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*'Providing Tribological Solutions'*

# ADVANTAGES OF VSG LUBRICATION OVER RETROFITTED "GREASELESS" BEARINGS

## 1. INTRODUCTION

To control the flow of water to the turbines at hydro-electric power stations they use the wicket gates. These are vertical plate like structures arranged in a circle around the water inlet to the runner. Bearings are required to support both the water forces and the weight of the gates. These bearings are usually made of bronze which require periodic replenishment of the lubricant and for years standard mineral oil based greases have been used.

A grease is primarily required for the bearings so that the operating forces are not excessive. Greases have the advantages of being able to form a seal to keep out water and silt plus provide corrosion protection for the bronze bearings and the steel journals.

Proper operation of the wicket gates is important because if they do not work correctly it can be more difficult to regulate the flow of water and there might be safety or overspeed implications. This could be especially true for unattended stations that require physical actions to lower stop logs or other control gates. Consequently, it is important that the wicket gates work and fortunately this is easy to ensure provided that a suitable correct lubricant is being used.

## 2. REGULATORY REQUIREMENTS

Greasing is a required maintenance activity and has not been treated considered a spill. This is because the amounts are very small in relation to the water flow and periodic grease re-lubrication is not known to form visible oil sheens. The latter is a criteria reportedly used by EPA. In addition, the amount of grease introduced to the water flow is calculated to be orders of magnitude below the limits for oil and grease used for other applications. For example, some MISA discharge water limits in Ontario are 15 ppm for oil in water and can be 150 ppm for vegetable oil. In comparison, the amount of grease from the wicket gates by volume is thousands of times less.

Plus, the total amount of grease used at a station is likely only a drum of grease a year. This amount is almost negligible in terms of the water throughput. Also, this should be considered in relation to other sources of hydrocarbons such as solvents, main bearing lubricants, transformer fluids, leaks from offroad equipment, outboard motors, and vehicle exhaust emissions.

This being said, it is only prudent to use a better grease and to use it in moderation.

## 3. "GREASELESS BEARINGS"

Some operators have gone to considerable expense to replace proven grease lubricated bearings with either metal or plastic bearings. These generally incorporate some type of solid lubricant into the bearing structure, often either as plugs or sintered into the body. Such lubricants include molybdenum disulphide, polytetrafluoroethylene and graphite. Plastic bearings are also available that can be based on polyurethane or nylon. These can incorporate additives for lubricity or fillers for strength.

While they may require the use of a run-in lubricant and while they might have lubricants in the structure, such bearing do not rely on external lubrication and are said to be self lubricating or greaseless. Consequently, when the lubricant is depleted or the bearing worn, they must be replaced.

The presumed advantage is that they are non polluting but this not necessarily the case because in the strict sense because some require a run in lubricant and there will be wear debris. While likely very little, few studies have apparently be performed and even the nickel in the stainless steel journals has been under review. In addition, considerable solid waste will be produced when the existing bearing and auxiliary equipment is scraped. Plus, a downtime is required to install the bearings so that alternative forms of energy production might be required. But the main disadvantage is the service life of these bearings. Lastly, many self lubricating bearings are made from non renewable resources and/or are manufactured using processes with considerable environmental impact. VSG is mainly canola oil which is a vegetable oil and as such is renewal with less intensive manufacturing considerations.

## 4. SERVICE LIVES

The maximum service life of properly greased bearings is decades and some have apparently been in-service since the late 1800's. On the other hand some “greaseless” bearings have failed in less than a few years. The causes can be misalignment, improper installation, high torques, and mechanical failure.

At the best, it is reported that the lives are only 10-15 years mainly because of wear. Consequently, the unit has to be down and the bearings replaced. These likely have to go to a landfill for disposal.

## 5. BENEFITS OF UPGRADING GREASES

Because there is apparently no regulatory requirement or technical advantage in retrofitting “greaseless” bearings, corporate environmental good will efforts might be better served by using a more ‘environmentally friendly’ grease lubricant.

This would have advantages in that the capital could then be used to better advantage elsewhere. For example, the most significant cost factor in changing out the bearings can be those associated with the outage required to install new bearings. Even when this work is combined with other activities there can still be significant costs.

Also the use of self lubricating bearings is not without risk because there have be a number of cases where the bearings have failed even after only a few year. For the most part these were a result of improper design and/or installation procedures, but there is a real risk.

## 6. WHAT TO DO?

First, establish a total environmental review to cover all issues include vehicle tune-ups and auxiliary equipment.

Secondly, use only as much grease as is required and use a more environmentally friendly product. Not also that not all the grease being used ends up in the waterway but only that grease discharging on the water side. The grease from the upper bearing goes into the regulating ring area and that from the bottom of the lower bearing into the structure.

Other benefits with the use of a better grease is that can be used for other applications at the stations and it heightens the awareness of such products. In addition, it has been found that when there are programs to retrofit bearings, even for those stations that are not scheduled, personnel appear to take the attitude that it is coming. As a result, there may be less attention paid to providing adequate lubrication for the wicket gates or to even use approved products.

## 7. SUMMARY

1. Grease lubrication bronze bearings have a proven track record whereas retrofitted solid lubricated and plastic bearings have an unknown life.

2. The amount of grease in waterways from the wicket gates is calculated to be orders of magnitude less than any known limits.

3. There appears to be no regulatory requirement to change out grease lubricated bearings.

4. Action should be taken to ensure that excess grease is not being used and that ‘environmentally friendly’ greases are being used.

5. ‘Environmentally friendly greases are now available that meet Ontario Hydro and Hydro-Québec specifications.

6. Use only greases that meet or exceed the required performance requirements and consider all the environmental issues as much as possible. Win-win combinations are attainable with the correct choice.

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# APPENDIX
# VSG VERSUS "GREASELESS" BEARINGS

| 1. Cost | VSG Grease Lubrication | Solid Lubricated Bearing Retrofits |
|---|---|---|
| Includes equipment changes and engineering, but not maintenance costs. | To change to the 'biofriendly' grease like VSG generally requires no equipment changes. In addition, the incremental cost of a better grease is usually only a few hundred dollars per year per unit. | The bearings themselves are more expensive than the bronze types and replacement requires an outage. Such bearings must also be well aligned and this may require machining of journals or housings.<br><br>In addition, hardened stainless steel sleeves for the journal are recommended as are elastomeric seals to keep out silt.<br><br>The most significant costs are those for the installation. These include engineering, planning and craft labourers. Plus lost or replacement power costs if an outage or outage extension is required to install the bearings. Also to be factored in are future replacement costs and unscheduled outage costs because there is risk. |

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|---|---|---|
| **Performance** | **VSG Grease Lubrication** | **Solid Lubricated Bearing Retrofits** |
| Includes meantime to failure, replacements and operating forces. | Grease lubricated bronze bearings for wicket gates have been in use for over 100 years. Have an excellent record. There are no known cases of where a properly lubricated bronze bearing caused an outage. | Self-lubricating bearings, and in particular the plastic ones, are fairly recent. The life is not known. There have also been a number of early replacements after only a few years.<br><br>Operating forces can also be higher. depending on the type of bearing chosen and the sealing arrangement. |
| **2. Maintenance** | **VSG Grease Lubrication** | **Solid Lubricated Bearing Retrofits** |
| All bearing require some maintenance. This can be regularly scheduled activities or failure based. | The bearings are supposed to be provided with fresh grease and this can be on a daily or weekly basis. Large turbines have automatic grease lubrication systems.<br><br>Requires periodic replacement of grease pump system components. These are generally easily accessible and repair can be done on-line.<br><br>Generally no special training is required and standard tools are used. | No maintenance is usually possible on the bearings. Requires an outage to replace bearings and/or seals. Some plastic types also recommend the use of a run-in lubricant which must be applied during the original installation.<br><br>Proper installation can require more care than with grease lubrication bronze bearings. Special insertion tools/procedures may be required and alignment is critical. |

## 3. Environmental Compliance

Hydro-electric stations are not covered by the same requirements as are thermal power stations. The regulatory requirements are generally those pertaining to the waterways. For example, the Fisheries Act in Canada and EPA requirements in the US. These come into play when the water quality is impaired or there as visible oil sheens on the surface of the water.

## VSG Grease Lubrication

Considerable improvements can be made by using only as much grease as required and by using more environmentally friendly greases.

VSG greases are not only biodegradable, biofriendly and high performing, but the largest constituent is also a renewal natural resource.

Vegetable oils are also received much more favourable where regulations do apply in other industries and they are also a renewable resource. Can be considered as one aspect of 'Sustainable Development' activities.

## Solid Lubricated Bearing Retrofits

It is not clear as to whether this is totally in compliance with the wording of the Fisheries act. This is because of the run-in lubricant which might be required and wear debris. Certainly the amounts are small and such bearings should be consistent with the intent of the act.

Care should be taken when selecting materials and when machining such bearings and stainless steel sleeves to avoid environmental of health and safety risks.

## 4. Life Cycle Consideration

This is the cradle to grave approach and in some cases also takes into account the production of the raw materials.

## VSG Grease Lubrication

VSG is based on canola oil which is a renewable resource. Also processing is fairly straight forward and is not know to use particularly hazardous chemicals or create hazardous waste. Much of the processing waste is the seeds which is organic matter. Some mineral oil is also used in the product which is not a renewable resource. However, it is biodegradable

The grease is typically supplied in steel kegs or drums. These can be reused and or recycled.

## Solid Lubricated Bearing Retrofits

This varies depending of the type of bearing material. One of the most common product uses a polyurethane core in a bronze sleeve. The feedstock is mineral oil based which is a non renewable natural resource. Chemical processing is also required. It is not known if the waste produced during manufacturing is recyclable. It is not expected that the wear debris is biodegradable but the amounts should be very small. Biotoxicity is not known.

Retrofitting such bearings does generate some waste. First the old bearings are scrapped, as are the long copper lubricating lines and the lubrication system. These would be still filled with grease. It is doubted if they are reused for recycled because many of the stations are in remote areas. In addition, when the plastic bearings, seals and sleeves wear out, they will generate a bit more waste when they are discarded.