VIBES
SERIOUS SERVICE ™

2017

Installation of CoolBlue Inductive Absorbers and Common Mode Current Measurement – Parc Riviera Pump Station

11/10/2017

Contents

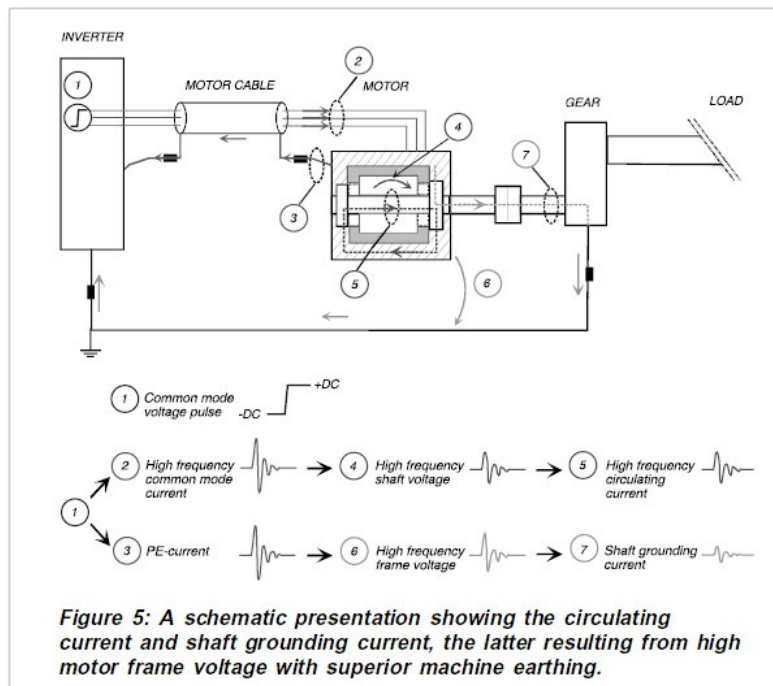# Overview

Problems with IGBT Systems

VFD systems are not sinusoidal but are a continuous generation of pulses (Pulse Width Modulation or PWM). The pulses have a constant voltage and a dv/dt rise and fall time of the pulse. The original VFD systems were based on Bipolar Junction Transistors. The trend now is toward IGBT (Insulated Gate Bipolar Transistor from Mitsubishi, On Semi, Infineon, ST Micro, etc.) systems which give a faster switching dv/dt with lower switching losses and a more efficient drive.

IGBT systems create problems associated with the system performance. The IGBT introduces parasitic currents in the form of two potential destructive characteristics:

a) Transient Voltage/ Harmonic Distortion/Reflective Waves
b) Higher magnitudes of electrical ground noise current

Electrical Discharge Machining

AC Motor Drive systems utilizing variable frequency controls produce high frequency electrical noise. The noise is superimposed on the power drive lines of the motors in the form of common mode noise. The common mode noise creates a voltage (dv/dt) across the rotor/stator of the motor resulting in a discharge current through the lubrication and motor bearings to the motor raceway.

Figure 5: A schematic presentation showing the circulating current and shaft grounding current, the latter resulting from high motor frame voltage with superior machine earthing.

This current discharge produces an EDM effect (Electrical Discharge Machining) that causes destructive pitting and damage to the motor raceway, and premature lubrication breakdown. The end result is premature failure of the motor causing expensive repairs and system downtime.

Overview
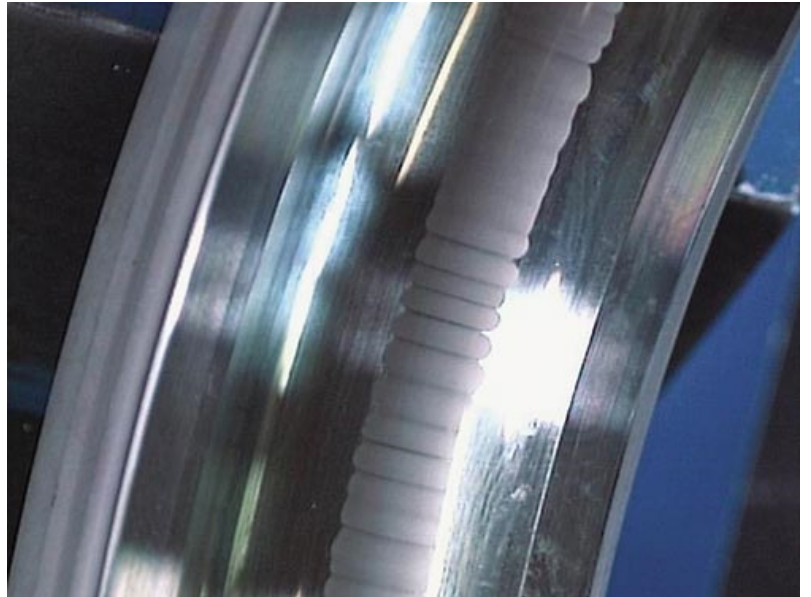
Typical bearing fluting caused by EDM

Problems with IGBT Systems

Each pulse in a PWM system is not a clean square pulse. Each Rise and Fall of the pulse has an over shoot or transient over-voltage. This over-voltage phenomenon is also known as "Reflected Wave", "Transmission Line Effect" or "Standing Wave".
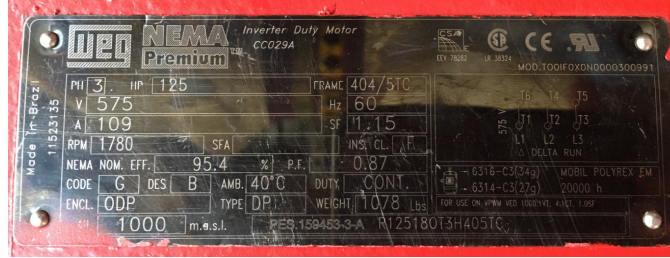
The per unit overvoltage magnitude is dependent upon drive-cable-motor circuit dynamics defined by drive output voltage magnitude and rise time, cable surge   impedance characteristics, motor surge impedance to the pulse voltage, cable length and spacing of the train of pulses by the PWM modulator.
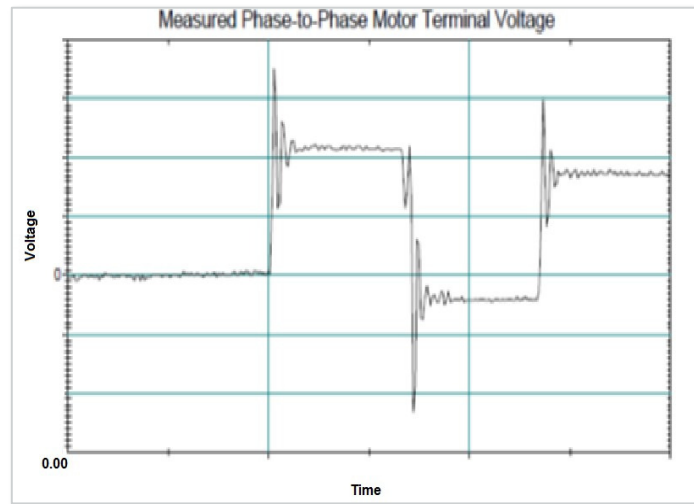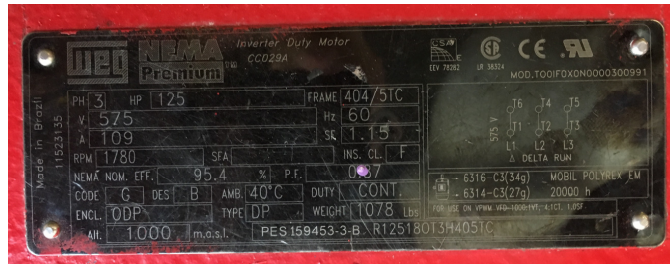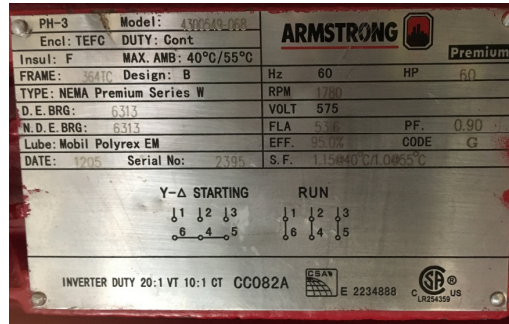
Equipment Information

Pump #1

Pump #2

Pump #3

Pump #4

Test Procedure

The simplest and safest way to measure common mode current is with a flexible, clip-around, Rogowski coil. This method is used to measure high frequency destructive common mode currents in motor drives . . . high frequencies produced by motor drive IGBT's in the kHz up to several MHz's.

The high frequency Rogowski coil simply connects around the 3 power phases of cable going from the drive to the motor to measure common mode current. If multiple cables per phase, coil would still go around all cables. The output of the Rogowski coil connects to the DCM 100, and measures the common mode current.

Simply power down, place the Rogowski coil around 3 phases of power.

Power up system. Measure current.

Test Results

DCM Project Report

Vibes Corp - Parc Riviera: *Pump #1*

Motor Power: 125.0hp
Cable Length: 30ft
Project Notes:

Created: Nov 10, 2017 9:42 AM
Modified: Nov 10, 2017 10:33 AM

Recommended Solution

CoolBLUE® Inductive Absorbers (all lines): 4 x M-302 -or- 4 x M-116
NaLA® Line Absorbers (per line): 1 x M-613
In applications where high reliability is needed the use of NaLA® differential mode line absorber is recommended.

Recorded Data

Date Recorded	Peak Spike	Reduction	Avg Spike	Reduction
Nov 10, 2017 10:27 AM	17.92 Amps	*BASELINE*	3.91 Amps	*BASELINE*
Nov 10, 2017 10:33 AM	5.07 Amps	-72%	1.86 Amps	-52%

BASELINE DATA

Peak Current Spike: 17.92 Amps
Average Current Spike: 3.91 Amps
Notes: *CoolBlue Defeated*

Recorded: Nov 10, 2017 10:27 AM
Time/Div: 5 µs

Test Results

DCM Project Report

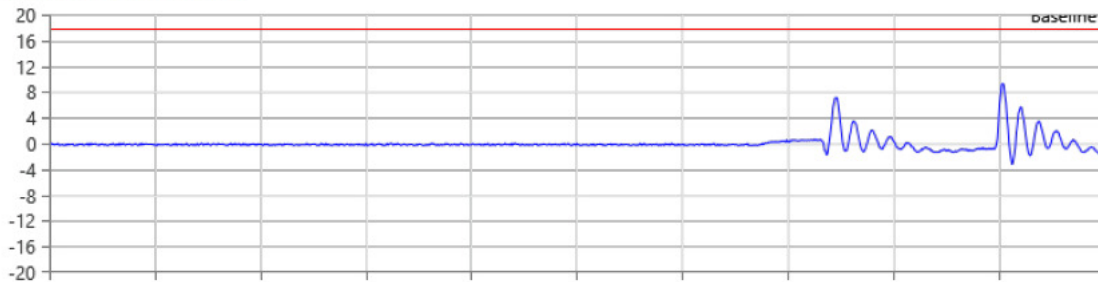## Vibes Corp – Parc Riviera: *Pump #1*
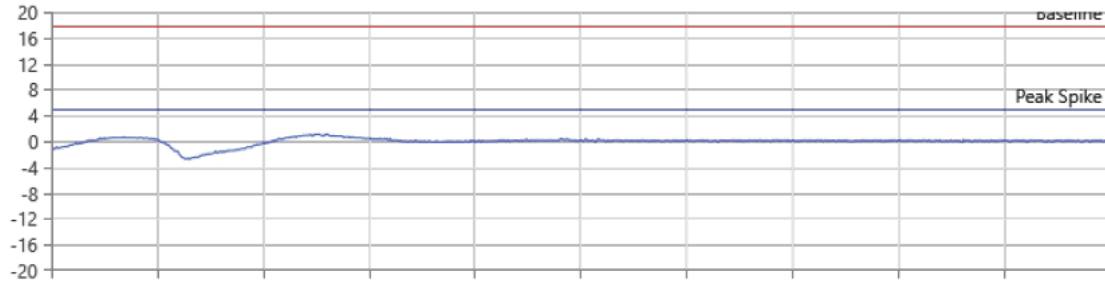
Peak Current Spike: 5.07 Amps (-72%)   **Recorded:** Nov 10, 2017 10:33 AM
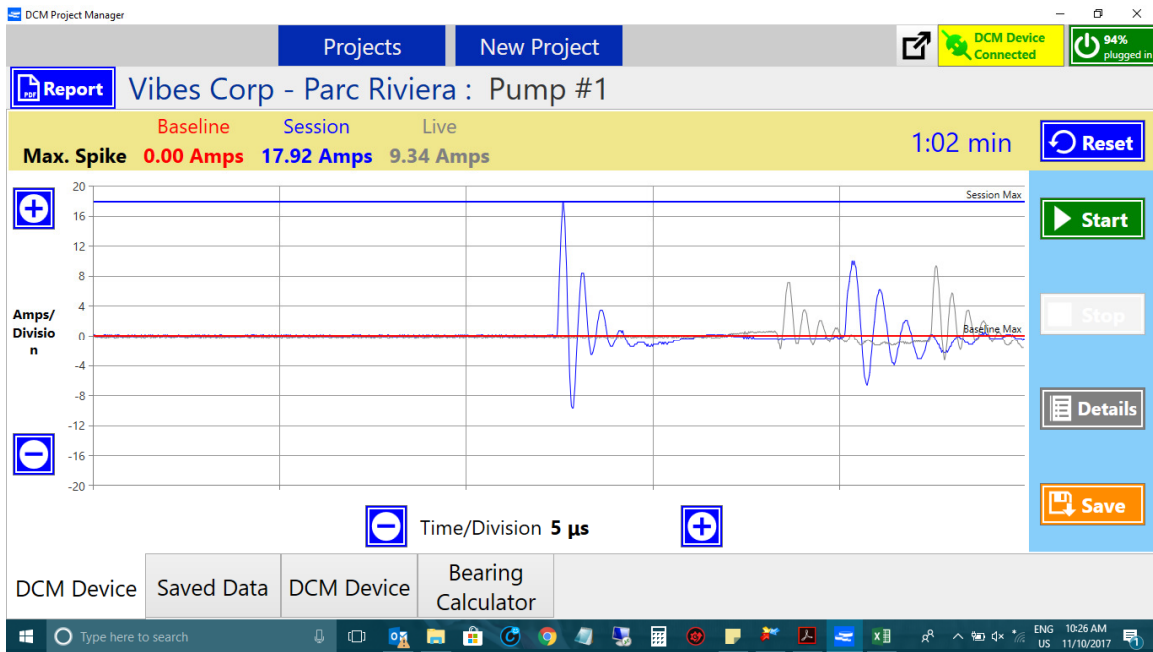**Average Current Spike:** 1.86 Amps (-52%)   **Time/Div:** 5 μs
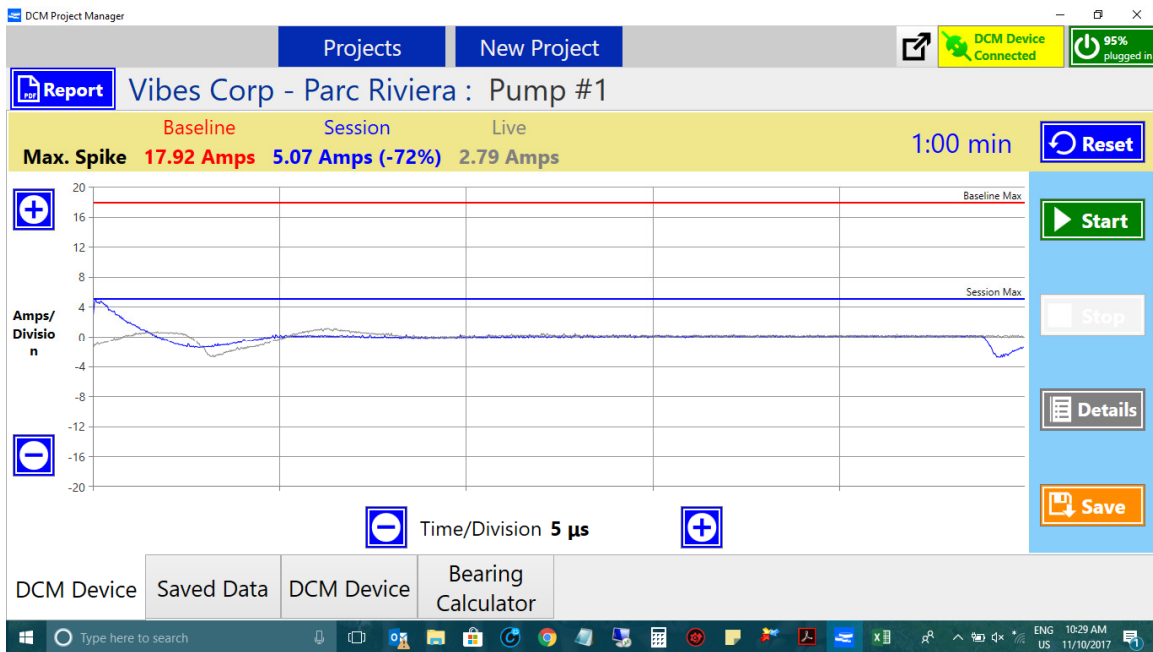**Notes:** *CoolBlue Installed*

Test Results

Baseline Snapshot

Snapshot After CoolBlue® Installation

Test Results

DCM Project Report

Vibes Corp - Parc Riviera: *Pump #2*

Motor Power: 125.0hp
Cable Length: 30ft
Project Notes:

Created: Nov 10, 2017 9:02 AM
**Modified:** Nov 10, 2017 10:38 AM

Recommended Solution
CoolBLUE® Inductive Absorbers (all lines): 4 x M-302 -or- 4 x M-116
NaLA® Line Absorbers (per line): 1 x M-613
In applications where high reliability is needed the use of NaLA® differential mode line absorber is recommended.

Recorded Data

Date Recorded	Peak Spike	Reduction	Avg Spike	Reduction
Nov 10, 2017 10:36 AM	19.62 Amps	*BASELINE*	4.19 Amps	*BASELINE*
Nov 10, 2017 10:38 AM	5.34 Amps	-73%	2.03 Amps	-51%
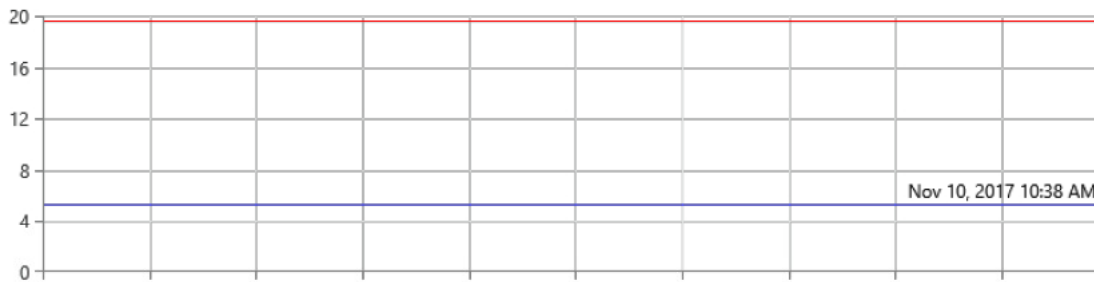
Nov 10, 2017 10:38 AM

BASELINE DATA
Peak Current Spike: 19.62 Amps
Average Current Spike: 4.19 Amps
Notes: *CoolBlue Defeated*

Recorded: Nov 10, 2017 10:36 AM
Time/Div: 5 µs

page 1

Test Results

DCM Project Report

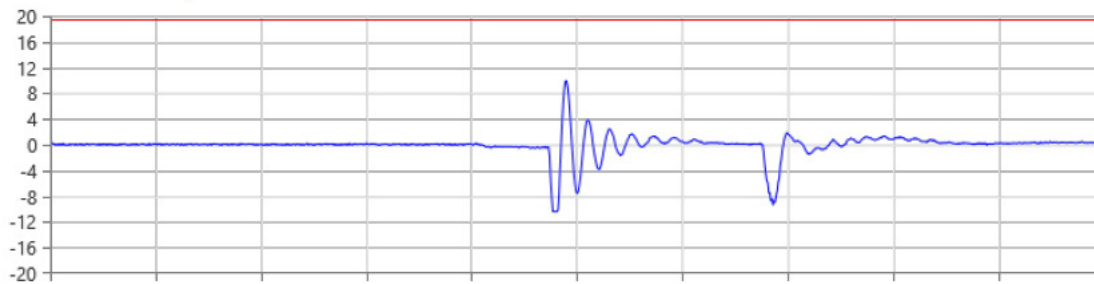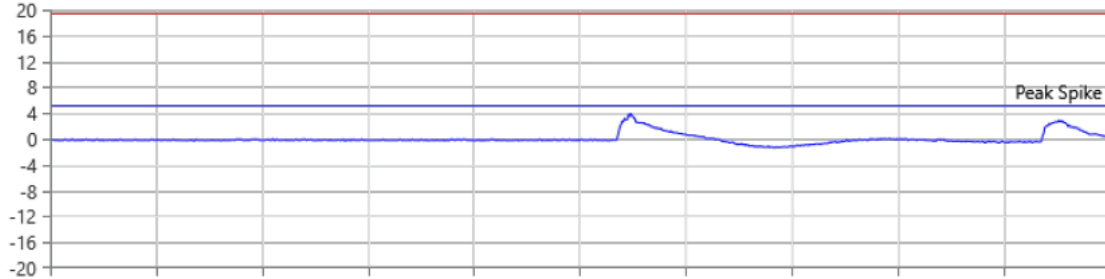## Vibes Corp – Parc Riviera: *Pump #2*

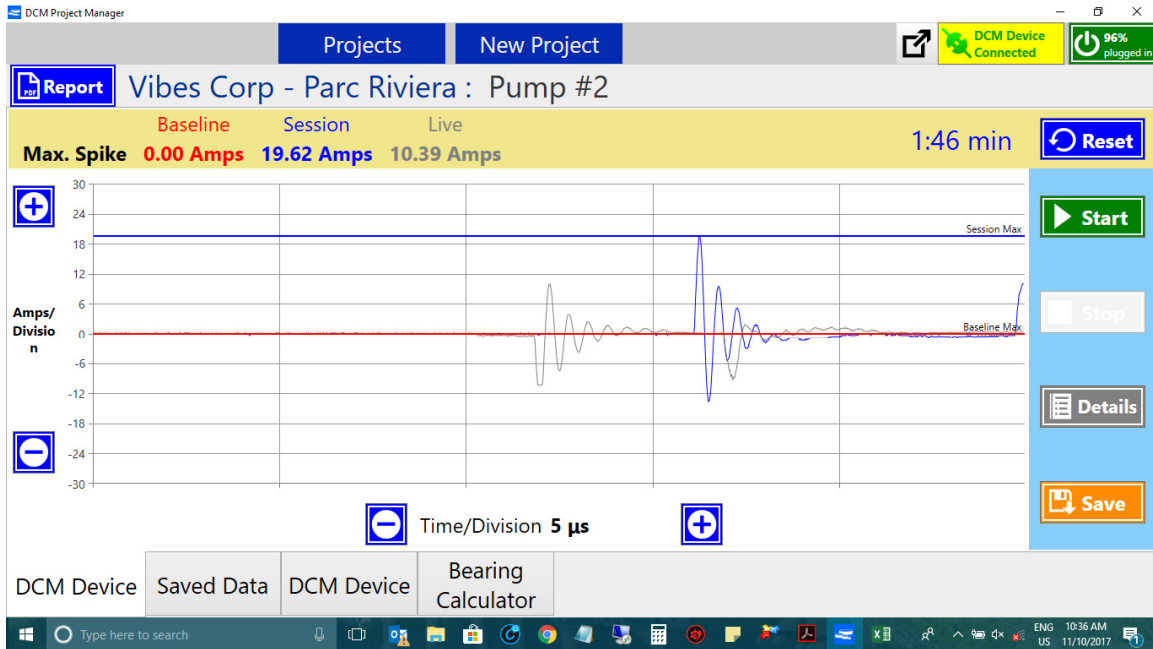**Peak Current Spike:** 5.34 Amps (-73%)   **Recorded:** Nov 10, 2017 10:38 AM
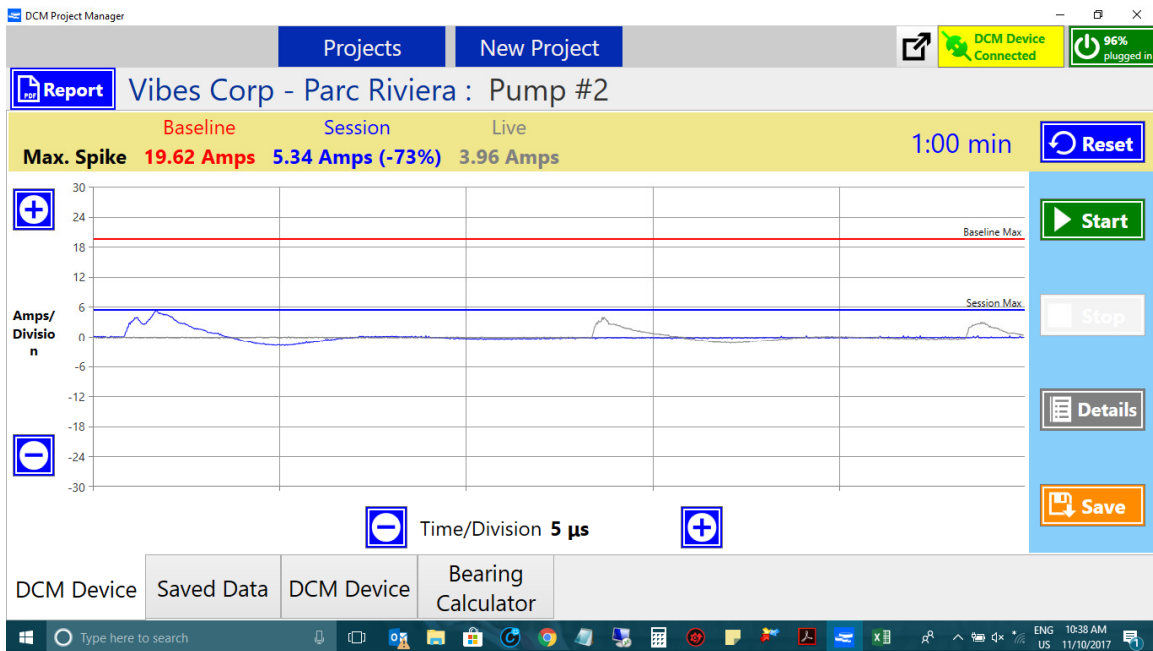**Average Current Spike:** 2.03 Amps (-51%)   **Time/Div:** 5 μs
Notes: *CoolBlue Installed*

Test Results

Baseline Snapshot

Snapshot After CoolBlue® Installation

Test Results

DCM Project Report

Vibes Corp - Parc Riviera: *Pump #3*

Motor Power: 60.0hp
Cable Length: 30ft
Project Notes:

Created: Nov 10, 2017 9:17 AM
**Modified:** Nov 10, 2017 10:48 AM

Recommended Solution

CoolBLUE® Inductive Absorbers (all lines): 4 x M-283 -or- 4 x N/A
NaLA® Line Absorbers (per line): 1 x M-381
In applications where high reliability is needed the use of NaLA® differential mode line absorber is recommended.

Recorded Data

Date Recorded	Peak Spike	Reduction	Avg Spike	Reduction
Nov 10, 2017 10:46 AM	12.57 Amps	*BASELINE*	2.60 Amps	*BASELINE*
Nov 10, 2017 10:48 AM	5.20 Amps	-59%	1.29 Amps	-50%
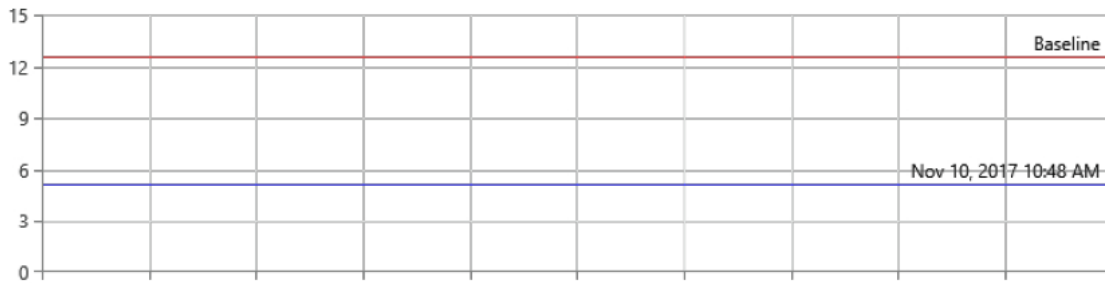
BASELINE DATA

Peak Current Spike: 12.57 Amps
Average Current Spike: 2.60 Amps
Notes: *CoolBlue Defeated*

Recorded: Nov 10, 2017 10:46 AM
Time/Div: 5 µs

page 1

Test Results

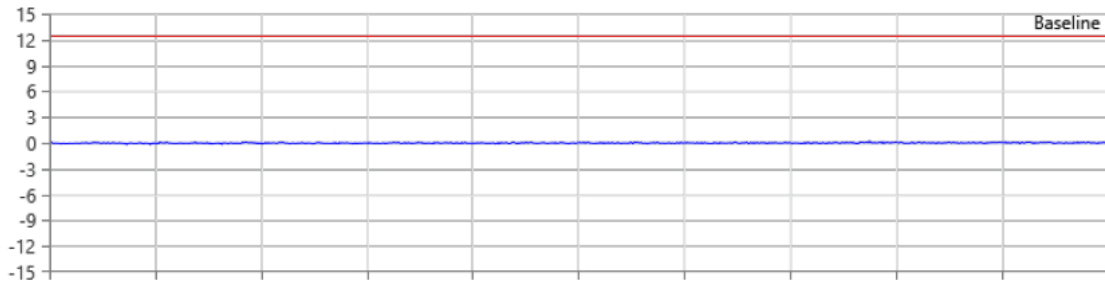### DCM Project Report

Vibes Corp – Parc Riviera: *Pump #3*
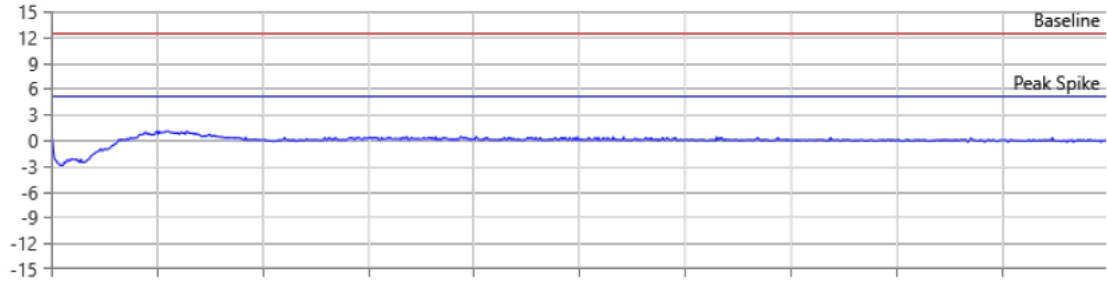
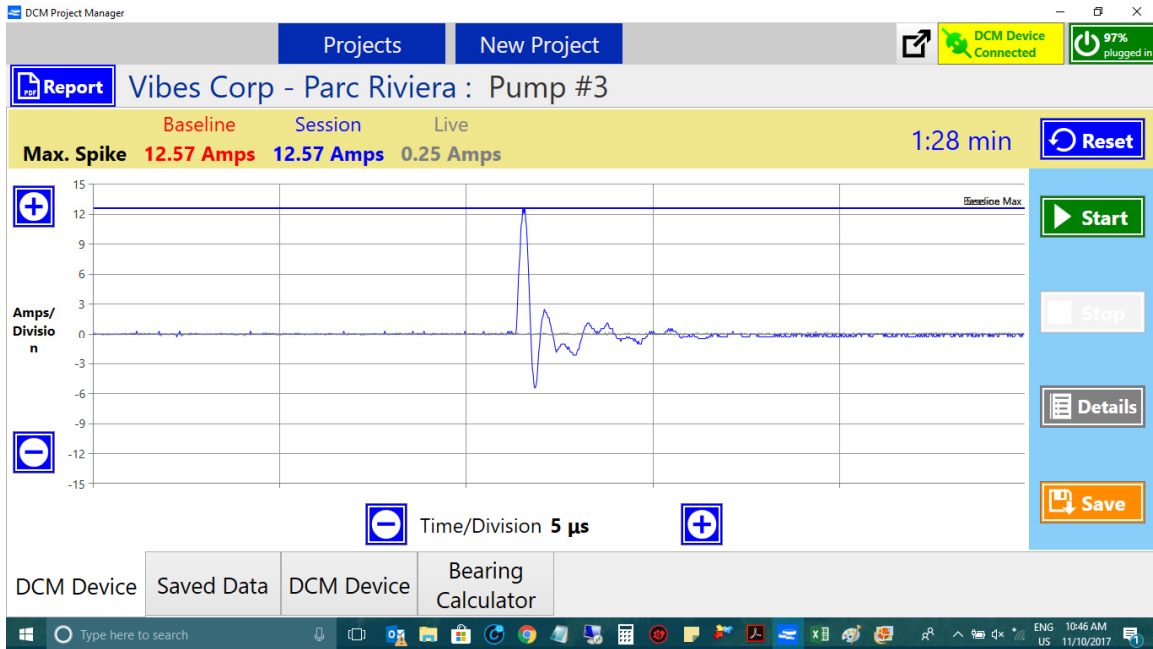**Peak Current Spike:** 5.20 Amps (-59%) **Recorded:** Nov 10, 2017 10:48 AM
Average Current Spike: 1.29 Amps (-50%) **Time/Div:** 5 μs
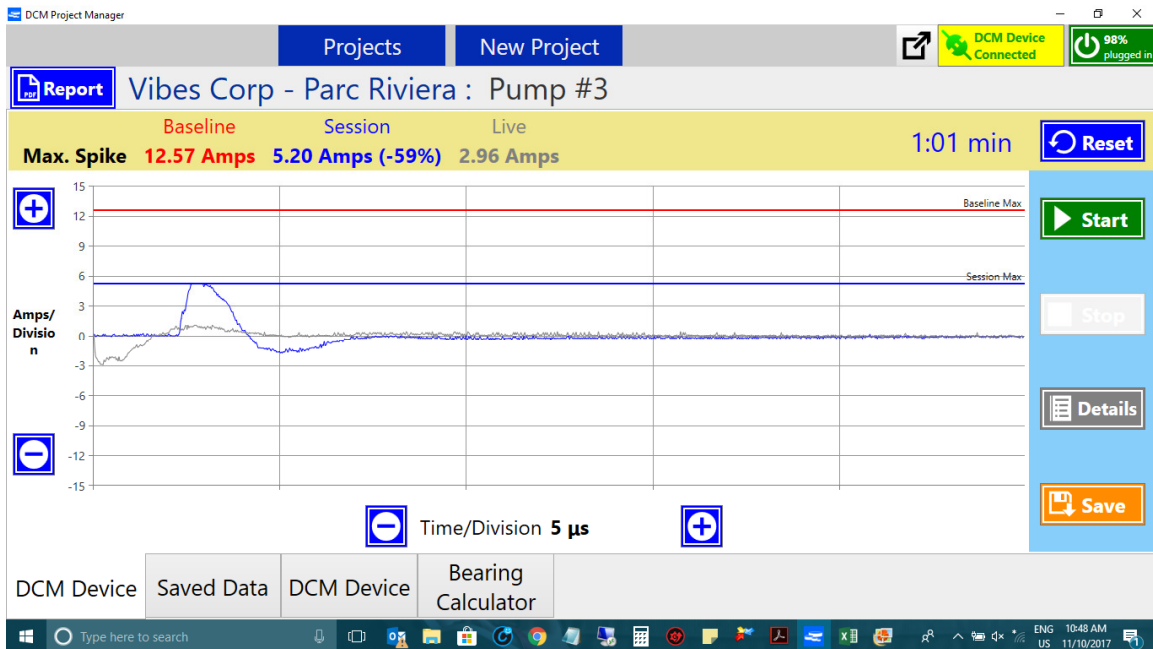**Notes:** *CoolBlue Installed*

Test Results

Baseline Snapshot

Snapshot After CoolBlue® Installation

Test Results

DCM Project Report

Vibes Corp - Parc Riviera: *Pump #4*

Motor Power: 60.0hp
Cable Length: 30ft
Project Notes:

Created: Nov 10, 2017 9:41 AM
Modified: Nov 10, 2017 11:03 AM

Recommended Solution
CoolBLUE® Inductive Absorbers (all lines): 4 x M-283 -or- 4 x N/A
NaLA® Line Absorbers (per line): 1 x M-381
In applications where high reliability is needed the use of NaLA® differential mode line absorber is recommended.

Recorded Data

Date Recorded	Peak Spike	Reduction	Avg Spike	Reduction
Nov 10, 2017 11:01 AM	12.53 Amps	*BASELINE*	5.05 Amps	*BASELINE*
Nov 10, 2017 11:03 AM	4.59 Amps	-63%	1.87 Amps	-63%

BASELINE DATA
Peak Current Spike: 12.53 Amps
Average Current Spike: 5.05 Amps
Notes: *CoolBlue Defeated*

Recorded: Nov 10, 2017 11:01 AM
Time/Div: 5 µs

page 1

Test Results

DCM Project Report

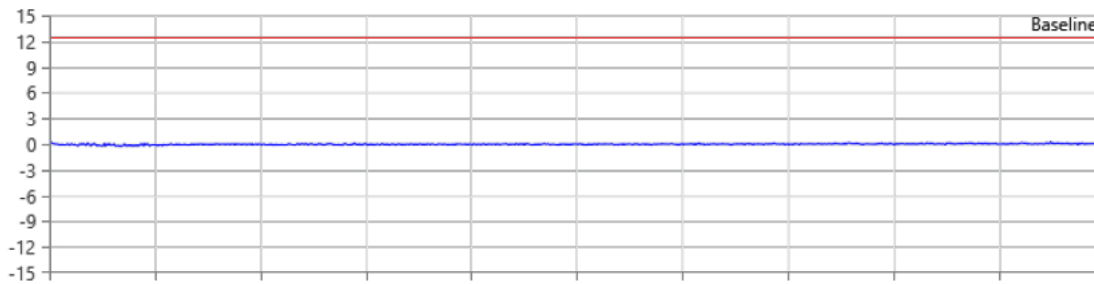#### Vibes Corp – Parc Riviera: *Pump #4*
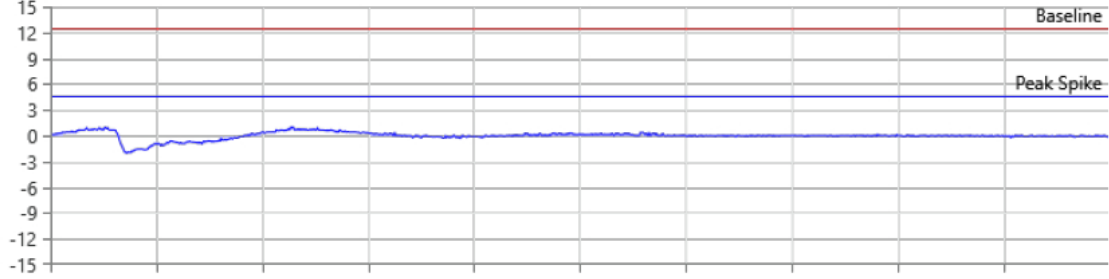
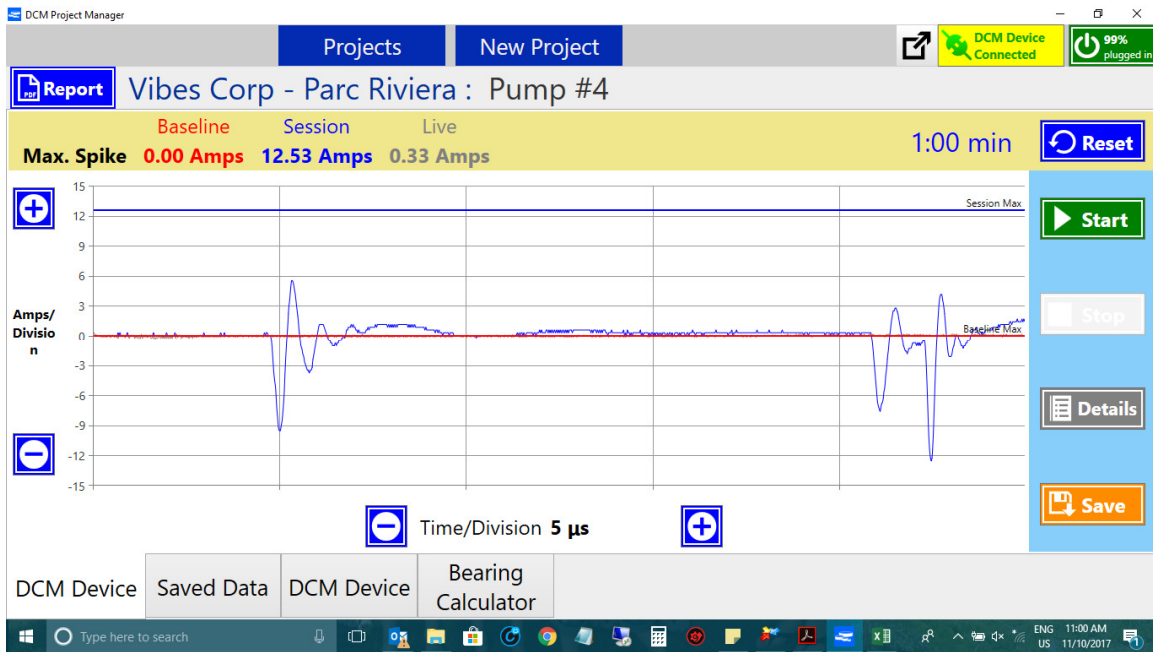**Peak Current Spike:** 4.59 Amps (-63%)   **Recorded:** Nov 10, 2017 11:03 AM
Average Current Spike: 1.87 Amps (-63%)   **Time/Div:** 5 μs
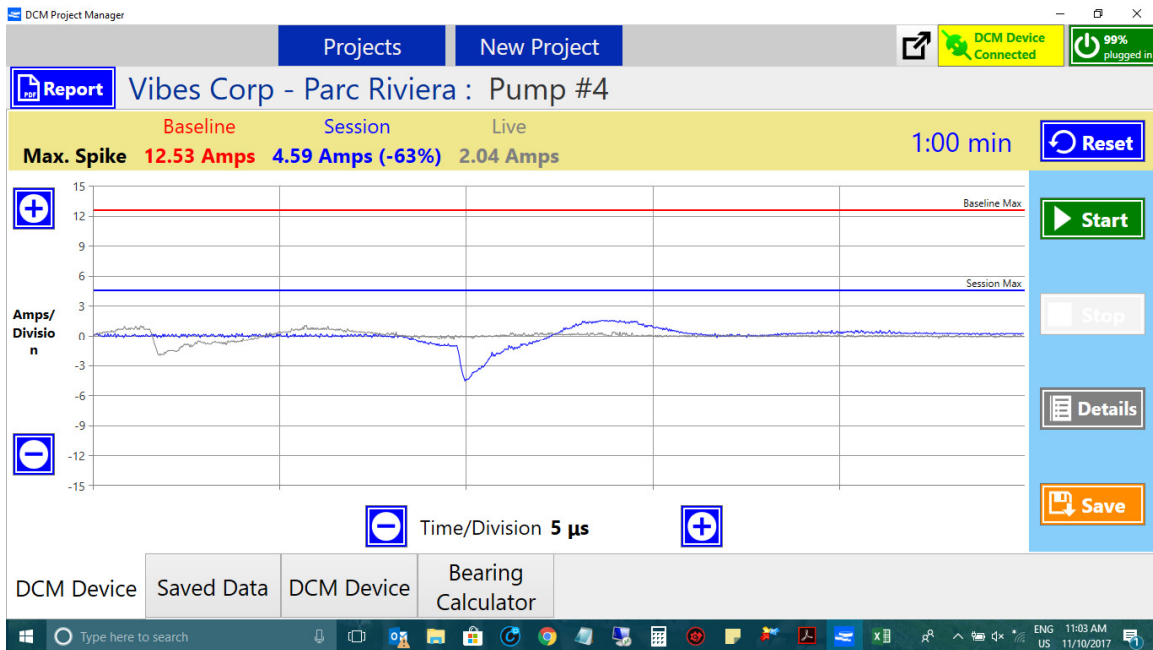**Notes:** *CoolBlue Installed*

page 2

Test Results

Baseline Snapshot

Snapshot After CoolBlue® Installation

Test Results

It is recommended that common mode currents are kept down to a level so that the current density in the bearing is below 0.2 Amps per mm^2 of ball to race contact surface area.

As displayed by our EDM bearing calculator below, the common mode current peaks measured after the CoolBlue's® were installed are now at a safe level for the bearings in these motors.

Pump #1 Before CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6316	
Ball Diameter (mm)	28.58	
Peak Current (A)	17.92	
Current Density (A/mm^2)	0.2	Fail*
Maximum Allowable Current (A)	13.46	

EDM BEARING CALCULATOR

Bearing Number	6314	
Ball Diameter (mm)	25.40	
Peak Current (A)	17.92	
Current Density (A/mm^2)	0.2	Fail*
Maximum Allowable Current (A)	11.96	

Pump #1 After CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6316	
Ball Diameter (mm)	28.58	
Peak Current (A)	5.07	
Current Density (A/mm^2)	0.1	Pass*
Maximum Allowable Current (A)	13.46	

EDM BEARING CALCULATOR

Bearing Number	6314	
Ball Diameter (mm)	25.40	
Peak Current (A)	5.07	
Current Density (A/mm^2)	0.1	Pass*
Maximum Allowable Current (A)	11.96	

Test Results

Pump #2 Before CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6316	
Ball Diameter (mm)	28.58	
Peak Current (A)	19.62	
Current Density (A/mm^2)	0.2	Fail*
Maximum Allowable Current (A)	13.46	

EDM BEARING CALCULATOR

Bearing Number	6314	
Ball Diameter (mm)	25.40	
Peak Current (A)	19.62	
Current Density (A/mm^2)	0.2	Fail*
Maximum Allowable Current (A)	11.96	

Pump #2 After CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6316	
Ball Diameter (mm)	28.58	
Peak Current (A)	5.34	
Current Density (A/mm^2)	0.1	Pass*
Maximum Allowable Current (A)	13.46	

EDM BEARING CALCULATOR

Bearing Number	6314	
Ball Diameter (mm)	25.40	
Peak Current (A)	5.34	
Current Density (A/mm^2)	0.1	Pass*
Maximum Allowable Current (A)	11.96	

Test Results

Pump #3 Before CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6313	
Ball Diameter (mm)	23.80	
Peak Current (A)	12.57	
Current Density (A/mm^2)	0.2	**Fail***
Maximum Allowable Current (A)	11.21	

Pump #3 After CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6313	
Ball Diameter (mm)	23.80	
Peak Current (A)	5.20	
Current Density (A/mm^2)	0.1	**Pass***
Maximum Allowable Current (A)	11.21	

Pump #4 Before CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6314	
Ball Diameter (mm)	25.40	
Peak Current (A)	12.53	
Current Density (A/mm^2)	0.2	**Fail***
Maximum Allowable Current (A)	11.96	

Pump #4 After CoolBlue®

EDM BEARING CALCULATOR

Bearing Number	6314	
Ball Diameter (mm)	25.40	
Peak Current (A)	4.59	
Current Density (A/mm^2)	0.1	**Pass***
Maximum Allowable Current (A)	11.96	

Summary

- Common mode peak currents measured since the installation of CoolBlue® Inductive Absorbers and NALA differential line absorbers are well below the recommended levels
- Peak Current reductions are as follows
    - Pump #1 – 72%
    - Pump #2 – 73%
    - Pump #3 – 59%
    - Pump #4 – 63%
- As well as the amplitude of the current being reduced, the frequency observed has slowed down significantly, and subsequent ringing in the lines after the peak spikes has almost been eliminated

End of Report