

**Grease Lubrication of Motor Operated Valves – A  
Sustainable Approach for the Nuclear Industry  
and Beyond**

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**Canoil Canada Ltd.**

## OUTLINE

- Canoil Canada Ltd.
- Valve operation
- Applications of MOVs
- Nuclear power plants
- OEM grease requirements
- Nuclear EQ program
- EQ test results
- Stem nut wear results
- Quality control
- A note on sustainability
- Questions?

# Canoil Canada Ltd



- Canoil has the rights to one of the most widely used MOV greases in nuclear applications – available in tubes, pails, kegs, drums
- Canoil also supplies a biobased grease used at hydro dams throughout the world. Both based on CSC technology
- Canoil is ISO 9001:2015 certified and & N299.3 compliant.
- North American distributor of Reolube phosphate ester fire resistant fluid



# VALVE OPERATION

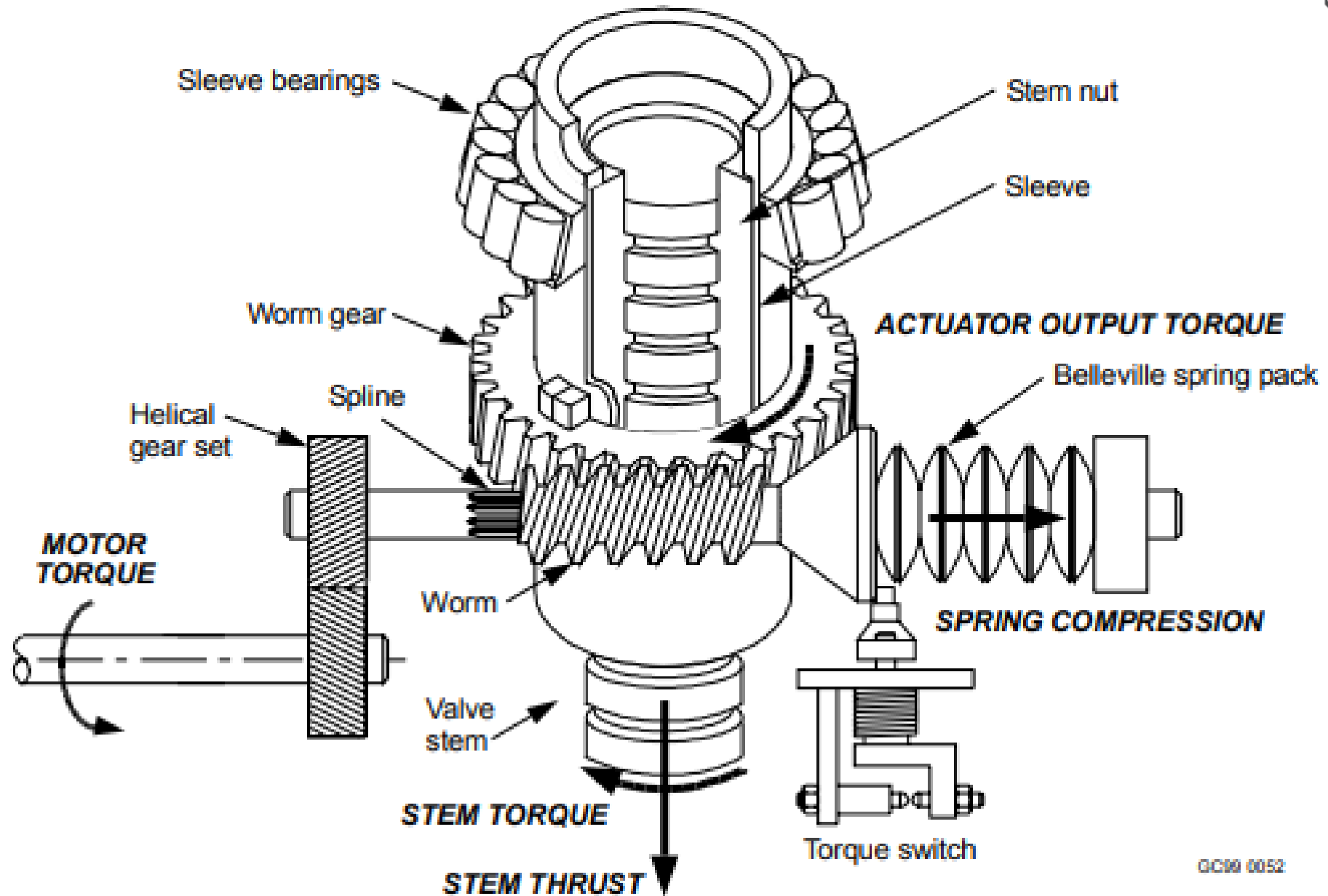
- Manual
- Pneumatic Power
- Hydraulic
- Electric → Solenoid or Motor-driven

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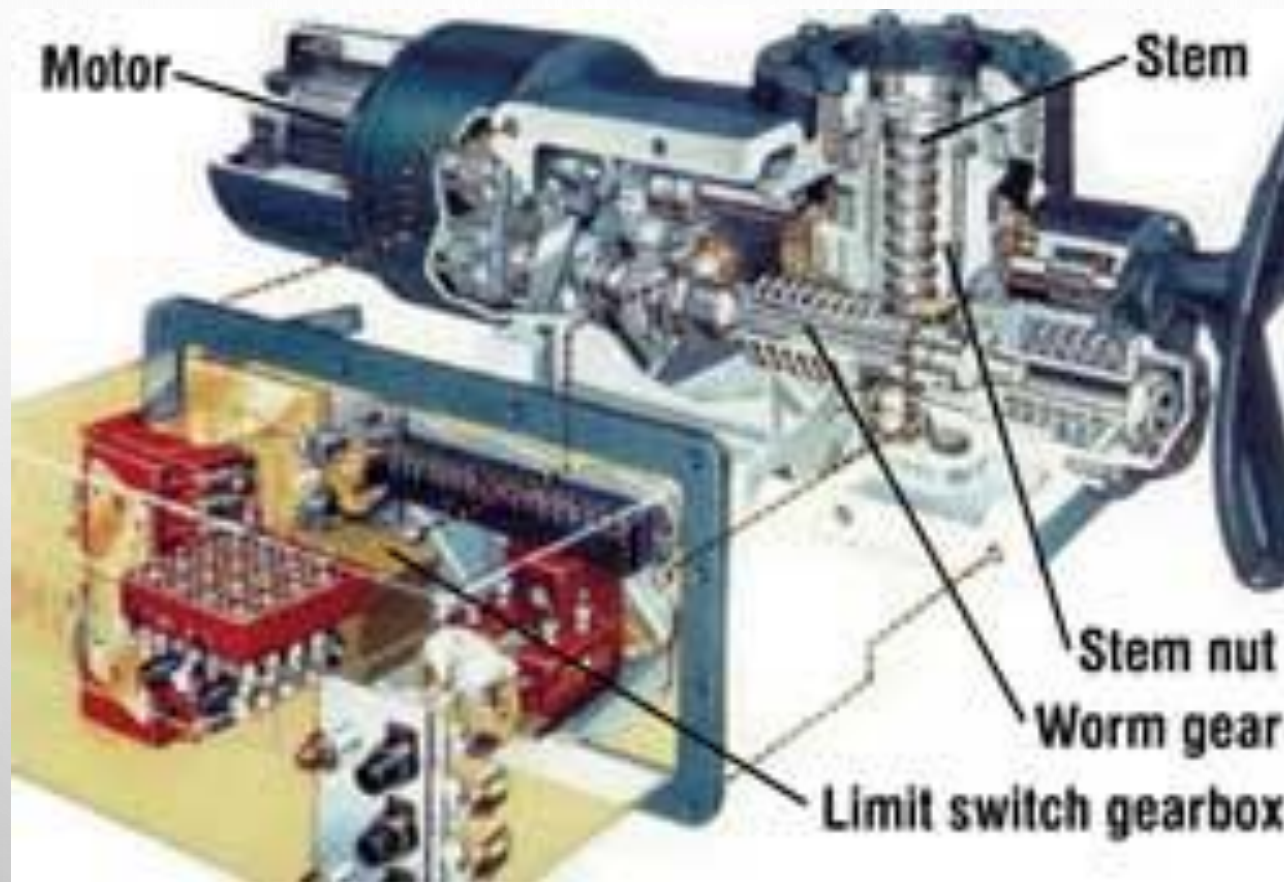
# Cutaway showing the gears and stem of an MOV actuator





Canoil Canada Ltd.

## CUTAWAY OF A TYPICAL MOTOR-OPERATED VALVE ACTUATOR



## APPLICATIONS

- Fossil-fired plants
- Oil & gas industry
- Nuclear plants



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- Fossil-fired plants
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## NUCLEAR POWER PLANTS

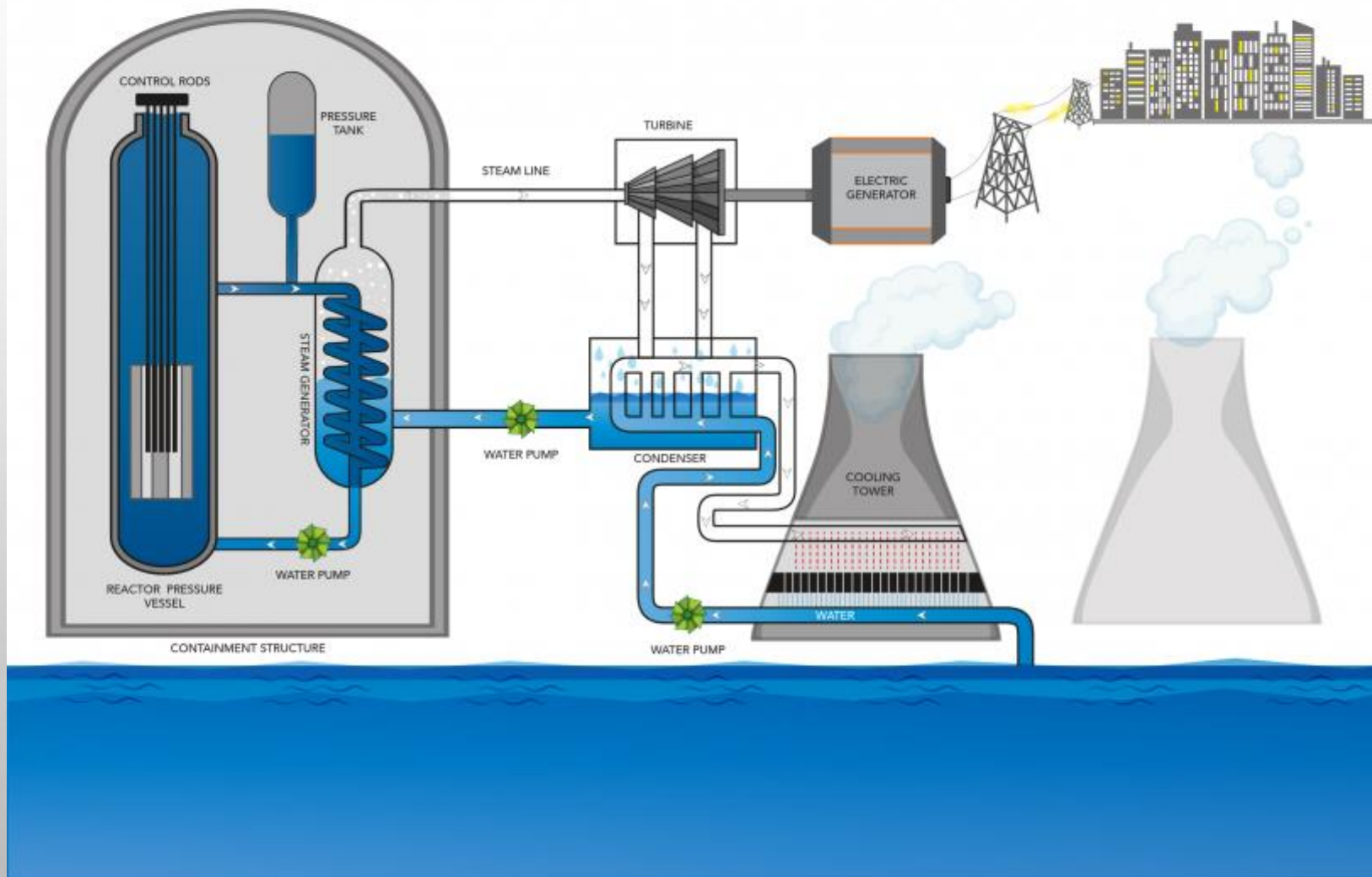
- Nuclear power continues to be one of the largest sources of reliable carbon-free electricity available.
- **440 commercial reactors worldwide**, including 94 in the United States
- All commercial nuclear reactors in the US are light-water reactors
- Canada and a handful of other countries use CANDU reactors. CANDU stands for CANada Deuterium Uranium - heavy water used as the reactor's neutron moderator and for primary heat transport
- CANDU uses natural uranium as a fuel (as opposed to enriched uranium)

# NUCLEAR POWER PLANTS



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## PRESSURIZED WATER REACTOR (PWR)

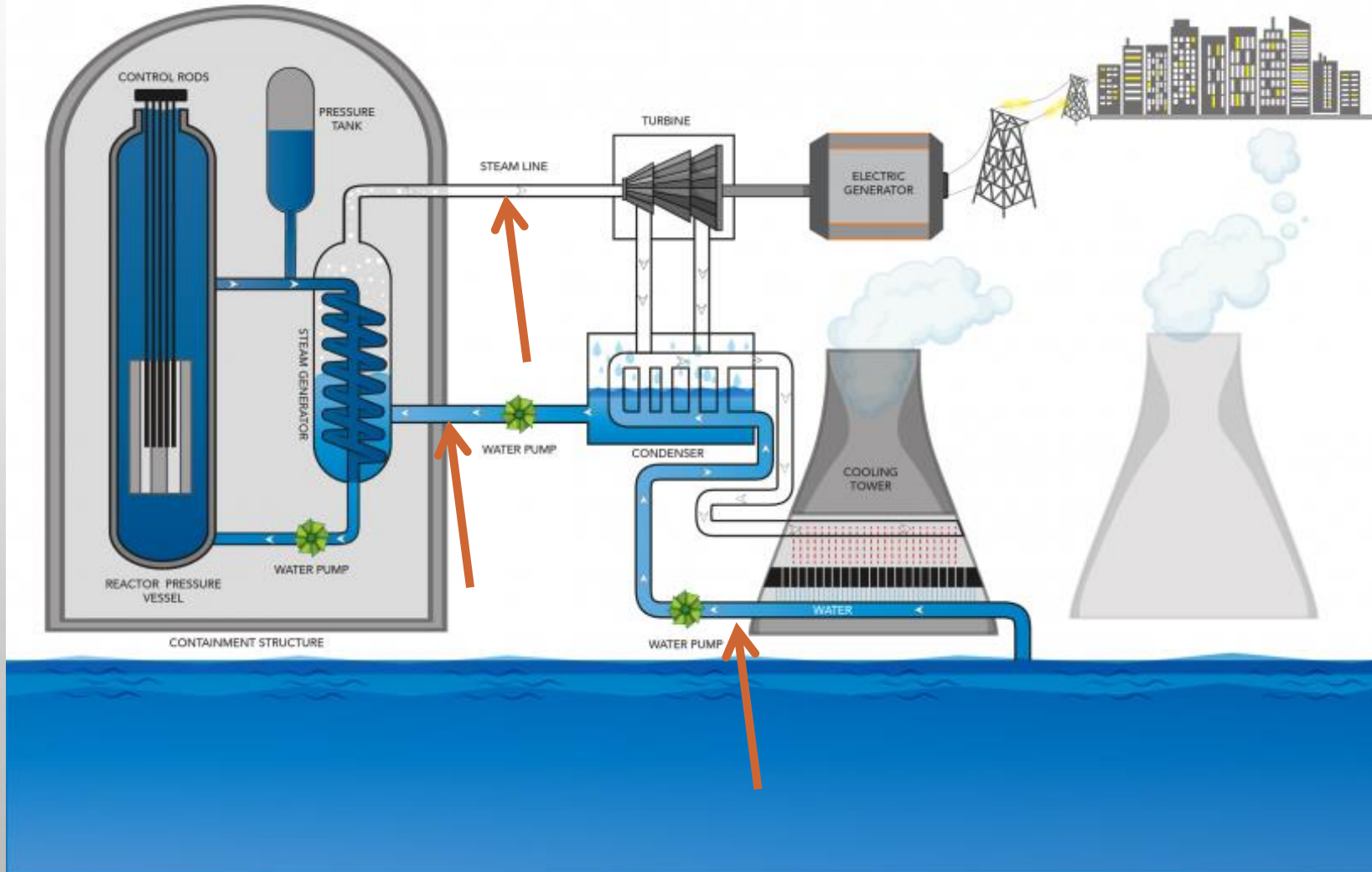


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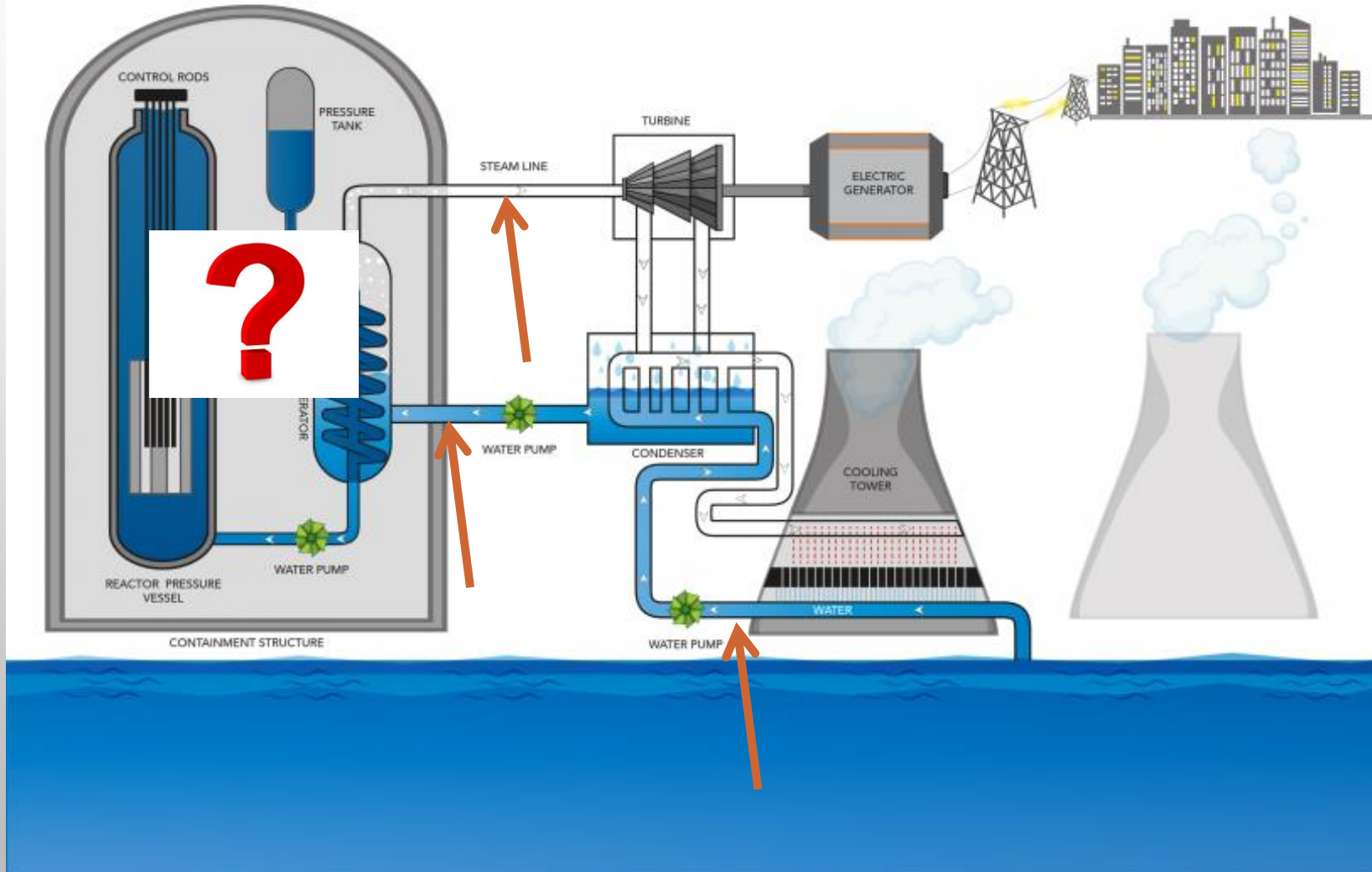


# NUCLEAR POWER PLANTS



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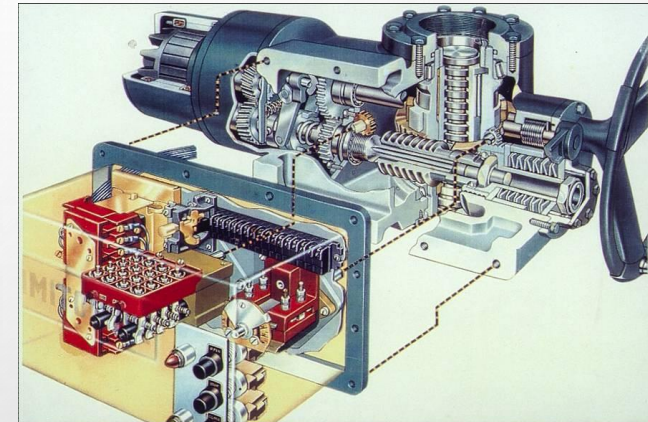
## PRESSURIZED WATER REACTOR (PWR)



## HOW WAS SUCH AN ACTUATOR LUBRICATED?

Historically, 3 separate greases were often used to lubricate the 3 main actuator parts:

- Limit switch gearbox
  - Main gearbox
  - Stems
- 
- One of the commonly used greases was about to be obsolete
  - Could a new grease replace all 3?



## CALCIUM SULFONATE COMPLEX GREASE

Based on reports issued from both the *Electric Power Research Institute* (EPRI) and the *CANDU Owners Group* (COG), one calcium sulfonate complex grease “CSC Grease A” was recommended to lubricate the main components of the actuator

### Characteristics of ‘CSC Grease A’:

Calcium sulfonate complex thickener  
Hydrotreated group II base oil – 95cSt  
Additives – contains a custom EP/AO package

## OEM REQUIREMENTS

### **The 8 minimum lubricant qualities required by one OEM were:**

1. Should contain an “EP” (*extreme pressure*) additive.
2. Must be suitable for the temperature range intended.
3. Resistant to water, heat and separation
4. Must not create more than 8% swell in Buna N or Viton.
5. Must not contain any grit, abrasive, or fillers.
6. Must slump - prefer NLGI grade 0 to 1.
7. Must not be corrosive to steel gears, ball or roller bearings
8. Dropping point must be above 316°F for temperature ranges of -20°F to 150°F.

## ENVIRONMENTAL QUALIFICATION (EQ) PROGRAM

- Qualifies nuclear safety-related equipment to guarantee operation under accident conditions
- Prescribed by US Nuclear Regulatory Commission 10 CFR 50 – this regulation outlines the requirements binding on any licence holder to operate a nuclear facility
- Equipment such as valves, actuators, pumps and motors etc. need to be evaluated
- EQ looks at cumulative normal operating and accident condition and qualifies equipment based on testing/analysis

# SAFETY CONCERNS AT A NUCLEAR POWER PLANT - WHAT COULD GO WRONG?

- main steam line break (**MSLB**) and
- loss of coolant accident (**LOCA**) conditions



## EQ TESTING

### **Electric Power Research Institute (EPRI) report:**

Testing included:

- oven aging at 150°C for 300 hours,
- **gamma irradiation** to 220 Mrad, and
- thin film air and thin film steam exposure at 150°C.

Analytical tests were penetration, weight loss, dropping points, infrared (FTIR) traces, differential scanning calorimetry (DSC), rheometer studies, and pin on disc (POD).

## EQ TESTING

**CANDU Owners Group (COG) Report:** simulation of worst-case service in CANDU stations:

- oven aging at 130C for 660h,
- **gamma irradiation** to 70Mrad,
- LOCA steam exposure including 6h exposure to 171C, 105kPag steam



CALCIUM COMPLEX



CSC GREASE A



CLAY THICKENER



CSC GREASE A



LITHIUM COMPLEX



CSC GREASE A

**Bulk aged samples – 66h at 177C (350F)**

*Courtesy: Utility Service Associates*

# COG REPORT – SIMULATED AGING, 70MRAD EXPOSURE AND LOCA CONDITIONS (CAN=BULK, VP=VERTICAL PLATES, THIN FILM)

Sample Description <sup>1</sup>	Full scale Penetration	NLGI Grease Grade
NEW UNAGED	326	1
1.6 YR	317	1
3.8 YR	314	1
5YR	318	1
5YR + 70 MR	326	1
5YR+70MR+LOCACAN	309	1.5
5YR+70MR+LOCAVP	283	2

CSC Grease A



Aged, pre- and post-LOCA

Sample Description <sup>1</sup>	Full Scale Penetration	NLGI Grease Grade
NEW	312	1
1.6 YR	281	2
- 3.8 YR	215	3.5
3.8 YR + 70MR	248	3

CC Grease B



Aged, pre- and post-LOCA

# FINAL FINDINGS – EPRI & COG REPORTS

**COG**: ‘CSC Grease A’ was recommended for use in the OEM gearboxes in nuclear applications of CANDU design stations and was also recommended as a top-up to existing OEM gearboxes filled with a calcium complex grease (compatible)

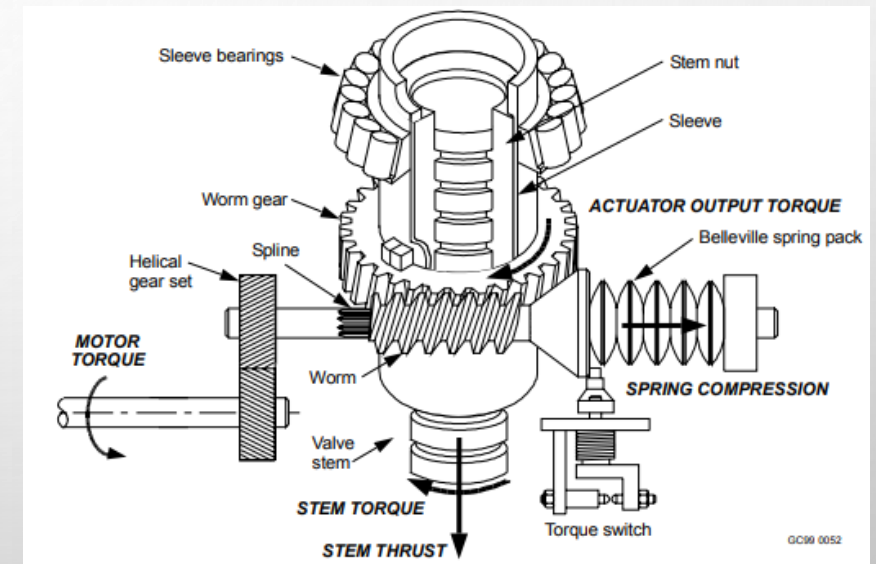
**EPRI**: ‘CSC Grease A’ was found to be superior to CC Grease B in the following areas:

- performance at LOCA temperatures,
- ability to withstand radiation doses,
- water- and heat-resistance & non-separating properties

## STEM NUT WEAR

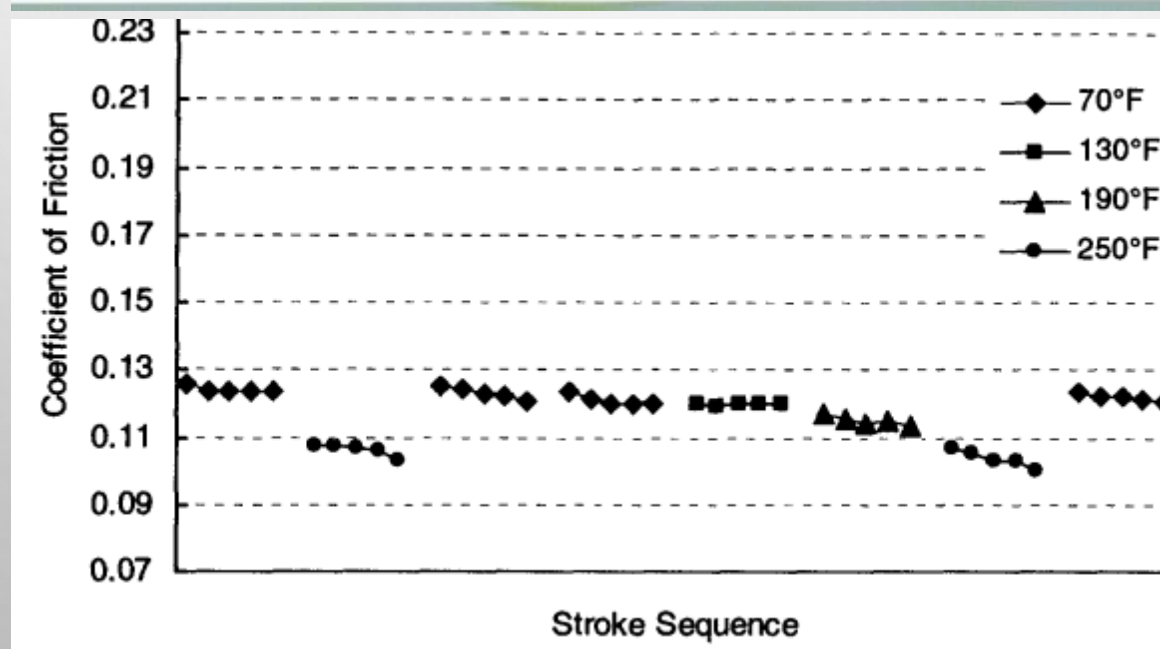
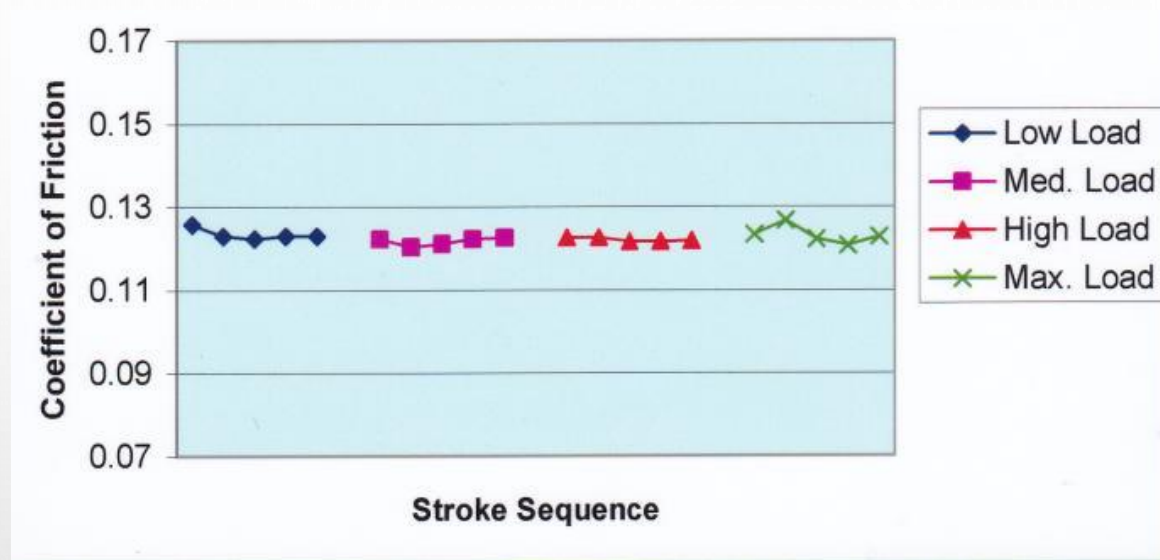
Lubrication of the stem is **more** severe than the gearbox because the lubricant can be directly exposed to heat (ambient, radiant and/or conduction), water, and radiation.

It can also be subjected to airborne contaminants and volatility of the grease constituents can play a role because the lubricant is not in a sealed compartment.





# STEM NUT WEAR



**Reference:** 'MOV Stem Lubricant Aging Research', US Nuclear Research Commission



# MODIFIED 4-BALL WEAR TESTING - BRASS AND STAINLESS STEEL BALLS

- The standard test (ASTM D2266) uses ½” 52100 steel balls.
- These were changed to balls made of 2600 brass and 302 stainless steel.
- Similar test conditions as the standard: 1200 rpm, 75C (162 F) for 60 minutes, but 15kg load

Lubricant	Wear Scar, mm
Anti-seize lubricant paste A	2.63
Polyurea grease	2.60
Anti-seize lubricant paste B	2.40
Clay-thickened grease	1.73
Lithium complex grease A	1.55
Lithium complex grease B	1.52
Lithium complex grease C	1.43
Calcium sulfonate A	1.05

**Reference:** ‘MOV Stem Wear Testing – 2014 MUG presentation (Ken Brown)

# PERFORMANCE IN THE FIELD

We were provided two samples from the harshest environment for an MOV within a nuclear power plant.

## Valve 1 - (HPCI) Steam Supply In-board Containment Isolation Valve

The previous grease used to be degraded, black with a burnt smell.

→ At the time of inspection (outage), the actuator grease level was a little low and graded as a 2 (caramel to dark tan), so some grease was added.

**This is 4x the life!**

## Valve 2 - Isolation Condenser Steam Supply In-board Containment Isolation Valve

Likewise, this grease was typically very degraded, black with a burnt smell.

→ At the time of inspection (outage), the actuator grease level was satisfactory and graded as a 2 (caramel to dark tan).

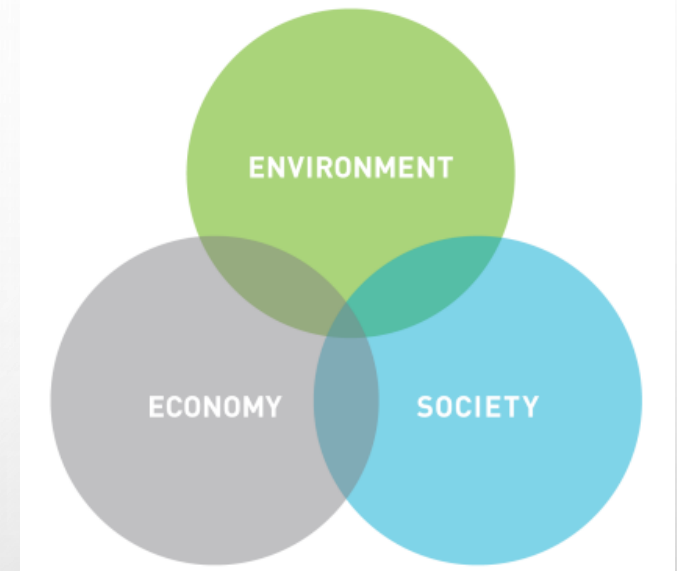
**This is now 3x the life!**

They used to have to rebuild each of these actuators every outage (18 months). The parts costs are not high, but the labor is huge.

Estimated to be 200 hours of labour every outage or **~\$20,000** just in labor, with an estimated \$1,200 for parts/per actuator.

## A NOTE ON SUSTAINABILITY

- Longer grease life = improved machine life – less need for re-greasing, less waste generation
- One way to minimize grease waste is to switch from time-based to condition-based approach (in-situ sampling e.g. Stem Thief)
- See ASTM D7718 (Standard Practice for Obtaining In-Service Samples of Lubricating Grease”)
- high quality product which creates value to the end user – cost savings



## ACKNOWLEDGEMENTS/ THANK YOU!

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- Andrew Sit, OPG



**Questions?**