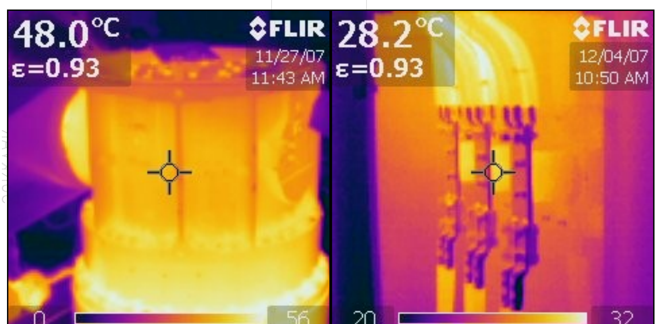
# Beaver Electrical Machinery
# Condition Monitoring Services

Generator winding "bump" test

Wood chipper plant condition monitoring


Ski lift motor condition monitoring




MCC thermal imaging and profiling

Vibration Analysis—Ultrasonic Bearing Analysis—Thermal Imaging
Laser Alignment—Current Signature Analysis—Static Electrical Testing
Commutator Profiling—Bearing Electrical Discharge Testing—Dielectric Oil Testing

BEAVER

Burnaby, BC
1-800-663-6505

Nanoose Bay, BC
1-888-468-9796

## Who are we?

Beaver Electrical Machinery has been serving industry in British Columbia since 1955.
In the early years, Beaver was a transformer rewind facility in Burnaby, British Columbia.
Since then, we have added a second location in Nanoose Bay serving all of Vancouver Island.
Beaver is a complete source for electromechanical sales and service. Our service shops provide complete machining, fabricating, welding, dynamic balancing, electrical rewinding, and automation control service to business and industry.
Beaver also represents a complete line of electric motors, motor control, power distribution, transformers, power transmission, switchgear, and power quality apparatus.

## What is a condition monitoring program?

Predictive Maintenance (proactive condition monitoring):
Predictive maintenance includes several non-destructive technologies such as vibration analysis, thermography, ultrasonics, and oil analysis. These tests can most often be performed without taking the unit out of service.
Through trending an analysis of collected data, a technician can determine not only if the machine has a problem, but can also help estimate the time to failure and determine the root cause of the issue.
Once a time to failure is estimated, replacement parts can be sourced and procured before any equipment fails. It also allows maintenance to be scheduled at a time that is most convenient for production and personnel.
Furthermore, catastrophic failures almost never occur on machines included in a good predictive maintenance program.

## What are the alternatives?

Run to failure:
This is the oldest philosophy and requires the least amount of expense until a problem actually occurs.
This type of maintenance can only be justified if:
1. The machine has no importance to continuing production.
2. All machine parts are readily available and inexpensive.
3. Scheduling downtime for maintenance may occur at any time.

*Rarely does a machine meet all of these criteria.*
Another major drawback of this type of maintenance plan is that a catastrophic failure cannot be predicted. A catastrophic failure could be dangerous. Repairs may be lengthy, expensive, or impossible.

Preventative maintenance:
Under this philosophy, machines are brought out of production at regularly scheduled intervals and maintenance is performed. It has proven somewhat successful in warding off catastrophic failures and reduces the cost associated with these failures.
However, this method has its drawbacks. Disadvantages are not unlike "run to failure" scenarios. The main difficulty is determining the proper service interval. If the maintenance interval is too short, time and money will be wasted replacing unnecessary parts. If the period is too long, it could result in a costly and dangerous catastrophic failure.

**Beaver believes that an effective predictive maintenance program is the key to equipment efficiency, reliability, and safety.**

## Data collection and aggregation:

The real key to a successful predictive maintenance program is the data collection, aggregation, analysis, and trending.

If you understand the equipment that you are dealing with, you can understand what can go wrong. By understanding the equipment, a skilled technician can determine the proper data to collect and trend in order to predict future performance or failure of the equipment.

## Vibration or electromechanical data:

A skilled technician takes into account all the specific properties of a machine to determine the correct data to collect. The speed of the machine, the physical layout of the machine, the horsepower, the style of bearings, number of blades or vanes on impellers, the number of teeth on meshing gears, and other factors are all taken into consideration.

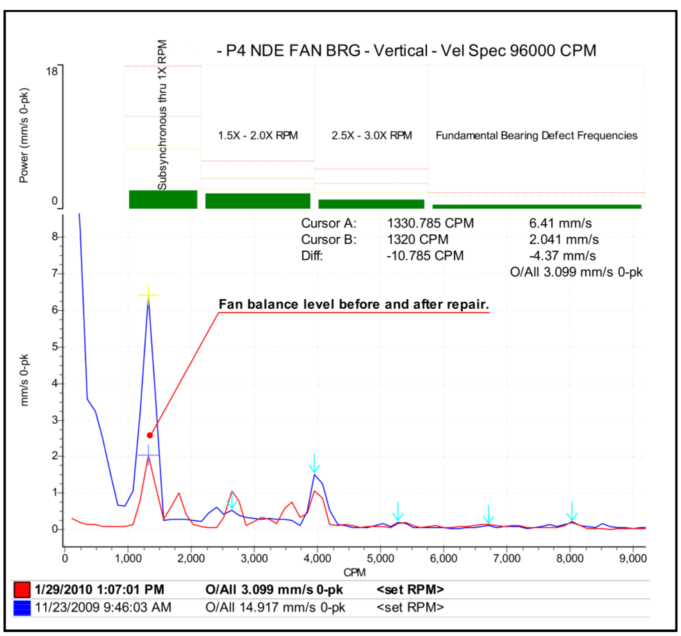
From this information we build a velocity spectrum that will clearly display information that takes place at a given speed along with data in the higher frequencies to look at rolling element bearings.

Along with the velocity spectrum at the bearing positions, we also collect a time waveform spectrum and an acceleration envelope demodulated spectrum.

Acceleration enveloping demodulation is a special process that takes place within the testing instrument. It places band-pass filters to remove information in the lower and higher frequency range. This allows us to look at energy within he known defect frequency range on rolling element bearings, allowing us to determine if the bearing has an outside race defect (BPFO) or an inside race defect (BPFI) along with rolling element defects (BSF) or a cage defect.

Demodulation gives a very early warning of defects within rolling element bearings of anywhere from 16 to 32 weeks before the defect would be visible in the velocity spectrum.

Once the defect is visible in the velocity spectrum, we can then plot a more accurate time to failure. But often, having the early knowledge of a potential problem allows us to change operating conditions to try to minimize further harm or growth of this condition.




Example data of a dataset comparing motor running conditions before and after balancing and repair.

**Condition Monitoring Report**

Vibration Analysis – Ultrasonic Bearing Analysis – Thermal Imaging – Laser Alignment – Current signature Analysis

| Feb-15 | | Beaver Electrical Machinery | | | Latest | Previous | Previous |
|---|---|---|---|---|---|---|---|
| | | Equipment Identification | | Defect | Condition | Condition | Condition |
| | | No. | MACHINE NAME | Band | Code | Code | Code |
| | | | | | Feb-15 | Jul-14 | Dec-13 |
| | | 32 | PMR2 Main Alternator #4 | | 1 | 1 | 1 |
| | | 33 | PMR1 M/E L/T Pump #1 | | 1 | 1 | 1 |
| | | 34 | PMR1 M/E L/T Pump #2 | See note | 1 | 1 | 1 |
| | | 35 | PMR2 M/E L/T Pump #3 | | 1 | 1 | 1 |
| | | 36 | PMR2 M/E L/T Pump #4 | | 1 | 1 | 1 |
| | | 37 | PMR1 M/E S/W Cooling Pump#1 | | 1 | 1 | 1 |
| | | 38 | PMR1 M/E S/W Cooling Pump#2 | | 1RP | 5D | 2B |
| | | 39 | PMR2 M/E S/W Cooling Pump#3 | | 1 | 1 | 1 |
| | | 40 | PMR2 M/E S/W Cooling Pump#4 | | 1 | 1 | 1 |
| | | 41 | PMR1 M/E H/T Pump #1 | | 1 | 1 | 1 |
| | | 42 | PMR1 M/E H/T Pump #2 | | 1 | 1 | 1 |
| | | 43 | PMR2 M/E H/T Pump #3 | | 1 | 1 | 2B |
| | | 44 | PMR2 M/E H/T Pump #4 | | 1 | 1 | 1 |
| | | 45 | PMR1 Hot Water Circ Pump #1 | | 1 | 1 | 1 |
| | | 46 | PMR1 Hot Water Circ Pump #2 | C | 2C | 2C | 1 |
| | | 47 | PMR2 Hot Water Circ Pump #1 | | 1 | 1 | 1RP |
| | | 48 | PMR2 Hot Water Circ Pump #2 | B | 3BC | 3BC | 3B |
| | | 49 | PMR1 F/O Purifier #1 | See note | 2 | 2 | 2 |
| | | 50 | PMR2 F/O Purifier #2 | | 1 | 1 | 1 |
| | | 51 | PMR1 L/O Purifier #1 | | 1 | 1 | 1 |
| | | 52 | PMR1 L/O Purifier #2 | | 1 | 1 | 2E |
| | | 53 | PMR2 L/O Purifier #3 | | 1 | 1 | 2E |
| | | 54 | PMR2 L/O Purifier #4 | See note | 2E | 1 | 2E |
| | | 55 | PMR2 Main Trim Pump | | 1 | 1 | 1 |
| | | 56 | PMR2 Aux Trim Pump | | 1 | 1 | 1 |

Example meta-report of a facility-wide condition monitoring program. Reporting draws attention to equipment requiring attention.

## Dielectric (transformer) oil and chemical data:

Dielectric oil tests fall into two main groups: tests that assess the immediate condition of the insulating system and tests that assess the future health and performance of the insulating system.
Beaver Electrical's condition monitoring programs for power transformers and switchgear uses a suite of ASTM standard tests suitable for each piece of equipment being tested and the conditions the equipment operates in. Collected data is retained in Beaver's equipment database and trended against historical results.

The two main tests to evaluate the immediate oil performance are:

**Dielectric breakdown** tests to determine the insulating power of the oil. The test has two electrodes submerged in a sample of oil. A voltage is applied and increased until arcing occurs. Test failure is most often caused by the presence of moisture or sludge in the oil.

**Moisture content** tests to detect the presence of emulsified water in the oil. This test is a basic chemical test. When the saturation level reaches a critical point, de-emulsification will occur; water will be precipitated and will collect at the bottom of the tank underneath the oil.

The two main tests to evaluate the future oil performance are:

**Acid Neutralization Number** to determine the acid content in the oil. New oil contains virtually no acid. Through oxidation, acids form. The acids then interact with the surfaces of the tank to form sludge. Acidity does not explicitly show that sludge is forming, but it is highly indicative of the potential for it to occur.

**Gas-in-oil** tests to determine the concentrations of various dissolved gasses in the oil. Ten different gas concentrations are analysed. These concentrations are then put into a database which analyses them and trends them against historical results. Conclusions can be drawn from abnormal trends or spikes in concentrations.

Polychlorinated biphenyl (PCB) testing:

As well as condition testing and monitoring, Beaver also can conduct **PCB contamination testing** to help ensure compliance with Canadian Environmental Protection Act (CEPA) (1999) and federal regulation SOR/2008-273.

**Oil Quality Analysis Report**

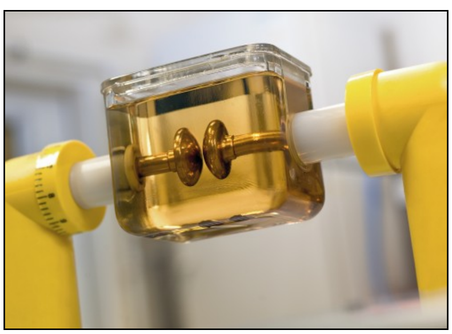
BEAVER ELECTRICAL MACHINERY LTD
Company Code: BEM-Bby
7440 LOWLAND DRIVE
BURNABY
BRITISH COLUMBIA
V5J 5A4

Attention:
Ph: (604) 431-5000 Fax (604) 431-5066
CC:

Main Station
Station Code: BEM-Bby-Ma
Project: PL-00040.00
Ref. Number: 122458
Report: OQB 2015-2494
Report Date: 20-Oct-15

| Sample Information | | | | Limits | |
|---|---|---|---|---|---|
| Equipment ID | | | | | |
| (Type ID) Equipment | (TX): West TX-M | (TX): East TX-M | (TX): Center TX-M | | |
| MFR/Serial | ? / A10900-23 | ? / A10900-21 | ? / A10900-7 | | |
| Component Type | Main Oil Tank | Main Oil Tank | Main Oil Tank | | |
| Component ID | Kenedy Pump-TNK1 | Kenedy Pump-TNK1 | Kenedy Pump-TNK1 | | |
| Sample Reason/Port | N / Main Tank Bot | N / Main Tank Bot | N / Main Tank Bot | IEEE-C57.106-2002<=69Kv | |
| Received Date | 28-Sep-15 | 28-Sep-15 | 28-Sep-15 | | |
| Analysed Date | 30-Sep-15 | 30-Sep-15 | 30-Sep-15 | | |
| Sample Date | 28-Sep-15 | 28-Sep-15 | 28-Sep-15 | | |
| Comments | | | | | |
| Lab Sample No. | QTY-15-2494-01 | QTY-15-2494-02 | QTY-15-2494-03 | | |
| Work Order / Ref. | | | | | |
| Top Oil Temp (C) | 25 | 25 | 25 | | |
| Results ASTM | | | | | |
| kV Breakdown | | | | | |
| (2.5mm gap): D877 | -- | -- | -- | | >D 877 |
| (2mm gap): D1816 | **44** | **49** | **56** | 40 | >D1816 |
| (1mm gap): D1816 | -- | -- | -- | 23 | >D1816 |
| Neut. Number. | | | | | |
| (mg KOH/g) : D664 | **0.01** | **0.05** | **0.01** | 0.2 | <D664 |
| IFT at 25C | | | | | |
| (dynes / cm): D971 | -- | -- | -- | 25 | >D971 |
| Colour (units): D1500 | < | < | < | | <D1500 |
| Inhibitor content | | | | | |
| (%w/w): D2668 | -- | -- | -- | | >D2668 |
| Power Factor | | | | | |
| 100 C (%): D924 | -- | -- | -- | 5 | <D924 |
| 25 C (%): D924 | -- | -- | -- | 0.2 | <D924 |
| Water (w/w) D1533 | -- | -- | -- | 27 | <D1533 |
| DC Resistivity | | | | | |
| 100 C ($10^{12}$ Ω· cm): D924 | -- | -- | -- | | >D924 |
| 25 C ($10^{12}$ Ω· cm): D924 | -- | -- | -- | | >D924 |

Drawing a sample



Dielectric breakdown test

Excerpt of a dielectric and Neut. No. test

# BEAVER ELECTRICAL MACHINERY


**Burnaby, BC**
**Head Office**
Phone: 604-431-5000
Tf: 1-800-663-6505
info@beaverelectrical.com

**Nanoose Bay, BC**
**Serving Vancouver Island**
Phone: 250-468-9796
Tf: 1-888-468-9796
nsh@beaverelectrical.com

24-Hour Emergency Service
www.beaverelectrical.com