INTRODUCTION
A solid or semisolid lubricant consisting of a thickening agent (soap or other additives) in a fluid lubricant (usually petroleum lubricating oil) is called grease.

Grease is a lubricant which has been thickened in order that it remains in contact with moving surfaces and not leak out under gravity or centrifugal action.

ASTM defines lubricating grease as “A solid to semi-solid product consisting of dispersion of a thickening agent in a liquid lubricant.”

There has been a need since ancient times for lubricating greases. The Egyptians used mutton fat and beef tallow to reduce axle friction in chariots as far back as 1400 B.C. Good lubricating greases were not available until the development of petroleum based oils in the late 1800’s. Today there are many different types of lubricating greases but the basic structure of these greases is similar.

Greases are used where a mechanism can only be lubricated infrequently and where a lubricating oil would not stay in position. In general greases contain 70-95% of base oils, 5-20% of thickening agent, and 0-10% of additives.

Depending on type of thickening agents different types of greases are classified as follows.

- Calcium
- Lithium
- Titanium
- Sodium
- Aluminium
- Clay
- Polyurea and others

There are two different methods by which grease can be manufactured.

- Batch process
- Continuous process

The manufacture of lubricating greases has shown constant progress with time. This holds true for raw materials, equipments, processes, and formulations.
RAW MATERIAL
As this definition indicates, there are three components that form lubricating grease. These components are oil, thickener and additives. The base oil and additive package are the major components in grease formulations, and as such, exert considerable influence on the behavior of the grease. The thickener is often referred to as a sponge that holds the lubricant (base oil and additives).

**BASE OIL**

Most greases produced today use mineral oil as their fluid components. These mineral oil-based greases typically provide satisfactory performance in most industrial applications. In extreme temperature conditions (low or high), grease that utilizes synthetic base oil provide better stability.

When formulating grease the selection of base fluid is not only about product properties, it’s also about production costs. And a significant proportion of the production cost is the amount of soap required to achieve a certain NLGI grade. The solvating power of the base fluid affects the amount of soap needed. The following test was performed to determine the difference in amounts of soap needed between naphthenic (high solvating power) and paraffinic (lower solvating power) oils.

NLGI grade 2 greases were produced using three naphthenic oils with increasing degrees of refining and a paraffinic oil, all of approximately the same viscosity. As can be seen, the naphthenic oils with higher solvating power result in a saving of as much as 25% on soap consumption if you compare the oil with the lowest aniline point with the paraffinic oil. This would obviously have a significant impact on production costs as 25% less soap would be needed to produce the same NLGI grade.

Another production cost to consider is energy consumption. When “cooking” the grease, the temperature must be raised until the fatty acids are dissolved. Obviously the higher the temperature needed, the more energy is consumed. Higher temperatures also increase the risk of soap oxidation.

The difference in the solution temperature of hydroxystearic acid in three naphthenic oils with different degrees of refining and one paraffinic oil. The concentration of hydroxystearic acid in each oil was 30 wt%, which is representative of the typical concentration during grease cooking. As can be seen, the temperature at which the fatty acid dissolves is significantly lower for all the naphthenic oils than for the paraffinic oil. The lower temperatures needed in greases with naphthenic oils is due to their higher solvating power.
Oils with higher solvating power by definition have a higher capability of dissolving additives. The additives are dissolved at lower temperatures and smaller amounts of them are required to achieve the same grades.

**Effect of base oil on grease properties**

Due to the higher solvating power of naphthenic oils they display a higher affinity towards the soap. In naphthenic-based greases there is a prevalence of physiochemical interaction between the oil and the soap, as opposed to paraffinic-based greases where most of the oil is physically rather than physiochemically trapped in the soap structure. This means the naphthenic oil is more intimately bonded with the soap structure and displays a lower tendency to separate or bleed from the grease.

**THICKENER**

The thickener is a material that, in combination with the selected lubricant, will produce the solid to semi fluid structure. The primary type of thickener used in current grease is metallic soap. These soaps include lithium, aluminum, clay, Polyurea, sodium and calcium. Lately, complex thickener-type greases are gaining popularity. They are being selected because of their high dropping points and excellent load-carrying abilities. Complex greases are made by combining the conventional metallic soap with a complexing agent. The most widely used complex grease is lithium based. These are made with a combination of conventional lithium soap and a low-molecular-weight organic acid as the complexing agent. Non-soap thickeners are also gaining popularity in special applications such as high-temperature environments. Smectonite or Bentonite and silica aerogel are examples of thickeners that do not melt at high temperatures. There is a misconception, however, that even though the thickener may be able to withstand the high temperatures, the base oil will oxidize quickly at elevated temperatures, thus requiring a frequent relube interval.

**ADDITIVES**

Additives can play several roles in lubricating grease. These primarily include enhancing the existing desirable properties, suppressing the existing undesirable properties, and imparting new properties. The most common additives are oxidation and rust inhibitors, extreme pressure, antiwear, and friction-reducing agents. In addition to these additives, boundary lubricants such as molybdenum disulfide or graphite may be suspended in the grease to reduce friction and wear without adverse chemical reactions to the metal surfaces during heavy loading and slow speeds.
### Different Types of Additives With Their Functions Are As Follows

<table>
<thead>
<tr>
<th>FUNCTIONS</th>
<th>TYPE OF ADDITIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antioxidant</td>
<td>Phenols, Amines, Phosphorous Compound, Sulfur Compound</td>
</tr>
<tr>
<td>Extreme Pressure &amp; Corrosion Inhibitor</td>
<td>Tricrysylphosphate, Amine Phosphate Triphenylphosphate</td>
</tr>
<tr>
<td>Rust Inhibitor</td>
<td>Barium &amp; Calcium Sulphonates</td>
</tr>
<tr>
<td>Corrosion Inhibitor</td>
<td>Benzotriazoles, Mercapto Ethiozoles, Dimercaptophtiozoles, Alkyl Benzene Sulphonates</td>
</tr>
<tr>
<td>Vi Improvers</td>
<td>Methacrylates.</td>
</tr>
<tr>
<td>Antiwear</td>
<td>ZDDP, Antimony Di Alkyl Dithio Phosphate</td>
</tr>
<tr>
<td>Water Repelling Agent</td>
<td>Fatty Oils</td>
</tr>
<tr>
<td>Tackiness Agent</td>
<td>Polymers (Methacrylate)</td>
</tr>
<tr>
<td>Friction Modifiers</td>
<td>MoS₂, Graphite</td>
</tr>
</tbody>
</table>
TYPE OF GREASES
 SOAP BASED GREASE

Soap based grease contains organic or inorganic thickeners. It is formed when the fatty acid or ester (from either animals or vegetables) is mixed with an alkali (such as lithium) and then heated under pressure with agitation. The process of this chemical reaction, which takes place is known as saponification.

LITHIUM GREASE.

(1) Lithium grease is smooth, buttery-textured and by far the most popular when compared to all others. The normal grease contains lithium 12-hydroxystearate soap. It has a dropping point around 205°C and can be used at temperatures up to about 150°C. It can also be used at temperatures as low as (-)35°C. It has good shear stability and a relatively low coefficient of friction, which permits higher machine operating speeds. It has good water-resistance, but not as good as that of calcium or aluminum base. Pumpability and resistance to oil separation are good to excellent. It does not naturally inhibit rust, but additives can provide rust resistance. Anti-oxidants and extreme pressure additives are also responsive in lithium greases.

(2) Lithium complex grease and lithium soap grease have similar properties except the complex grease has superior thermal stability as indicated by a dropping point of 260°C. It is generally considered to be the nearest thing to true multipurpose grease.

CALCIA GREASE.

(1) Calcium or lime grease, the first of the modern production greases, is prepared by reacting mineral oil with fats, fatty acids, small amount of water, and calcium hydroxide (also known as hydrated lime). The water modifies the soap structure to absorb mineral oil. Because of water evaporation, calcium grease is sensitive to elevated temperatures. It dehydrates at temperatures around 79°C at which its structure collapses, resulting in softening and, eventually, phase separation. Greases with soft consistencies can dehydrate at lower temperatures while greases with firm consistencies can lubricate satisfactorily to temperatures around 93°C. In spite of the temperature limitations, lime grease does not emulsify in water and is excellent at resisting “wash out.” Also, its manufacturing cost is relatively low. If calcium grease is prepared from 12-hydroxystearic acid, the result is an anhydrous (waterless) grease. Since dehydration is not a concern, anhydrous calcium grease can be used continuously to a maximum temperature of around 110°C.

(2) Calcium complex grease is prepared by adding the salt calcium acetate. The salt provides the grease with extreme pressure characteristics without using an additive. Dropping points greater than 260°C can be obtained and the maximum usable temperature increases to approximately 177 °C. With the exception of poor pumpability in high-pressure centralized systems, where caking and hardening sometimes occur calcium complex greases have good all-around characteristics that make them desirable multipurpose greases.
SODIUM GREASE.

Sodium grease was developed for use at higher operating temperatures than the early hydrated calcium greases. Sodium grease can be used at temperatures up to 121°C but it is soluble in water and readily washes out. Sodium is sometimes mixed with other metal soaps, especially calcium, to improve water resistance. Although it has better adhesive properties than calcium grease, the use of sodium grease is declining due to its lack of versatility. It cannot compete with water-resistant, more heat-resistant multipurpose greases. It is, however, still recommended for certain heavy-duty applications and well-sealed electric motors.

ALUMINUM GREASE.

(1) Aluminum grease is normally clear and has a somewhat stringy texture, more so when produced from high-viscosity oils. When heated above 79°C this stringiness increases and produces a rubber like substance that pulls away from metal surfaces, reducing lubrication and increasing power consumption. Aluminum grease has good water resistance, good adhesive properties, and inhibits rust without additives, but it tends to be short-lived. It has excellent inherent oxidation stability but relatively poor shear stability and pumpability.

(2) Aluminum complex grease has a maximum usable temperature of almost 100 °C higher than aluminum-soap greases. It has good water-and-chemical resistance but tends to have shorter life in high-temperature, high-speed applications.
NON-SOAP BASED GREASE

A non-soap based grease consists of inorganic like molybdenum disulphide and graphite, as well as organic thickeners. The organic thickeners are considered as non-abrasives, which have high capacity to absorb and "hold" the base oil.

POLYUREA GREASE.

Polyurea is the most important organic non soap thickener. It is a low-molecular-weight organic polymer produced by reacting amines (an ammonia derivative) with iso cyanates, which results in an oil soluble chemical thickener. Polyurea grease has outstanding resistance to oxidation because it contains no metal soaps (which tend to invite oxidation). It effectively lubricates over a wide temperature range of -20 to 177 °C and has long life. Water-resistance is good to excellent, depending on the grade. It works well with many elastomer seal materials. It is used with all types of bearings but has been particularly effective in ball bearings. Its durability makes it well suited for sealed-for-life bearing applications.

ORGANO-CLAY.

Organo-clay is the most commonly used inorganic thickener. Its thickener is modified clay, insoluble in oil in its normal form, but through complex chemical processes, converts to platelets that attract and hold oil. Organo-clay thickener structures are amorphous and gel-like rather than the fibrous, crystalline structures of soap thickeners. This grease has excellent heat-resistance since clay does not melt. Maximum operating temperature is limited by the evaporation temperature of its mineral oil, which is around 177 °C. However, with frequent grease changes, this multipurpose grease can operate for short periods at temperatures up to its dropping point, which is about 260 °C. A disadvantage is that greases made with higher-viscosity oils for high thermal stability will have poor low temperature performance. Organo-clay grease has excellent water-resistance but requires additives for oxidation and rust resistance. Work stability is fair to good. Pumpability and resistance to oil separation are good for this buttery textured grease.
FUNCTION
FUNCTIONS OF LUBRICATING GREASE:
1. Reduce wear and tear.
2. Sealant to contaminants.
3. Prevent corrosion.
4. Prevent rust.
5. Heat transmission.
6. Resist

DIFFERENCE BETWEEN LUBRICATING GREASE & LUBRICATING OIL:

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>LUBRICATING GREASE</th>
<th>LUBRICATING OIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Less frequent application is necessary with lubricating grease.</td>
<td>Frequent application is necessary with lubricating oil.</td>
</tr>
<tr>
<td>2.</td>
<td>Lubricating grease act as a seal against the entrance of dirt &amp; dust.</td>
<td>Lubricating oil does not act as a seal against foreign particles.</td>
</tr>
<tr>
<td>3.</td>
<td>When machine is grease lubricated dripping &amp; spattering can be eliminated.</td>
<td>Dripping &amp; spattering protection is not possible with lubricating oil.</td>
</tr>
<tr>
<td>4.</td>
<td>Less expensive.</td>
<td>Cost is more than lubricating grease.</td>
</tr>
<tr>
<td>5.</td>
<td>Retention time &amp; stickiness is more than lubricating oil.</td>
<td>Retention time &amp; stickiness is less than lubricating grease.</td>
</tr>
<tr>
<td>6.</td>
<td>Saponification reaction is the key factor of lubricating grease.</td>
<td>Saponification reaction does not take place.</td>
</tr>
<tr>
<td>7.</td>
<td>Operating over wider temperature range.</td>
<td>Operating temperature range is less than lubricating grease.</td>
</tr>
<tr>
<td>8.</td>
<td>Solve the problem of lubrication without corrosion in presence of water.</td>
<td>Can not used in the presence of water.</td>
</tr>
</tbody>
</table>
CHARACTERISTICS
As with oil, grease displays its own set of characteristics that must be considered when being chosen for an application. The characteristics commonly found on product data sheets include the following:

**PUMPABILITY**
Pumpability is the ability of a grease to be pumped or pushed through a system. More practically, pumpability is the ease with which pressurized grease can flow through lines, nozzles and fittings of grease-dispensing systems.

**WATER RESISTANCE**
This is the ability of grease to withstand the effects of water with no change in its ability to lubricate. Soap/water lather may suspend the oil in the grease, forming an emulsion that can wash away or, to a lesser extent, reduce lubricity by diluting and changing grease consistency and texture.

**CONSISTENCY**
Grease consistency depends on the type and amount of thickener used and the viscosity of its base oil. Grease’s consistency is its resistance to deformation by an applied force. The measure of consistency is called penetration. Penetration depends on whether the consistency has been altered by handling or working. ASTM D 217 and D 1403 methods measure penetration of unworked and worked greases. To measure penetration, a cone of given weight is allowed to sink into a grease for five seconds at a standard temperature of 25°C. The depth, in tenths of a millimeter, to which the cone sinks into the grease, is the penetration. A penetration of 100 would represent solid grease while a penetration of 450 would be semi fluid.

**DROPPING POINT**
Dropping point is an indicator of the heat resistance of grease. As grease temperature increases, penetration increases until the grease liquefies and the desired consistency is lost. The dropping point is the temp which grease becomes fluid enough to drip. The dropping point indicates the upper temperature limit at which grease retains its structure, not the max temperature at which grease may be used.

**OXIDATION STABILITY**
This is the ability of grease to resist a chemical union with oxygen. The reaction of grease with oxygen produces insoluble gum, sludge and lacquer-like deposits that cause sluggish operation, increased wear and reduction of clearances. Prolonged exposure to high temperatures accelerates oxidation in greases.
HIGH-TEMPERATURE EFFECTS
High temperatures harm greases more than they harm oils. Grease, by its nature, cannot dissipate heat by convection like circulating oil. Consequently, without the ability to transfer away heat, excessive temperatures result in accelerated oxidation or even carbonization where grease hardens or forms a crust. Effective grease lubrication depends on the grease's consistency. High temperatures induce softening and bleeding, causing grease to flow away from needed areas. The mineral oil in grease can flash, burn or evaporate at temperatures greater than 177°C.

LOW-TEMPERATURE EFFECTS
If the temperature of grease is lowered enough, it will become so viscous that it can be classified as hard grease. Pumpability suffers and machinery operation may become impossible due to torque limitations and power requirements. As a guideline, the base oil's pour point is considered the low-temperature limit of grease.
PROPERTIES OF GREASE
## PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th>Properties</th>
<th>Aluminum</th>
<th>Sodium</th>
<th>Calcium</th>
<th>Lithium</th>
<th>Aluminum Complex</th>
<th>Calcium Complex</th>
<th>Sodium Complex</th>
<th>Lithium Complex</th>
<th>Poly urea</th>
<th>Organo-Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dropping Point (°C)</td>
<td>110</td>
<td>163-177</td>
<td>135-143</td>
<td>177-204</td>
<td>260+</td>
<td>260+</td>
<td>096-104</td>
<td>260+</td>
<td>243</td>
<td>260+</td>
</tr>
<tr>
<td>Maximum usable Temp (°C)</td>
<td>79</td>
<td>121</td>
<td>110</td>
<td>135</td>
<td>177</td>
<td>177</td>
<td>93</td>
<td>177</td>
<td>177</td>
<td>177</td>
</tr>
<tr>
<td>Water resistance</td>
<td>Good to Excellent</td>
<td>Poor to fair</td>
<td>Good</td>
<td>Good to Excellent</td>
<td>Excellent</td>
<td>Fair to excellent</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
<td>Good to Excellent</td>
<td>Fair to Excellent</td>
</tr>
<tr>
<td>Work stability</td>
<td>Poor</td>
<td>Fair</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
<td>Fair to good</td>
<td>Fair to good</td>
<td>Good to excellent</td>
<td>Poor to good</td>
<td>Fair to Good</td>
</tr>
<tr>
<td>Oxidation stability</td>
<td>Excellent</td>
<td>Poor to good</td>
<td>Fair to excellent</td>
<td>Fair to excellent</td>
<td>Fair to excellent</td>
<td>Poor to good</td>
<td>Poor to good</td>
<td>Fair to excellent</td>
<td>Good to excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Protection against Rust</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
<td>Poor to excellent</td>
<td>Poor to excellent</td>
<td>Good to excellent</td>
<td>Fair to excellent</td>
<td>Poor to excellent</td>
<td>Fair to excellent</td>
<td>Poor to excellent</td>
<td>Poor to excellent</td>
</tr>
<tr>
<td>Oil separation</td>
<td>Good Fair to good</td>
<td>good</td>
<td>Good</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
<td>Poor to good</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
<td>Good to excellent</td>
</tr>
<tr>
<td>Appearance</td>
<td>Smooth and Clear</td>
<td>Smooth fibrous</td>
<td>Smooth and buttery</td>
<td>Smooth and buttery</td>
<td>Smooth and buttery</td>
<td>Smooth and buttery</td>
<td>Smooth and buttery</td>
<td>Smooth and buttery</td>
<td>Smooth and buttery</td>
<td>Smooth and buttery</td>
</tr>
<tr>
<td>Principal Uses</td>
<td>Thread lubricants</td>
<td>Rolling contact economy</td>
<td>Military Multiservice</td>
<td>Multiservice automotive &amp; industrial</td>
<td>Multiservice automotive &amp; industrial</td>
<td>General uses for economy</td>
<td>Multiservice automotive &amp; industrial</td>
<td>Multiservice automotive &amp; industrial</td>
<td>High temp. (frequent relube)</td>
<td></td>
</tr>
</tbody>
</table>
Lithium based grease is generally manufactured with two methods.

1. **Batch process**
2. **Continuous process**

Between these two methods Batch process is preferable because, it is more advantageous over Continuous process.
BATCH PROCESS

BASE OIL TANK

REACTOR 1

REACTOR 2

KETTLE 1
KETTLE 2
KETTLE 3
KETTLE 4
KETTLE 5
KETTLE 6

FILTER

GREASE PRODUCT

TANK

215 °C

6-7 atm

215 °C

6-7 atm

BASE OIL

TANK

215 °C

6-7 atm

215 °C

6-7 atm

FILTER

GREASE PRODUCT
STEPS INVOLVED DURING BATCH PROCESS

1. Saponification
2. Dehydration
3. Dilution, additive addition
4. Homogenization / milling
5. Check for suitability
6. Packaging

TYPICAL FLOWCHART FOR BATCH PROCESS
Batch production is the most common manufacturing method. The steps of manufacturing include the following.

1. Bulk ingredients are metered or weighed into the processing reactor. For soap-based greases made by saponification (the process of forming soap by splitting a fat with an alkali), the fatty ingredient, alkali and a portion of the oil are added to the reactor. By heating (300 - 450°F) and mixing, the fat is converted to soap, and the soap is dispersed throughout the mixture. This may be done in open kettles or in closed pressure kettles. After completion of saponification and dehydration (removal of water), the remaining oil is added to the batch to lower the temperature. Next, the grease is milled or homogenized.

2. This step of homogenization or milling is very important, because it will produce a uniform crystal and gel structure that will not change when the grease is used. Homogenizing the grease will break down the solid particles or fibers and will disperse the resultant small particles in the liquid. It also breaks up lumps, eliminates graininess and produces a smooth product. Homogenization of certain types of greases will stiffen the grease producing lower penetration value. Homogenization can improve texture and “brighten” grease’s appearance. In many cases this homogenization process is carried out at temperatures greater than 200°F (93°C).

3. After homogenization, the grease is further cooled, desecrated and packaged. Of course, it is understood that there are many different grease manufacturing methods depending on the type of grease and the manufacturer.
CONTINUOUS PROCESS

SAP MATERIAL → LUBRICATING OIL → METAL BASE

REACTOR

200-350°F
50-200 PSI
225°F

LUBRICATING OIL

ADDITIVES

DEHYDRATION ZONE

GREASE PRODUCT

LUBRICATING OIL
The saponifiable material, lubricating oil & metal base flow into inlet of saponification zone of tubular reactor. In saponification zone pressure is about 100-300 psig and temperature up to 180°F.

The reactant stream is passed through saponification zone at a velocity which is preferably sufficient to maintain turbulent flow within the tubular reactor. Reactant mixture flow velocity is sufficient for producing highly turbulent flow with Reynolds number in the range of about 4000 to 100000. Flow rates required for obtaining the degree of turbulence are generally within the range of about 0.6-12.0 ft³/min. of reaction mixture. For obtaining such high flow rates of reactant mixture through saponification zone reactor outlet may be recycled to reactor via reactor inlet. It is desirable to minimize the water injected into the grease with the additives. Temperature of the reaction mixture which comes out of the saponification zone is maintained in the range of about 250-350°F. A temperature of about 350°F is sufficient to provide the necessary amount of heat to such combined mixtures. The temperature of the combined mixture should not exceed the melting point of soap component of the grease. Additional heat is imparted to the combined mixture in heating means to restore or increase the temperature of the combined mixture to about 250°F and to prevent condensation of water.

Dehydration zone comprises a vertical cylindrical vessel having a volume sufficient to receive combined mixture and water vapour and provide residence time of about 1 to 20 minute. Dehydration zone is maintained under vacuum conditions. Due to such conditions all the liquid water present in the combined mixture flash vaporizes. The grease mixture is recycled continuously from the bottom of the dehydration zone with the pressure up to 10-200 psi. Recycling of the grease mixture is preferably carried out at a rapid rate such that the turnover rate in the dehydration zone is at least equivalent to about the average volume of grease therein per minute. The recycle rate and average residence time in dehydration zone are sufficient to provide a soap conditioning period of at least about 5 minute. By such conditioning the soap of grease mixture is reduced to a consistency which contributes to the desired consistency for the product grease.

The base oil which is added in grease mixture is at lower temperature than that of the grease mixture. This is done for cooling purpose. In case if additional cooling is desirable then the grease may be passed through cooler and the grease mixture may be recycled for obtaining multiple passes.
PROCESS SELECTION
ADVANTAGES OF BATCH PROCESS

1. Batch process offers great advantage over continuous process, which include manufacturing operation in which flexibility required in either a rate or mixture of products.

2. Batch process adjusts production either operating the flexibility on fewer shifts or manufacturing a different product that is in higher demand.
   eg. Continuous distillation column has an efficient range of production that is set by the hydraulic limitations of flooding at the high end and weeping at the low end. Operations outside this limit are not feasible.

3. In batch process equipment can be reuse.

4. Process variables can be subjected to adjustments.

5. In batch process multi-product operation can be done.

6. Grease has a demand that changes over time or has seasonal variability. And this type of variability is well suited to batch manufacturing.

7. Cost required is less in case of batch process.
LITHIUM BASED GREASE

DISCOVERED- 1887 BY SWIDISH
PRODUCTION STARTED- 1938

BASIS

1. Product to be manufactured - Lithium Based Grease
2. Ambient air temperature - 20-50 deg C
3. Atmospheric pressure - 760 mm Hg
4. Power characteristics - 415 V/380, 50/60 HZ,
   3 Phase 240V, 50Hz Phase
5. Fuel - Furnace Oil

OPERATING DATA

1. Furnace oil temperature - 260 deg C for Lithium
2. Reactor pressure - 6-7 Kg/cm2
3. Reactor temperature - 215+/-5°C.
4. Space requirement - approx. 600 sq meters
   for plant and 600 sq meters for raw material and
   finished good storage.

PERFORMANCE

- +/- 5%

UTILITIES

- +/- 10%

RAW MATERIAL

<table>
<thead>
<tr>
<th></th>
<th>LITHIUM HYDROXIDE</th>
<th>0.8-2.2%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADDITIVE</td>
<td>1 – 6%</td>
</tr>
<tr>
<td></td>
<td>BASE OIL</td>
<td>70- 94%</td>
</tr>
</tbody>
</table>
CHEMICAL REACTION:-

\[
\text{CH}_3-(\text{CH}_2)_5-\text{CHOH}-(\text{CH}_2)_{10}-\text{COOH} \quad + \quad \text{LiOH}
\]

12-hydroxy stearic acid \quad \text{Lithium Hydroxide}

\[
\downarrow
\]

\[
\text{CH}_3-(\text{CH}_2)_5-\text{CHOH}-(\text{CH}_2)_{10}-\text{COOLi} \quad + \quad \text{H}_2\text{O}
\]

Lithium 12-OH stearate soap \quad \text{(steam)}

EQUIPMENT REQUIRED

1. PRESSURE VESSEL WITH JACKATED & STIRRING SYSTEM
2. HOT OIL SYSTEM
3. FURNACE OR BOILER
4. HOMOGENISER
5. COOLING SYSTEM
6. FILTER
7. STORAGE TANK FOR OIL
8. FILLING LINE/ PACKAGING MATERIAL
FACTORS AFFECTING QUALITY OF GREASE

1. Rate of saponification reaction
2. Acidity / Alkalinity
3. Rate / Sequence of addition of additives and oil
4. Temperature of grease formation
5. Temperature of additive addition
6. Temperature and duration of de-aeration, filtrations and homogenization


**Raw material required is :-**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASE OIL</td>
<td>5174</td>
</tr>
<tr>
<td>STEARIC ACID</td>
<td>600</td>
</tr>
<tr>
<td>LITHIUM HYDROXIDE MONOHYDRATE</td>
<td>90</td>
</tr>
<tr>
<td>WATER</td>
<td>5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>5869</strong></td>
</tr>
</tbody>
</table>

Mass before entering to the reactor

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base oil</td>
<td>3221</td>
</tr>
<tr>
<td>Lithium hydroxide monohydrate</td>
<td>600</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>90</td>
</tr>
<tr>
<td>Water</td>
<td>5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3916</strong></td>
</tr>
<tr>
<td>COMPONENT</td>
<td>MOLECULAR WEIGHT</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>300</td>
</tr>
<tr>
<td>Lithium hydroxide</td>
<td>23.95</td>
</tr>
<tr>
<td>Soap</td>
<td>305.914</td>
</tr>
<tr>
<td>water</td>
<td>18</td>
</tr>
</tbody>
</table>

**Material balance for soap**

1 mol stearic acid = 1 mol soap

300 gm stearic acid = 305.914 gm soap

600 Kg of stearic acid = X Kg of soap

\[ X = \frac{600 \times 305.91}{300} \]

\[ X = 611.828 \text{ Kg of soap.} \]

**Material balance for water**

1 mol of stearic acid = 1 mol water

300 gm of stearic acid = 18 gm water

600 Kg of stearic acid = Y Kg of water

\[ Y = \frac{600 \times 18}{300} \]

\[ Y = 36 \text{ Kg of water as steam.} \]

Total grease without additive = 3221 + 611.828

\[ = 3832.828 \text{ Kg} \]

Total water steam formed = 36 + 5

\[ = 41 \text{ Kg} \]
Loss (accumulation) = 3916 – (3832.828 + 41)

= 42.172 Kg

**Mass leaving the reactor**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw grease (without grease)</td>
<td>3832.828</td>
</tr>
<tr>
<td>Steam</td>
<td>41</td>
</tr>
<tr>
<td>Loss(Accumulation)</td>
<td>42.172</td>
</tr>
</tbody>
</table>

**TOTAL**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3916</strong></td>
</tr>
</tbody>
</table>

**Mass input = Mass output + Loss**
### Mass before entering the kettle

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw grease (without additives)</td>
<td>3832.828</td>
</tr>
<tr>
<td>Additives</td>
<td>68</td>
</tr>
<tr>
<td>Base oil</td>
<td>1953</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5853.828</strong></td>
</tr>
</tbody>
</table>

### Mass after leaving the kettle

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease</td>
<td>5853.828</td>
</tr>
<tr>
<td>Loss(Accumulation)</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>5853.828</strong></td>
</tr>
</tbody>
</table>

**Mass input = Mass output + Loss (Accumulation)**
ENERGY BALANCE
ENERGY BALANCE

BASIS: Energy Balance taking the basis as one Batch time = 5.50 hrs.
- Reference temperature: - 61.2°C.
- Maximum temperature in reactor: - 215°C.
- All masses (m) are expressed in Kg unless specified.
- All specific heats (Cp) are expressed in KJ/Kg°C.
- All temperatures (T) are in °C unless specified.
- All enthalpies (H) are in KJ.

ENERGY BALANCE ACROSS OF THE REACTOR

<table>
<thead>
<tr>
<th>Component</th>
<th>M Kg</th>
<th>Cp KJ/Kg°C</th>
<th>T °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base oil</td>
<td>3221</td>
<td>0.8</td>
<td>61.2</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>600</td>
<td>2.3</td>
<td>61.2</td>
</tr>
<tr>
<td>Lithium hydroxide monohydrate</td>
<td>90</td>
<td>1.91</td>
<td>61.2</td>
</tr>
<tr>
<td>water</td>
<td>5</td>
<td>1</td>
<td>61.2</td>
</tr>
</tbody>
</table>
HEAT GAINED BY COMPONENT IN REACTOR

- Component 1: Stearic Acid  
  \( (C_p = 2.3 \text{ KJ/Kg}^\circ\text{C} , \ m= 600 \text{ Kg}) \)
  
  Sensible heat for Stearic Acid  
  \[ = mC_p dT \]
  \[ = 600 \times 2.3 \times (215 - 61.2) \]
  \[ = 212244 \text{ KJ} \]

- Component 2: Lithium Hydroxide Monohydrate  
  \( (C_p = 1.91 \text{ KJ/Kg}^\circ\text{C} , \ m = 90 \text{ Kg} ) \)
  
  Sensible heat for Lithium Hydroxide Monohydrate  
  \[ = mC_p dT \]
  \[ = 90 \times 1.91 \times (215 - 61.2) \]
  \[ = 26438.22 \text{ KJ} \]

- Component 3: Base Oil Mixture  
  \( (C_p = 0.8 \text{ KJ/Kg}^\circ\text{C} , \ m = 3221 \text{ Kg} ) \)
  
  Sensible heat for Base Oil Mixture  
  \[ = mC_p dT \]
  \[ = 3221 \times 0.8 \times (215 - 61.2) \]
  \[ = 396311.84 \text{ KJ} \]

- Component 4: Water  
  \( (C_p = 1 \text{ KJ/Kg}^\circ\text{C} , \ m = 5 \text{ Kg} \ & \ \lambda = 2120 \text{ KJ/Kg}^\circ\text{C} ) \)
  
  Sensible heat and heat for phase change of water  
  \[ = mC_p dT + m\lambda \]
  \[ = 41 \times 1 \times (100 - 61.2) + 41 \times 2120 \]
  \[ = 1590.8 + 86920 \]
  \[ = 88510.8 \text{ KJ} \]

Heat Gained = Sensible heat of all components  
Heat for phase change of component water

\[ = 212244 + 26438.22 + 396311.84 + 88510.8 \]
\[ = 723504.86 \text{ KJ} \]

Heat Gained = 723504.86 KJ.
HEAT SUPPLIED BY COMPONENT TO THE REACTOR

<table>
<thead>
<tr>
<th>Component</th>
<th>In to the reactor with</th>
<th>Out from the reactor with</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M Kg Cp KJ/Kg°C T °C</td>
<td>T °C</td>
</tr>
<tr>
<td>Thermic fluid</td>
<td>1049.56 4.22 210</td>
<td>240</td>
</tr>
</tbody>
</table>

Heat supplied = Heat supplied by heating media * Time required for one batch * Correction factor

Heat supplied by thermic fluid = 1049.56 * 4.22 * (240-210) * 5.50 * 0.99
=723504.86 KJ

So from above we say that,

**Heat Supplied = Heat Gained**
MATERIAL OF CONSTRUCTION
MATERIAL OF CONSTRUCTION

Carbon Steel for Reactor

Structural Steel for vessel supports

Carbon steel, also called plain carbon steel, is a metal alloy, a combination of two elements, iron and carbon, where other elements are present in quantities too small to affect the properties. The only other allowing element allowed in plain-carbon steel are manganese (1.65% max), silicon (0.60% max), and copper (0.60% max). Steel with low carbon content has the same properties as iron, soft but easily formed. As carbon content rises, the material becomes harder and stronger but less ductile but difficult to weld. Higher carbon contents lowers steel’s melting point and its temperature resistance in general.

Carbon content influences the yield strength of steel because carbon molecules fit into the interstitial crystal lattice sites of body centered cubic arrangement of the iron molecules. The interstitial carbon reduces the mobility of dislocations, which in turn has a hardening effect on iron. To get dislocations to move, a high enough stress level must be applied in order for dislocations to “break away”. This is because the industrial carbon atoms cause some of the iron BCC lattice cells to distort.

Typical compositions of carbon:

- **Mild (low carbon) steel**: Approximately 0.05-0.15% carbon content for low carbon steel and 0.16-0.29% carbon content for mild steel (e.g. AISI 1018 steel). Mild steel has a relatively low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing.

- **Medium carbon steel**: Approximately 0.30-0.59% carbon content (e.g. AISI 1040 steel). Balances ductility and strength and has good wear resistance; used for large parts, forging and automotive components.

- **High carbon steel**: Approximately 0.6-0.99% carbon content. Very strong, used for spring and high-strength wires.
- **Ultra-high carbon steel**: Approximately 1.0-2.0% carbon content. Steel that can be great hardness. Used for special purposes like (non-industrial purpose) knives, axles or punches. Most steel with more than 1.2% carbon content are made using powder metallurgy and usually fall in the category of high alloy carbon steel.

Steel can be heat-treated which allows parts to be fabricated in an easily-formable soft state. If enough carbon is present, the alloy can be hardened to increase strength, wear, and impact resistance. Steel are often wrought by cold-working methods, which is the shaping of metal through deformation at a low equilibrium or metastable temperature.

**METALLURGY**

Carbon steel which can successfully undergo heat-treatment have carbon content in the range of 0.30-1.70% by weight. Trace impurities of various other elements can have a significant effect on the quality of the resulting steel. Trace amounts of sulfur in particular make the redlow alloy carbon steel, such as A36 grade, contains about 0.05% sulfur and melts around 1426-1538 °C (2600-2800°F). manganese is often added to improve the harden ability of low carbon steels. These addition turn the material into low alloy steel by some definition, but AISI’s definition of carbon steel allows up to 1.65% manganese by weight.
**Structural steel for vessel support**

Structural steel is steel construction material, a profile, formed with a specific shape or cross section and certain standards of chemical composition and strength. Structure steel shape, size, composition, strength, storage etc., is most industrialized countries.

Structural steel, such as I-beams, has a large polar moment of inertia, which allows the beam to be very stiff in respect to its cross-section area.

Structural steel in construction: - A primed steel beam is holding up the floor above, which consists of a metal deck (Q-Deck), upon which a concrete slab has been poured.

Most industrialized countries prescribe a range of standard steel grades with different strength, corrosion resistance and other properties.

**Thermal properties**

The properties of steel vary widely, depending on its alloying elements. The austenizing temperature, the temperature where steel transform to an austenite structure, for steel at 900°C for pure iron, then, as more carbon is added, the temperature falls to a minimum 724°C for steel (steel with only 0.83% by weight of carbon in it). As 2.1% carbon (by mass) is approached, the austenizing temperature climbs back up, to 1130°C. Similarly, the melting point of steel changes based on the alloy.

The lowest temperature at which plain carbon steel can begin to melt, its solids, is 1130°C. Steel never turns into a liquid below this temperature. Pure iron (‘steel’ with 0% carbon) starts to melt at 1492°C, and is completely liquid upon reaching 1539°C. Steel with 2.1% Carbon by weight begins melting at 1130°C and is completely molten upon reaching 1315°C. ‘Steel’ with more than 2.1% Carbon is no longer steel, but is known as cast iron.
REACTOR DESIGN
SHELL DESIGN

Design pressure = 1.1 * 0.6864 N/mm$^2$

\[= 0.75504 \text{ N/mm}^2\]
\[\approx 0.8 \text{ N/mm}^2\]

The thickness of shell is found by using the formula

\[t_s = \left[ \frac{PD_i}{2fJ - P} \right] + C\]

\[= \frac{(0.8 * 2500)}{(2*140*0.85) - 0.8} + C\]
\[= 8.43 \text{ mm} + C\]
\[\approx 9 \text{ mm} + C\]
\[= 9 + 3 \text{ mm} \quad \text{where corrosion allowance, } C = 3 \text{ mm}\]
\[= 12 \text{ mm}\]

Testing for other stresses:

a) Circumferential stress:

\[f_i = \frac{P(D_i + t)}{2t} \quad \text{(Tensile)}\]
\[= \frac{0.8*(2500 + 9)}{2*9}\]
\[= 111.51 \text{ N/mm}^2\]

b) Axial stress:

1) Due to internal pressure

\[f_i = \frac{P.D_i}{4.t} \quad \text{(Tensile)}\]
\[= \frac{(0.8*2500)}{(4*9)}\]
\[= 55.55 \text{ N/mm}^2 \quad \text{(Tensile)}\]

2) Due to weight of vessel and contents

\[f_2 = \frac{W}{\pi t_s(D_i + t_i)} \quad \text{(Compressive)}\]

Where \(W = \text{Weight of Vessel and contents} = 100000 \text{ N}\)
\[ f_2 = \frac{1000000}{(\pi \times (2500+9) \times 9)} \]
\[ = 1.4096 \text{ N/mm}^2 \text{ (Compressive)} \]

3) Stress due to wind load

No, Stress due to wind load

So \[ f_3 = 0 \text{ N/mm}^2 \]

Total stress in axial direction

\[ f_a = f_1 + f_2 + f_3 \]
\[ = 55.55 + 1.4096 + 0 \]
\[ = 56.95 \text{ N/mm}^2 \text{ (Tensile)} \]

c) Stress due to offset piping or wind

\[ f_s = \frac{2T}{\pi t D_i (D_i + t)} \]

\[ T = \text{Torque about vessel axis} = 1500 \times 10^3 \text{ N.mm} \]
\[ = \frac{(2 \times 1500 \times 10^3)}{\pi \times 2500 \times 9(2500 + 9)} \]
\[ = 0.046 \text{ N/mm}^2 \]

**Combining the above stresses the equivalent stress is:**

\[ f_R = \sqrt{f_1^2 - f_1 f_a + f_a^2 + 3f_s^2} \]
\[ = \sqrt{111.51^2 - 111.51 \times 56.95 + 56.95^2 + 3 \times 0.046^2} \]
\[ = 96.57 \text{ N/mm}^2 \text{ (Tensile stress)} \]

For satisfactory design the following conditions must be satisfied

\[ f_R \text{ (tensile)} \leq f_i \text{ (permissible)} \]
\[ f_a \text{ (tensile)} \leq f_i \text{ (permissible)} \]

We have found that

\[ f_R = 96.57 \text{ N/mm}^2 \]
\[ f_a = 56.95 \text{ N/mm}^2 \]
\[ f_t = 140 \text{ N/mm}^2 \]

**THEREFORE THE SHELL DESIGN AND THICKNESS USED IS SATISFACTORY**
JACKET DESIGN

We use a plain jacket for heat transfer.

Design pressure = 0.8 N/mm$^2$
Jacket Design pressure = 0.8*1.1 N/mm$^2$
= 0.88 N/mm$^2$
≈ 0.9 N/mm$^2$

The heating fluid steam is at atmospheric pressure and hence the shell need not be checked for stability under external pressure.

Thickness of Jacket

The thickness of jacket is calculated as

$$t_j = \frac{PD_j}{2fJ - P} + C$$

$D_j =$ Internal diameter of jacket
= 2765 mm

$$t_j = \frac{0.9 \times 2765}{(2 \times 140 \times 0.85) - 0.9} + C$$
= 10.49 mm
= 11+3 mm where corrosion allowance, $c = 3$
= 14 mm

The minimum thickness to be used is 14 mm.

$t_j = 14 \text{ mm}$

The jacket closer thickness

$T_{jc} = 2 \times t_j$ OR $t_{jc} = \frac{0.866 \times w_j \times \sqrt{p_l}}{f}$

= 2*14 OR $w_j = (2765-2524)/2$
= 28 mm OR $= 120.5 \text{ mm}$

$t_{jc} = 8.36 \text{ mm}$

The jacket closer thickness , $t_{jc} = 28 \text{ mm (larger value)}$
TORISPHERICAL HEAD

Thickness of head ($t_h$) = \( \frac{PRcW}{2fg} + C \)

\( R_c = D_t = 2500 \text{ mm} \)

Where,

Stress intensification factor = $W$

\[ W = \frac{1}{4} \left[ 3 + \sqrt[3]{\frac{Rc}{Rk}} \right] \]

\( R_K = R_c \times 0.06 \)
\( = 2500 \times 0.06 \)
\( = 150 \)

\[ W = \frac{1}{4} \left[ 3 + \sqrt[3]{2500} \right] \]

\( W = 1.77 \)

Thickness of head ($t_h$) = \( \frac{0.8 \times 2500 \times 1.77}{2 \times 140 \times 0.85} + 3 \)

\( t_h = 17.87 \text{ mm} \)

\( t_h \approx 18 \text{ mm} \)
CONICAL BOTTOM

For conical bottom angle of cone $\alpha = 30^\circ$

Thickness of conical bottom $(t_h) = \frac{pDi}{2fJ \cos \alpha} + c$

\[
t_h = \frac{0.8 \times 2500}{2 \times 140 \times 0.85 \times \cos 30} + 3
\]

$t_h = 12.70$ mm

$t_h \approx 13$ mm
**GASKET**

Out side diameter of shell \((D_o) = D_i + (2 \times t_i)\)
\[
= 2500 + 2 \times 12 \\
= 2524 \text{mm}
\]

So, Inner diameter of gasket \((G_i) = D_o + 10\)
\[
(G_i) = 2524 + 10 \\
(G_i) = 2534 \text{ mm} \\
(G_i) \approx 2535 \text{ mm}
\]

Gasket outside diameter of gasket \((G_o) = \frac{G_o}{G_i} = \sqrt{\frac{y - pm}{y - p(m + 1)}}\)
\[
\frac{G_o}{2535} = \sqrt{62 - 0.8 \times 3.75} \\
G_o = 2552.36 \text{ mm} \\
G_o \approx 2555 \text{ mm}
\]

Width of gasket \((N) = \frac{(G_o - G_i)}{2}\)
\[
= \frac{(2555 - 2535)}{2} \\
N = 10 \text{mm}
\]
BOLT

Diameter of gasket at lode reaction (G) =G₀ - 2b
G=2555 - 2*5
G=2545 mm

b₀= Basic gasket seating width

b₀ = N / 2
   = 10 / 2
b₀ = 5 mm

Load under atmospheric condition = Wm₁
Wm₁ = πGbyb₀

Load under operating condition
Wm₂ = πG(2b)mp + π / 4 * G²

We have b₀ = 5
2545² * 0.8
So. b = 5
Wm₁ = π * 2545 * 5 * 62
Wm₁ = 2.47 * 10⁶ N

so
Wm₁ < Wm₂
Wm=Wm₂

Area of bolt : - A = Wm/ fₐ
Aₐ = 4.309 * 10⁶ / 138
Aₐ = 31224.63 mm²

Number of bolts = N = G / 25
N = 2545 / 25
N = 101.8
N ≈ 104

Diameter of bolt (dₖ) = \( \sqrt{\frac{4}{\pi \frac{Aₐ}{N}}} \)
= \( \sqrt{\frac{4}{\pi \frac{31224.63}{104}}} \)

\( dₖ = 19.55 \text{ mm} \)
\( dₖ ≈ 20 \text{ mm} \)

Bolt circle diameter = B
B = G₀ + 2dₖ + 12
B = 2553 + (2 * 20) + 12
B = 2605 mm

Actual bolt spacing (b_s)

\[ b_s = \frac{\pi \times B}{n} \]

\[ b_s = \frac{\pi \times 2605}{104} \]

\[ b_s = 78.69 \text{ mm} \]

\[ b_s \approx 80 \text{ mm} \]
**FLANGE**

Thickness of flange \((t_f) = G \sqrt{\frac{P}{k * f}}\)

But, \(k = \frac{1}{0.3 + \frac{1.5 WmHg}{HG}}\)

Where, \(H = \left(\frac{\pi}{4}\right) * G^2 * P\)

\(H = \left(\frac{\pi}{4}\right) * 2545^2 * 0.8\)

\(H = 4.06 * 10^6 \text{ N}\)

and \(H_g = (B - G) / 2\)

\(H_g = (2605 - 2545) / 2\)

\(H_g = 30\)

So, \(k = \frac{1}{0.3 + \frac{1.5 * 4.309 * 10^6 * 30}{4.06 * 10^6 * 2545}}\)

\(k = 3.137\)

So, Thickness of flange \((t_f) = 2545 * \sqrt{\frac{0.8}{3.137 * 140}}\)

\(t_f = 108.62 \text{ mm}\)

\(t_f \approx 110 \text{ mm}\)

Outside diameter of flange \((D_{F0}) = B + 2b_D + 12\)

\(D_{F0} = 2605 + (2 * 20) + 12\)

\(D_{F0} = 2657 \text{ mm}\)

Width of flange = \((D_{F0} - D_t) / 2\)

\[= \frac{(2657 - 2500)}{2}\]

\[= 78.5 \text{ mm}\]

\[\approx 80 \text{ mm}\]
**NOZZLE**

Thickness of nozzle \( (tn) = \frac{PDi}{2 \cdot jf - p} + C \)

\[
\begin{align*}
\text{tn} &= \frac{0.8 \cdot 350}{2 \cdot 140 \cdot 0.85 - 0.5} + 3 \\
\text{tn} &\approx 2.180 + 3 \\
\text{tn} &\approx 6 \text{ mm}
\end{align*}
\]

Outer diameter of nozzle \( (D_0) \)

\[
D_0 = D_i + 2C
\]

\[
D_0 = 350 + (2 \cdot 3)
\]

\[
D_0 = 356 \text{ mm}
\]

So, \( x = D_0 \)

\[
x = 356 \text{ mm}
\]

\[
\begin{align*}
\text{h}_1 &= 2.5(ts - C) \\
\text{h}_1 &= 2.5 \cdot (9 - 3) \\
\text{h}_1 &= 15 \text{ mm}
\end{align*}
\]

So, \( \text{h}_1 = 7.5 \text{ mm} \) (Choosing the smaller value)

Area removed \( = A = D_0 \cdot ts \)

\[
A = 356 \cdot 12
\]

\[
A = 4272 \text{ mm}^2
\]

Area compensated in vessel wall \( (As) = (2x - d) \cdot (ts - tn - C) \)

\[
\begin{align*}
As &= (2 \cdot 356) - 356) \cdot (12 - 6 - 3) \\
As &= 1068 \text{ mm}^2
\end{align*}
\]

Area compensated in nozzle wall \( (A_0) = 2h_1(ts - tn - C) \)

\[
\begin{align*}
A_0 &= 2 \cdot 15 \cdot (12 - 6 - 3) \\
A_0 &= 90 \text{ mm}^2
\end{align*}
\]

Area inside extension of nozzle wall \( (A_I) = 0 \)
Area for reinforcement \( (A_r) = A - (A_s + A_0 + A_i) \)

\[ A_r = 4272 - (1068 + 90 + 0) \]

\[ A_r = 3114 \text{ mm}^2 \]

**As area is positive, compensation in the form of reinforcing pad is required**

Hence, \( A_r = 2 \times (w_p \times t_n) \) where \( (w_p) \) is width of pad

\[ 3114 = 2 \times (w_p \times 6) \]

\[ w_p = \frac{3114}{2 \times 6} = 259.5 \text{ mm} \]

Inner diameter of pad \( (D_{ip}) = D_0 + 2t_n \)

\[ D_{ip} = 356 + (2 \times 6) \]

\[ D_{ip} = 368 \text{ mm} \]

Outer diameter of pad \( (D_{op}) = D_0 + 2 \times w_p \)

\[ D_{op} = 368 + (2 \times 259.5) \]

\[ D_{op} = 887 \text{ mm} \]

Hence, reinforcing pad of inner diameter 368 mm and outer diameter of 887 mm and thickness of 6 mm is required
SUPPORT

1. DESIGN OF HORIZONTAL PLATE

- Vessel diameter is 2500 mm so 4 bracket are required
- Maximum compressive load on the bracket due to dead load \( p = \frac{W}{n} \)
  \[
  = \frac{100000}{4} \\
  = 25000 \text{ N}
  \]

Maximum pressure on horizontal plate \( P = \frac{p}{(A \times B)} \)
\[
P = \frac{25000}{(250 \times 300)} \\
P = 0.33 \text{ N/mm}^2 \\
P \approx 0.35 \text{ N/mm}^2
\]

Maximum stress on horizontal plate \( f = \frac{0.7 \times P \times B^2}{Th^2} \left( \frac{A^2}{B^2 + A^2} \right) \)
\[
157 = 0.7 \times 0.35 \times \frac{300^2}{Th^2} \left( \frac{250^2}{250 + 300^2} \right) \\
Th = 7.586 \text{ mm} \\
Th \approx 8 \text{ mm}
\]

Horizontal plate thickness = 8 mm

2. DESIGN OF COLUMN SUPPORT

- Selecting standard channel section ISMC 100 having size 100 * 50 mm
- Area of cross section \( A = 11.7 \text{ cm}^2 = 1170 \text{ mm}^2 \)
- Modulus of elasticity \( Z_{yy} = 7500 \text{ mm}^2 \)
- Radius of gyration \( X_{yy} = 14.9 \text{ mm} \)

Effective Length of column \( (L_e) = \frac{L}{2} \)
\[
L_e = \frac{3500}{2} \\
L_e = 1750 \text{ mm}
\]
Slenderness ratio = \( \frac{L_e}{X_{yy}} \)
\[ = \frac{1750}{14.9} = 117.44 \]

Maximum combined stress due to compress load \( f \) = \( \frac{P}{nA} \left[ 1 + a \left( \frac{L_e}{R_{yy}} \right)^2 \right] + \frac{p_e}{nZ} \)

\[ f = \frac{130.34 \text{ N/mm}^2}{157 \text{ N/mm}^2} \]

The calculated combined stress is less than permissible compressive stress i.e. 157 N/mm².

**Hence channel selected is satisfactory.**

3. **DESIGN BASE PLATE FOR COLUMN**

Area required for base plate
\[ A_p = \frac{p}{4} \]
\[ A_p = \frac{25000}{4} = 6250 \text{ mm}^2 \]

For square base plate
- Size of column selected = 100 * 50 mm
- So providing base of 150 * 100 mm

Rectangular plate size
\[ A = \frac{(150 - 100)}{2} \quad B = \frac{(100 - 50)}{2} \]
\[ A = 25 \text{ mm} \quad B = 25 \text{ mm} \]

Pressure intensity on base plate \( W \)
\[ W = \frac{25000}{(150 * 100)} = 1.66 \text{ N/mm}^2 \]

Maximum thickness of base plate \( t_B \) = \( \sqrt{\frac{3W}{F_b}} \) * \( A^2 - \frac{B^2}{4} \)
\[ t_B = 3.855 \text{ mm} \]
\[ t_e = 4 \text{ mm} \]

Thickness of base plate = 4 mm
UTILITIES
Utility services are supplied from a central site facility, and include:

1. Electricity
2. Steam
3. Cooling water
4. Water for general use
5. Effluent disposal facilities
6. Air
7. Chilled water

1. **ELECTRICITY**

The power required for the processes, compressors, motor drives, lighting and general use may be generated on site, but more usually will be purchased from the local company. The voltage at which the supply is taken or generated will depend on the demand.

2. **COOLING WATER**

Natural and forced-draft cooling towers are generally used to provide the cooling water required on a site unless water can be drawn from a convenient river or lake in sufficient quantity. Cooling water is needed for cooling of reactor after reaction.

3. **WATER**

The water required for general purposes on a site will usually be taken from the local mains supply, unless cheaper source of suitable quality water is available from a river, lake or well.

4. **EFFLUENT DISPOSAL**

Facilities will be required at all sites for the disposal of waste minerals without creating a public nuisance. The disposal of aqueous waste and toxic waste to public sewers and surface waters is controlled by legislation. Strict controls are placed on the nature of effluent that can be discharged.

I grease manufacturing as such no effluents will form. But remaining grease is recycle back or either incineration methods are used.
5. CHILLED WATER

The chilled water, which absorbed heat from the air, is sent via return lines back to the utility facility, where the process described in the previous section occurs. Utility generated chilled water eliminates the need for chillers and cooling towers at the property, reduces capital outlays and eliminates ongoing maintenance costs.

The advantage of utility-supplied chilled water is based on economy of scale. A utility can operate one large system more economically than a customer can operate the individual system in one building. The utility's system also has back-up capacity to protect against sudden outages. The cost of such “insurance” is also markedly lower than what it would be for an individual structure.

The use of utility supplied chilled water is most cost effective when it is designed into the building’s infrastructure or when chiller/cooling tower equipment must be replaced. Commercial customers often lower their air conditioning costs from 10-20% by purchasing chilled water.

6. STEAM

In other industrial applications steam is used for energy storage, which is introduced and extracted by heat transfer, usually through pipes. Steam is a capacious reservoir for energy because of water's high heat of vaporization.
SITE SELECTION
Plant location plays critical role in the economic viability of the process. Hence it is desirable to select a plant place with safer working condition, cheap and skilled labor, availability of raw material and probable effect of waste generated.

**Profitability factors:**

1. **Raw Material**
   For this plant raw materials are
   - Base oil
   - 12-hydroxy stearic acid
   - Lithium hydroxide
   - Additives

   All of the raw materials should be made available near the plant location. Base oil receiving from HPC refinery while additives supply receive from various chemical companies like Lubrizol. Transportation and handling are the major contributor to the cost of these raw materials. Thus it is advantageous to set a plant near a location where these raw materials are available.

2. **Environmental Factors:**
   Now-a-days environmental factor has become most important for site location. Since this project does not create any hazardous waste, environmental factor is not critical for this project.
**Productivity factors:**

1. **Energy consideration:**

   Process requires continuous supply of electricity to fulfill consumers necessities. Also the availability of Fuel is important. To enhance productivity continuous supply of energy is essential.

2. **Labour**

   Hostile labor can affect continuous profile of the plant. If the labor is a militant one it creates adverse effects on the project. Hence to maintain the productivity labour factor should be reconsider. Skilled and friendly labor is available in Mumbai. Similarly they are available in cheaper rate.

3. **Storage**

   Timely delivery of raw materials should be ensured to minimize inventory.

4. **Transportation:**

   Transport of raw material and product is important. For this particular project, the required raw materials are transported by trucks. Site should have well connectivity by rail, road.

5. **Availability of utilities:**

   Utilities required for the production facility must be easily available
Other Factors:


If the state government policies are not in favor of setting up of new project, it may take time to get the required clearances and finally it will result in delaying of the project and project cost goes up. Since byproduct in manufacturing of grease is only the water, which will not affect the environment. So there will not be any problem for getting license from the government regarding the environmental issues.

:: Proposed Site: Vashi, Navi Mumbai
COST ESTIMATION & FINANCIAL ANALYSIS
**RAW MATERIAL COSTS:**

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Rs. / Kg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base oil</td>
<td>27.61</td>
</tr>
<tr>
<td>12-hydroxy stearic acid</td>
<td>80.70</td>
</tr>
<tr>
<td>Lithium hydroxide</td>
<td>6.5305</td>
</tr>
<tr>
<td>Additives</td>
<td>238</td>
</tr>
</tbody>
</table>

**PRODUCT COST:**

<table>
<thead>
<tr>
<th>Products</th>
<th>Rs. / Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li based grease</td>
<td>113.62</td>
</tr>
</tbody>
</table>

**Assumption:**

- The interest rate for term loan from financial institutes = 14%
- The interest rate for bank borrowing = 18%
- Calculation of working capital is based on assumption of full capacity utilization.
1. ESTIMATION OF PLANT AND MACHINERY COST

A  EQUIPMENT COST

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Type</th>
<th>Cost(lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor</td>
<td>R 1001</td>
<td>35</td>
</tr>
<tr>
<td>Kettle</td>
<td>M 1001</td>
<td>60</td>
</tr>
<tr>
<td>Storage tanks</td>
<td>R 1001-R1002</td>
<td>20</td>
</tr>
<tr>
<td>Heat exchanger</td>
<td>HE 1001</td>
<td>3.50</td>
</tr>
<tr>
<td>Compressor</td>
<td>C 1002</td>
<td>4.20</td>
</tr>
<tr>
<td>Filter</td>
<td>F 1001</td>
<td>2.30</td>
</tr>
<tr>
<td>Homogenizer</td>
<td>H 1001</td>
<td>1.2</td>
</tr>
<tr>
<td>Pump</td>
<td>P 1001</td>
<td>5</td>
</tr>
</tbody>
</table>

Total equipment cost = 131.2 lakhs

To convert ex-works costs to at site cost, we add 35 % for packing forwarding and transportation

Therefore total equipment cost for plant = 177.12 lakhs
### Outside battery unit costs:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power receiving station</td>
<td>20.00</td>
</tr>
<tr>
<td>Safety equipments</td>
<td>10.00</td>
</tr>
<tr>
<td>Furnace</td>
<td>15.00</td>
</tr>
<tr>
<td>Chilling plant</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**Total cost = 49 lakhs**

**Hence total delivered cost = 226.12 lakhs**

### (B ) INSTALLED COST OF EQUIPMENTS:

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>% of Delivered cost</th>
<th>Cost (Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping</td>
<td>30</td>
<td>67.83</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>20</td>
<td>45.22</td>
</tr>
<tr>
<td>Electricity</td>
<td>15</td>
<td>33.91</td>
</tr>
<tr>
<td>Installation</td>
<td>10</td>
<td>22.61</td>
</tr>
<tr>
<td>Insulation</td>
<td>8</td>
<td>18.08</td>
</tr>
<tr>
<td>Excise duty for all</td>
<td>10</td>
<td>22.61</td>
</tr>
<tr>
<td>equipment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total cost = 210.26 lakhs**

Total plant & machinery cost = Total delivered cost + Installed cost of equipments

= 226.12 + 210.26

= 436.38 lakhs
Assuming the equipment cost to be 45% of the project cost we can get an approximate estimate of the project cost, which turns out to be **632.751 lakhs**

This project cost can be distributed among various project cost components as follows:

(C) **ELEMENTS OF PROJECT COST**:

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>% OF PROJ. COST</th>
<th>AMOUNT (LAKHS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land site &amp; Development</td>
<td>3</td>
<td>18.98</td>
</tr>
<tr>
<td>Building &amp; Civil Works</td>
<td>10</td>
<td>63.27</td>
</tr>
<tr>
<td>Plant &amp; Machinery</td>
<td>45</td>
<td>284.73</td>
</tr>
<tr>
<td>Know-how and engineering</td>
<td>10</td>
<td>63.27</td>
</tr>
<tr>
<td>Miscellaneous fixed assets</td>
<td>5</td>
<td>31.63</td>
</tr>
<tr>
<td>Pre-operational expenses</td>
<td>10</td>
<td>63.27</td>
</tr>
<tr>
<td>Contingencies</td>
<td>10</td>
<td>63.27</td>
</tr>
<tr>
<td>Preliminary and capital issue</td>
<td>1</td>
<td>6.32</td>
</tr>
<tr>
<td>Issue related expenses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Margin money</td>
<td>6</td>
<td>37.96</td>
</tr>
</tbody>
</table>

**Total delivered cost** = **632.751 lakhs**
ESTIATION OF COST OF PRODUCTION:

A) Raw Material Cost:

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Requirements (TPA)</th>
<th>Cost (lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base oil</td>
<td>16662.033</td>
<td>4600</td>
</tr>
<tr>
<td>12-hydroxy steric acid</td>
<td>1932.2033</td>
<td>1559.28</td>
</tr>
<tr>
<td>Lithium hydroxide</td>
<td>289.83</td>
<td>18.92</td>
</tr>
<tr>
<td>Additives</td>
<td>218.98</td>
<td>521.17</td>
</tr>
</tbody>
</table>

Total cost of raw materials = 6699.37 lakhs

Utilities:

We assume the cost of utilities to be 10% of the cost of raw materials.

Cost of utilities = 669.937 lakhs
Total raw material and utility cost = 7369.307 lakhs

B) Maintenance

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CONTRIBUTION (%)</th>
<th>COST (Lakhs/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating labor cost (OLC)</td>
<td>8% of project cost</td>
<td>31.12</td>
</tr>
<tr>
<td>Maintenance &amp; repairs</td>
<td>5% of project cost</td>
<td>19.45</td>
</tr>
<tr>
<td>Supervision</td>
<td>15% of OLC</td>
<td>4.66</td>
</tr>
<tr>
<td>Labor charges</td>
<td>15% of OLC</td>
<td>4.66</td>
</tr>
<tr>
<td>Operating supplier</td>
<td>15% of maintenance &amp; repairs</td>
<td>2.91</td>
</tr>
</tbody>
</table>

Indirect product cost = 62.8 lakhs
C) **Fixed Charges**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CONTRIBUTION (%)</th>
<th>COST (Lakhs/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local taxes</td>
<td>4% of project cost</td>
<td>15.56</td>
</tr>
<tr>
<td>Insurance</td>
<td>1% of project cost</td>
<td>3.89</td>
</tr>
</tbody>
</table>

**Total fixed cost = 19.45 lakhs**

D) **Plant overheads**

Plant overheads = 40% of (OLC + Supervision + Maintenance and repairs cost)  

= 22.09 lakhs

E) **General expenses**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CONTRIBUTION (%)</th>
<th>COST (Lakhs/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>25% of OLC</td>
<td>7.78</td>
</tr>
<tr>
<td>Distribution</td>
<td>0.5% of project cost</td>
<td>1.94</td>
</tr>
</tbody>
</table>

**Total general expenses = 9.72 lakhs**

F) **Salary & Wages:**

Salary and wages is taken as 10% of the cost of raw materials

Salary and wages  
669.937 lakhs

Gross cost of production (GCOP)  
8153.304 lakhs
**ESTIMATION OF WORKING CAPITAL:**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>AMOUNT (Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material inventory for 7 days</td>
<td>132.33</td>
</tr>
<tr>
<td>Utilities for 7 days</td>
<td>132.33</td>
</tr>
<tr>
<td>Product inventory for 7 days</td>
<td>520.31</td>
</tr>
<tr>
<td>Salaries and wages for 1 month</td>
<td>588.68</td>
</tr>
</tbody>
</table>

**Working capital** 1373.65 lakhs

Project cost 632.751 lakhs

Debt equity ratio 1:1

Debt 316.37 lakhs

Equity 316.37 lakhs

**EQUITY PARTICIPATION:**

Promoters contribution (51%) 161.34 lakhs

Shareholders contribution 161.34 lakhs

Margin money (25% of the working capital) 343.41 lakhs

Working capital borrowed (WCB)(75% of working capital) 1030.23 lakhs
**PROFITABILITY ANALYSIS:**

**C)** Sales realization (SR)  
10000 **lakhs**

**D)** Financial expenses  
=0.14*term loan + 0.18*WCB  
= 229.73 **lakhs**

14 % of the project cost is non-depreciable (includes land and site development, preliminary and issue related expenses and margin money)

- Depreciable cost (DC)  
  = (1-0.14)*PC  
  =544.16 **lakhs**

- SLM contribution (10% of DC)  
  = 54.41 **lakhs**

- WDV contribution (30% of DC)  
  = 163.24 **lakhs**

- Gross profit (GP)  
  = SR – GCOP  
  = 1846.696 **lakhs**

- Operating profit (OP)  
  = GP - (SLM+FE)  
  =1562.556 **lakhs**

- Taxable profit (TP)  
  = OP+SLM-WDV  
  = 1453.72 **lakhs**

- Corporate tax (CT)  
  = 33% of TP  
  = 479.72 **lakhs**

- Net profit (NP)  
  = OP-CT  
  = 1082.83 **lakhs**

- Dividend (D)  
  = 30% of NP  
  = 324.85 **lakhs**
Tax on dividend (TOD) = 20% of dividend = 64.97 lakhs

Total dividend (TD) = D+TOD = 389.82 lakhs

Balance (B) = NP-TD = 693.01 lakhs

Net cash accruals (NCA) = B+SLM = 747.42 lakhs

Investment (I) = WCB+DC = 1574.39 lakhs

PERFORMANCE RATIO:

Return on investment (ROI) = NCA*100/I = 47.473%

Payback period = 1/ROI*12 months = 25.27 months
MARKET SURVEY
FACTORS AFFECT ON GROWTH OF GREASE MANUFACTURING INDUSTRIES

1. Second World War

The Second World War, particularly for aircraft lubricating grease was a large factor in the progress of grease manufacture and the development of new types of lubricating greases.

2. Industrial Growth.

Basic industries to which improved lubricating greases have made a valuable contribution are steel manufacture industries. Lubricating grease has played a steadily increasing role in maintaining maximum capacity of the various operating units that make up a steel plant.


The lubricating grease industry can also take pride in the fact that it made valuable and important contribution to the operation of equipment used in vehicles, which are used for transportation of goods and people.
MAJOR MANUFACTURERS OF LUBRICATING GREASES IN INDIA

1. Indian Oil Corporation Ltd.
2. Hindustan Petroleum Corporation Ltd.
3. Balmer Lawrie
4. Bharat Petroleum Corporation Ltd.
5. Castrol
6. Tide Water
7. Elf
8. Shell

WORLDWIDE GREASE USE

Central and Eastern Europe account for the majority of worldwide grease usage, followed by Asia-Pacific, North America, Western Europe, Central and South America, Africa and the Middle East. A significant difference in the types of products used exists among these regions. Western Europe and North America typically require higher quality products than do Central and Eastern European users. Africa uses specialized products (such as greases for mining equipment) and the use of Polyurea products predominates in Asia. Throughout the world, industrial applications account for most of the grease used for railroad, general manufacturing, steel production and mining. Among automotive applications, trucks and buses account for the majority of grease used, followed by agricultural/construction equipment and passenger cars.
WORLDWIDE PRODUCTION OF GREASE

According to the 2007 NLGI Grease Survey, North America reported grease production of 544 million pounds, which is approximately 29 percent of the worldwide grease production. All countries participating in the 2007 survey reported a total production of 1.9 billion pounds of grease.

North America reports a higher percentage of aluminum complex, calcium sulfonate, lithium complex, Polyurea and clay greases in comparison to the international data. Conversely, the worldwide production reports higher percentages of hydrated calcium, conventional lithium and sodium soap grease. This could be due to a difference in equipment lubrication demands in various parts of the world. In general, high-speed or heavily loaded equipment can generate more heat, which creates an increased need for greases with higher dropping points. In addition, higher labor costs in North America factor into the need to extend relubrication intervals and therefore increase the need for grease that can function for longer periods of time.
PRODUCTION OF GREASE IN INDIA

According to the 2007 NLGI Grease survey, India reported grease production of 344 million pounds, which is approximately 12 percent of the worldwide grease production. All countries participating in the 2007 survey reported a total production of 1.9 billion pounds of grease.

India reports a higher percentage of lithium, lithium complex and greases in comparison to the international data. This could be due to a difference in equipment lubrication demands in various parts of the India. In general, high-speed or heavily loaded equipment can generate more heat. Which creates an increased need for grease with higher dropping points. In addition, higher labor costs in India factor into the need to extend relubrication intervals and therefore increase the need for grease that can function for longer periods of time.
TYPE OF GREASE USE IN WORLDWIDE

Conventional lithium is the most popular grease type in all regions, but leads lithium complex only by one percent in North America. Polyurea production accounted for a higher production percentage in Japan than in other regions. Hydrated calcium grease accounted for the second highest production in China, the Pacific region and in the Caribbean region.
Above two diagrams represents the difference in consumption pattern of India with other countries. In India only 40% of grease is used for industrial applications while remaining 60% is used for automobile applications. While this picture is opposite in other advanced countries, where 60% is used for industrial applications & 40% for automotive purposes.
PLANT LAYOUT
**PLANT LAYOUT**

The various auxiliary buildings are services required on the site in addition to the main plant are,

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MAIN PROCESS UNIT OF OPERATION</td>
</tr>
<tr>
<td>2</td>
<td>PROCESS CONTROL OPERATION</td>
</tr>
<tr>
<td>3</td>
<td>BOILER AND TRANSFORMER</td>
</tr>
<tr>
<td>4</td>
<td>COMPRESSOR ROOM</td>
</tr>
<tr>
<td>5</td>
<td>HEAT EXCHANGER AND COOLING TOWER</td>
</tr>
<tr>
<td>6</td>
<td>ENTERANCE GATE FOR PROCESS UNIT OPERATION</td>
</tr>
<tr>
<td>7</td>
<td>ENTERANCE GATE FOR STORAGE OF PRODUCT GREASE</td>
</tr>
<tr>
<td>8</td>
<td>STORAGE OF PRODUCT GREASE MATERIAL</td>
</tr>
<tr>
<td>9</td>
<td>EXIT GATE FOR STORAGE OF PRODUCT GREASE</td>
</tr>
<tr>
<td>10</td>
<td>MAIN GATE NO.2 (EXIT GATE FOR TRUCKS AND CAREERS )</td>
</tr>
<tr>
<td>11</td>
<td>SECURITY OFFICE NO.2</td>
</tr>
<tr>
<td>12</td>
<td>GARDEN</td>
</tr>
<tr>
<td>13</td>
<td>WATER STORAGE TANK</td>
</tr>
<tr>
<td>14</td>
<td>FIRE FIGHTING SYSTEM</td>
</tr>
<tr>
<td>15</td>
<td>WORKSHOP AND MAINTENANCE WORKSHOP</td>
</tr>
<tr>
<td>16</td>
<td>LAB AND RESEARCH DEPARTMENT AND QUALITY CONTROL DEPARTMENT</td>
</tr>
<tr>
<td>17</td>
<td>SECURITY OFFICE NO.1</td>
</tr>
<tr>
<td>18</td>
<td>MAIN GATE NO.1 (ENTRY GATE FOR TRUCKS AND CAREERS, CAR, BIKE)</td>
</tr>
<tr>
<td>19</td>
<td>CHANGING ROOM FOR ENGINEERS</td>
</tr>
<tr>
<td>20</td>
<td>MAIN ADMINISTRATIVE OFFICE</td>
</tr>
<tr>
<td>21</td>
<td>FINANCE DEPARTMENT</td>
</tr>
<tr>
<td>22</td>
<td>BIKE AND CAR PARKING AREA</td>
</tr>
<tr>
<td>23</td>
<td>ENTERANCE GATE FOR RAW MATERIAL STORAGE</td>
</tr>
<tr>
<td>24</td>
<td>WEIGH BRIDGE</td>
</tr>
<tr>
<td>25</td>
<td>STORAGE OF RAW MATERIAL</td>
</tr>
<tr>
<td>26</td>
<td>EXIT GATE FOR RAW MATERIAL STORAGE</td>
</tr>
<tr>
<td>27</td>
<td>EMERGENCY GATE FOR SAFETY PURPOSE</td>
</tr>
<tr>
<td>28</td>
<td>CONFERANCES ROOM</td>
</tr>
<tr>
<td>29</td>
<td>ENGINEERING DEPARTMENT</td>
</tr>
<tr>
<td>30</td>
<td>CANTEEN</td>
</tr>
<tr>
<td>31</td>
<td>AREA FOR FUTURE EXPANSION PURPOSE OF PLANT</td>
</tr>
<tr>
<td>32</td>
<td>AREA FOR WASTE MANAGEMENT</td>
</tr>
</tbody>
</table>
The Process units and ancillary buildings should be laid to give the most economical flow of materials and personnel around the site. Hazardous processes must be located at a safe distance from the buildings. Consideration must also be given to future expansion of plant. The ancillary buildings and services required are storage, maintenance, workshops, stores for maintenance, laboratories for quality control, fire station, utilities, offices for general administration, canteens and car parks.

When roughing the preliminary site layout the process units will normally be sited first and arranged to give a smooth flow of materials through the various processing steps from raw materials to final product. Storage process units are normally placed at least 30m apart.

Adopting a layout that gives the shortest run of connecting pipe between equipment, and the least amount of structural work can minimize the cost of construction.

**CONSIDERATIONS IN LAYOUT:**

1. **OPERATION:**

   Equipments that need to have frequent operator attention like the two reactors should be near to the control room. Equipments that require frequent dismantling such as compressors and large pumps should be placed under cover.

2. **PLANT EXPANSION:**

   Equipment should be located so that it can be conveniently tied up with any future expansion of the process.

3. **ADMINISTRATIVE OFFICES:**

   They should be close to the main entrances so as to facilitate movement of personnel working there. Canteen should be close to security offices, management service buildings, time office.

4. **TANK FARMS & UTILITIES:**

   They should be close to the roads connecting main roads.
TESTING METHODS
TESTING OF GREASES

- Cone Penetration
- Dropping Point
- Mechanical Stability
- Rolling stability
- Oxidation Stability
- Anti Wear
- Extreme Pressure
- Water Washout
- Oil Separation
- Evaporation Loss
- Corrosion
- Rust
KEY TEST: - CONE PENETRATION.

Aim: - The penetration is determined at 25 °C by releasing the cone assembly from penetrometer and allowing the cone to drop freely in the grease for 5 seconds.

Two type of penetration

- Worked penetration
- Unworked penetration
WORKED PENETRATION:-

It is the penetration of grease sample subjected to 60 double strokes in standard grease worker and penetration done at 25°C.

UNWORKED PENETRATION:-

It is the penetration at 25°C of grease, which is transferred in grease worker cup and leveled with minimum working.

PROCEDURE FOR WORKED PENETRATION:-

Fill the cup with grease. Jar the cup from time to time to remove any air entrapped. Fill excess grease above rim. Assemble the worker with vent open. Plunger pull out and close the cap slightly and place the plunger bottom. Close the vent, bring the cup and tighter cup remove excess grease to 60 full double strokes of the plunger to top open the vent, remove the plunger along with the top of the cup level the grease and determine the penetration as described in upward penetration.

PROCEDURE FOR UNWORKED PENETRATION:-

- Place 400gm to 500gm test sample in a fridge to 25+/-2c. Transfer the grease preferably in lumps to the cup. Jar the cup to remove the entrapped air. Scrape off the excess grease extending above the rim by moving the blade of spatula (knife) held inclined towards the direction of motion at an angle 45c across the rim of cup.
- Clean the penetrometer cone thoroughly before each test. Rotation of cone to be avoided.
- Place the cup on the table of the penetrometer. Set the mechanism to hold cone in the 0 position and adjust apparatus carefully so that the tip of the cone just touches the surface of the test sample. Release the cone shaft rapidly, and allow to drop for 5 seconds freely. Read the penetrometer reader to read penetration reading gently depressed the indicator shaft until the dial touché the cone shaft.
- For sample having penetration lesser than 200 use the sample for doing additional penetration by allowing the cone to drop at some other place near the previous and not allowing to the side.
The depth, in tenths of a millimeter, to which the cone sinks into the grease is the penetration. A penetration of 100 would represent a solid grease while one of 450 would be semi-fluid. The NLGI has established consistency numbers or grade numbers, ranging from 000 to 6, corresponding to specifies ranges of penetration numbers. The following table lists the NLGI grease classification along with a description of the consistency of each classification.

**NLGI GREASE CLASSIFICATION:**

<table>
<thead>
<tr>
<th>NLGI grade</th>
<th>Penetration at 25 deg C</th>
<th>Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>445-475</td>
<td>Semi-fluid</td>
</tr>
<tr>
<td>00</td>
<td>400-430</td>
<td>Semi-fluid</td>
</tr>
<tr>
<td>0</td>
<td>355-385</td>
<td>Very soft</td>
</tr>
<tr>
<td>1</td>
<td>310-340</td>
<td>Soft</td>
</tr>
<tr>
<td>2</td>
<td>265-295</td>
<td>Common grease</td>
</tr>
<tr>
<td>3</td>
<td>220-250</td>
<td>Semi hard</td>
</tr>
<tr>
<td>4</td>
<td>175-205</td>
<td>Hard</td>
</tr>
<tr>
<td>5</td>
<td>130-160</td>
<td>Very hard</td>
</tr>
<tr>
<td>6</td>
<td>85-115</td>
<td>Solid</td>
</tr>
</tbody>
</table>

**TEST METHOD FOR WORKING STABILITY OF GREASE IN PRESENCE OF WATER.**

*Aim:* The method is intended for the determination of change when subjected to work in presence of water.

*Working:* Grease is filled in cup and exposed to prolonged mechanical working in presence of water (10% water) and in absence of water and difference in penetration is determined.
**DROPPING POINT TEST:**

**Aim:** This method covers the determination of dropping point of lubrication grease. This point being the temperature at which first drop of material falls from cup.

**Working:** Small quantity of grease is taken in drop point and heated slowly to the temperature at which first drop of the oil comes out from the hole bottom of the test cup. The temperature at which grease drop falls is noted as the dropping point of the grease.

**DETERMINATION OF HEAT STABILITY TEST:**

**Aim:** The method describes a procedure for the determination of heat stability of grease by observing the separated out and structure of the grease after test.

**Working:** About 10 gm. Grease is heated at 120 °C for 1hr and grease is examine visually for any evidence of oil separation and structure change after 24hrs.

**DETERMINATION OF EVAPORATION LOSS TEST:**

**Aim:** This method covers determination of the evaporation loss in lubricating grease.

**Working:** The sample weighted in Petri dish and kept for 2hrs. in oven maintained at 105+/-10°C. The loss in mass is calculated as evaporation loss of sample.

**OXIDATION STABILITY TEST:**

**Aim:** The method for oxidation stability of lubricating grease bomb method.

**Working:** The sample of grease is oxidized in bomb heated to 99°C and fitted with oxygen at 7.5 bar. Pressure is observed and recorded at started. Then the degree of oxidation after a given period of time determined by corresponding decrease in oxygen pressure.

**ROLL STABILITY TEST:**

**Aim:** Standard test method for roll stability of lubricating grease.

**Working:** As small sample of grease is worked for specific test period in the roll stability tester. Under specific test temp. 60 strokes worked penetration are taken on grease before and after rolling.
MATERIAL SAFETY DATA SHEET
MATERIAL SAFETY DATA SHEET

A) 12 hydroxy stearic acid

CAS NUMBER: 106-14-9

1. POTENTIAL HEALTH EFFECTS:

INHALATION:
SHORT TERM EXPOSURE: Irritation
LONG TERM EXPOSURE: Lung damage

SKIN CONTACT:
SHORT TERM EXPOSURE: Irritation
LONG TERM EXPOSURE: Irritation, skin disorders

EYE CONTACT:
SHORT TERM EXPOSURE: Irritation
LONG TERM EXPOSURE: No information available

INGESTION:
SHORT TERM EXPOSURE: Diarrhea, difficulty breathing
LONG TERM EXPOSURE: No information on significant adverse effects

2. HAZARDOUS MATERIAL IDENTIFICATION SYSTEM (HMIS):
Health – 1
Flammability – 1
Reactivity – 0

3. FIRST AID MEASURES

INHALATION: Vapor pressure is very low and inhalation at room temperature is not a problem. If overcome by vapor from hot product, immediately remove from exposure and call a physician.

SKIN CONTACT: Remove any contaminated clothing and wash with soap and warm water. If injected by high pressure under skin, regardless of the appearance or its size, contact a physician IMMEDIATELY. Delay may cause loss of affected part of the body.
EYE CONTACT: Flush with clear water for 15 minutes or until irritation subsides. If irritation persists, consult a physician.

INGESTION: If ingested, call a physician immediately. Do not induce vomiting.

4. FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Slight fire hazard

EXTINGUISHING MEDIA: Foam, Dry Chemical, Carbon Dioxide or Water Spray (Fog)

SPECIAL FIRE FIGHTING PROCEDURES: Cool exposed containers with water. Use air-supplied breathing equipment for enclosed or confined spaces.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Do not store or mix with strong oxidants. Empty containers retain residue. Do not cut, drill, grind, or weld, as they may explode.

5. ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE: Scrape up grease, wash remainder with suitable petroleum solvent or add absorbent. Keep petroleum products out of sewers and water courses. Advise authorities if product has entered or may enter sewers and water courses.

6. HANDLING AND STORAGE

STORAGE: Keep containers closed when not in use. Do not handle or store near heat, sparks, flame, or strong oxidants.

7. EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:

OIL MIST IN AIR (Not Encountered in Normal Usage):
5 mg/m³ UK OES TWA
10 mg/m³ UK OES STEL

VENTILATION: Provide local exhaust ventilation system. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.
CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: Wear appropriate chemical resistant (nitrile) gloves.

RESPIRATOR: Consider the need for appropriate protective equipment, such as self-contained breathing apparatus, adequate masks and filters.

8. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: semi-solid
APPEARANCE: smooth
COLOUR: off-white
PHYSICAL FORM: grease
ODOR: mineral oil odor
BOILING POINT: >288°C
FLASH POINT: 166°C (COC)
LOWER FLAMMABLE LIMIT: 0.9% by volume
UPPER FLAMMABLE LIMIT: 7.0% by volume
VAPOUR PRESSURE: <0.01
VAPOR DENSITY (air=1): >5
SPECIFIC GRAVITY (water=1): 0.91
WATER SOLUBILITY: negligible
EVAPORATION RATE (Butyl acetate = 1): <0.01

9. STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressures
CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Avoid contact with incompatible materials.
INCOMPATIBLES: Oxidizing materials, chlorine
HAZARDOUS DECOMPOSITION: Thermal decomposition products or combustion: oxides of carbon, oxides of Sulphur
POLYMERISATION: Will not polymerize.
10. TOXICOLOGICAL INFORMATION

TOXICITY DATA: Greater than 5 g/kg LD50 oral-rat

11. DISPOSAL CONSIDERATIONS
Dispose in accordance with all applicable regulations
B} Lithium hydroxide

1) **Chemical Name:** Lithium Hydroxide

2) **Chemical Formula:** LiOH

3) **Hazards Identification**

**Potential Acute Health Effects**

Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Hazardous in case of eye contact (corrosive). Corrosive to eyes and skin. The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Inhalation of dust will produce irritation to gastro-intestinal or respiratory tract, characterized by burning, sneezing and coughing. Severe over-exposure can produce lung damage, choking, unconsciousness or death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

**Potential Chronic Health Effects**

Hazardous in case of ingestion, of inhalation. The substance may be toxic to kidneys, gastrointestinal tract, upper respiratory tract, skin, eyes, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure of the eyes to a low level of dust can produce eye irritation. Repeated skin exposure can produce local skin destruction, or dermatitis. Repeated inhalation of dust can produce varying degree of respiratory irritation or lung damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

4) **First Aid Measures**

**Eye Contact:**
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

**Skin Contact:**
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.
**Serious Skin Contact:**
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

**Inhalation:**
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

**Serious Inhalation:**
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation.
WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

**Ingestion:**
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

5. **Fire and Explosion Data**

**Flammability of the Product:** Non-flammable.

**Special Remarks on Fire Hazards:** Hazardous Products of Decomposition: Oxides of lithium

6. **Accidental Release Measures**

**Small Spill:**
Use appropriate tools to put the spilled solid in a convenient waste disposal container. If necessary: Neutralize the residue with a dilute solution of acetic acid.

**Large Spill:**
Corrosive solid. Poisonous solid. Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of acetic acid. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.
7. Handling and Storage

Precautions:
Keep container dry. Do not ingest. Do not breathe dust. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Air Sensitive Hygroscopic

8. Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor and dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
STEL: 1 (mg/m3) [United Kingdom (UK)]
CEIL: 1 from AIHA [United States]
Consult local authorities for acceptable exposure limits.

9. Physical and Chemical Properties

Physical state and appearance: Solid. (Hygroscopic powder.)
Molecular Weight: 23.95 g/mole
Color: White.
pH (1% solution/water): 14 [Basic.]
Melting Point: 450°C (842°F)
Specific Gravity: 2.54 (Water = 1)
Dispersion Properties: See solubility in water, methanol.
Solubility: Soluble in cold water. Partially soluble in methanol, Insoluble in diethyl ether.
10. **Stability and Reactivity Data**

**Stability:** The product is stable.

**Conditions of Instability:** Exposure to moist air, water, heat, incompatible materials, heat, air. Air sensitive. Absorbs carbon dioxide from the air. Hygroscopic. Absorbs moisture or water from the air.

**Incompatibility with various substances:** Reactive with oxidizing agents, acids.

**Corrosivity:** Slightly corrosive in presence of glass.

**Special Remarks on Reactivity:** Incompatible with aluminum, carbon dioxide, zinc, aluminum, moisture (hygroscopic). Air sensitive, Absorbs moisture from the air. Absorbs CO2 from air. Hygroscopic; keep container tightly closed.

**Polymerization:** Will not occur.

11. **Toxicological Information**

**Routes of Entry:** Inhalation. Ingestion.

**Toxicity to Animals:**
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE.
Acute oral toxicity (LD50): 210 mg/kg [Rat].
Acute toxicity of the dust (LC50): 960 mg/m3 4 hours [Rat].

**Chronic Effects on Humans:** May cause damage to the following organs: kidneys, gastrointestinal tract, upper respiratory tract, skin, eyes, central nervous system (CNS).

**Other Toxic Effects on Humans:** Extremely hazardous in case of skin contact (corrosive), of inhalation (lung corrosive). Very hazardous in case of skin contact (irritant), of ingestion, Hazardous in case of eye contact (corrosive).

**Special Remarks on other Toxic Effects on Humans:**
Acute Potential Health Effects:
**Skin:** Corrosive. Causes severe skin irritation and burns.
**Eyes:** Causes severe irritation and burns of the eyes. May cause chemical conjunctivitis, and corneal damage.
**Inhalation:** Harmful if inhaled. Causes chemical burns to the respiratory tract. Inhalation may be fatal as a result of spasm, inflammation, edema of the larynx and bronchi, chemical pneumonitis, and pulmonary edema. May affect respiration (shortness of breath) and cause burning sensation, coughing, wheezing, laryngitis. May also cause nausea, vomiting, and headache.
**Ingestion:** Harmful if swallowed. Causes gastrointestinal tract burns. May cause abdominal pain, nausea, vomiting, diarrhea. May cause corrosion and permanent tissue destruction of the esophagus and digestive tract. May affect behavior/central nervous system/nervous system (headache, somnolence, tremors, disorientation, confusion, irritability, impaired concentration, lethargy, confusion, drowsiness, muscle weakness, convulsions), metabolism (loss of appetite, weight loss). May cause kidney damage. May affect respiration (shortness of breath) and cause burning sensations, coughing, wheezing, laryngitis.

**Chronic Potential Health Effects:**
**Ingestion:** Lithium's toxicity is due to its cumulative effects. It causes poor appetite, weight loss, weakness, fatigue, dehydration, thirst, dryness of mouth. Finer tremors of the hands, lips, or jaw may be apparent signs of involvement of the nervous system/central nervous system, together with loss of coordination, mental confusion, dizziness, slurred speech, blurred vision, drowsiness, and hyperactivity of the nervous system, including twitching and seizures, as well as coma. May also cause goiter/thyroid disturbances, skin effects (various types of dermatitis such as psoriasis, cutaneous ulcers, follicular papules, exfoliate dermatitis, xerosis cutis, acne, anesthesia of the skin), ringing in the ears, and affect liver (liver function tests impaired), kidneys (kidney damage), and blood (pigmented or nucleated red blood cells).

12. **Ecological Information**

**Products of Biodegradation:**
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

**Toxicity of the Products of Biodegradation:** The products of degradation are less toxic than the product itself.

13. **Disposal Considerations**

**Waste Disposal:** Waste must be disposed of in accordance with federal, state and local environmental control regulations.

14. **Transport Information**

**DOT Classification:** Class 8: Corrosive material
**Identification:** Lithium hydroxide, solid UNNA: 2680 PG: II
15. Other Regulatory Information

Federal and State Regulations:
Minnesota: Lithium hydroxide
TSCA 8(b) inventory: Lithium hydroxide

Other Regulations:
EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:
WHMIS (Canada): CLASS E: Corrosive solid.
DSCL (EEC):
R20/22- Harmful by inhalation and if swallowed.
R35- Causes severe burns.
S22- Do not breathe dust.
S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39- Wear suitable protective clothing, gloves and eye/face protection.
S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):
Health Hazard: 3
Fire Hazard: 0
Reactivity: 0
Personal Protection: j

National Fire Protection Association (U.S.A.):
Health: 3
Flammability: 0
Reactivity: 0
Specific hazard:

Protective Equipment: Gloves. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.
1. **Product**
MINERAL OIL

2. **Composition/Information on Ingredients**
MINERAL OIL

<table>
<thead>
<tr>
<th>Hazardous Components (Chemical Name)</th>
<th>CAS #</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINERAL OIL USP</td>
<td>8042-47-5</td>
<td>90.0 -100.0 %</td>
</tr>
</tbody>
</table>

3. **Hazards Identification**

**Route(s) of Entry:** Inhalation? No, Skin? No, Eyes? No, Ingestion? Yes

**Potential Health Effects (Acute and Chronic)**
Under Manufacturing Conditions: On rare occasions, prolonged and repeated exposure to oil mist poses a risk of pulmonary disease such as chronic lung inflammation. This condition is usually asymptomatic as a result of repeated small aspirations. Shortness of breath and cough are the most common symptoms. Aspiration may lead to chemical pneumonitis which is characterized by pulmonary edema and hemorrhage, and may be fatal. Signs of lung involvement include increased respiration rate, increased heart rate, and a bluish discoloration of the skin. Coughing, choking, and gagging are often noted at the time of aspiration. Gastrointestinal discomfort may develop, followed by vomiting, with a further risk of aspiration.

Carcinogenicity:
NTP? No,
IARC Monographs? No,
OSHA Regulated? No

**Signs and Symptoms Of Exposure**
May cause slight eye irritation

4. **First Aid Measures**

**Emergency and First Aid Procedures**
**IF INGESTED:** Do NOT induce vomiting because of aspiration hazard. If victim is conscious, give 1 to 3 glasses of water or milk and contact physician or Poison Control Center. May act as laxative.

**IF INHALED:** Remove to fresh air. Administer respiration if indicated. If unconscious, seek medical attention.
IF IN EYES: Immediately flush with large amounts of water and continue flushing for 15 minutes. If material is hot, treat for thermal burns and take patient to hospital immediately.

IF ON SKIN: Remove contaminated clothing. If material is hot, submerge injured area in cold water. If patient is severely burned, remove to a hospital immediately.

5. Fire Fighting Measures

Flash Pt: 400.00 F Method Used: TCC
Explosive Limits: LEL: NE UEL: NE
Auto ignition Pt: N.A. Extinguishing Media
dry chemical, foam, water spray, or carbon dioxide

Fire Fighting Instructions
Water may be ineffective but can be used to cool containers exposed to heat or flame. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid. Water runoff can cause environmental damage. Dike and collect water used to fight fire.

Flammable Properties and Hazards
Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.

6. Accidental Release Measures

Steps To Be Taken In Case Material Is Released Or Spilled:
Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert material such as sand, clay, etc.. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or other suitable containers.

7. Handling and Storage

Precautions To Be Taken in Handling
Do not transfer to unmarked containers. Store in closed containers away from heat, sparks, open flame, or oxidizing materials. Flammable and combustible liquids.

Other Precautions
KEEP OUT OF REACH OF CHILDREN
8. Exposure Controls/Personal Protection

Respiratory Equipment
none under normal use, NIOSH cert. OVR w/dust & mist filter
Eye Protection: Chemical goggles

Protective Gloves: Impervious gloves
Other Protective Clothing: Clothes to prevent skin contact
Work/Hygienic/Maintenance Practices: Wash hands before eating, smoking or using restroom.

9. Physical and Chemical Properties

Boiling Point: 740.00 F
Specific Gravity (Water = 1): 0.840000 at 77.0 F
Vapor Density (vs. Air = 1): > AIR
Appearance and Odor: Clear, light colored liquid

10. Stability and Reactivity
Incompatibility - Materials to Avoid: strong oxidizing agents
Hazardous Decomposition or Byproducts: In fire conditions, CO, CO2, and reactive hydrocarbons may be produced.

11. Disposal Considerations
Waste Disposal Method
Dispose of in accordance with local, State and Federal regulations.
APPLICATIONS
- General processing industries.
- High temperature, pressure and shock load conditions.
- Food processing industries.
- Mining applications.
- Automotive industries.
- Defense purpose, pumps, tanks.
- Railways, steel industry, nuclear power plant.
- Aircraft landing wheel bearing.
- Water pumps.
- Building equipments.
- Farm machineries.
- Ball and roller bearing.
- Railway antifriction bearing.
- Lubricant for wire ropes and chains.
- Lubricant for open gear aircraft industry.
- Elevators.
- Paper mills.
- Textile industries.
- Steam locomotives.
- Drilling machine.
CONCLUSION
CONCLUSION

- In this preliminary feasibility report a design of a plant to produce 19000 TPA of Lithium based grease is proposed and its feasibility was studied.

- Total project cost is 632.75 lakhs and the payback period expected is 25.27 months assuming 100% capacity utilization.

- Project seems to be economically very attractive.

- However it is assumed that all the product produced will be sold. It is essential to carry out detail market survey about the need of the Lithium based grease acid in the Indian Market to ascertain the economic feasibility of the project.

- Demand of lithium based grease and lithium complex grease are showing increasing trends.
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