Product Bulletin

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What you need to know about DENSO compressor oils!

Part 2 Properties of ND-oil 8 and ND-oil 12

	
DND08250 - ND-oil 8 **R134a**	**DND12250 - ND-oil 12** **R134a & R1234yf**

In the first publication we explained the basic differences between DENSO ND oils and Ordinary PAG oils. In this second publication, we will explain the differences in further detail.

We can distinguish three types of Compressor Oils which use the Polyalkylene Glycol Base Oil Technology.

DENSO Oils	**Double End Capped**
Ordinary PAG oils	**Double End Capped**
~~**PAG oils**~~	~~**Single End Capped**~~

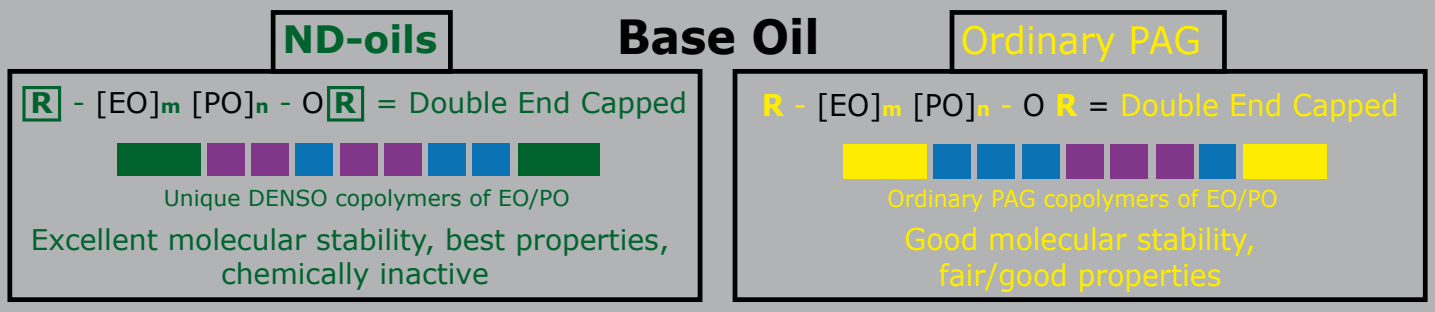
We do not compare the Single End Capped Oil with both Double End Capped Oils, due to the low quality of this oil type.

Base oil

DENSO ND-oils and (Ordinary) PAG oils consist of a base oil and different additives. To look more deeply into the differences between the DENSO ND-oils and the (Ordinary) PAG oils, we will start with the big differences between the base oils.

End-Capping in more detail

Although briefly discussed in the first publication, we would like to explain in more detail what 'End Capping' is and why ND-oil 8 and ND-oil 12 differs from (Ordinary) 'End Capped' PAG oils.



Main chain of Double End Capped ND-oils vs Double End Capped Ordinary PAG oils

With End Capping, the reactive hydroxyl (-OH) group is converted into an unreactive ether group (-O R).

End Capping improves the Hygroscopicity Stability and increases the Viscosity Index (VI) of the ND-oils, which reduces the risk of corrosion and therefore improves the integrity of the A/C system. With the increased VI, the ND-oils will operate over a wider temperature range.

The difference in quality between the Double End Capped, ND-oils and the (Ordinary) Double End Capped PAG oils is distinguished by the difference of the structure of the -O R group, as explained in the first publication.

Due to the structural difference of the -O R group, the improvements of the ND-oils are vast in comparison with (Ordinary) Double End Capped PAG oils.

Hygroscopicity

Hygroscopicity is the measurement of a material's ability to absorb moisture. Idemitsu has conducted significant research into the effect of moisture ingress by creating a unique structure of the main chain of the ND-oils. As a result, the Double End Capped ND-oils are most suitable for use in automotive A/C systems, as moisture enters at the seals or through rubber hoses. The right End Capping process in ND-oils reduces the hygroscopicity of the lubricant at its best, keeping the water attraction to a minimum.

This is important because the more moisture that the lubricant absorbs, the higher the risk of corrosion, which results in the failure of main A/C components, resulting in the degradation of the A/C system itself.

Thermal stability

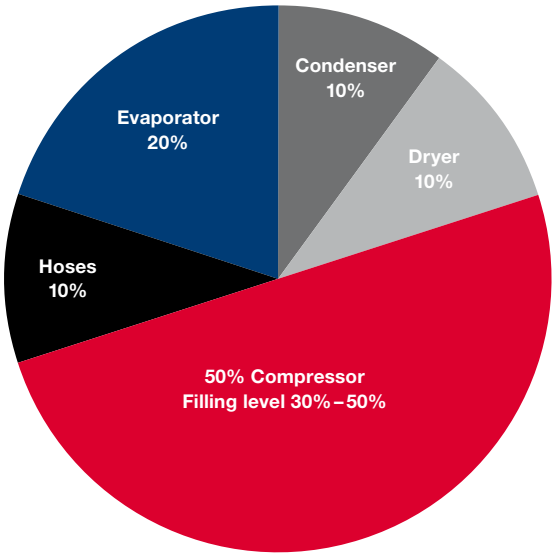
ND-oils operate under high temperature differences inside the compressor and expansion valve. Therefore, excellent thermal stability is required. Single End Capped oils are less thermally-stable, due to the Un Capped end group (-OH), which makes it chemically active, resulting in increased hygroscopicity. ND-oils have “best in class” thermal stability, due to the unique structure of the End Capping group (-O R).

Viscosity index (VI)

One important attribute of any oil is its viscosity index (VI). It should be noted that as the temperature in a lubricant increases, the viscosity decreases. High VI oils should, theoretically, be less affected by temperature fluctuations. For compressor applications, a stable lubricant film is vitally important in order to minimize wear and extend the compressors operating life. A high VI is therefore critical since viscosity is one of the most important properties of a lubricant. At low temperatures, DENSO ND-oils do not thicken as much as other market oils, and at high temperatures they do not thin down as much. DENSO ND-oils provide higher viscosity and greater film strength at elevated temperatures.

Miscibility

The miscibility refers to the ability of the oil to mix with the refrigerant. Some degree of miscibility is necessary between the oil and refrigerant so that the oil can return to the compressor during system operation. The propylene oxide (PO) component inside the base oil provides the oil with the right miscibility properties. The DENSO ND-oils have the highest percentage of PO component in the market, giving the oil excellent miscibility properties. (Ordinary) PAG oils have a lower percentage of the PO component in the base oil and therefore the miscibility of the oil in the gaseous phase is less, which results in a lower oil return to the compressor. **Due to the lower oil return, the 50% fill level inside the compressor decreases, which results in compressor failure.**



Oil distribution within the A/C system (reference values, varying depending on outside temperature and engine load)

Polar

'Polar' is a molecular structure with an uneven distribution of electron density. Due to their comparatively polar structure, PAG's absorb water rapidly. DENSO ND-oils based on Double End Capped polyalkylene glycols (PAG) are less hygroscopic with an optimum value of polarity than (Ordinary) PAG oils.

The reason for blending a copolymer of ethylene oxide & propylene oxide (EO/PO) is the increase in polarity, which lends to the product's molecular structure related extreme pressure effect (EP). As a result, anti-wear (AW) and extreme pressure (EP) additives, which are present in high amounts in (Ordinary) PAG oils, can be kept low in DENSO ND-oils. One benefit to low additive levels is resistance to micro pitting. Experiments have shown EP additives to be chemically aggressive, which may promote micro pitting.

Solubility

Solubility refers to the ability of one compound to dissolve into another. Water is soluble in various degrees with the refrigerants and refrigeration oils.

Hydrolytic stability

As a lubricant is contaminated with water, the question then becomes how stable the fluid is in relation to the water. The ability of a lubricant and its additives to resist chemical decomposition in the presence of water is known as the lubricant's hydrolytic stability.

About the Additives

DENSO ND-oils do not only excel in the difference in quality to the base oil, but also the additive composition is developed according to DENSO's specific requirements. It is a complex interaction between the tailored base oil and the additivation, containing 6 different additives, whereas (Ordinary) PAG oils use 5. Below we will explain every additive used in DENSO ND-oils. The anti-wear additive (5) is the "secret ingredient" compared with the (Ordinary) PAG oils. Due to the unique mixture of these 6 additives, in combination with the premium quality of the base oil, there is no equivalent of DENSO ND-oils available on the after-market.

1. Antioxidant (Phenol Type)

All lubricants, since they are hydrocarbon in character, have thermal limits when reacting with oxygen. Synthetic lubricants such as PAG require the use of anti-oxidants to modify their chemical reaction-ratio with oxygen. Their chemical role is to modify the radical chain-reaction mechanism of the oxidation-process, slowing it to a rate that is consistent with long-term stability against significant decomposition.

2. Acid Catcher (Epoxy Type)

The use of compounds to control acid levels is especially important in synthetic lubricant systems. PAG absorb by hydrogen-bounding significant amounts of moisture / water. Reaction between the lubricant, refrigerant and water can occur, forming organic acids that can result in wear and corrosion. A potential disadvantage in the use of acid catchers is their reaction with other additives such as anti-wear agents. The special Double End Capped PAG in DENSO oils reduces the absorption potential of water compared to (Ordinary) PAG oils, so that the percentage of acid catchers can be kept very low.

3. Extreme Pressure (EP) agent (Sulfur, Chlorine, Phosphorus Type)

The tribological (wear, friction and lubrication) properties of lubricants can be significantly improved by adding high-pressure additives. Specific DENSO Extreme Pressure (EP) additives protect the metal materials by chemically reacting with the metal surface, forming a sacrificial coating that prevents two metal surfaces from welding together under the high temperature and high pressure that occurs during boundary lubrication. DENSO Extreme Pressure (EP) additives produce a surface that is softer than the unprotected base metal.

Extreme Pressure additives, or EP additives, are additives for lubricants with a role to decrease wear of moving parts even under high loads / pressure induced by rotating velocity (like gears, compressor parts etc.).

Extreme Pressure oils perform well over a range of temperatures, speeds and product sizes to help prevent damage during the starting and stopping of moving parts. Extreme Pressure additives typically contain organic sulfur, phosphorus – including sulfur-phosphorus and sulfur-phosphorus-boron compounds – which chemically react with the metal surface under high pressure conditions. Alkanes and polar polymers are also used.

4. Lubricity Additives

A lubricity improver additive is an imprecise term for an additive that is added to a lubricant formulation to perform one or more specific tasks, such as; reducing wear, preventing metal-metal welding, lowering torque through reduced friction or to control friction within a specific range. DENSO ND-oils use lubricity additives that work hand in hand with the EP Agent, improving the protection from welding under extreme pressure or load conditions.

5. Anti-Wear Additives

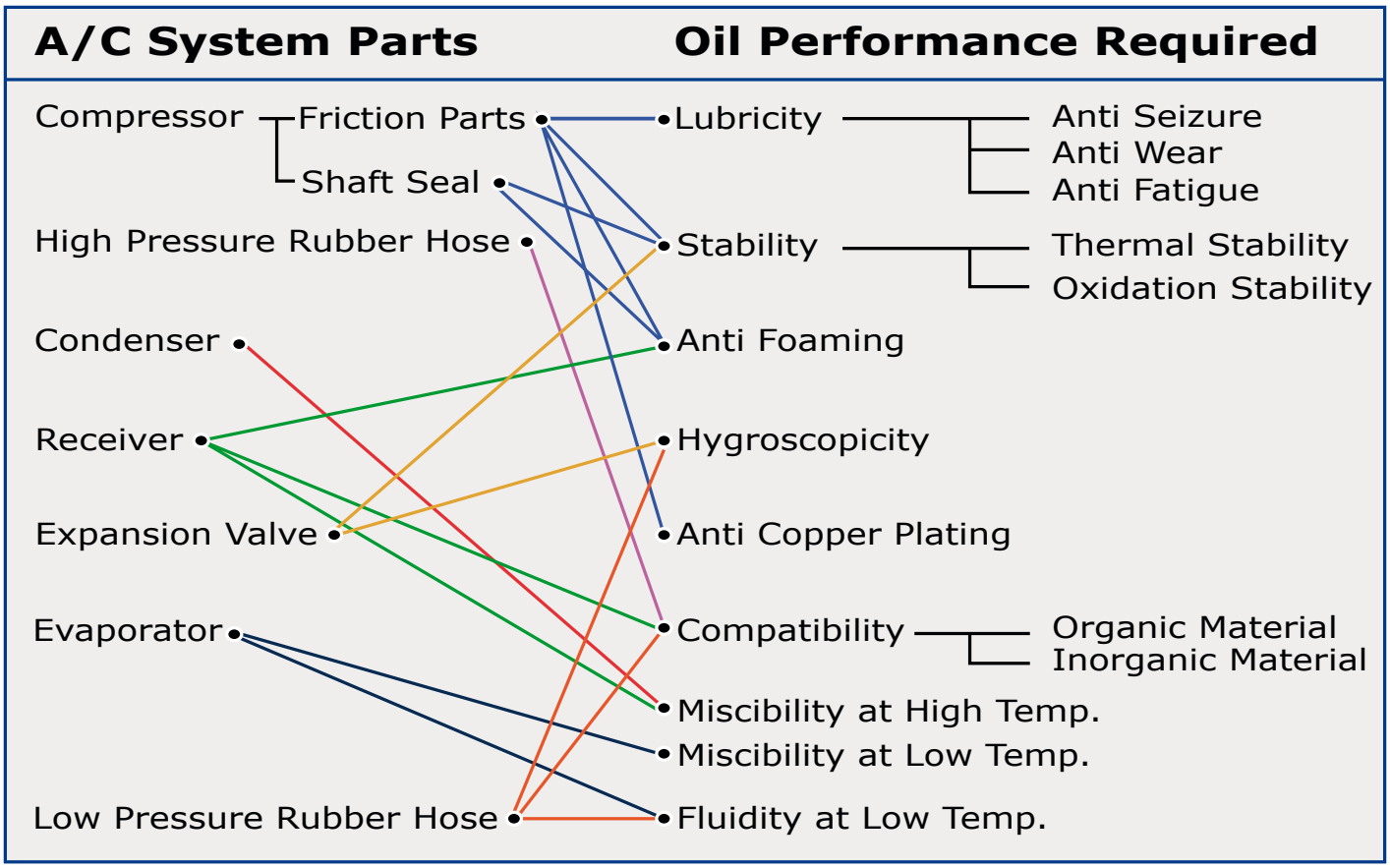
Lubricants used in A/C systems suffer from dilution effects of the refrigerant with a corresponding decrease in viscosity. Therefore, in DENSO ND-oils the EP additives are also supplemented with a specific anti-wear additive to prevent adhesive wear and protect the metal components by keeping the necessary film thickness stable.

6. Antifoaming Agent (Silicon type)

Foaming in a refrigeration system is caused by mechanical mixing of the lubricant and the refrigerant, by the sudden release of refrigerant gas from the lubricant when pressures are reduced and by outgazing, which can occur by system start-up. In HFC /PAG Systems foam typically forms and collapses rapidly with the potential of lubricant transport out of the compressor sump and ineffectiveness in its action to modify compressor noise. DENSO oil containing extreme chemical-stable polydimethyl siloxanes to avoid the potential disadvantage that the necessary anti foaming agents often react with other additives in the system rendering them ineffective.

A/C System efficiency and oil performance

A/C System efficiency is a complex interaction of parts-needs and oil performance. The below overview gives a clear indication of which oil properties are needed for which part of the A/C system.

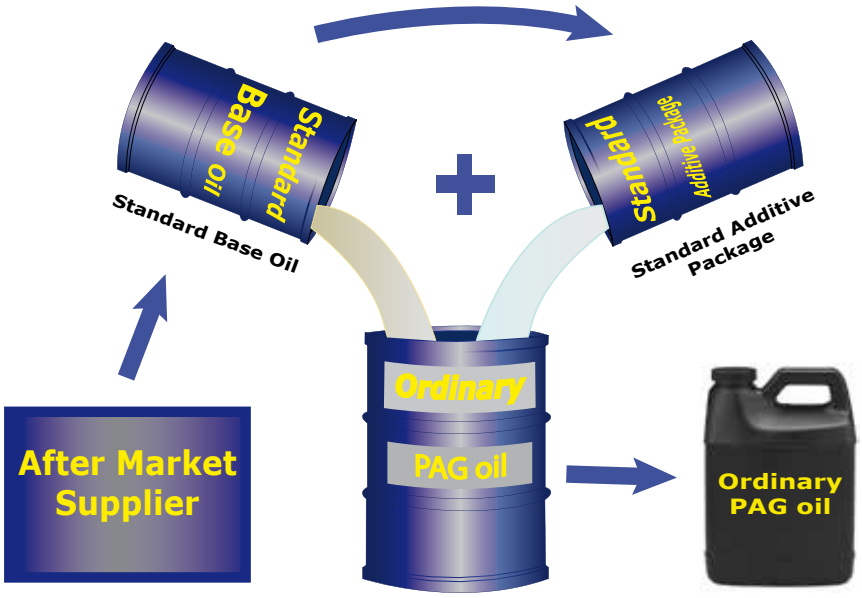


Examples: For the expansion value, Thermal- & Oxidation Stability are important as the refrigerant temperature decreases rapidly after the expansion valve. Hygroscopicity is another important factor at the expansion valve.

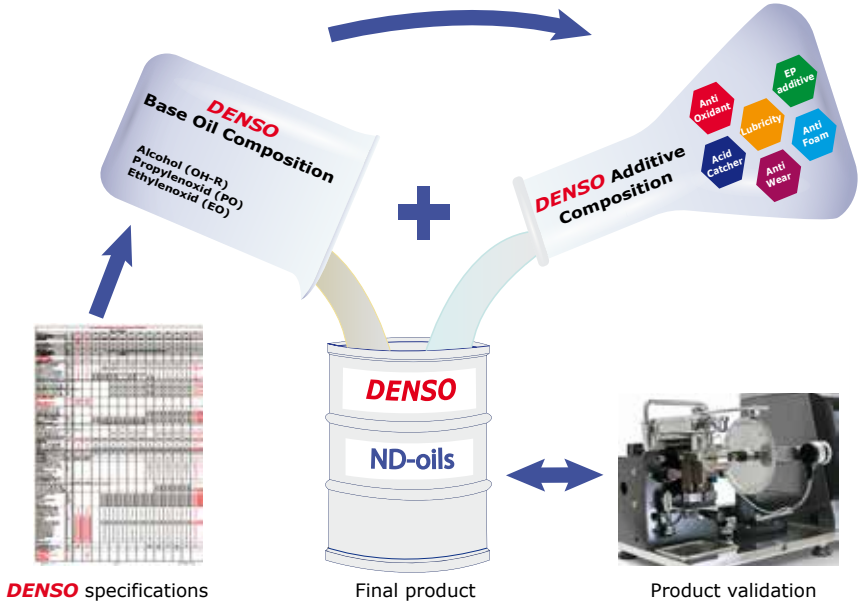
For compressor inner parts, Lubricity, Stability, Anti Foaming and Anti Copper Plating are important factors.

Ordinary PAG oils - How are most of the (Ordinary) PAG oils produced?

(Ordinary) PAG oils are mostly produced by blending a commercially available base oil and a standard additive package. Following this particular process, however, can mean that the quality of the compressor oil is never guaranteed, as it depends on the (unstable) quality level of both components. It also explains the difference in price level of DENSO ND-oils vs (Ordinary) PAG oils.



Common formulations to meet international standards only



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Production of **DENSO** ND-oil versus (Ordinary) PAG oils

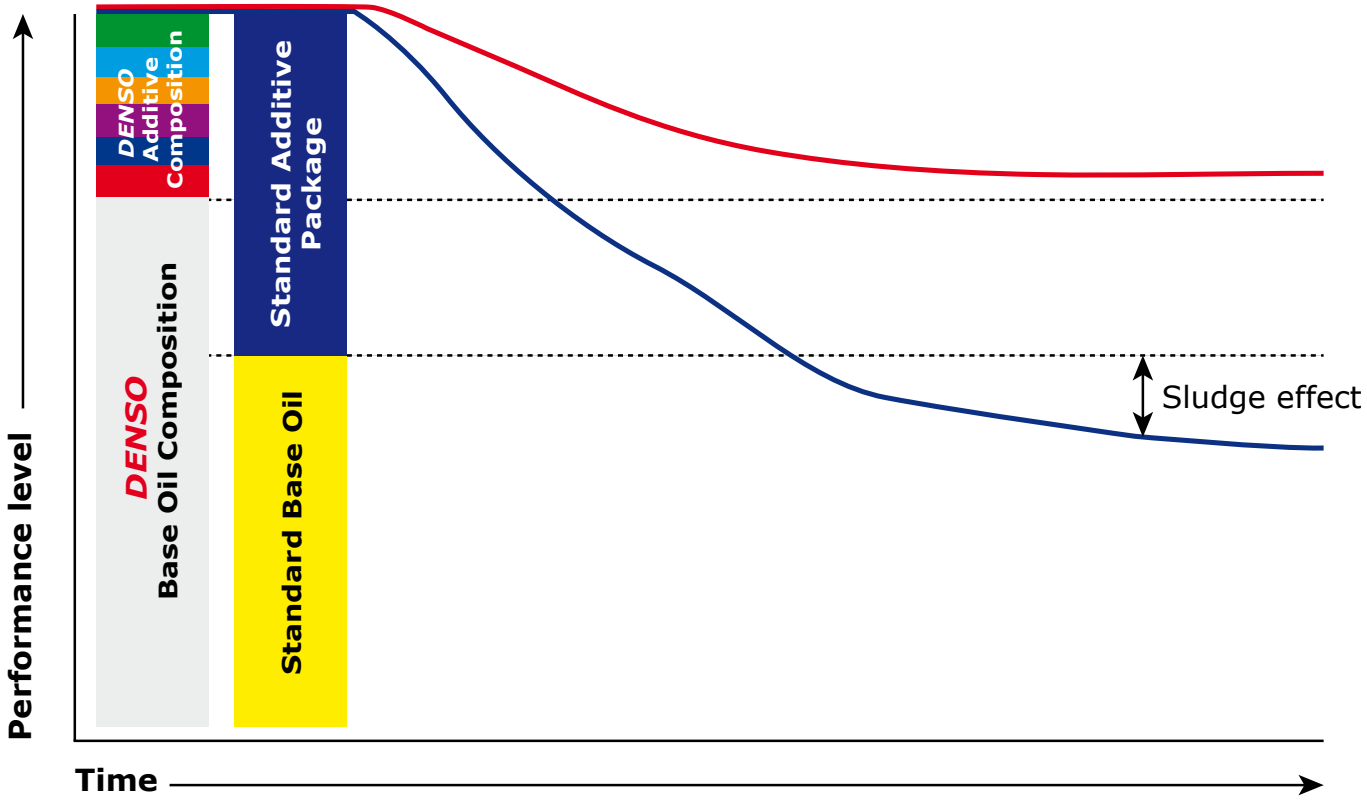
ND-oils vs Ordinary PAG's performance curve over time

In order to achieve the required minimum performance capability in (Ordinary) PAG oils, a standard base oil is mixed with an excess of additives. In the long term, additives cannot compensate for poor base oil performance.

In addition to the fact that overdosed additives can initiate wear reactions, they are consumed very quickly throughout A/C system lifespan due to low base oil performance. This consumption leads, on the one hand, to an unnecessary and avoidable formation of sludge and to surface deposits. On the other hand, strong additives consumption leads to a premature loss of performance of the compressor oil, which shortens the service life of the A/C system.

Less is more

Due to the high-performance level of the DENSO specific base oil, the additive level can be limited. Better solubility and reduced sludge formation keeps the performance on high level and long lasting stable.



Typical chart of the interaction between loss in performance and additive consumption. Comparison of DENSO ND-oils vs (Ordinary) PAG oils.

Summary

DENSO ND-oils offer exceptionally high-performance lubrication in HFC's, like R134A or R1234yf, as they have excellent refrigerant miscibility and lubricity properties. DENSO ND-oils, with their specific main chain structure of the base oil and the chosen type and level of additives provide better hydrodynamic and boundary lubrication properties than (Ordinary) PAG oils. A high kinematic viscosity index ensures maintained lubrication at high temperatures. The unique main chain structure also provides chemical stability with system components, even at high temperatures. Energy efficiency benefits by improved lubricity which is also apparent at system start up.

DENSO ND-oils are Double End Capped PAG's, with high quality alcohols suitable for R134A, R1234yf, CO_2 and for hybrid electric vehicles. They are more expensive and are specially formulated from optimized base stocks to create the required miscibility, lubricity, extreme pressure tolerance, and di-electric properties respectively.

The technical advantages of DENSO Double End Capped ND-oils are generally considered to have (compared to (Ordinary) Double End Capped PAGs):

- Better extreme performance and anti-wear properties, especially at higher pressures and temperatures
- Better miscibility with (gaseous) refrigerant
- Reduced water absorption
- Better chemical, hydrolytic and thermal stability

DENSO's premium quality ND-oils have a different price level compared with (Ordinary) PAG oils. This is due to the unique structure of the main chain of the base oil, next to the high quality of the alcohol used and the high percentage of the propylene oxide (PO) component used. PO is more expensive than ethylene oxide (EO), because of the low availability of PO and the decreasing numbers of manufacturers worldwide. Also, the additive composition is exclusively developed for the DENSO ND-oils. The quality of the production process, including packaging, is second to none.

As a result, DENSO's Double End Capped ND-oils outperform any available (Ordinary) Double End Capped PAG oil, which makes the DENSO ND-oils the oil of choice for any workshop servicing and repairing A/C systems.

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This bulletin is created in cooperation with Idemitsu.

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