Environmentally Acceptable Lubricants (EALs) in Dams & Navigation Structures - Background

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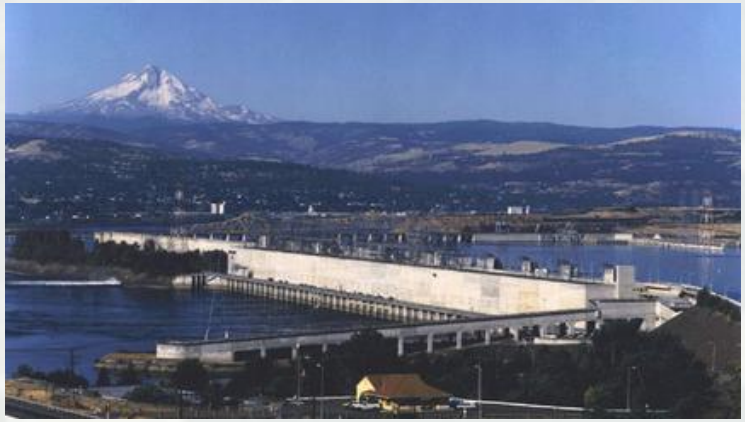
Background

- Support USACE settlement with Riverkeepers
  - Indicates that 8 USACE dams must assess the use of EALs for all in water applications
- Purpose: to indentify in water use by studying 3 dams
- Field trip on 10-11 February 2015
- Dams studied were the Dalles, John Day, and McNary
- Studies were supported by Operations personal



The Dalles Dam

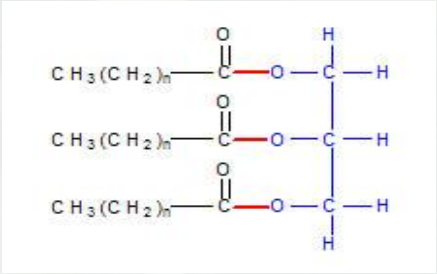
Dams Affected by Settlement

- Bonneville
- John Day
- McNary
- The Dalles
- Ice Harbor
- Lower Monumental
- Little Goose
- Lower Granite.

What is an EAL?

- Defined in EPA 800-R-11-002
- An effective lubricating oil
- Composition
  - Low or no mineral oil content
  - Low metals, minimal hazardous or toxic constituents
- Meets thresholds for
  - Bioaccumulation
  - Biodegradability
  - Toxicity

What are EALs made of?



- Biolubricants/Vegetable oils
  - Oils derived from natural sources
  - Canola, caster, sunflower, soybead, rape seed, etc.
  - Natural, triglyceride esters provide lubricating property
- Synthetic esters
  - Formulated by chemical synthesis (petroleum or natural sources)
  - Can be formulated to meet nearly any requirement
  - But can be costly
- Polyalkaline glycols (PAGs)
  - Derived from petroleum sources, but modified to from alcohols (glycols)

Confusion

- Greases that are termed as environmental friendly, environmentally aware, or even EAL may not actually have sufficient testing to meet EAL requirements
- Food grade greases are not EALs and generally do not meet EAL requirements.

In Water Lubrication at USACE Dams

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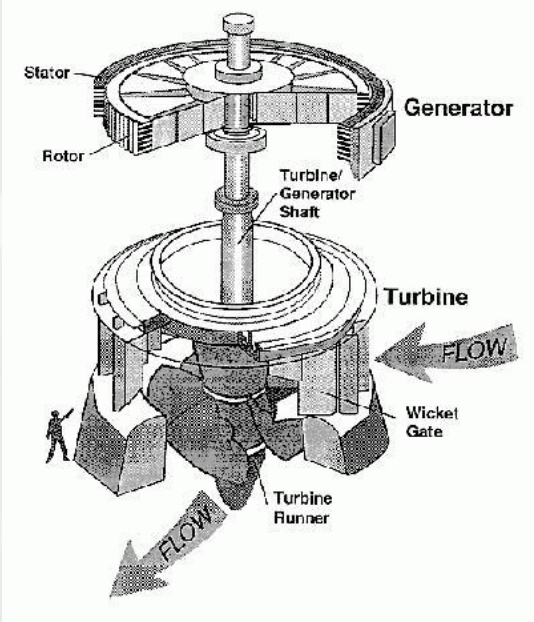
Applicability

Discussions with experts and operations from these dams suggest that the operations at these 3 dams encompass virtually all the primary operations expected at USACE dams. However, there are differences in the actual equipment used for many of the operations, and this variability could have some affect on lubrication needs.

Wicket Gate Lubrication

- Wicket gates are structures that control water flow through hydropower turbines.
- One of there more demanding in water uses



Schematic of hydrodam turbines & wicket gates

Picture of open wicket gates at Parker Dam (CA)

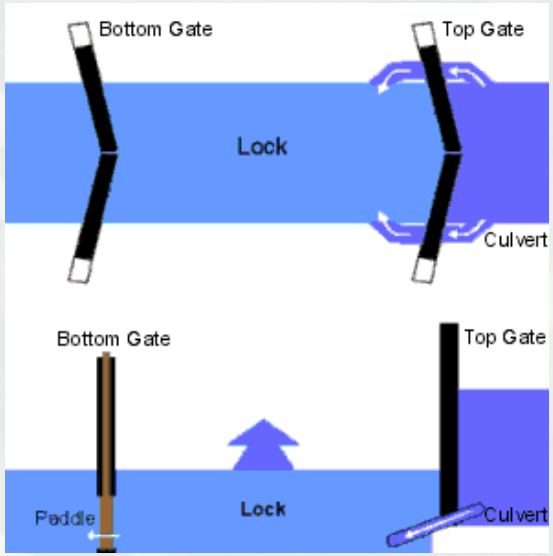
Fish Screens

- These are devises to keep fish (particularly juveniles) from the turbines.
- Spray lubricants are used during periodic maintenance.

Fish screen undergoing maintenance at John Day.

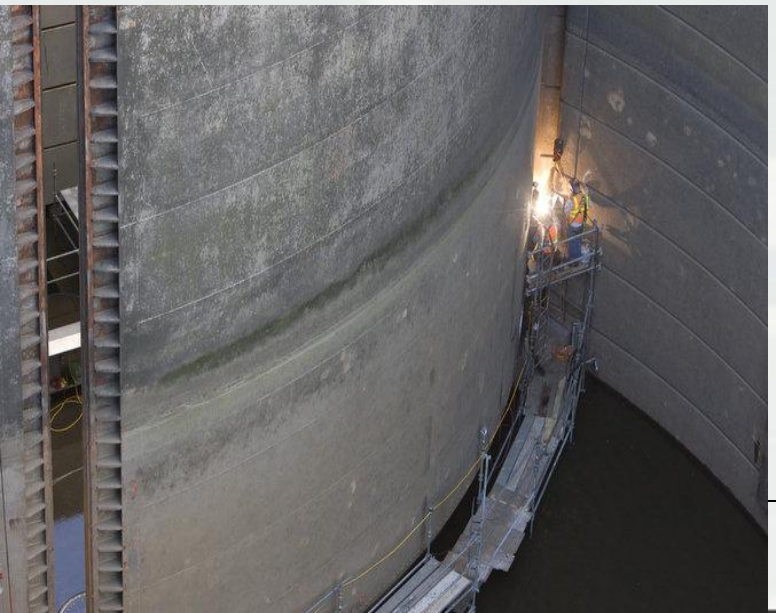
Spray on chain lubricant used on fish screens

Navigation Locks



Schematic showing
Top and lower gates
In a navigation lock

- Massive structures that must deal with massive water forces.
- General design has two gates (top and bottom) that work together to allow vessel movement in the lock.



Repairs at the Dalles bottom gate in 2010 showing the massive size of the structure

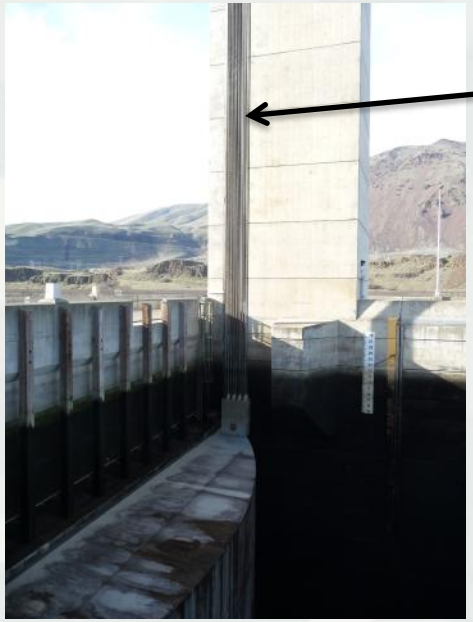
Bottom Gate Structures

Upper Pintle Bearing at the Dalles

The Dalles & McNary

- Uses a dual door swing gate structure – Miter Gates
- Pintle bearings are the primary area requiring lubrication
- At the Dalles, the Pintie bearings are designed for greaseless operation.
  - However, upper bearings are greased (above water)
  - Grease lines are maintained to lower bearings

Bottom Gate Structures



Wire ropes that raise & lower the gate

Bottom Gate at John Day

Rotating drum that Raises & lowers the Gate, & heavily Greased wire ropes.

John Day

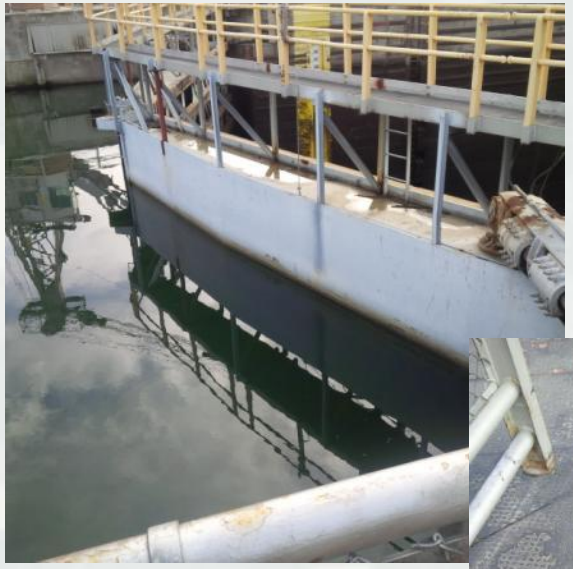
- Use a single door vertical lift gate
- Lifting is performed using massive wire ropes that are heavily lubricated. They are not submerged, but are above water.
- Side runner are greaseless in these dams, but should be checked in other dams.

Top Gate Structures

The Dalles

- Uses a Tainter gate design (swings up and down)
- Bearings on these gates are lubricated and are generally above the water level.

Top Gate Structures



Top gate at McNary

Upper pintle bearing showing grease lines

John Day & McNary

- These dams use Miter gates
- Upper and lower pintle bearings on these gates are generally lubricated.
- Upper pintle bearing are above water, but lower bearings are submerged.

Spillway gates

- Spillway gates open and close to control water height held by the dam
- Like the navigation gates, the actual design of such gates can vary from dam to dam. Tainter and lift gates are common
- Depending on the design, such gates can have in-water lubrication points or above water lubricated wire ropes or gearing.

Lift gate style spillway gate at McNary. Gates are moved using greased wire ropes, which are above water

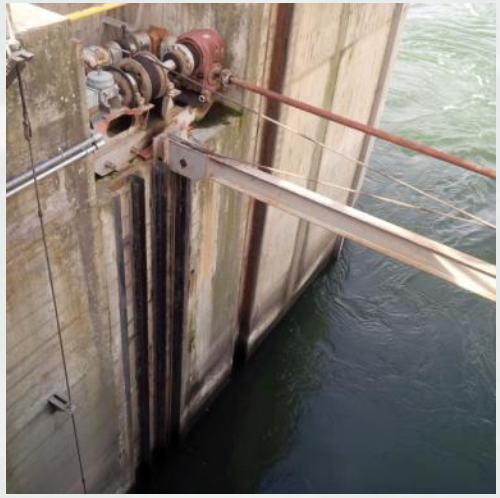
Open spillways at John Day

Fishways

Heavy greased gearing for movement of adjustable fishway weirs at McNary. Above water

- These have a lot of above water lubricated devises that could impact water
- These include gates, adjustable weirs, etc.

Greased cable system movement of adjustable fishway entrance gates McNary. Above water



Fish Pumps

- Powerful pumps are used to create a strong current to attract fish to the fish ladders (Fish attraction water).
- The turbines of the pumps are grease lubricated, and the lubricant eventually is discharged into the water.

Fish pump at John Day dam.

Grease metering system

Cranes

Large crane & hoist at the John Day Dam

- Cranes are used for numerous operations at the dams studied
- Depending on the exact use, the cranes may have hoists and wire ropes that actually submerge in the water (in-water).
- Cranes are also a potential above water source

Lifting beams

- These are structures that snap onto overhead crane systems.
- Used for a wide range of applications throughout the dams.
- Rollers and other fittings are commonly greases.
- These can be submerged

Other Above Water Sources

- Cable ratchets were observed at John Day, which had lubricated gearing. Although the gearing was housed, leakage was observed at the fill points.
- Leakage of oil lubricant was found associated with spillway gate motors. Sorbent pads were used to contain the leakage.

Questions - Structures

- Any we are missing?
- Can we lump structures together (if lubricant works for one, it will work for several others?)

Performance

Preliminary Assessment

Assessment Projects

- HDR assessment for the Hydropower Design Center
  - Focuses strictly on hydropower aspect of Riverkeeper's settlement (wicket gates)
  - Includes testing
- ERDC study
  - For Riverkeeper's, will focus on non-hydropower
  - Also includes a post-Riverkeeper's component
    - Applications beyond in water
    - Uses beyond the 8 dams in the settlement

Existing Lubrication at the 8 Dams

- A mix of mineral oils, food grade oils, and some EALs

EAL Alternatives

- Mobil EAL Series
  - Synthetic ester
  - Used at the Dalles & at TVA dams
  - Comparable performance to mineral oil greases
  - Lithium base, reportedly highly compatible with most greases
- Husky Hydrolube
  - Used at Bonneville
  - Some incompatibility issues
- VSG
  - Canola Oil with additives, including a small amount of mineral oil
  - Used at Dvorshack, Parker Dam (BOR), and TVA
  - Wicket gate grease, but can be used for other purposes as well.
  - Tested by BOR 1998, out performed all other greases.
  - Reportedly very compatable with most lithium based greases.
- Others
  - There are several other greases that may be suitable, but do not have as much practical application to date.

Are EALs, EALs?

- We checked greases for data supporting bioaccumulation, biodegradability, and toxicity.
- Green indicates supporting data shows that grease meets requirements specified in EPA 800-R-11-002
- Yellow indicates no data, but based on composition, the grease would likely meet requirement
- Orange means no data, but based on composition, would presumably not meet requirement
- Red. Data shows grease does not meet requirement.
- We accepted test results or data provided on specification sheets.

Sample of Table

rand Name of Grease	Mobil SHC Aware Grease EP 2	Renewable Lubricants Bio-EP Wire Rope Lubricant	Bio-Ultimax Hydraulic Fluids 1000	Vickers Oil Product (Biogrease EP 2)
Source	http://www.exxonmobil.com/MarineLubes-En/Files/mobil-shc-aware-grease-ep-2.pdf	http://www.renewablelube.com/MSDS/4Ea-Bio-E.P%20Wire%20Rope%20Lubricant%20MSDS.pdf	http://www.renewablelube.com/MSDS/3A1-Bio-Ultimax%20Hydraulic%20Fluids%20AW%201000%20ISO%2032,%2046,%2068,%20100%20%20MSDS.pdf	http://marinebiolubes.vickers-oil.com/files/2013/08/BIOGREASE-EP2.pdf http://marinebiolubes.vickers-oil.com/files/2012/02/BIOGREASE-EP2-VGP-Compliance-statement-300713-3.pdf
Potential for ioaccumulation	**Non-bioaccumulative;** Bioaccumulation, OECD 117, Partition Coefficient, log KOW <3	**No Data** Composition (vegetable oil) suggests non-accumulative (EPA 800-R-11-002 Section 4 Table 6)	**No Data** Composition (vegetable oil) suggests non-accumulative (EPA 800-R-11-002 Section 4 Table 6)	**No Data** Composition (synthetic esters) suggests non-accumulative (EPA 800-R-11-002 Section 4 Table 6)
Toxicity	**Nontoxic;** Aquatic Toxicity, OECD 201, 72h EC50 >1000	**Nontoxic;** Based on previous studies, LC50/EC50 is greater than 1,000 ppm.	**Nontoxic;** Based on previous studies, LC50/EC50 is greater than 3,000 ppm	**Nontoxic;** FISH; LC50 exceeds 1000 mg/l DAPHNIA; EC50 exceeds 1000 mg/l ALGAE; EC50 exceeds 1000 mg/l
iodegradability	**Readily biodegradable;** Biodegradability of ester base oil, OECD 301B, wt% >60	**Readily biodegradable;** Based on previous biodegradability studies, the products provide Ultimate Biodegradation Pw1 >60% within 28 days in ASTM D-5864.	**Readily biodegradable;** Based on previous biodegradability studies, the products provide Ultimate Biodegradation Pw1 >60% within 28 days in ASTM D-5864.	**Readily biodegradable;** greater than 60% in the 28 day OECD 301B test
Composition	Formulated based on biodegradable saturated ester-base oils and a lithium/calcium soap thickener	Vegetable oil	Vegetable oil base stock	Synthetic Esters Thickener: Lithium/Calcium;

Results

- 12 greases evaluated to date
- 2 met all criteria
  - Biogen Wireshield & Mobil SH Aware Grease EP 2
  - None of these have been identified at the 8 dams
- 6 greases had one yellow category
  - 3 have been used on the 8 dams: Mobil EAL 101/102, Ecofluids VSG, and Dynaguard
- 4 greases had 2 yellow catagories or 1 orange
  - Including Husky Hydrolube, used at Bonneville.
- No greases had a red category.

Evaluation criteria

- Only accept if original source test data is provided.
- Accept test data given in spec sheet (our green)
- Accept manufacturers statement (separate, or on spec sheet).
- Accept based on composition. (our yellow)

Questions

- How restrictive should we be in evaluating parameters?
- Can we accept results based on composition
  - If we can accept this for bioaccumulation, we can greatly increase the number of EALs available.
- Should we consider doing our own testing?
  - Kow for bioaccumulation?

EAL Performance

- Can EALs protect equipment?
- Are they comparable to currently used greases & lubricants?
- Do they meet performance standards?

Preliminary comparison to comparable greases

	Lubricant				
Properties	Ultra Duty EP NGLI-0	Ultra Duty EP NGLI-1	FM ALC EP1	FM ALC EP2	VSG Wicket Gate Grease
Penetration @ 77 F	370	325	280	325	325
Dropping Pt, F	342	491	500	500	480
Four Ball Weld Pt. kgf	315	500	500	500	400
Four Ball Wear Scar, mm	0.45	0.43	0.60	0.60	0.42
Timken OK Load, lb	55	70	40	40	55
Water Washout, wt%	15	7			1.29
Copper corrosion	--	1B			1B
Thickener, % Type	5.6 Lithium	7.0 Lithium complex	6.9 Aluminum complex	7.7 Aluminum complex	-- Calcium sulfanate

VSG has similar properties to several of the mineral oil greases used At the Columbia Dam projects.

Uses of EALs

- USACE
- Parker Dam
- Orillia Power District
- TVA
- All report similar (in one case superior) performance to previous mineral oils

Performance Criteria (non-hydropower)

- No specific numerical performance specifications have been found yet.
- We have interviewed (by email) engineering & operations personnel at NWD/P/W.
- Researched USACE lubrication manual.
- We are still looking, but this comparison may not be feasible with existing information available.

Questions

- What do we need to confidently recommend use of a grease (EAL or otherwise)?
- Are comparisons to existing greases useful?
  - How do we handle of some of the parameters are below the existing grease's performance?
- Uses at other dams?
- Evaluation panel?

EAL Implementation

- Can an EAL be applied to an existing grease and work?
- Experiences
  - USACE, TVA, Orillia Power District, Parker Dam
  - In each case, EAL appears to applied over existing greases with little preparation (although records are spotty)
  - One case of incompatibility reported (Husky grease at Bonneville

EAL Implementation

- Binders
  - Generally, if oils have the same binders, they will likely be compatible.
- Compatibility testing
  - Being conducted as part of HDR project for HDC

Riverkeepers & Incompatibility

- The Riverkeeper's settlement does not include a waiver due to grease incompatibility
- However, incompatibility could be addressed in an implementation plan

Addressing grease incompatibility

- Thoroughly remove the old grease
  - Least attractive, most costly
  - Partially removal might be sufficient.
- Consider selecting another, compatible alternative
  - There are several EAL greases, so it is likely a compatible alternative could be found.
- Consider using an intermediate or a series of intermediates
  - Gradually change the grease composition until the new grease can be used with no problem.

Questions - Implementation

- Limited applications for testing?
- Monitoring upon application?
  - For compatibility
  - For performance

The Path Forward

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Path Forward

- Riverkeeper's settlement
  - Are there things we are missing?
    - In water sources?
    - EAL evaluation?
    - Performance?
  - Implementation
    - Approach
    - Concerns
    - Demonstration or testing?

Path Forward

- Other uses
  - What other equipment
    - New Operational requirements
  - Vehicles
- Beyond the 8 dams
  - Any processes or uses significantly different?
  - Any other lubricants that may present unique compatibility issues?
  - Need to visit other projects?