



## Technical Topic

# Grease — Its Components and Characteristics

Depending on the application, grease can present several benefits over fluid lubrication. Greases provide a physical seal preventing contamination ingress, resist the washing action of water, and can stay in place in an application even in vertically mounted positions. Greases are uniquely suited for use in applications where relubrication is infrequent or economically unjustifiable, due to the physical configuration of the mechanism, type of motion, type of sealing or the need for the lubricant to perform all or part of any sealing function in the prevention of lubricant loss or ingress of contaminants. Due to their semisolid nature, greases do not provide application cooling and cleaning functions associated with the use of a fluid lubricant. With these exceptions, greases perform all other functions of a fluid lubricant. While fluid lubricants are typically preferred by design, the aforementioned mechanical circumstances will always exist and thus the need for grease remains. As a result, greases are used in approximately 80% of rolling elements bearings.

## Grease Components

Greases are manufactured by combining three essential components: **base oil**, **thickener**, and **additives**.

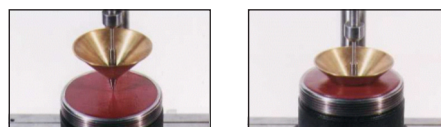
**Base Oils:** Base oil comprises the largest component of a grease, representing 80 - 97% by weight. The choice of base fluid may be mineral oil, synthetic oil, or any fluid that provides lubricating properties. It must be noted that the base oil portion of a grease performs the actual lubrication except in very slow or oscillating applications. The same rules applied to determine proper viscosity grade in a fluid lubricant apply to the selection of the base oil portion of lubricating grease.

**Thickeners:** The thickener may be any material that, in combination with the base oil, will produce the solid to semi-fluid structure. Simply put, a grease thickener in combination with the base oil acts much the same way as a sponge holding water. Principal thickeners used in greases include lithium, aluminum, calcium soaps; clay; polyurea; either alone or in combination. Lithium soap is the most common thickener in use today.

**Additives:** As in lubricating oil additives, grease additives and modifiers impart special properties or modify existing ones. Additives and modifiers commonly used in lubricating greases are oxidation or rust inhibitors, polymers, extreme pressure (EP) additives, anti-wear agents, lubricity or friction-reducing agents



Picture 1: ASTM D217 Grease Worker



Picture 2: Penetrometer cone released in grease

(soluble or finely dispersed particles such as molybdenum disulfide and graphite) and dyes or pigments. Dyes or pigments impart color **ONLY** having no effect on grease's lubricating capability.

## Grease Consistency

Consistency is defined as the degree to which a plastic material resists deformation under the application of force. In the case of lubricating greases, this is a measure of the relative hardness or softness and has some relation to flow and dispensing properties. Consistency is measured by ASTM D 217, Cone Penetration of Lubricating Grease and is often reported in terms of NLGI grade.

**Cone Penetration:** Grease consistency is measured at 25°C / 77°F after the sample has been subjected to 60 double strokes in the ASTM grease worker. After the sample has been prepared, a penetrometer cone is released and allowed to sink into the grease under its own weight for 5 seconds. The depth the cone has penetrated is then read, in tenths of a millimeter. The further the cone penetrates the grease, the higher the penetration result and the softer the grease.

**NLGI Grade:** The NLGI (National Lubricating Grease Institute) has standardized a numerical scale for grease consistency based upon ASTM D 217 worked penetration ranging from 000 for semifluid to 6 for block greases. The most common

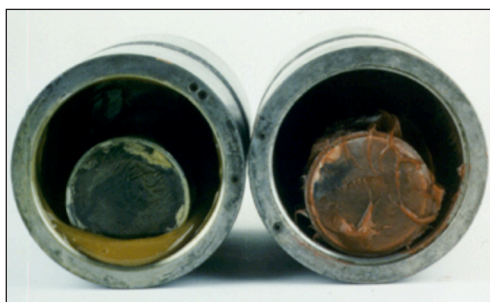
grease grade is NLGI 2 representing a smooth, buttery consistency. It must be noted that grease consistency is related to thickener content and has no relationship to base oil viscosity.

NLGI Consistency Grade	Penetration Range (1/10mm)	Description
000	445 - 475	Fluid
00	400 - 430	Semi-Fluid
0	355 - 385	Very Fluid
1	310 - 340	Soft
2	265 - 295	Medium
3	220 - 250	Medium-Hard
4	175 - 205	Hard
5	130 - 160	Very Hard
6	85 - 115	Block

Table 1: Definition of NLGI grades

### Grease Structural Stability

**Mechanical stability:** This is an essential performance characteristic of lubricating grease as it is a measure of how the grease consistency will change in service when it is subjected to mechanical stress (shear) resulting from the churning action caused by moving elements or vibrations generated by, or external to, the application. Grease softening in a bearing may eventually cause grease to leak out from the housing, requiring more maintenance and frequent grease replenishment to avoid premature failure resulting from lack of lubricant on the rolling elements. In order to have good mechanical stability, greases are developed through careful selection of the thickener composition and optimization of the manufacturing process. Mechanical stability is often measured using the ASTM D217 prolonged worker test (e.g., 100,000 double strokes), or the ASTM D1831 Roll Stability test. ASTM D1831 subjects the grease to shearing by rotating a cylinder containing a 5kg roller at 165 rpm for 2 hours. The change in penetration at the end of the tests is a measure of the mechanical stability. Picture 3 illustrates extreme mechanical softening of one grease on the left compared to little softening of another grease on the right. This test produces low shearing forces approximately equal to those found in the grease worker used for ASTM D217.

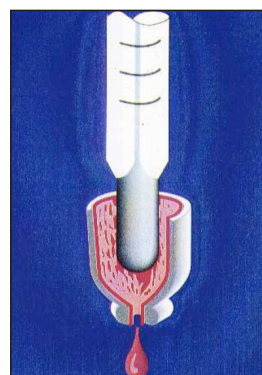


Picture 3: Grease at end of ASTM D1831 Roller Test

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In application and use, ingress of environmental contaminants is unfortunately a common reality that often adversely affects the mechanical stability of the grease. It is important that greases not only be developed to provide excellent structural stability in a pristine state, but also in the presence of environmental contaminants such as water, process fluids, or other contaminants. This can be assessed by means of laboratory bench tests operating in a variety of conditions with presence of water.

**Dropping point:** The dropping point of grease is the temperature at which the thickener loses its ability to maintain the base oil within the thickener matrix. This may be due to the thickener melting or the oil becoming so thin that the surface tension and capillary action become insufficient to hold the oil within the thickener matrix. ASTM D2265 (preferred over the older and less precise ASTM D566) is the standard method used to determine the dropping point of grease. A small grease sample is placed in a cup and heated in a controlled manner in an oven-like device. When the first drop of oil falls from the lower opening of the cup, the temperature is recorded to determine the dropping point. Dropping point is a function of the thickener type. High drop points, typically above 240°C / 465°F, are commonly observed for lithium complex, calcium complex, aluminum complex, polyurea and clay greases while much lower dropping points are typical of conventional lithium (180°C / 355°F), calcium (180°C / 355°F) and sodium (120°C / 250°F) soaps. The dropping point is one of the determinations that characterise the grease's thermal stability. However it is NOT an accurate prediction of the grease's upper operating temperature limit which is a function of many variables such as base oil oxidation stability, additive degradation, thickener shearing, oil separation and so forth. A high dropping point, while not a predictor of upper operating temperature, is an indicator of the maximum peak temperature that the grease may be subjected to for a short duration while not releasing oil excessively and therefore drastically reducing the life of the grease and potentially damaging the application in the long run.



Picture 4: Dropping Point Determination — Thermometer positioned in cup for determining the temperature at which the 1st drop of oil is released