.

JASO DH-2 Heavy duty diesel, similar to API CJ-4 and ACEA E9.

JASO MA Japanese four stroke motorcycles, non-friction modified. Now further split into MA1 and MA2.

JASO MB Japanese four stroke motorcycles low friction oil.

NMMA FC-W® Released in 2004 for four stroke outboard oils.

TWO STROKE OILS

These are low ash or ashless oils depending on the end use. Products can be used in oil injection systems or premixed with the fuel. As they are consumed with the fuel, two stroke oils must not cause excessive combustion chamber or piston deposits, or engine failure may result.

The most common two stroke specifications are

Air Cooled

API TC

ISO EG-B/JASO FB
Provides good protection against scuffing and varnish

ISO EG-C/JASO FC
As per EG-B/FB but with severe restrictions on exhaust smoke, system blocking and detergency

ISO EG-D/JASO FD
Enhanced detergency and varnish protection compared to EG-C/FD

TISI
Thai Industrial standard with limits on smoke, generally equivalent to JASO FC

Water Cooled

NMMA TC-W3®
Ashless Oil for two stroke outboard engines. Oils can be licensed to this category.

AUTOMATIC TRANSMISSION FLUID CLASSIFICATIONS

There are no API standards for automatic transmission fluids. Indeed, it is only in recent times that the Japanese have released a general industry standard that stands alongside their individual requirements. (JASO-1A).

GENERAL MOTORS

TYPE A AND TYPE A SUFFIX A
The original fluids. They came out on 1949 and 1957 respectively and are long obsolete.

DEXRON®-IID
Now obsolete as far as General Motors is concerned, it was the closest we had to an industry specification. Indeed, it formed the basis of many other OEM (Original Equipment Manufacturer) ATFs specifications. It is still used by GM Europe up until recently and by other European and some Japanese OEMs.

DEXRON®-IIE
A development that had better low temperature properties than IID. Now superseded.

DEXRON®-III
For many years it was in "F" and "G" specifications, which had the same low temperature characteristics as the IIE version, but with modifications to antioxidancy and friction material. The 2003 IIIH specification was for 160,000km drain intervals and extended durability and superceded "G". This specification became obsolete at the end of 2006 and was replaced by;

DEXRON®-VI
Initially released in 2005, this is a special low viscosity fluid which will replace DEXRON®-III in all GM manufactured

automatic transmissions. It has a very long oil drain capability of up to 400,000km.

DEX-CVT®
Special specification for CVTs.

FORD MOTOR COMPANY

M2C33-F and M2C33-G
F came out for the USA and G for Europe. These are non-friction modified fluids and as such cannot be used in most transmissions.

M2C138-CJ and M2C166-H
Introduced to deal with problems with the C-6 and C-5 transmissions, these are satisfied by DEXRON®-IID.

MERCON®
The original MERCON® fluids were again satisfied by DEXRON®-IID and the revised MERCON®-IV fluids by DEXRON®-IID/E and DEXRON®-III. (now obsolete)

MERCON®-C

Special specification for CVTs.

MERCON®-V
This is the first MERCON® fluid not satisfied by a standard DEXRON® type fluid. Usually semi or fully synthetic, it has more severe requirements on friction, fluidity, shear loss and oil drain. While fluids meeting MERCON®-V must pass DEXRON®-III initially, they are then subjected to many other tests. Updated in mid 2008.

MERCON®-SP and MERCON®-LV
Both fluids are low viscosity fluids. MERCON®-SP was based around a ZF specification and was used in six speed automatic transmissions, for both front and rear wheel drive. LV was introduced in 2007 and Ford plan to make it backwards compatible.

BTR 5M-52
Special fluid for Ford Australia that uses the BTR 4 speed automatic models, 85/91/95LE. Modified DEXRON®-IID type.

CHRYSLER

ATF+3® (MS-7176F/MS7176E)
Satisfied by modified DEXRON®-IID/IIE type fluids such as MM SP and MM SP2.

ATF+4® (MS-9602)
Synthetic or semi synthetic product with special shift requirements.

MERCEDES BENZ

They have the 236.x series of approvals. Some are DEXRON®-IID/III type and some are not. With some of the newer transmissions, highly specific products are used. Their sheet numbers also may be indicative of a transmission from a supplier such as ZF. The more common ones are shown below.

236.1 For MB, Allison and ZF transmissions.

236.2 Older specification used in power steering and manual transmissions, although it is also used in some MAN automatics and in the Differential Lock in UNIMOG.

236.6, 236.7
most common ones used, and satisfied by DEXRON®-IID.

236.9 long drain fluid usually a DEXRON®-III type with more severe shear stability limits.

236.10 for 5 speed Mercedes EC^3 transmissions (NAG-1)

236.11 for 5 speed ZF automatics used by Mercedes Benz

236.12 For 7 speed Mercedes automatics (NAG-2) (now replaced)

236.13 Issued as an in-service 'fix' oil for transmissions specifying 236.12

236.14 New initial and service fill specification for NAG-2 transmissions

236.20 For CVT

MITSUBISHI

MM SP and MM SP2 – DEXRON®-III fluidity but with different frictional characteristics.

MM SP 3 – a more developed version with better low temperature properties and longer drain life and shift durability. Semi-synthetic at minimum.

ZF

Stands for Zahnradfabrik Friedrichshafen in case you were wondering.

A large transmission maker, it supplies units to many car and truck OEMs.

TE ML-11
: Contains the special products listing for many passenger car automatic transmissions (such as MB 236.11 type) and also for where automatic transmission fluids are used in manual transmissions.

TE-ML 14A
: Full mineral, DEXRON®-IID/III type, 5.3cSt after shear, 30,000km drains.

TE-ML 14B
: Part synthetic, DEXRON®-III type, 5.3cSt after shear, 60,000km drains.

TE-ML 14C
: Full synthetic, DEXRON®-IID/III type, 5.7cSt after shear 120,000km drains.

ALLISON

C-4 Designed for heavy-duty transmissions in off-highway vehicles. ATFs and special fluids are qualified against it. Supercedes C-3.

TES295 Special formulation-specific, PAO based fluid for heavy duty applications.

TES389 Introduced in 2006 to cover DEXRON®-III applications. Now required for all on-highway transmissions instead of C-4.

CATERPILLAR

TO-4 specialised fluid for Caterpillar units. Oils meeting TO-4 and C-4 find wide application in heavy-duty construction equipment manufactured by many OEMs such as Komatsu. Also used in manual transmissions.

Other OEM specifications worth noting:

Honda	ATF 96, Z1
Nissan	Nissanmatic C, D, J, K
Mazda	MIII, MIV, MV
Toyota	TII, TIII, TIV, WS
Voith	G607, G1363

Gear Oil Designation and Description

For gear oils (loosely including MTFs), there is the below set of standards:

GL-1 Oil without additive

GL-2 Usually contains fatty materials

GL-3 Contains a mild EP additive

GL-4 Equivalent to MIL-L-2105B and is usually satisfied by a 50% GL-5 additive level.

GL-5 Equivalent to MIL-PRF-2105E. Primary field service recommendation for Passenger cars and trucks worldwide.

GL-6 For severe service involving high offset hypoid gears. Often used to describe oils used in limited slip differentials.

MT-1 For non-synchronised manual transmissions in buses and trucks at a higher level than GL-4.

GL-2, GL-3 and GL-6 are not normally used for automotive applications.

MIL-PRF-2105E – designed by the US military it takes conventional GL-5 and adds more demands to the specification. Most hypoid oils conform to this standard. Now superceded by SAE J2360 (2003).

MANUAL TRANSMISSION FLUID AND GEAR OIL CLASSIFICATIONS

Most of these start with a basic API GL-3, GL-4 or GL-5 and add their own requirements. Some started from engine oils.

HONDA MTF-94/ROVER MTF-94

Describes a GL-4 type 10W-30/75W-80 oil that is semi-synthetic for long drain and good low temperature shift feel.

MAN 341

API GL-4 type.

MAN 342

API GL-5 type.

Caterpillar TO-4

Makes an appearance here as the SAE 30, 50 and 60 versions are used in manual transmissions and some final drive units.

Caterpillar FD-1

Describes a fluid used in differentials of heavy-duty Caterpillar equipment where additional wear protection is needed. Cannot be used in wet-brake applications. Usually a SAE 60 grade or multigrade synthetic.

MB 235.5

Heavy duty API GL-4.

MB 235.0/235.6

Heavy duty API GL-5 type oils for long drains.

MB 235.10

Light duty, synthetic performance 75W-80 for MB Sinter Synchromesh tranmissions.

Mack GO-J

Designed to deliver 250,000km oil-drain intervals. More severe than API GL-5. GO-J/S is the synthetic version.

Mack TO-A Plus

Specialised manual transmission fluid with long life.

Volvo 1273.07

SAE 30 type (SAE 80) oil based on GL-4.

Volvo 1273.10

API GL-5, SAE 80, 90

Volvo 1273.12

SAE 50 (SAE 90) type usually satisfied by TO-4 type oils.

ZF

TE ML-01

Non-synchro, heavy-duty manual transmissions. SAE 80W to 90, API GL-4 and SAE 30/40 engine oils

TE ML-02

Manual and automatic transmissions for trucks and buses. Various sub-groups.

TE ML-03

Torque converters in off road vehicles.

TE ML-04

Marine transmissions, SAE 30/40 engine oils.

TE ML-05

Axles in off road vehicles. Various sub groups for different grades and types.

TE ML-06

Tractor transmissions and hydraulics.

TE ML-07

Hydrostatic and mechanical drives and electric drive systems.

TE ML-11

Manual and automatic transmissions in cars.

TE ML-12

Axles for cars, commercial vehicles and buses. Various sub-groups

BTR specifications:

5M-42, 5M-31, 5M–36, 5M-41, 5M-50, 5M-48

Ford specifications:

M2C-86A/B/C, M2C 105A, M2C 1013A, M2C 108A, M2C 197A, M2C 1006B, M2C 104A, M2C 200C

Holden specifications:

HN1855, HN1820, HN1046, HN1070, HN1181, HN 386, HN1561, HN1187, HN 2013, HN2040

Rockwell:

O-76A, O-76B, O-76N, O-76D

Eaton Fuller:

PS 164 (Rev. 7)

TYPES OF INDUSTRIAL OILS

There are many different types of industrial oils. Let's take a little time to look at some of them.

HYDRAULIC OILS

The primary application of a hydraulic oil is to transmit force applied at one point in a system to another. As well as this it must also protect seals, lubricate and transfer heat.

The viscosity of the oil is important to ensure efficient power transfer. Too heavy, and high-pressure drops may occur, the system becomes sluggish and power usage increases. If too low, then wear can be a problem, efficiency decreases and leaks may occur.

Typically these products contain anti wear, anti rust/corrosion and anti oxidation inhibitors. These may be ashless (non-metallic) or use a zinc di-thiophosphate type system. Some older higher zinc additives can be corrosive to silver.

Hydraulic oils can be a 'monograde' (HM) or 'multigrade' (HV) type.

INDUSTRIAL GEAR OILS

Typically API GL-3 oils which use low doses of conventional sulphur-phosphorus additives. They tend to be straight grade oils.

COMPRESSOR OILS

Compressors may use a multitude of products, depending on the type of compressor and its service. Types of oils include:

- Conventional motor oils
- Non-metallic hydraulic oils
- Ashless engine oils
- Specialised fluids (mineral or synthetic)
- Automatic transmission fluids
- Refrigeration oils

The use of the wrong oil can cause wear, failure, carbon build up and even reaction with the gas being compressed, so great care must be taken when recommending fluids.

HEAT TRANSFER FLUIDS

As the name suggests they transfer heat in a system. They must be highly oxidatively stable to minimise build up of carbon deposits (which of course inhibit heat transfer).

TRANSFORMER OILS

Highly specialised fluids used in electrical transformers. They are characterised by extremely low water content and good oxidation stability.

WHITE OILS

Ever wonder what baby oil is? Highly refined mineral oil, 100% paraffinic and approved by health and food authorities. Used by the food and cosmetic industry as a lubricant or carrier fluid.

PROCESS OILS

Straight oils used in various industrial processes such as in rubber or as flushing fluids. Large quantities of these are used by heavy industry.

MISCELLANEOUS

There are many special products used by industry that are not covered here. The mining and food industries have some special lubricants for very specific applications. These may be fire resistant fluids, specialised greases, control fluids and many others.

SHELF LIFE OF LUBRICATING OILS

The performance properties of liquid lubricants (oils) will remain intact for many years provided they have been in protected storage and not exposed to severe high/low temperature cycles. Generally, the simpler the oil formulation, the longer the oil will remain satisfactory. The old 'cool dry place' term certainly applies when storing oil products.

Hydraulic Food Grade/Compressor/Turbine and General Purpose Lubricating Oils

These oils contain low but very effective additive treatments. They may be stored for 3 years under protected conditions without any significant deterioration in performance.

Engine/Motor Oils and Transmission Oils

Although these oils contain high additive contents, they are extremely stable. They may be stored for 5 years under protected conditions without any significant deterioration in performance. However, as the industry is always developing new specifications these oils may be out of date by the time they are fully used.

Industrial and Automotive Gear Oils

These highly additised formulations can occasionally exhibit some long term instability. Under protected conditions they should only be stored for 3 years.

INDUSTRIAL METALWORKING

Soluble cutting and grinding fluids

These are mineral oil, synthetic or semi-synthetic water miscible products designed for use in all water types for metal cutting and grinding operations. These products may contain bactericides and fungicides that help to prevent the growth of bacteria and mould and also extreme pressure additives for heavier duty work. Where it is desirable to be able to see the tool and machining operation, products that make clear emulsions are available.

Neat Cutting Oils

These products offer superior performance where the demands upon the lubricant cannot be met by a water miscible fluid. They cover a wide range of viscosities and light, medium and heavy duty machining operations such as cutting, drilling, broaching, deep hole boring, reaming, grinding, threading, honing and many others. These products may contain active or inactive sulphur compounds and therefore care needs to be taken to select the correct grades to ensure that staining of metal does not occur.

Forming Lubricants

These are solvent or mineral based oils and additives that are used neat or as emulsions to shape or form all metal types during light, medium and heavy duty operations such as pressing, punching, stamping, cold-heading and drawing. They contain additives that help the forming process such as active or inactive sulphur compounds and therefore care needs to be taken when recommending products to meet the needs of the metal and the application to reduce the risk of staining.

Heat Treatment oils

Also called quenching oils, these are mineral oil based normal and accelerated speed products and water based polymer quench and induction hardening fluids that cover a wide range of heat treatment applications where metal components are immersed in a heated bath to increase the structural hardness of the metal.

Chemical Parts Wash Cleaners

These types of products can be water based or solvent based component and are used extensively throughout the metalworking industry for the cleaning and work-in-progress corrosion inhibition of all metal types. They contain surfactants or detergents and depending on the base material, either these or the solvents do the cleaning. Notice needs to be taken of the flash points when handling.

Rust Preventatives

Rust preventatives may be solvent, oil or water and emulsion-based and provide excellent water displacement properties and short, medium and long-term indoor and outdoor protection to suit a wide variety of metal types. Where metal components are to be shipped overseas a thicker film rust preventative may be applied to prevent any exposure to salt spray.

Way Lubricants

Also called slideway oils. These products contain a tacky additive to help stay in the lathe bed and hence prevent dripping of oil. They also contains “stick-slip” additives which are designed to assist with smooth operation of machine tool slideways. Can often be used as industrial gear oils and in hydraulic systems.

STORAGE OF METALWORKING FLUIDS

Water based products need to be stored indoors at 5 C or above with a maximum shelf life of 12-months. These products need to be protected from water entry and frost. Neat Metalworking Fluids and Way Lubricants can be delicately balanced and have a shelf of about 2 years and should be stored as per the soluble fluids. Other products generally have storage lives of 2-5 years.

GREASES

Greases are defined as solid or semi-solid materials produced by the dispersion of a thickening agent in a liquid lubricant (like adding a sponge to water).

Greases are manufactured in either a grease kettle or in a contactor. A soap-based grease uses a thickener made by reacting a metallic hydroxide with a fatty acid, which is where we get our basic types from, eg lithium soap.

Non-soap greases include silica, polyurea and clay (bentone).

Depending on what the grease needs to achieve, different thickener and base oils can be used.

GREASE CHARACTERISTICS

The most important factors affecting the properties and characteristics of a grease are:

- Amount and type of thickener
- Additives

A grease is expected to:

- Reduce friction and wear
- Provide corrosion protection
- Seal bearings from water and contaminants
- Resist leakage, dripping and throw off
- Resist change in structure or consistency during service
- Maintain mobility under conditions of application
- Be compatible with seals
- Tolerate or repel moisture

GREASE DEFINITIONS

Consistency – is the degree of hardness of a grease and may vary considerably with temperature. This has been classified by the National Lubricating Grease Institute (NLGI) into the following categories:

NLGI GRADE PENETRATION @ 25°C (1/10th mm)	
000	445 - 475
00	400 - 430
0	355 - 385
1	310 - 340
2	265 - 295
3	220 - 250
4	175 - 205
5	130 - 160
6 (block grease)	85 – 115

Oil Separation – is the percentage of oil which separates from the grease under static (eg. storage) conditions. It cannot predict separation tendencies in use under dynamic conditions.

High Temperature Stability – is the ability of a grease to retain it's consistency, structure and performance at temperatures above 125°C.

GREASE SERVICE CLASSIFICATION

There are 5 categories for Automotive Service Greases developed by the NLGI. The classification (ASTM D 4950) covers greases designed for the lubrication of chassis components and wheel bearings of passenger cars, trucks and other vehicles. The NLGI classifies automotive service greases into two main groups. Chassis greases, designed by the prefix L and Wheel Bearing greases designated by the prefix G. These are shown in the following table.

CATEGORY	SERVICE	PERFORMANCE
LA Chassis	Frequent relubrication intervals (<3200 km). Mild duty (non-critical applications).	Oxidation resistant, shear stable, and corrosion and wear protective.
LB Chassis	Prolonged relubrication intervals (>3200 km). Mild to severe duty (high loads, vibration, exposure to water).	Oxidation resistant shear stable, and corrosion and wear protective even under heavy loads and in presence of aqueous contamination. Temperature range: -40°C to 120°C
GA Wheel Bearings	Frequent lubrication intervals. Mild duty (non-critical applications).	Temperature range: -20°C to 70°C
GB Wheel bearings	Mild to moderate duty (cars, trucks in urban and highway service).	Oxidation and evaporation resistant, shear stable and corrosion and wear protective. Temperature range: – 40°C to 120°C with occasional excursions to 160°C.
GC Wheel Bearings	Mild to heavy duty (vehicles in frequent stop-and-go service, trailer hauling, mountain driving, etc)	Oxidation and evaporation resistant, shear stable, and corrosion and wear protective. Temperature range: – 40°C to 120°C with frequent excursions to 200°C.

GREASE SHELF LIFE

The shelf life of any grease is affected by the type and amount of thickener used, consistency of the grease, manufacturing method employed and the formulation complexity. Generally straight Lithium, Lithium Complex and Calcium Complex greases remain stable for a long time. Aluminium Complex greases tend to set and harden, but remain stable. Bentone and Barium greases tend to soften on aging. Based on these observations:

The shelf life of most Penrite greases is about 5 years. However, Steering Box Lubricant and Semi Fluid Grease only have a 2 year shelf life.

GREASE TYPES

There are many types of greases which are shown below. As can be seen they have different properties which helps to define where they are best suited.

THICKENER	DROP POINT,°C	MAX SERVICE CONTINUOUS OPERATING TEMP,°C	HIGH TEMP USE	STRUCTURE	SHEAR STABILITY	WATER RESISTANCE
Calcium	100	<80	☐	☐	○	■
Lithium	160 - 200	125	■	☐	■	■
Calcium complex	>260	150	■	☐◿	■	■
Lithium complex	>240	160	■	☐	■	■
Aluminium complex	>260	150	■	☐◸	■	■
Barium complex	>200	150	■	◸	○	■
Polyurea	>230	150	■	■	■	■
Bentone	NA	150	■	☐	○	■
Sodium	170 - 190	125	■	◸	■	☐

☐ Very Poor ■ Poor ○ Fair ■ Good ■ Excellent
◿ Buttery ☐ Smooth ◸ Fibrous ◸ Gel
■ Opaque

GREASE COMPATIBILITY

Occasionally, grease substitution in an application may be necessary to correct problems arising from the original product in service. If the thickeners are incompatible, the mixture will not meet the properties of the individual greases and in some cases, the greases will fall apart. The below table provides a rough guide.

	Calcium	Lithium	Calcium Complex	Lithium Complex	Aluminium Complex	Barium Complex	Polyurea	Bentone	Sodium
Calcium		✔	✔	✔	●	✘	✔	✘	✘
Lithium	✔		✔	✔	●	●	✔	✘	●
Calcium Complex	✔	✔		●	✘	●	●	✘	✘
Lithium Complex	✔	✔	●		●	●	✔	✘	●
Aluminium Complex	✘	●	✘	●		✘	●	✘	✘
Barium Complex	✘	●	●	●	✘		●	✘	✘
Polyurea	✔	✔	●	✔	●	●		✘	✘
Bentone	✘	✘	✘	✘	✘	✘	✘		✘
Sodium	✘	●	✘	●	✘	✘	✘	✘	

✔ Compatible ✘ Incompatible ● Borderline

It is strongly advised that, in all cases, the old grease be purged or cleaned out from the system before a new one is introduced. However, compatibility between greases is temperature dependent. As the temperature rises, the problems associated with incompatibility also increase. With unknown competitors' products, it is strongly advised to treat them as incompatible.

GREASE APPLICATIONS

Greases are used instead of oils in many applications. They find use where:

- a good seal from the elements is required
- leakage is a problem
- exposed gears or chains are used and water wash-off is a problem
- less frequent application of lubricant is possible due to isolation or inaccessibility

Some examples where greases are used include:

- Wheel bearings
- Universal joints
- Chassis lubrication
- Track rollers
- Rolling bearings
- Shackles and pins
- CV Joints
- Electric motor bearings*

*(Note that extreme pressure greases are not generally recommended in electric motors.)

ENGINE COOLANTS

Engines can be air cooled or water cooled.

Water cooled engines use water to assist the heat transfer process from the engine as it operates. However, engines are made from metal – usually of more than one type – and are likely to rust over time.

Hence an engine coolant is required.

What must engine coolant do?

Be an effective heat exchange fluid

Protect against rust and corrosion in alloy, mixed metal and cast iron engines

Provide freezing and boiling protection

Be compatible with plastics and rubbers

Be chemically stable (ie no "drop out")

Mix readily with water!

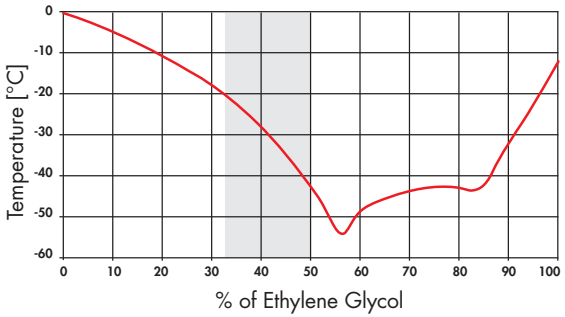
There are two types of Coolants.

Water based products are just water and inhibitors.

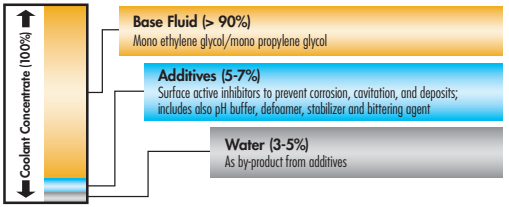
However some engines run very hot and hence require the use of ethylene or propylene glycol to raise the boiling point water, ie Anti Freeze Anti Boil. Some engines also may operate at less than the freezing point of water and to lower the freezing point, ethylene or propylene glycol are also used.

However, ethylene or propylene glycol mixed with water is corrosive, so fully formulated anti-freeze, anti-boil products contain corrosion inhibitors to protect the engine.

Typical, anti freeze anti boil coolants are used at between 33% and 50%, although in some cases, 60% has been used. They should never be used at higher than these rates as coolant performance is decreased and in the case of conventional coolants, additive deposition may occur which blocks the radiators.



Chemical Composition of Engine Coolants



Additives may include:
Organic acids
Silicates and phosphates
Nitrites
De-foamers
Bittering agents
Borates

These all fulfil different functions within the coolant.

There are three basic "types" of coolants.

CONVENTIONAL – uses conventional technology – in other words, does not use any of the newer style, organic inhibitors.

ORGANIC – uses 100% organic acid salts

HYBRID – these products use mainly organic acids but with up to two or three conventional inhibitors.

Automotive manufacturers will generally specify silicates and phosphates.

Heavy Duty engine manufacturers will generally specify nitrites and molybdates.

Common Specifications

AS 2108-2004 Type A (Anti-Freeze Anti Boil)
AS 2108-2004 Type B (Water Based product)
JASO M325 (Japan)
JIS K2234 (Japan)
KSM 2142 (Korea)
ASTM D3306
German Army TL 6850-0038/1
SAE J1034
BMW N 600 69.0
Caterpillar EC-1
Cummins 85T8-2
Ford ESE M97-B44A/C/D
GM 1825M/1899M/6277M
Holden HN 2217/HN2043
JI Case JIC 501
MAN 324NF/324SNF
MB 325.0/325.3
MTU MTL 5048
Opel B 040 1065
VW/Audi/Skoda TL 774C/D/F (G12)

STORAGE LIFE OF COOLANTS

Concentrated coolants have a shelf life of about 2 years when stored correctly.

INDUSTRY TERMS

ACEA – Association des Contructuers Europeens de l'Automobile.

ACID NUMBER – (see NEUT NUMBER)

AGMA – American Gear Manufacturers Association, one of whose activities is the establishment and promotion of standards for gear lubricants.

ANTI-FOAM AGENT – (see FOAM INHIBITOR)

ANTI-WEAR AGENT – An additive that minimises wear caused by metal-to metal contact during conditions of mild boundary lubrication (e.g. stops and starts, oscillating motion). The additive reacts chemically with, and forms a film on, metal surfaces under normal operating conditions.

ANTI-OXIDANT – (see OXIDATION INHIBITOR)

API – (American Petroleum Institute) – society organised to further the interests of the petroleum industry.

ASH CONTENT – non-combustible residue of a lubricating oil (also fuels) determined in accordance with ASTM D582 – also D874 (sulphated ash).

ASTM – (American Society for Testing and Materials) – organisation devoted to "the promotion of knowledge of the materials of engineering, and the standardisation of specifications and methods of testing

AUTO IGNITION TEMPERATURE – See description under FLASH POINT.

BASE NUMBER – (see NEUT NUMBER)

BOUNDARY LUBRICATION – a state of lubrication characterised by partial contact between two metal surfaces, and partial separation of the surfaces by a fluid film of lubricant. Due to metal-metal contact, severe wear can take place during boundary lubrication.

BROOKFIELD VISCOSITY – viscosity, in centipoises, as determined on the Brookfield viscometer (ASTM D2983). The operating principle for the Brookfield viscometer is the torque resistance on a spindle rotating in the fluid being tested.

CARBON RESIDUE – percent of coked material remaining after a sample of lubricating oil has been exposed to high temperatures under ASTM Method D189 (Conradson) or D524 (Ramsbottom).

CENTISTOKE (cSt) – (see VISCOSITY)

CENTIPOISE (cP) – (see VISCOSITY)

CHANNELLING – formation of a 'groove' in grease (or in oil too viscous to flow readily under existing conditions).

COMPOUNDED OIL – a blend of petroleum oil with small amounts of fatty or synthetic fatty oils

COPPER STRIP CORROSION – evaluation of a product's tendency to corrode copper or copper alloys, ASTM D130.

CORROSION INHIBITOR – a lubricant additive for protecting surfaces against chemical attack from contaminants in the lubricant.

DEMULSIBILITY – test time required for a specified oil-water emulsion to break, using ASTM D1401 test method.

DETERGENT – an additive in crankcase oils generally combined with dispersant additives. A detergent chemically neutralises acidic contaminants in the oil before they become insoluble and fall out of the oil, forming sludge.

DISPERSANTS – operate to break up insoluble contaminant particles already formed. Particles are kept finely divided so that they can remain 'dispersed' or colloidally suspended in the oil.

DROPPING POINT – the temperature at which a grease changes from semisolid to a liquid state under test conditions.

EMULSION – a mechanical mixture of two mutually insoluble liquids (such as oil and water).

EP AGENT – an additive to improve the extreme pressure properties of a lubricant.

FIRE POINT - the minimum sample temperature at hich vapor is produced at a sufficient rate to sustain combustion.

FLASH POINT – minimum temperature of a petroleum product or other combustible fluid at which vapor is produced at a rate sufficient to yield a combustible mixture.

FOAM INHIBITOR – an additive which causes foam to dissipate more rapidly. It promotes the combination of small bubbles into large bubbles which burst more easily.

FOUR BALL TESTS – two test procedures based on the same principle – the Four-Ball EP Test (ASTM D2596) and Four-Ball Wear Test (ASTM D2266). The three lower balls are clamped together to form a cradle upon which the fourth ball rotates in a vertical axis. The balls are immersed in the lubricant under investigation. The FOUR BALL WEAR TEST is used to determine the relative wear-preventing properties of lubricants operating under boundary lubrication conditions. The FOUR-BALL EP TEST is designed to evaluate performance under much higher unit loads Two values are generally reported – LOAD WEAR INDEX (formerly mean Hertz load) and WELD POINT.

HYDROCRACKING – is a process which is used by a few manufacturers of superior quality lubricant basestock. In the process, a petroleum feedstock is reacted with hydrogen, in the presence of a catalyst, at very high temperatures (400-425°C) and pressures (3000 plus psi). Under these severe conditions, virtually all the aromatic hydrocarbons present are isomerised and saturated to yield a basestock containing 96% to 99.5+% saturated hydrocarbons. The process also virtually eliminates all traces of sulphur, nitrogen and oxygen-containing impurities.Hydrocracking produces very high quality, synthetic-like basestocks, which when blended with carefully selected additives, give extremely stable lubricants of a synthetic level performance.

HYDROFINISHING – (see HYDROTREATING)

HYDROTREATING – a generic name for a refinery process for treating fuels and lubricant feedstocks, at elevated temperatures, in the presence of pressurised hydrogen and a catalyst. This relatively mild process is sometimes called ‘Hydrofinishing’ and is used to improve the colour and odour of fuels and lubricant basestocks.

HYDRODYNAMIC LUBRICATION – a lubrication regime characterised by a full fluid film between two moving surfaces.

INHIBITOR – additive for the control of an undesirable phenomenon in grease, oils, or fuels, etc., for example: oxidation inhibitors, rust inhibitors, foam inhibitors, etc.

ISO – (International Organization for Standardisation) – an organisation which establishes internationally recognised standards for products and test methods.

NEUT NUMBER – or NEUTRALIZATION NUMBER: the specific quantity of reagent required to ‘neutralise’ the acidity or alkalinity of a lube oil sample

OXIDATION – A form of chemical deterioration to which petroleum products like most other organic materials are subject.

OXIDATION INHIBITOR – chemical added in small quantities to a petroleum product to increase its oxidation resistance and hence to lengthen its service or storage life.

POISE – CGS unit of absolute viscosity: shear stress (in dynes per square centimetre) required to move one layer of fluid along another, over a total layer thickness of one centimetre at a shear rate of one centimetre per second. The CENTIPOISE (cP) is 1/100 of a poise and is the unit of absolute viscosity most commonly used.

POUR POINT – is a widely used low-temperature flow indicator and is 3°C above the temperature to which a normally liquid petroleum product maintains fluidity.

RUST INHIBITOR – a lubricant additive for protecting ferrous (iron and steel) components from rusting caused by water contamination or other harmful materials from oil degradation.

SAPS – Sulphated Ash, Phosphorus and Sulphur. Basic chemical specifications in engine oils that are being further limited as emissions requirements tighten.

SCR – Selective Catalytic Reduction. Exhaust emissions treatment system used mainly on heavy duty trucks

SCUFFING – engine wear resulting from the localised welding and fracture of rubbing surfaces.

SOLVENT EXTRACTION – a traditional refinery process that is used to upgrade chemical and physical properties in the manufacture of lube oil basestocks.

STLE – Society of Tribologists and Lubrication Engineer.

SULPHATED ASH – (see ASH)

SYNTHETIC LUBRICANTS - lubricants manufactured by a process where a chemical conversion or transformation of one complex mixture of molecules into another complex mixture takes place. Common types of synthetic base oil include:

- Polyalpha olefins
- Hydrocracked/HydroIsomerised Unconventional Base Oils (UCBOs)
- Organic esters
- Polyglycols

TIMKEN OK LOAD – measure of the extreme pressure properties of a lubricant.

TOTAL BASE NUMBER – (see NEUT NUMBER)

VISCOSITY – measure of a fluid's resistance to flow. It is ordinarily expressed in terms of the time required for a standard quantity of the fluid at a certain temperature to flow through a standard orifice.

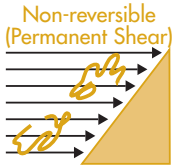
VISCOSITY INDEX (V.I.) – an indicator of the rate of change of viscosity with temperature.

VOLATILITY – that property of a liquid that defines its evaporation characteristics.

PERMANENT VS TEMPORARY SHEAR

The below diagrams show the two types of shear that can occur with viscosity index improvers (VII). Permanent Shear is defined as the physical breaking apart of the polymer into smaller pieces and hence the oil suffers from a permanent loss of viscosity. Temporary shear occurs when the polymer is squashed but does not break apart and hence "springs back" to its original size after going through the area of high stress.

Normal polymer coil in oil



Rupture of coil under permanent shear

Polymer coil is squashed under temporary shear forces

The shearing effect occurs when the oil is forced through areas of tight clearances or is "squashed" (eg cam lobe to follower) and if the gap is too small, then the polymer will rupture.

Penrite SIN 15 and 25 are formulated "shear free" and do not use any polymers but use special base oil combinations to achieve the desired viscosity grades. As such, there are no components in the oil that can suffer from Permanent shear so the oil holds its original viscosity for the life of the oil drain.

MODERN BASE OILS

Current trend is toward Group II and Group III

Separation process – Conversion process

Hydrocracking with (wax) hydroisomerization provides greatest flexibility

Hydroprocessing technology can be integrated with existing solvent refineries

Slack wax and Gas to Liquids (GTL) products can be used to produce base oils similar to PAO.

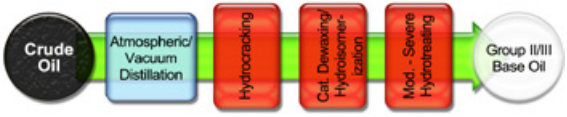
Group 1

Solvent Refining Separation process

- Remove Aromatics
- Remove Wax
- May include "Hydro Finishing"

Primary process for Group II/III base oils is all Hydroprocessing

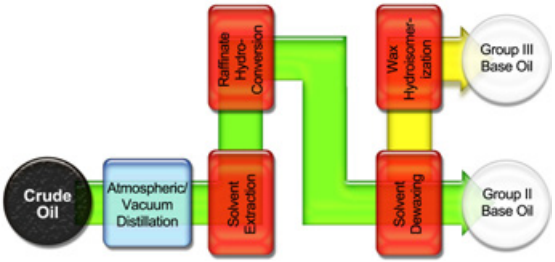
- Molecular conversion
- Hydrocracking
- Catalytic dewaxing (wax cracking)
- Hydroisomerization



Slack Wax Hydroisomerization

Production of high VI Group III base oils

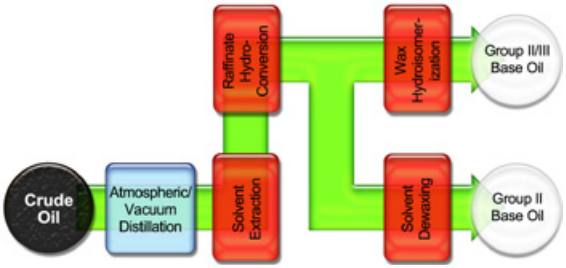
- Production limited to slack wax availability and quality



Hybrid Process

Utilizes existing Group I plant

- Wax production can be maintained
- Increased VI via hydroprocessing of solvent extracted material
- Relatively mild conditions vs. Hydrocracking
- Dewaxing can be either solvent or catalytic

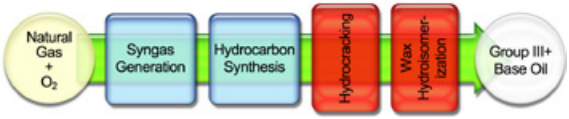


Dewaxing can be either solvent or catalytic

Gas to Liquids (GTL) Conversion

Technology for converting methane to liquid products

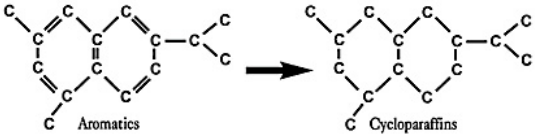
- Sulfur and nitrogen free
- Very low aromatic content
- Products are very much like PAOs.



Hydroprocessed based oils – what do they look like?

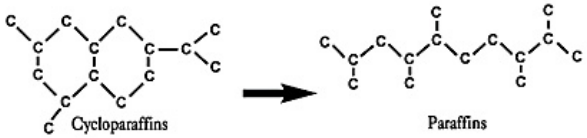
Group II

- 400°C
- >500 psi H
- Removes sulfur & nitrogen
- Converts aromatic hydrocarbons to cycloparaffins.



Group III

- 425-430°C
- 1,500-3,000 psi H
- Converts cycloparaffins to paraffin chains



SYNTHETIC BASE OILS – MAN MADE TYPE

PAOs – Poly alpha olefins

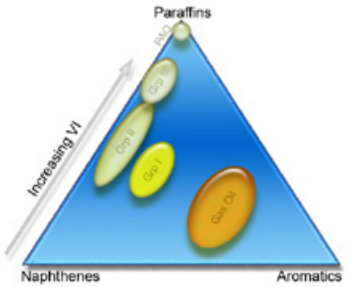
PAOs are derived from the oligomerization of 1-decene

1-decene is derived from the oligomerization of high purity ethylene (C_2H_4)

PAOs are extremely pure

- Identical molecules
- No sulfur or phosphorus
- No wax

So from a "purity perspective", the graph looks like this.



Esters

Manufactured by reacting an acid and an alcohol to give ester plus water.

Principal Types of Diesters

- Adipates, Phthalates, Azelates, Sebacates, Principal Types of Polyolesters
- Glycols, Trimethylolpropane (TMP), Pentaerythritol (PE)

HOW DOES A DIFFERENTIAL WORK?

The wheels are connected to the differential unit via half shafts. Power from the transmission drives the pinion gear which in turn drives the ring gear.

The ring gear is connected to 1 or 2 pairs of smaller bevel gears (known as spider gears), and ultimately power is transferred to the wheels.

It is these smaller bevel gears that form the heart of the differential unit: a mechanical device that detects when one wheel is turning faster than the other, and uses the spider gears to absorb the different speeds of both wheels and allow smooth cornering.

Types of differential

The most basic type is an :-

Open differential:

- Under good traction, it applies the same torque to both wheels
- However when traction is poor and one wheel slips on ice or mud, the slipping wheel will receive all the torque whilst the other wheel receives none, even though it does have grip.

Limited Slip differentials are better in poor traction conditions:

- Similar to open differentials but they have clutch packs inside the differential carrier, which apply friction between the side gears and the carrier.
- The friction from the clutches encourages the side gears to turn at the same as the differential carrier.
- When torque is applied under slippery conditions, friction from the clutch packs prevents the wheel with little traction from spinning wildly and ensures that some torque is transmitted to the other wheel which has grip.

Locking differentials contain a mechanism to fully lock both halves of the axle at the same speed:

- Must not be locked on a hard surface, but quite common to improve traction in heavy trucks, especially in poor weather conditions and off-road applications.
- Locking differentials may be automatically activated (when the difference in wheel speeds reaches a given point) or driver-actuated.

Torque Sensing or Torsen® differentials

- These tend to be complex arrangements of spur, helical and/or bevel gears, which prevent extreme differences in wheel speeds, therefore maintaining useful traction at each wheel all the time.
- They do not use clutches or electronics, so are both reliable and durable, and are used in many rear, front and centre differentials.

Centre differentials manage the power split between front and rear axles or axle pairs, in vehicles with more than one drive axle:

- Centre differentials can be any of the above mentioned types, or can be a viscous coupling similar to a torque converter in operation.

Limited slip differentials with electronic control

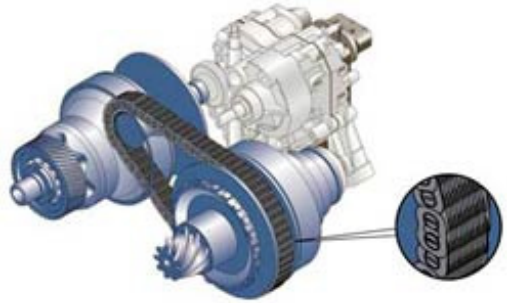
Similar to Limited Slip differentials with clutch packs to prevent slipping of one wheel. The friction of the clutches is controlled externally using sensors at the wheels to detect slipping. The hydraulic pressure needed for the clutches is electronically controlled.

HOW DOES AN AUTOMATIC TRANSMISSION WORK?

Automatic transmissions do not have a solid style conventional clutch like manual transmissions. Instead, they use a fluid coupling called a torque converter to transmit power from the engine to the transmission.

The changes in the ratios by the planetary gear sets (as distinct from hypoid or bevel type used in differentials or manual gear boxes), are done through the combined use of multiple disc clutches, one-way clutches and bands. These are the friction elements. The shift points are now electronically controlled (instead of simple hydraulic pressure) and these electronics in the valve bodies are also reliant on the oil.

HOW DOES A CVT WORK?



A CVT (continuously variable transmission) is different again. There are two types of CVT. They both work on the basis of keeping the engine at the most efficient rev range for power and economy.

Traditional automatic transmissions use gears. Continuously variable transmissions don't have a gearbox but they operate on an pulley system that allows an infinite variability between highest and lowest gears with no discrete steps or shift.

Most CVTs only have three basic components:

- A high-power metal or rubber belt
- A variable-input "driving" pulley
- An output "driven" pulley

The variable-diameter pulleys are the heart of a CVT. Each pulley is made of two 20-degree cones facing each other. A belt rides in the groove between the two cones. V-belts are preferred if the belt is made of rubber.

When the two cones of the pulley are far apart (when the diameter increases), the belt rides lower in the groove, and the radius of the belt loop going around the pulley gets smaller. When the cones are close together (when the diameter decreases), the belt rides higher in the groove, and the radius of the belt loop going around the pulley gets larger. This is how it "changes gear". CVTs may use hydraulic pressure, centrifugal force or spring tension to create the force necessary to adjust the pulley halves.

Variable-diameter pulleys must always come in pairs. One of the pulleys, known as the drive pulley (or driving pulley), is connected to the crankshaft of the engine. The driving pulley is also called the input pulley because it's where the energy from the engine enters the transmission. The second pulley is called the driven pulley because the first pulley is turning it. As an output pulley, the driven pulley transfers energy to the driveshaft.

Both types put specific strains on the oil and it must be very shear stable. Penrite CVT Fluid V is our primary recommendation for most CVTs, but there is no Penrite product for European CVTs (that use "Luk" chains, eg VW/Audi), at this stage. General Motors and VW are among those manufacturers who have specifications for these oils.

HOW DOES A MANUAL TRANSMISSION WORK?

The purpose of a transmission is to provide different ratios of speed between the crankshaft of the engine and the output shaft leading to the final drive. A clutch separates the engine from the driveline to allow the vehicle to drive away and change gears. The number of gear sets depends on the number of ratios provided.

The gears on the Main Shaft are free wheeling and in constant mesh with the gears on the Counter Shaft. To select a ratio the respective gear on the main shaft is connected to the shaft after synchronising the speed of the gear to the shaft. Synchronising is necessary to prevent clashing.

In low ratio the speed of the engine is high relative to the speed of the car. This provides power for driving away, acceleration and hill climbing. In direct (4th) gear both input and output shafts are running 1:1. In highest gear (5th, 6th or overdrive) the output shaft is turning faster than the crankshaft providing lower noise and fuel saving but less power.

How does gear selection work?

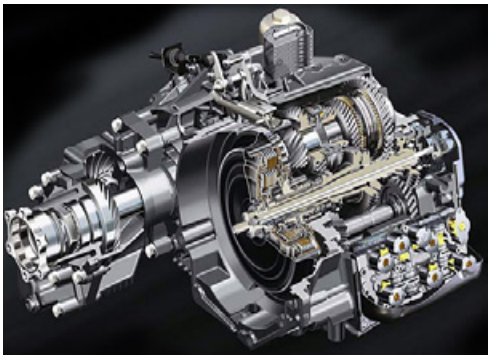
Following the route of power from the engine, the Input Shaft is connected to the 2nd gear via the dog clutch. As the 2nd gear is in constant mesh with the corresponding gear on the counter shaft the power is transferred to the gear set at the end of the Counter Shaft. Here the power is guided to the Output Shaft.

To engage a gear smoothly the clutch between engine and transmission has to be opened. Then both the Input Shaft and the 2nd gear need to be brought to the same speed. This is the purpose of the Synchroniser Ring. The synchroniser ring builds up friction between the synchroniser hub (connected to the input shaft) and the cone on the 2nd gear. As soon as the speeds of hub and gear are equal full engagement can occur. The clutch can be closed again and power can flow.

Other types of Manual Transmission include: Automated Manual Transmission (AMT) - a manual transmission where shifting and clutch operation is done by hydraulic or electric actuators under electronic control. Double Clutch Transmission (DCT) - an AMT modified to allow shifting without torque interruption . This is achieved through employing 2 clutches and an additional countershaft.

WHAT IS A DUAL CLUTCH TRANSMISSION?

A Dual Clutch Transmission (DCT) is effectively two gearboxes in one. Two clutches to eliminate shift shock - one closes as the other opens



Sophisticated electronics and hydraulics control the clutches, just as they do in a standard automatic transmission. In a DCT, however, the clutches operate independently.

One clutch controls the "odd" gears), while the other controls the "even" gears). Using this arrangement, gears can be changed without interrupting the power flow from the engine to the transmission. The gear shafts have constantly meshed gears and synchronisers, so the driving style is very like a conventional automatic transmission.

Some DCTs use a wet clutch system and some use a dry clutch system – so slightly different oils are required.

Advantages :

No torque loss or limitation

- Overcomes "shift shock" associated with the more conventional automated manual transmissions.
- Fuel efficiency: +15% vs 5-speed stepped automatic transmissions.
- Uses existing manual transmission manufacturing facilities
- Better acceleration than a manual transmission
- Size

The most common DCT at the time or writing is a six speed unit used by the Volkswagen group. They call it a DSG transmission. VW have also lauched a new seven speed DSG.

It is felt that these will become widely used and across a wide range of vehicles. High performance vehicles made by Ferrari and BMW (large capacity, high output engines) will be released shortly with a DCT.

References

Afton Chemical - Getting Into Gear 2006.
Caltex Lubrication Vol 77 No 1 and Vol 82 No 1.
Infineum Trends 2005, 2008
Lubrizol Grease Guide
PetroCanada Lubricants Handbook 2004
Afton Chemical - Base Oils 2008