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## **Bitumen is Non-Hazardous and Non-Carcinogen:**

### **Introduction:**

This paper will address what bitumen is and its history. It will also address why an open gear lubricant with bitumen is one of the best methods of protecting an Open Gear set and give supporting evidence that bitumen's are non-hazardous and non-carcinogen.

### **Bitumen and its History:**

Bitumen is classified as a Chemical Substance. Bitumen is a black, highly viscous sticky material that is derived from the processing of a raw material that comes from the earth. It is a product that is produced during the distillation process of heavy crude oils. Bitumen will move quite freely when it is heated due to the long chain molecular structures moving across each other. However, when cooled Bitumen becomes a solid. Bitumen is a good material to use in manufacturing other compounds because it is a naturally occurring compound; very low in water solubility, low volatility (due to very high flashpoints) and is relatively inert.

Bitumen provides waterproofing and adhesive qualities that come from natural sources. It is considered the oldest known engineering material dating as long ago as 6000BC. The Ancient Egyptians used bitumen in their mummification process, to coat their buildings and waterproof their boats.

Bitumen and coal tar are often confused and considered the same product. They are however, very different. Bitumen can be found as a naturally occurring substance but can also be manufactured from select crude oils that go through fractional distillation. In this process the crude is heated to temperatures up to 350°C (662 °F). The heaviest fraction (the highest boiling point fraction) is taken off using a vacuum process which determines the hardness of the bitumen that will be produced. Coal tar on the other hand is derived from coal by destructive distillation at very high temperatures. Bitumen and coal tar are different in physical characteristics as well as chemical composition. The degree of hazard is significantly higher in coal tars due to the level of polycyclic aromatics (PCA's). Coal tars are considered carcinogenic, whereas bitumen's are not.

Bitumen has many uses today such as high quality specialty lubricants, dams, reservoirs, swimming pool linings, pipe coatings, paints, disinfectants, chalk, artificial lumber, printing inks, well drilling fluids, rugs and shoes just to name a few.

### **Why does Bitumen work well when used as a raw material in Lubricants?**

The nature of bitumen molecules are a solid at room temperature. In the manufacturing process, bitumen will typically have oxygen blown through; the oxygen helps to make the bond in the hydrocarbon molecules stiffer. We measure this hard stiff bond through penetration testing. As stated earlier, bitumen (as a raw material) moves very slowly as one molecule slides over another. At increased temperatures bitumen will completely soften and actually become a liquid. These are very important qualities in bitumen and are really the key to imparting the excellent EHD levels that are needed when lubricating some of the most heavily loaded open gearing that is used in industry today. Petron's Gear Shield ® NC product line provides this protection as proven through 30 years of experience with not a single lubricant related performance issue. Bitumen formulated into open gear lubricants provides the highest viscosity possible. This high viscosity provides the greatest Lambda numbers attainable in open gear applications. When calculating the Lambda of today's heavily loaded open gear drives, this viscosity is able to maintain your EHD level so that boundary lubrication will not occur and preventing metal on metal contact from taking place. **Note:** See Appendix A for an example showing the EHD Lambda levels of Petron's Gear Shield ® NC when it is compared to a typical synthetic and typical grease.

### **SAFETY & HEALTH**

Bitumen has a long history of safe use. It has been used as sealants, adhesives, and construction material for well over 8,000 years. The emissions coming from working with hot bitumen does not pose health risks in a well-ventilated or open environment. The emissions are comprised of the fume, which is also called blue smoke (considered the aerosol phase), and the vapor phase (considered the semi-volatiles). Around 150°C (302°F) visible emissions begin developing which is usually a makeup of light boiling hydrocarbons. As the temperature is increased the vapor phase and aerosol phase begin to form.

The debate on the carcinogenicity of bitumen dates back to 1985 when the International Agency for Research on Cancer (IARC) concluded that there was insufficient evidence to make a judgment on the carcinogenicity of undiluted bitumen's.

There have been many studies conducted over the years. Unfortunately, interpretation of the findings of these studies is limited by a lack of consistency amongst studies and issues. Many of the findings are from population based and case controlled studies that have job classifications that are broad. Other chemicals in which industry workers are exposed to were not taken into consideration, especially noting that diesel exhaust, silica, and asbestos was present in many of the instances. Another very big issue that caused a problem is that asphalt fumes were produced in a laboratory setting. To collect these fumes the researchers were heating to temperatures more than twice the normal temperatures, concentrating them, and then using them in animal experiments. These fumes manufactured in the laboratory were an attempt to duplicate the field samples; however, the laboratory samples were showing opposite results to the actual field testing.

This rendered many experiments invalid. Shortly after 1988, NIOSH acknowledged that no animal studies have been performed and that only the laboratory manufactured fumes were found genetically damaging, not the field collected samples. At this point, the evidence for an association between nonrespiratory cancer and asphalt were not linked and it was recommended that studies with better control and identification of asphalt exposures were needed.

A study was carried out using hot-mix asphalt fumes that were collected from a storage tank. This study indicated that the fumes collected from the storage tank were not mutagenic and the laboratory-generated fumes were mutagenic [Reinke and Swanson, 1993]

**Table 1. Reinke and Swanson[1993], mg/mL Data Summary**

PAH's	S-PAC's	Mutagenicity			index <sup>1</sup>
		<3-ring	≥3-ring	≥3-ring	
<b>Asphalt fume condensates</b>					
Storage tank headspace		7.0 (84) <sup>2</sup>	0.8 (9)	0.5 (7)	>0 and <1
Lab-generated at 149°C		6.9 (51)	2.6 (19)	4.0 (30)	5.3
Lab-generated at 316°C		0.5 (7)	2.8 (38)	4.1 (55)	8.3

<sup>1</sup> Raw data not provided. Positive control had an index of 4.6.  
<sup>2</sup> Percentage of total PAH's and S-PAC's.

Some research looking specifically at the dermal exposure of paving crews determined that hygienic behavior through the use (or lack) of protective clothing of the individual greatly affected the exposure.

In 2000 the NIOSH continued to support the 1977 assessment that associates exposure to asphalt fumes from roofing, paving, and other uses of asphalt with irritation of the eyes, nose, and throat. There is insufficient evidence to support any chronic pulmonary effects that are associated with asphalt fume exposures. The evidence for lung cancer and asphalt fumes during paving provided insufficient evidence to link the two together. "NIOSH concludes that the collective data currently available from studies on paving asphalt provide insufficient evidence for an association between lung cancer and exposure to asphalt fumes during paving." Hazard review: Health Effects of Occupational Exposure to Asphalt, DHHS (NIOSH) Publication No. 2001-110.

The NIOSH recommended the following practices:

- Prevent dermal exposure.
- Keep the application temperature as low as possible.
- Use good work practices at all work sites to minimize exposure to fumes.
- Use appropriate respiratory protection.

Industry experience shows that bitumen fumes do not present a health risk to workers that use good manufacturing practices. In 2001 the world-renowned International Agency for Research on Cancer (IARC), part of the UN WHO reported epidemiological research on bitumen. The independent research produced no evidence of a causal link between cancer and exposure to bitumen fumes. This research covered 7 countries and took several years which concluded that:

- “Asphalt workers are, in general, a healthier group of people than the general population;
- The results do not allow to conclude on the presence or absence of a causal link between exposure to bitumen fume and lung cancer
- The study has also demonstrated improving working conditions in road paving in the form of a gradual, but significant, reduction in fumes in recent years.”  
(3/20/06 eurobitume.org/Html/Health.htm)

CONCAWE is an organization that offers advice in classification and labeling of petroleum substances as they pertain to the Dangerous Substances Directive to the European Inventory of Existing Chemical Substances. Their report # 6/05 lists the classification and labeling of bitumen as:

“BITUMEN

**Definition:**

**Bitumen or vacuum residue**

Streams obtained as residues from vacuum distillation and cracking processes (some of which are subjected to further processing) and containing saturated and aromatic hydrocarbons, mainly having carbon numbers predominantly greater than C25.

**Flammability:**

High flash point.

**No classification recommended.**

**Acute Toxicity:**

Data available indicate low acute oral and dermal toxicity.

**No classification recommended.**

**Irritation:**

Limited data available do not indicate the need for classification.

**No classification recommended.**

**Sensitisation:**

Limited data available do not indicate the need for classification.

**No classification recommended.**

**Sub-Acute/Chronic Toxicity:**

Available data do not indicate the need for classification.  
**No classification recommended.**

**Carcinogenicity:**

Dermal studies on bitumen and inhalation studies for bitumen fume do not reveal a clear carcinogenic hazard.  
**No classification recommended.**

**Mutagenicity:**

Available data do not provide sufficient evidence for classification.  
**No classification recommended.**

**Toxicity for Reproduction:**

No data available.  
**No classification recommended.**

**Environmental Effects:**

Aquatic toxicity expected to be low. Bitumen's do not meet criteria for ready degradability and components have log  $K_{ow}$  values greater than 6. However, they are not expected to represent a long-term danger in the aquatic environment.  
**No classification recommended.**

**Summary of classification and labeling recommendations:**

**No classification and labeling required."**

Most recently, June 2006, the Fraunhofer Study was completed and released. The research for this study was completed in mid 2005. This study was carried out as a long-term inhalation study in rats. The material used was a condensate that was collected from the headspace of a storage tank containing bitumen which was held at 175°C (347°F). The level of exposure of aerosol and vapor was up at the 100mg/m<sup>3</sup> (THC), which is 20 times the current OEL (Occupational Exposure Level) in Unites States. The following is the main conclusion from the draft study report:

- "Exposure of rats by inhalation to bitumen fumes (aerosol and vapor) for 2 years did not result in any statistically significant increases in total or organ-specific tumor incidence, compared to clean air 'control' and bitumen exposure groups. Based on these results bitumen fume is not considered to be carcinogenic to rats. Bitumen-related irritant effects were observed in the nasal passages and in the lungs." (3/20/06 eurobitume.org/Html/Health.htm)

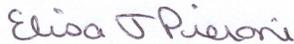
**Conclusion:**

It has been found that at most work sites where hot asphalt is used, the concentrations of asphalt fumes are generally below the NIOSH REL of 5 mg/m<sup>3</sup>.

“Bitumen’s are known to contain very small traces of PAC’s”. “The Eurobitume advises that no classification and labeling is required for refined bitumen’s.” It is important to note that the EU Dangerous Waste List does NOT list bitumen because it is not a dangerous waste.

The Refined Bitumen Association (RBA) says that Bitumen is a non-ecologically toxic product which presents no danger to plant and aquatic environments.

Bitumen’s #1 safety hazard comes from handling this material as it is typically used at elevated temperatures and can cause severe burns. Prolonged, unprotected exposure to fumes can cause respiratory track and eye irritation which can be avoided with the encouragement of good manufacturing practices. This minimizes the exposure to possible burns or fumes. Bitumen emissions are not considered to give significant risk to workers health, but it is always good practice to minimize the exposure to any hot product. One way to limit exposure is to remain below 200°C (392°F) and not exceed 230°C (446°F).



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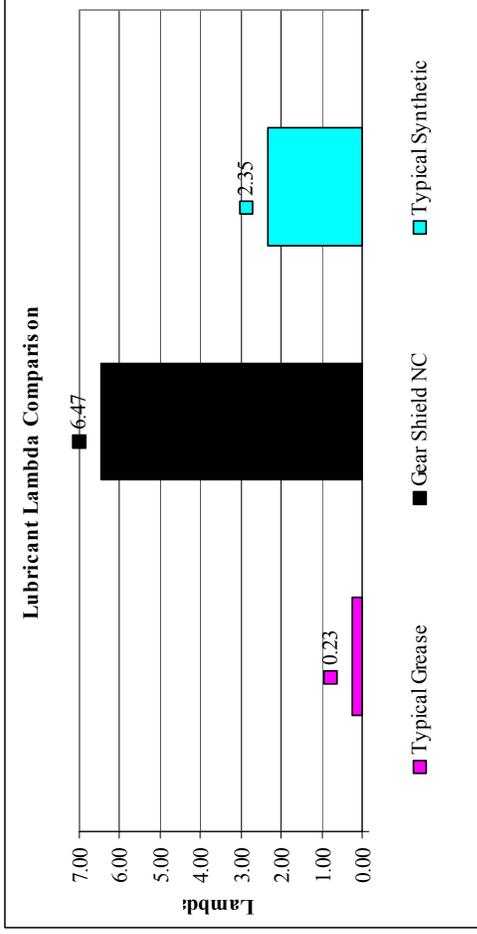
Considerable efforts have been taken in the preparation of this document. Any warranties or representations, expressed or implied, and no liability is accepted for the accuracy of the information and or completeness contained.



Customer : Mining  
 Site : N/A  
 Reference Number : N/A

<u>Input Data</u>			
Pinion Teeth	20		
Gear Teeth	246		
Pinion Speed	171	rpm	
Face Width	30	inches	
Power	6,000	hp	
Tooth Pitch	28	Module	
Gear Tooth Temperature	72	°C	
Gear Type	Single Helical		
Normal Pressure Angle	20 Degrees		
Tooth Condition	Minor Pitting		

<u>Calculated Values</u>	<u>English</u>	<u>Metric</u>
Center Distance	147.7 in	3,752 mm
Pinion Outside Diameter	24.4 in	620 mm
Gear Outside Diameter	275.4 in	6,995 mm
Pinion Pitch (ref) Diameter	22.2 in	564 mm
Gear Pitch (ref) Diameter	273.2 in	6,940 mm
Lube Quantity	1.02 oz	30.2 ml
Pitch Line Velocity	994 fpm	5.1 m/s
Gear Ratio	12.300	:1
Helix Angle	7 Helical	degrees
Gear Speed	13.9	



Lubricant 1 is	Typical Grease	0.23
Lubricant 2 is	Gear Shield NC	6.47
Lubricant 3 is	Typical Synthetic	2.35

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