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Misure accelerometriche in campo Navale

26/04/2022

GIOVANNI PALAMA'

Sede Legale

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Gate @ Pisa
Largo Padre Spadoni 1,
56126 Pisa
Italia

Z.I. Macchiareddu
Terza strada
09032 Assemini (CA)
Italia

Mission

Without data you are just

A D V

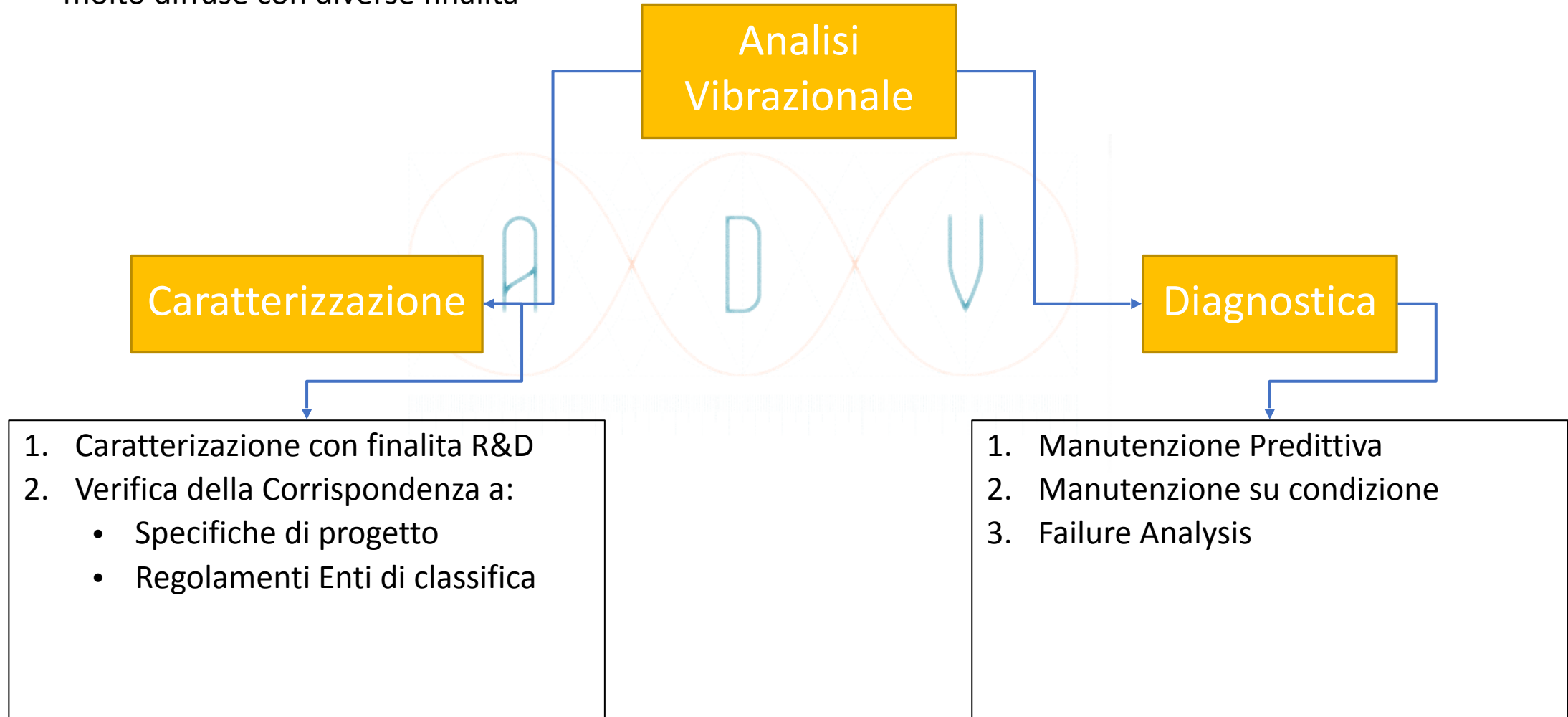
another person with an opinion

What we do

Translate into numbers onboard events

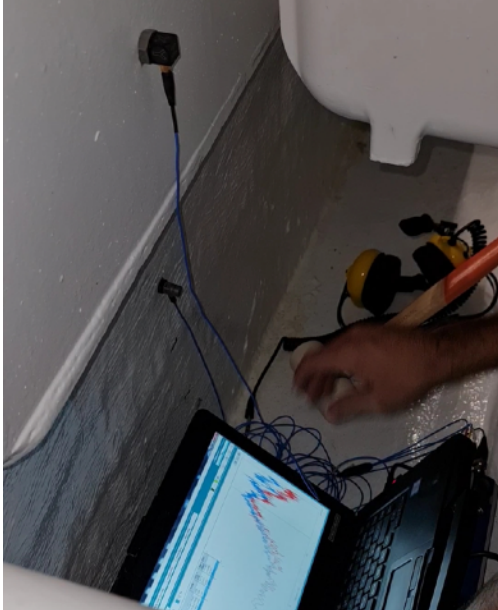


In campo navale le misure accelerometriche e l'analisi dei fenomeni vibrazionali sono una tecnica NDT molto diffusa con diverse finalità



In campo navale le misure accelerometriche e l'analisi dei fenomeni vibrazionali benchè molto diffuse, sono rese complesse da molti fattori:

1. Elemento mare difficilmente omogeneo e ripetitivo
2. I materiali di costruzione navale sono scarsamente ferromagnetici e quindi spesso si deve prevedere l'incollaggio di supporti (basette)
3. Acqua, Olii, Grassi sono nemici degli incollaggi ma assidui frequentatori del sentine delle navi
4. Accessibilità dei punti di misura , frequentemente difficile accessibilità



Sistema di Misura

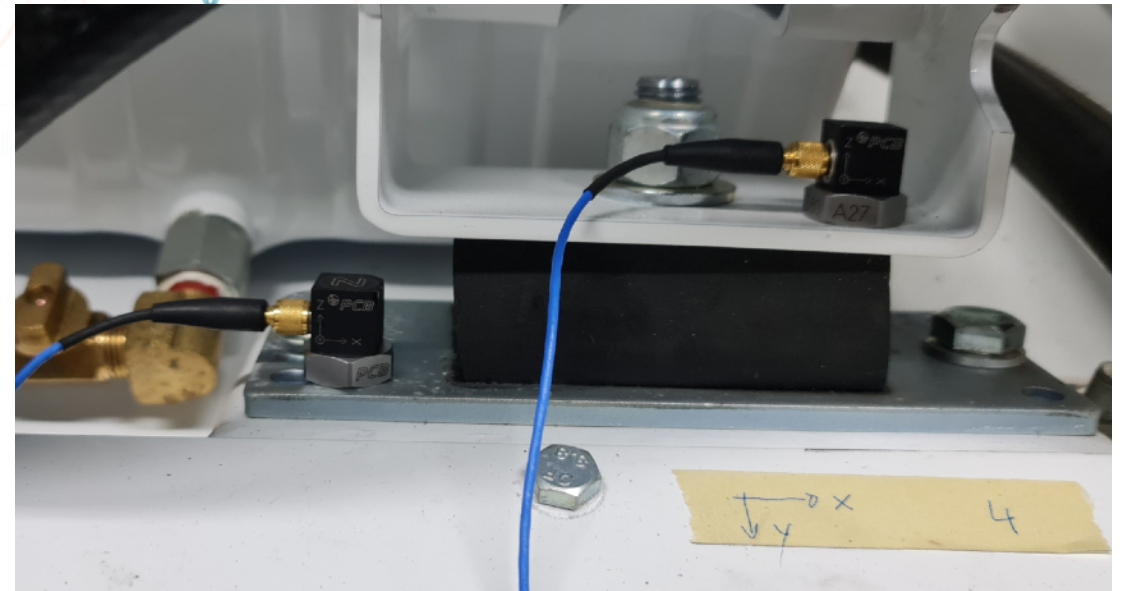
Definite le richieste/necessita del cliente eseguiamo le acquisizioni utilizzando diversi sistemi di misura:

1. Sistema di acquisizione multicanale NI C-Dac 9185

- a) Moduli NI 9230 -9234
- b) Accelerometri Triassiali 100 mV/g
- c) Accelerometri Triassiali 1V/g
- d) Accelerometri mono assiali
- e) Handheld Shaker di calibrazione
- f) Martello Accelerometrico (Hammer Test) PCB

2. Motion Amplifier

- a) Ottica



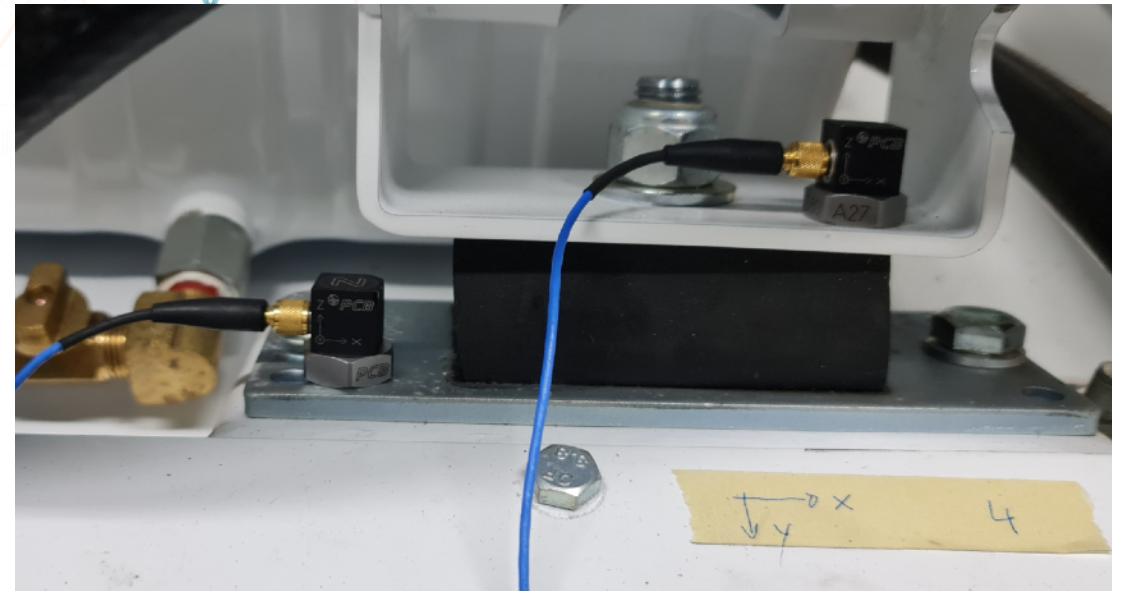
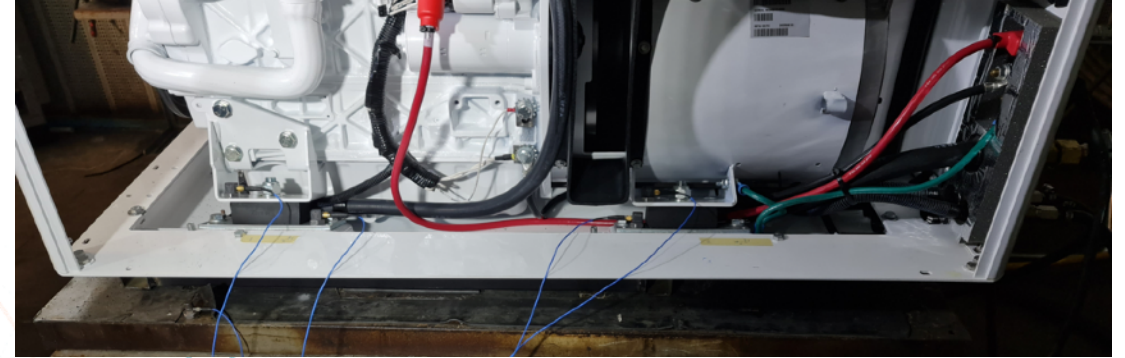
Data Acquisition

Le acquisizioni accelerometriche normalmente effettuate

- Longitudinale Accelerometer X axes
- Trasversale Accelerometer Y axes
- Verticale Accelerometer Z axes.

I livelli di vibrazione sono stati misurati in termini di velocità RMS [mm/s] e analizzati in FFT. (dF 0,3 hz – Media Hanning).

Un valore complessivo è stato calcolato come RMS nel dominio della frequenza tra Fmin e Fmax.



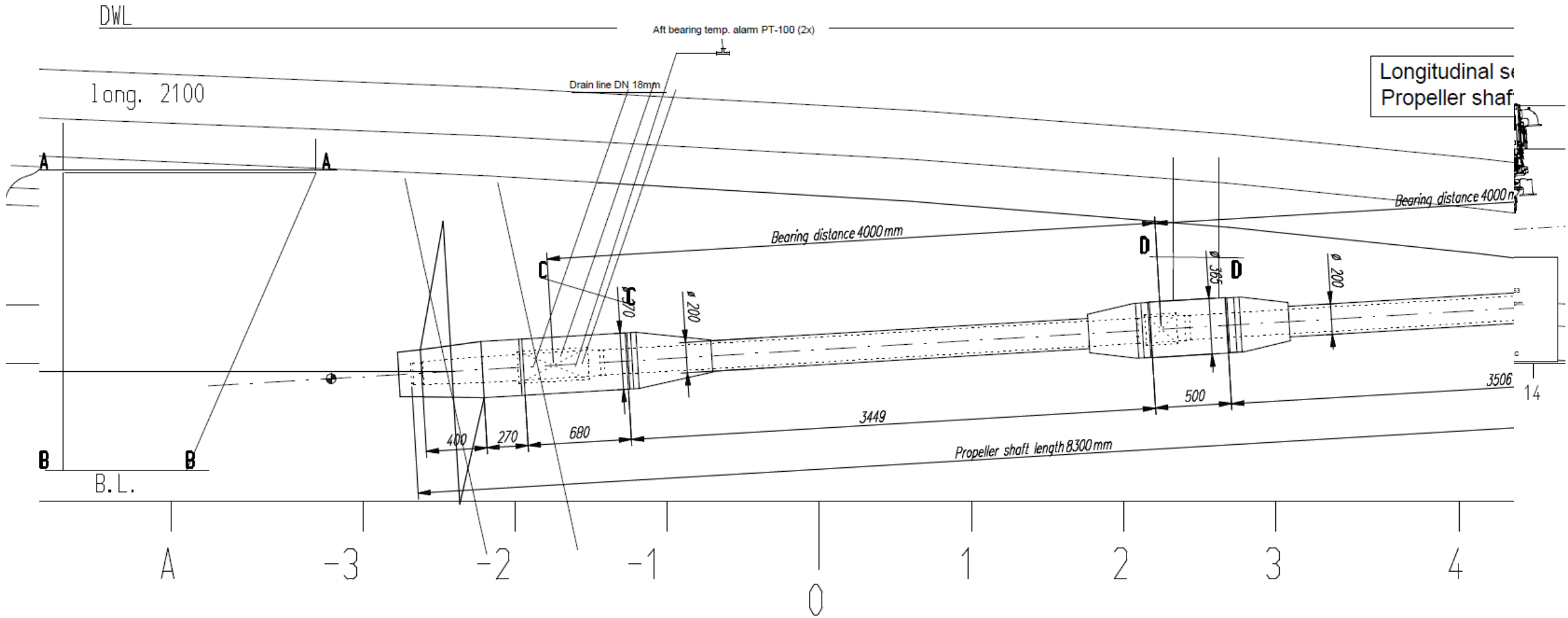
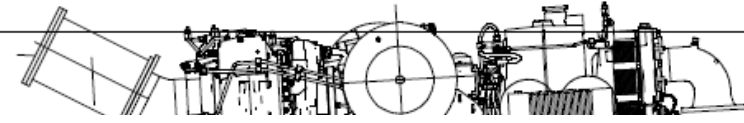
Layout di Linea Asse

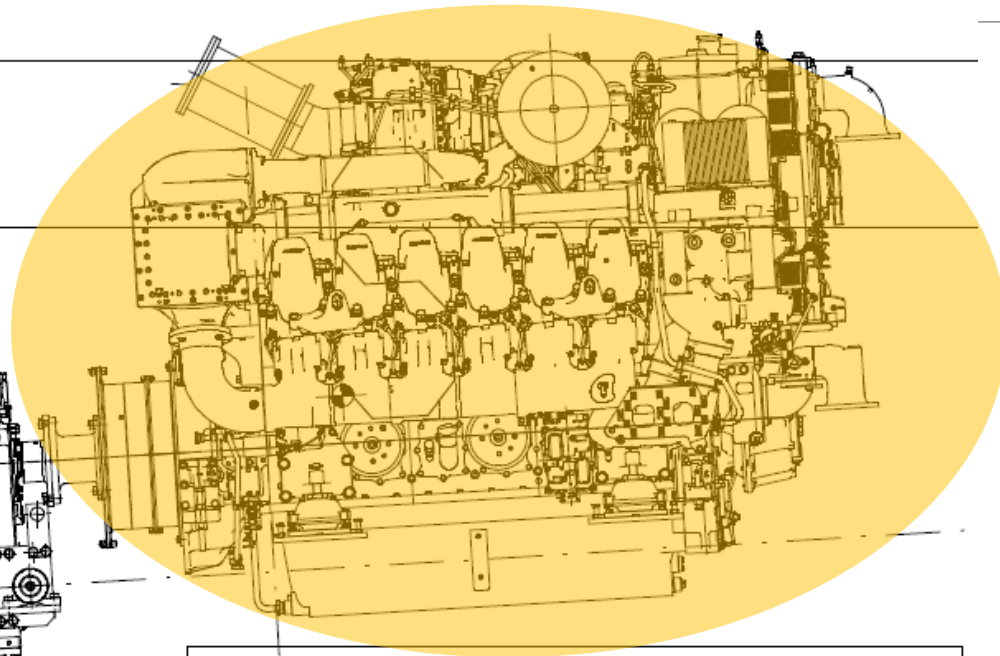
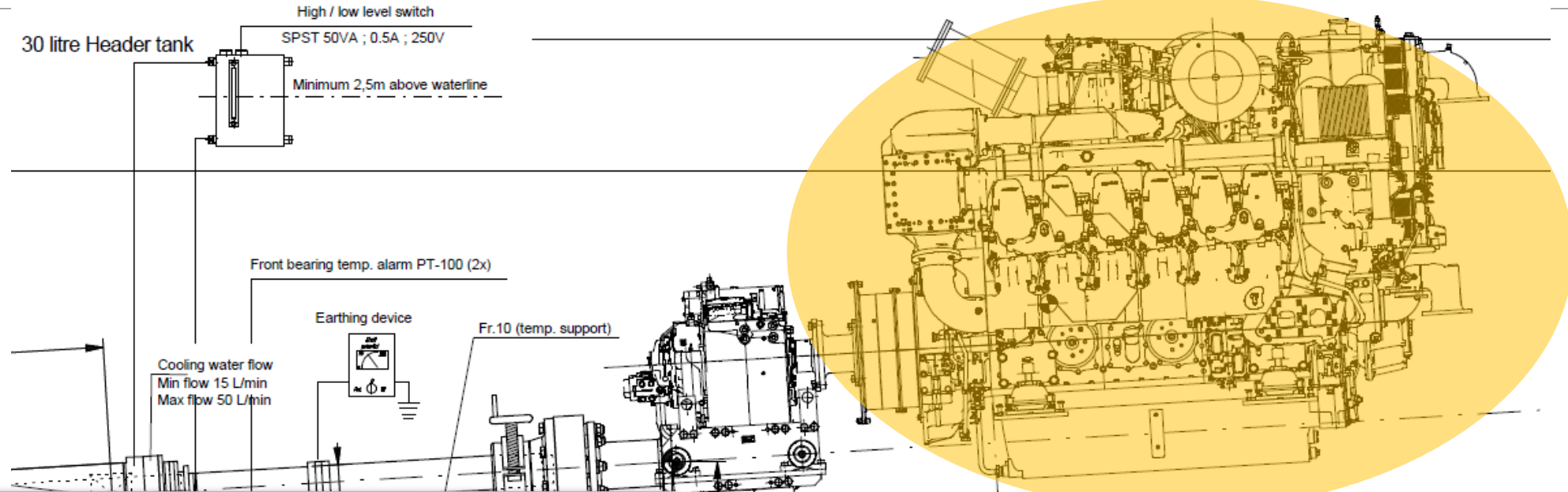
30 litre Header tank

High / low level switch

SPST 50VA ; 0.5A ; 250V

Minimum 2,5m above waterline





Motore di Propulsione: (Forzante Principale)

Frequenze attese:

- 1x engine speed
- 0.5 x Firing
- Engine Firing

Type of Vessel	: Yacht
Classification society	: Lloyd's
Engine	: MTU 12V4000 M53
Power	: 1380kW at 1800rpm.
Gearbox	: ZF 5356
Reduction	: i = 4.464 : 1
Flexible coupling	: EK111SA
Propeller shaft installation	: RD-170-OLS.tlx.C

9

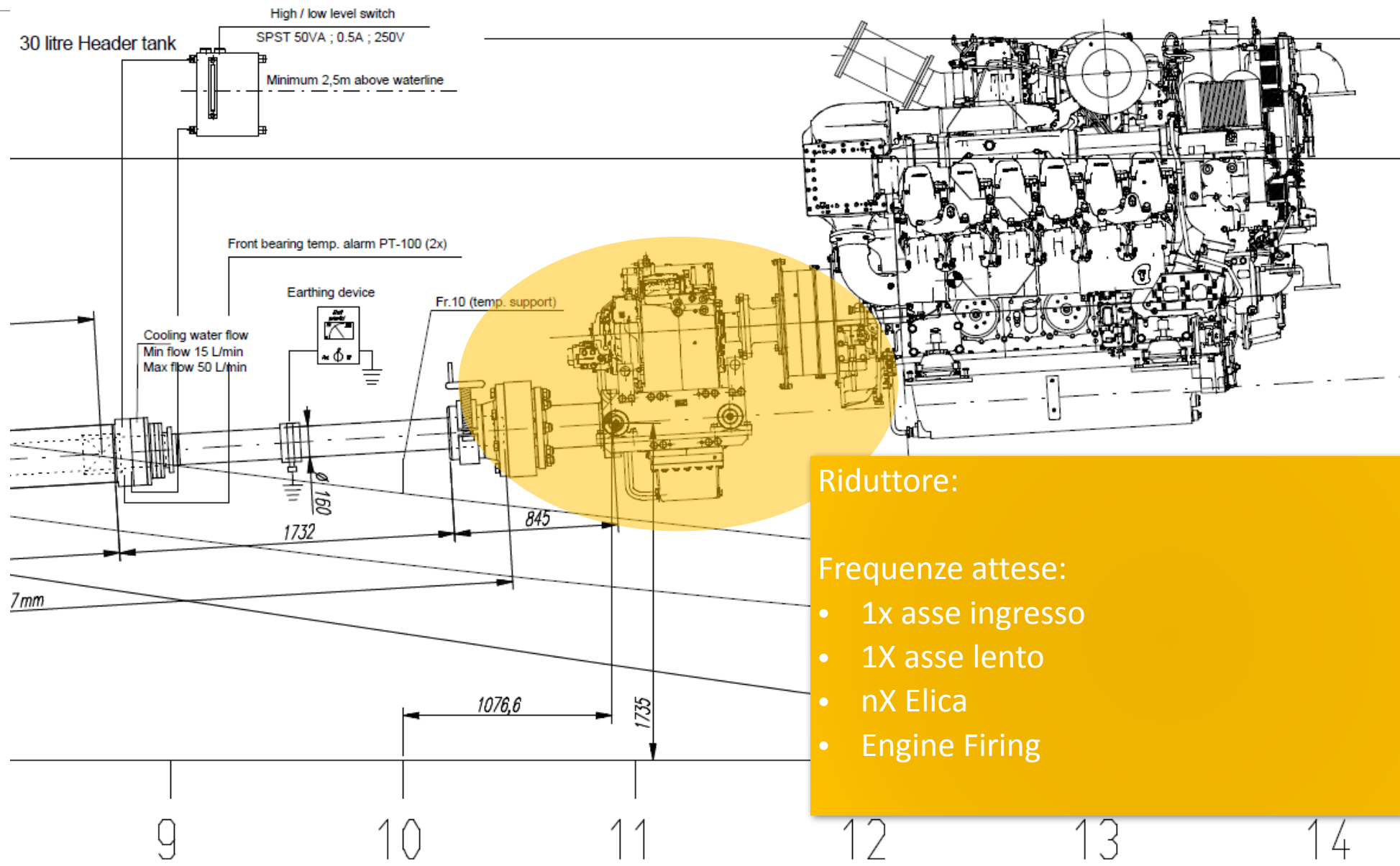
10

11

12

13

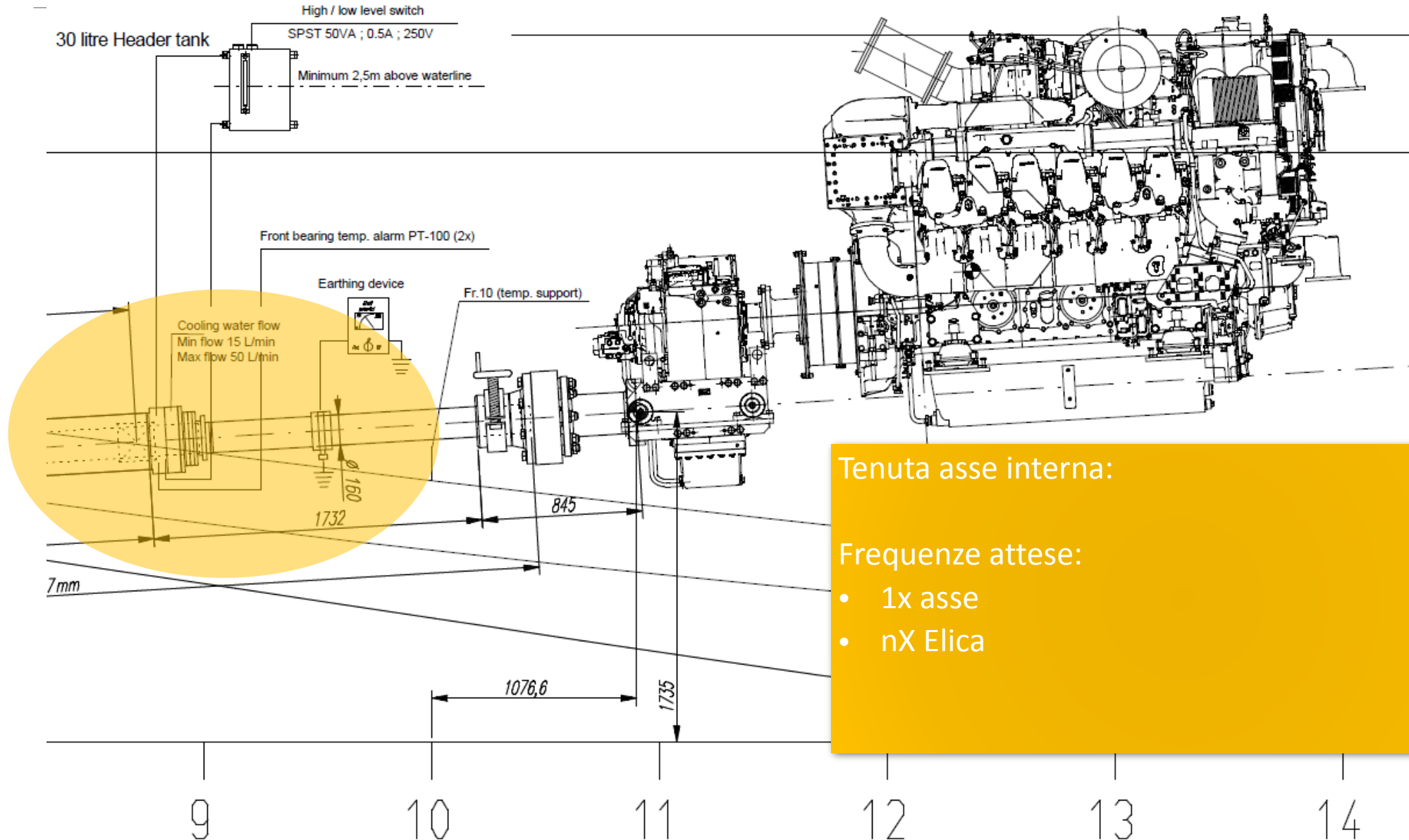
14



Riduttore:

Frequenze attese:

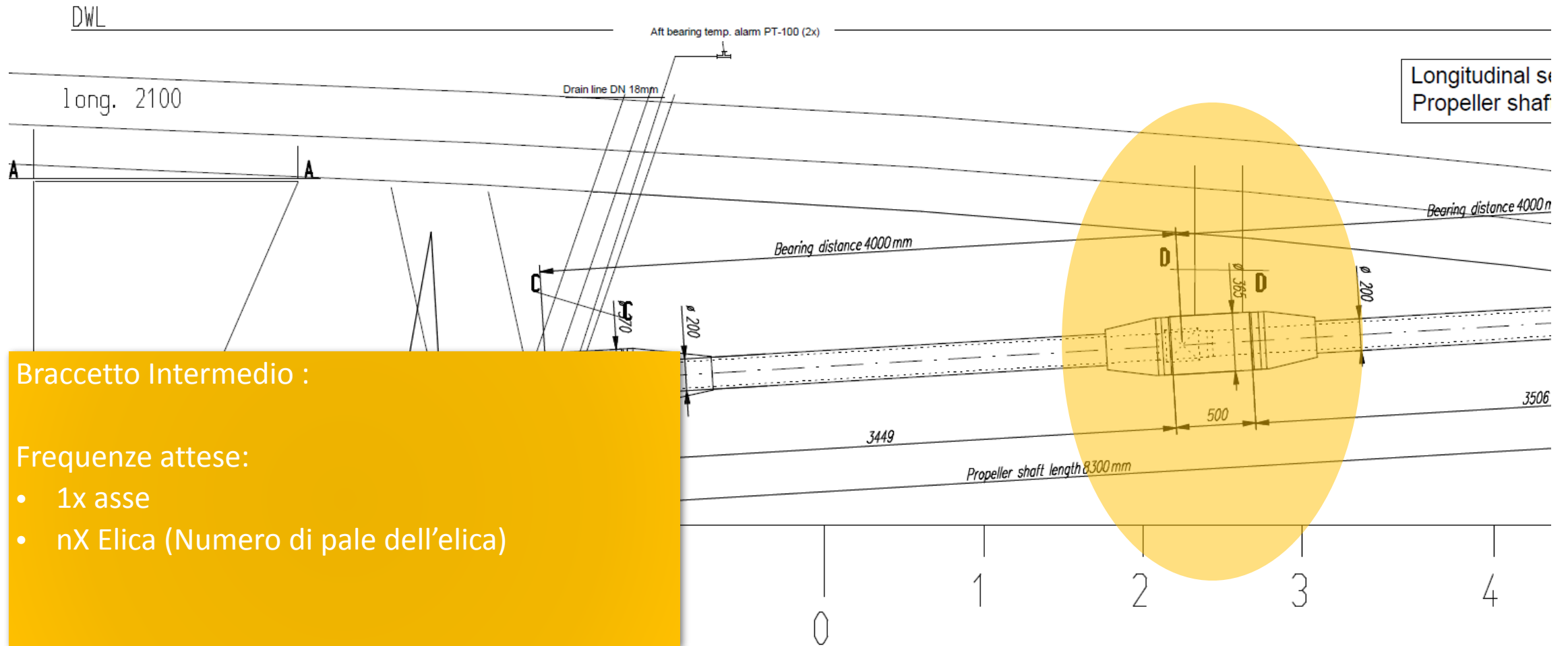
- 1x asse ingresso
- 1X asse lento
- nX Elica
- Engine Firing



Tenuta asse interna:

Frequenze attese:

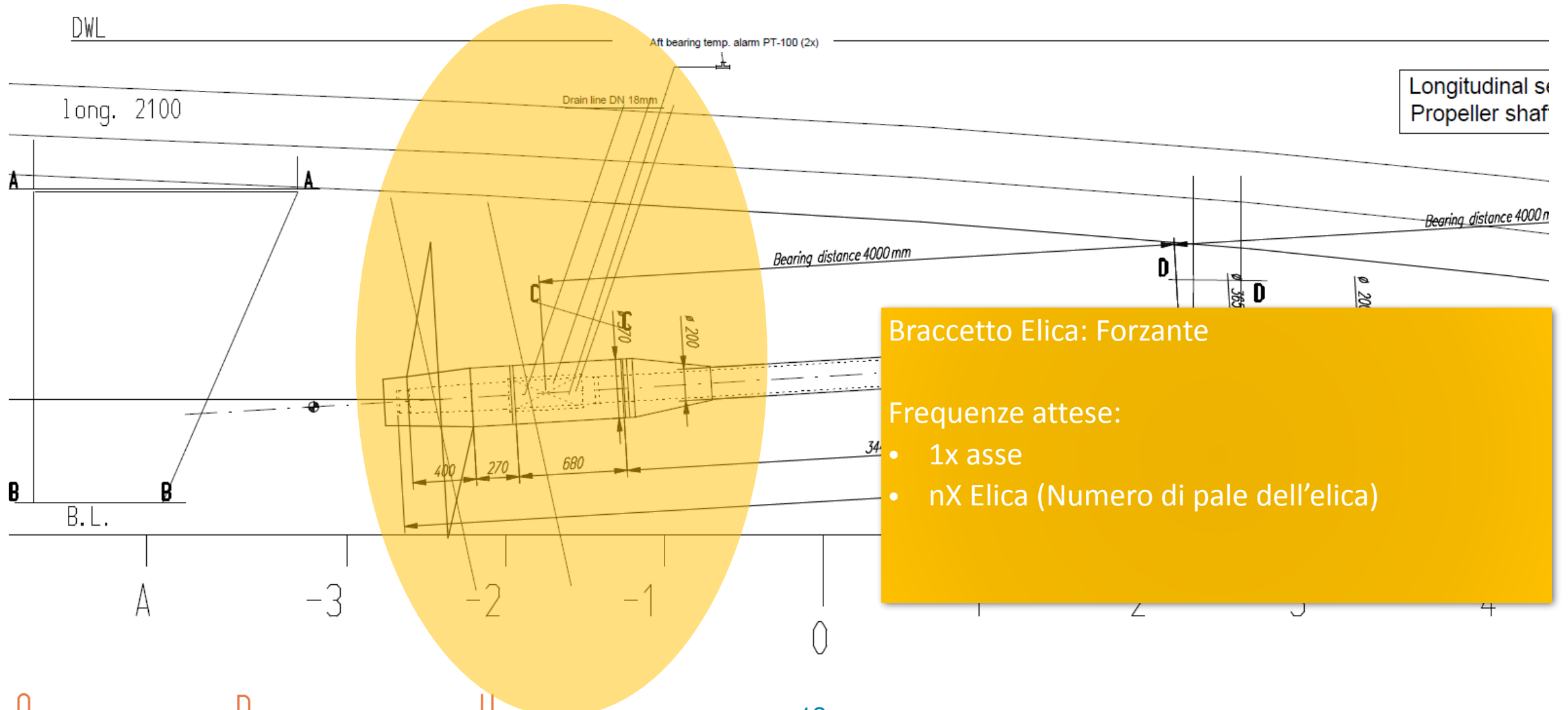
- 1x asse
- nX Elica



Braccetto Intermedio :

Frequenze attese:

- 1x asse
- nX Elica (Numero di pale dell'elica)



Braccetto Elica: Forzante

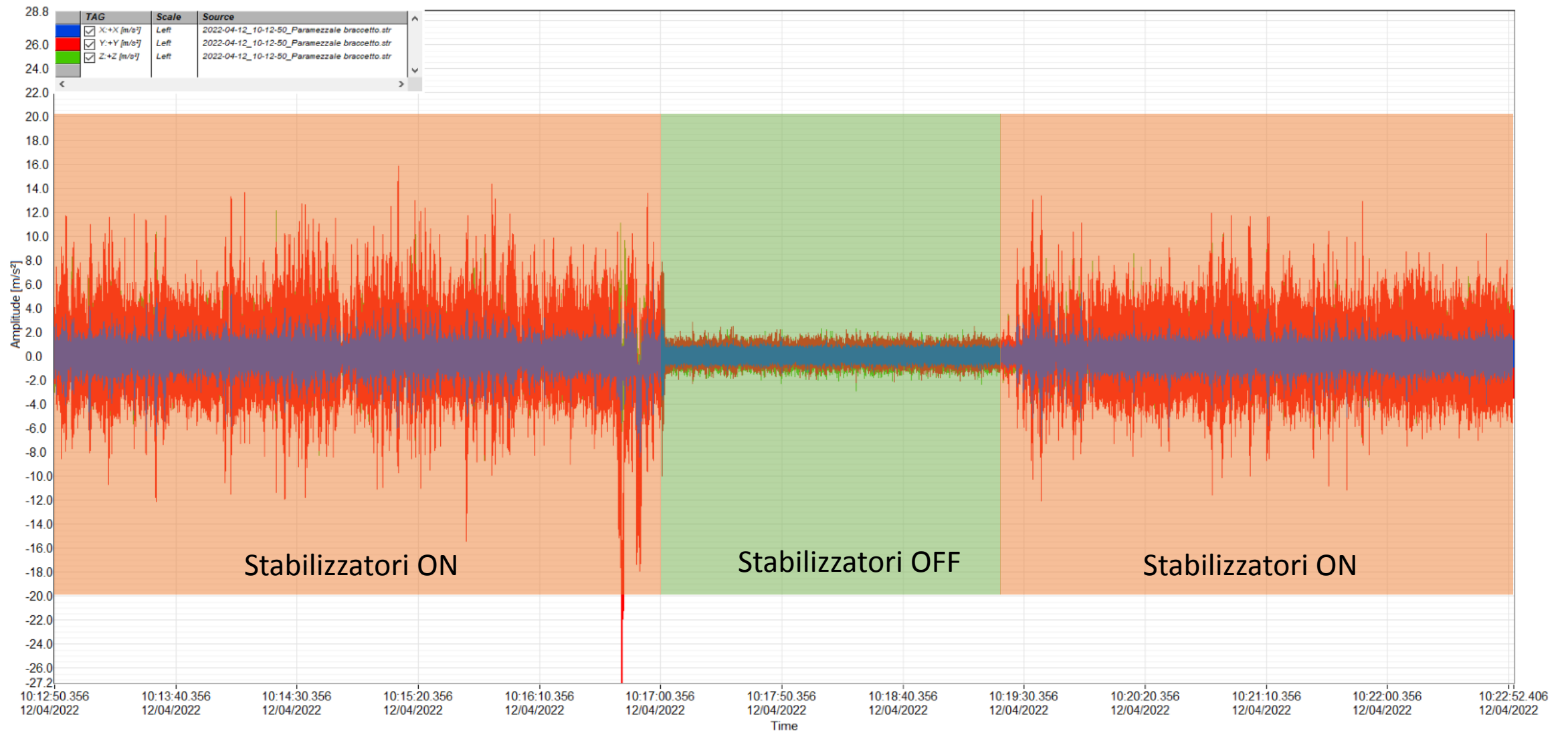
Frequenze attese:

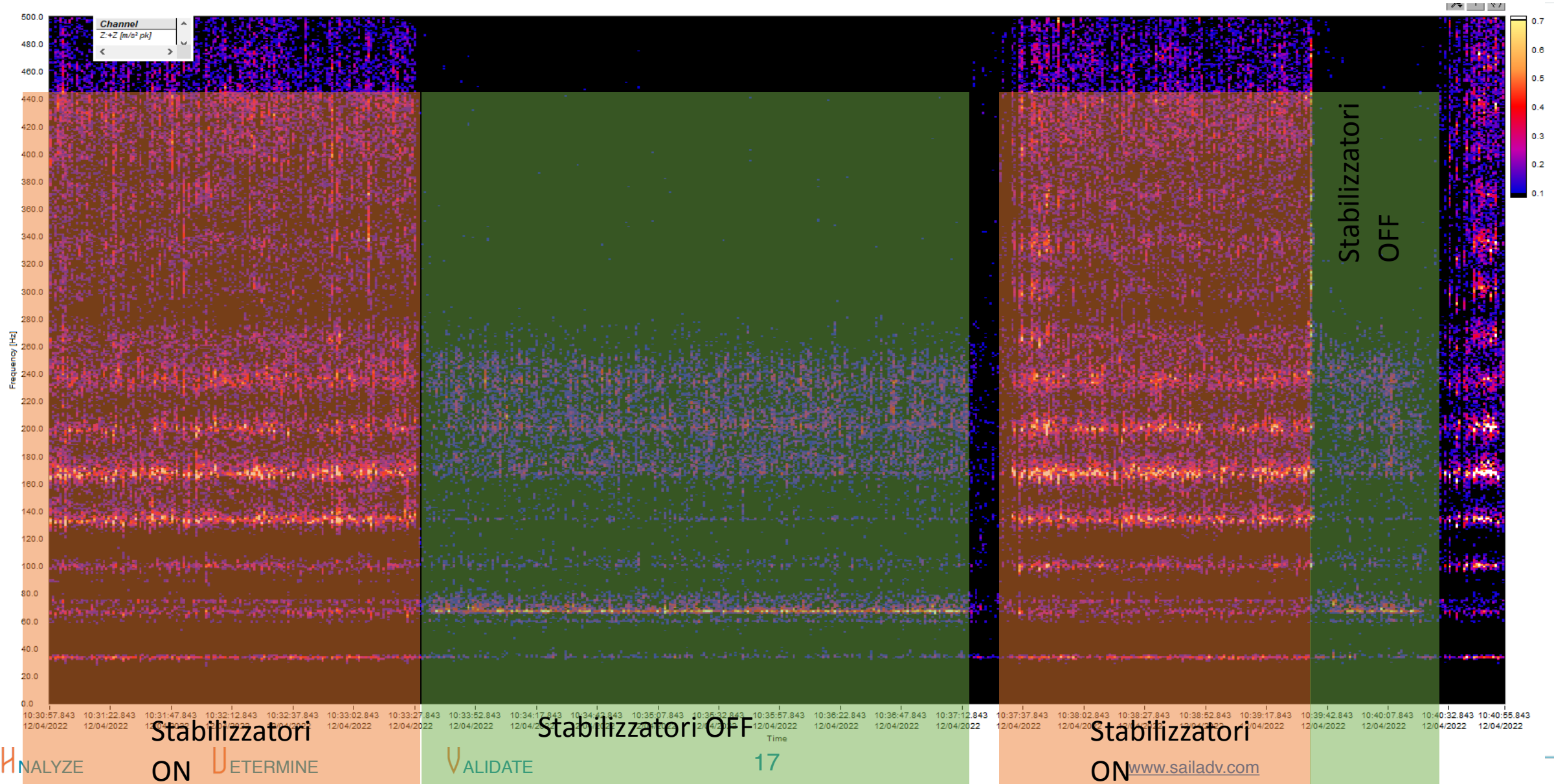
- 1x asse
- nX Elica (Numero di pale dell'elica)

Storia

Interessante









Frequenze attese

Rpm max	1800																				
Cylinder	12																				
ciclo	2	4T																			
Reduction Ratio	4.464	/1																			
Propeller		Pitch																			
		Diameter																			
		Blade N°	5																		
Shaft & Propeller																					
Engine Speed [rpm]	Engine Freq [1X]	Shaft Freq [1X]	Shaft Freq [2X]	Prop. Freq [.5X]	Prop. Freq [1X]	Prop. Freq [2X]															
1800	30.0	6.7	13.4	16.8	33.6	67.2															
403.2																					
Engine Freq																					
Order	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	
Freq [Hz]	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0	165.0	180.0	195.0	210.0	225.0	240.0	255.0	270.0	285.0	300.0	
Order	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	
Freq [Hz]	315.0	330.0	345.0	360.0	375.0	390.0	405.0	420.0	435.0	450.0	465.0	480.0	495.0	510.0	525.0	540.0	555.0	570.0	585.0	600.0	
Shaft Freq																					
Order	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	
Freq [Hz]	3.4	6.7	10.1	13.4	16.8	20.2	23.5	26.9	30.2	33.6	37.0	40.3	43.7	47.0	50.4	53.8	57.1	60.5	63.8	67.2	
Order	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	
Freq [Hz]	70.6	73.9	77.3	80.6	84.0	87.4	90.7	94.1	97.4	100.8	104.2	107.5	110.9	114.2	117.6	121.0	124.3	127.7	131.0	134.4	
Propeller Freq																					
Order	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	
Freq [Hz]	33.6	67.2	100.8	134.4	168.0	201.6	235.2	268.8	302.4	336.0	369.6	403.2	436.8	470.4	504.0	537.6	571.2	604.8	638.4	672.0	

Analisi dei Risultati

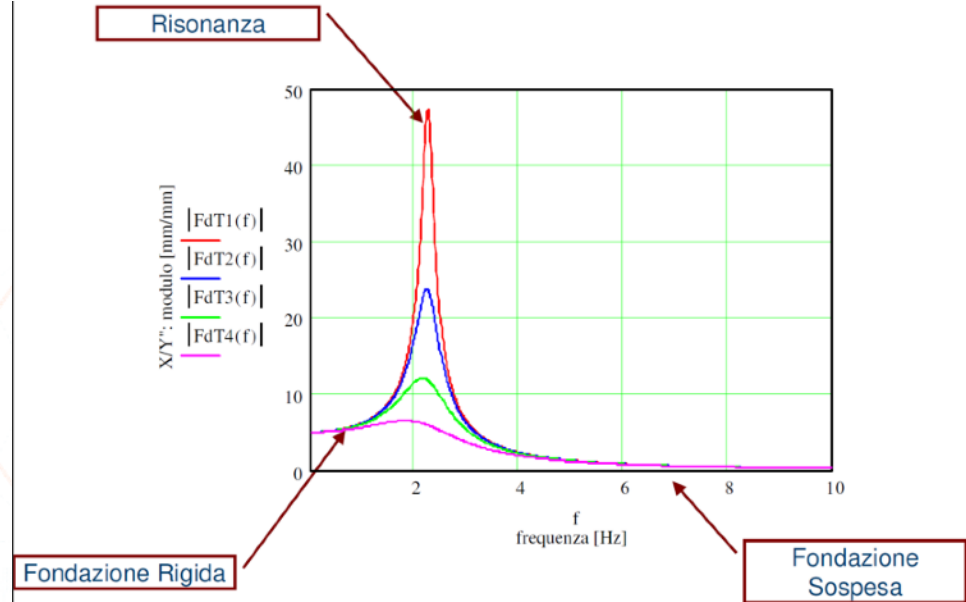
La teoria del funzionamento dei resilienti afferma in maniera univoca che il funzionamento dei resilienti stessi dipende dalle caratteristiche della struttura ricevente, che necessariamente deve "adeguatamente rigida "

I dati acquisiti sono stati analizzati nel dominio della velocità e di valori efficaci (mm/s e RMS) e non nel dominio delle accelerazioni e di valori puntuali.

Da sottolineare che non c'è normativa di riferimento verso al quale confrontarsi ed è importante sottolineare che i valori in accelerazione pesano di più le alte frequenze rispetto alle basse (nel caos specifico, interessano i moti sui resilienti, piuttosto che le vibrazioni dovute alle accensioni)

Nell'analisi della efficienza dei supporti elastici non si definisce «l'insulation» come variazione percentuale di picchi, bensì si utilizza il concetto di taglio e di trasmissibilità grandezze espresse solitamente in funzione della frequenza ed in dB, queste grandezze considerano la variazioni di energia trasmessa tra sorgente e struttura ricevente

La tabella seguente riepiloga i dati acquisiti lungo l'asse verticale Z in diverse condizioni di carico del generatore:



Carico [Kw]	Freq [Hz]	Supporto 1			Supporto 2			
		Up	Sotto	Basamento	Freq [Hz]	Up	Sotto	Basamento
0	62.5	10.6	0.9	1.3	62.5	7.7	0.8	1.3
4.5	61.8	11.3	0.6	1.0	61.8	7.5	0.5	1.0
8.2	61.8	11.2	0.4	0.9	61.8	6.9	0.4	0.9
14.7	61.0	12.5	0.4	1.0	61.0	7.9	0.5	1.0
19.2	60.3	13.6	0.5	1.0	60.4	7.6	0.6	1.0
22.2	57.4	13.5	1.3	1.6	57.4	7.4	1.5	1.6

Carico [Kw]	Supporto 1		Supporto 1
	UP / Down	Basamento	
0	10.8	-0.1	9.8
4.5	13.1	0.1	11.4
8.2	14.9	0.1	12.0
14.7	14.7	-0.1	12.1
19.2	14.5	0.1	11.1
22.2	10.1	0.0	7.0

Misure espresse in [Db]

Analisi dei Risultati

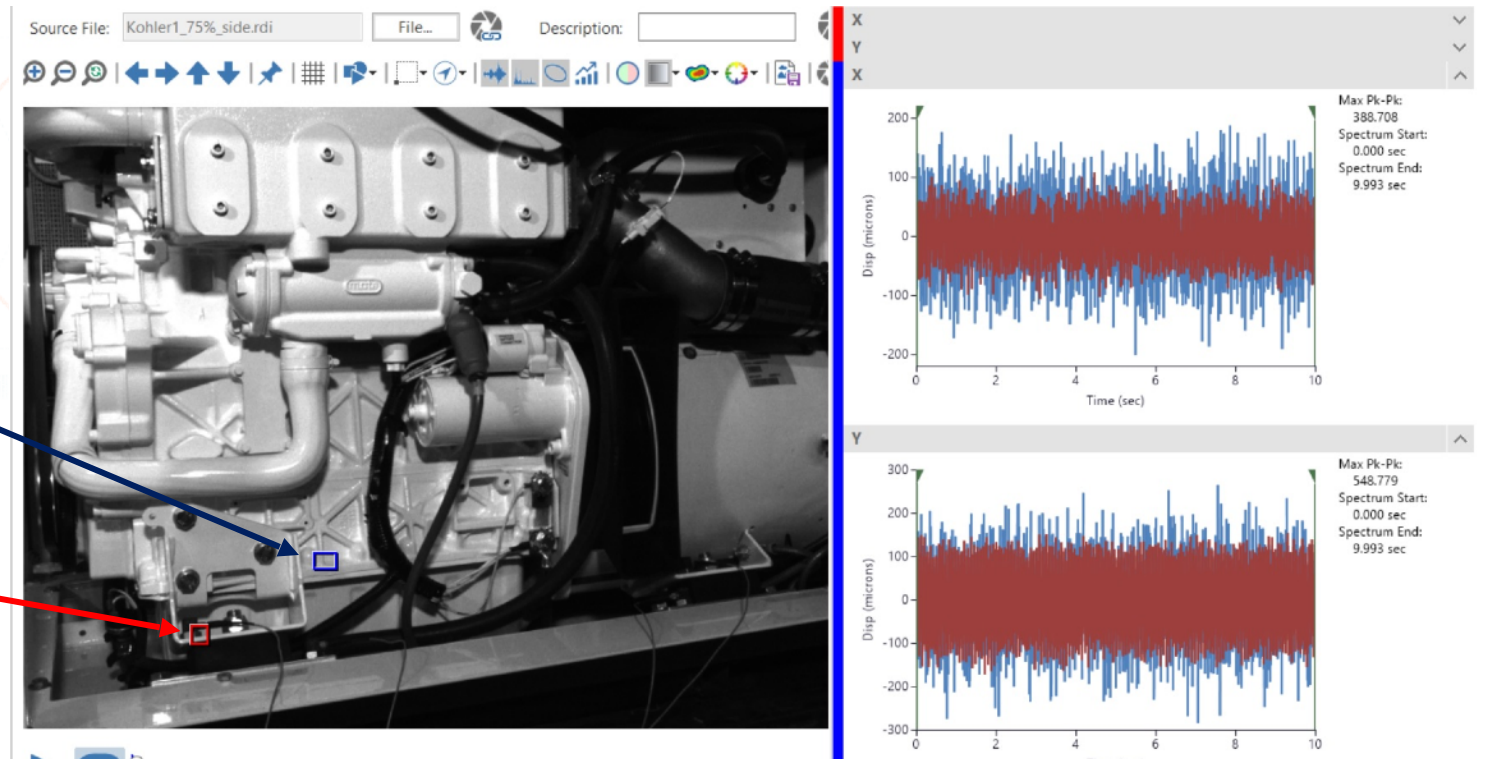
Relativamente a i valori totali rappresentati è da evidenziare che non si può fare la somma aritmetica di valori istantanei di vibrazioni in direzioni differenti. Eventualmente si può fare una somma in termini energetici ma purtroppo perdendo l'informazione sulla fase.

La misura sul blocco motore non è particolarmente interessante, non è quella la forza che si scarica sul resilente ed inoltre la lettura dei dati sul monoblocco del motore perde tutta la dinamica del piede motore

Nell'immagini qui a fianco si può facilmente evidenziare come il punto di misura sia importante per valutare in maniera attendibile le componenti in analisi

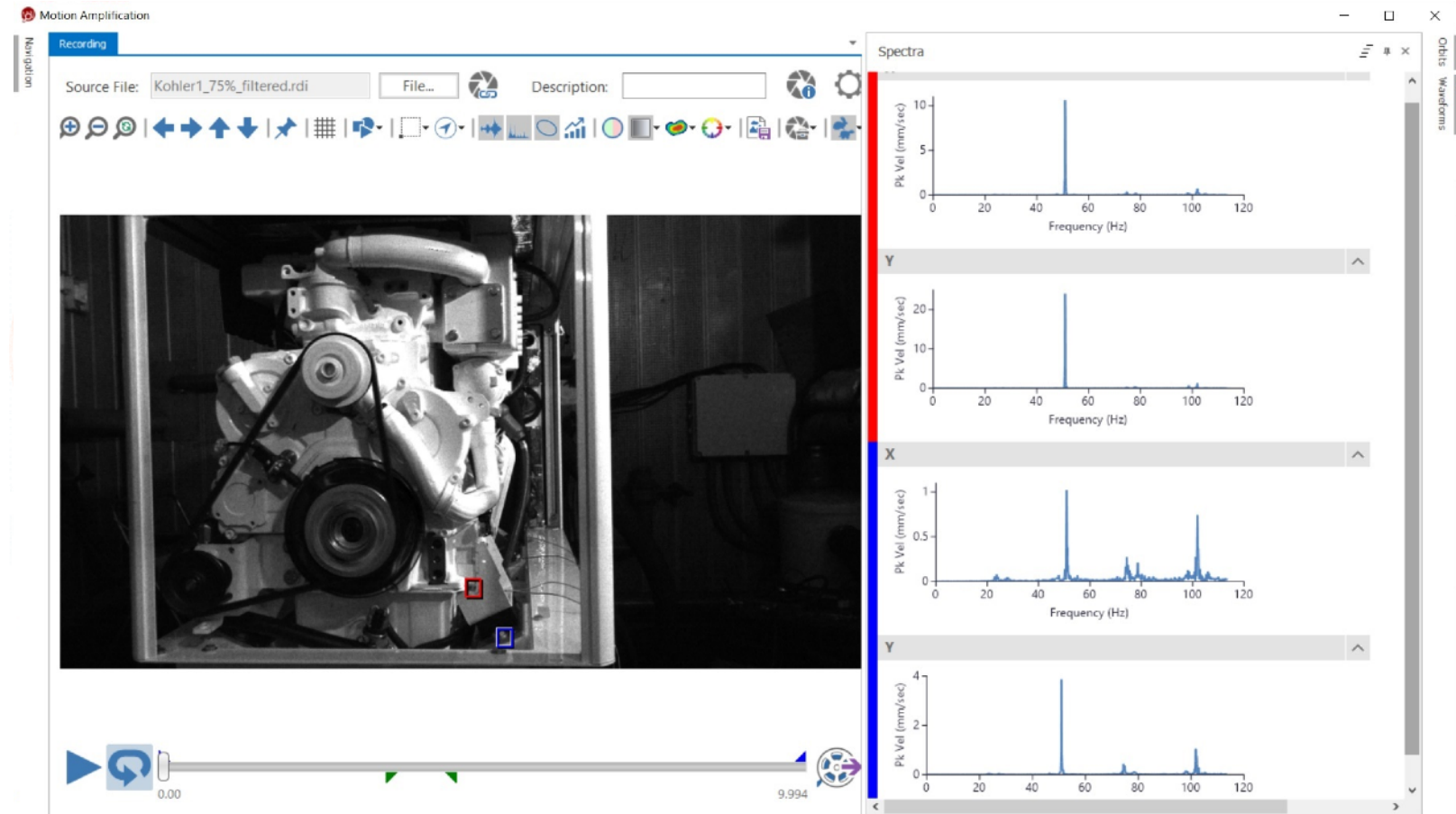
In blu la traccia dello spostamento nel dominio del tempo del particolare

In rosso la traccia dello spostamento nel dominio del tempo del particolare



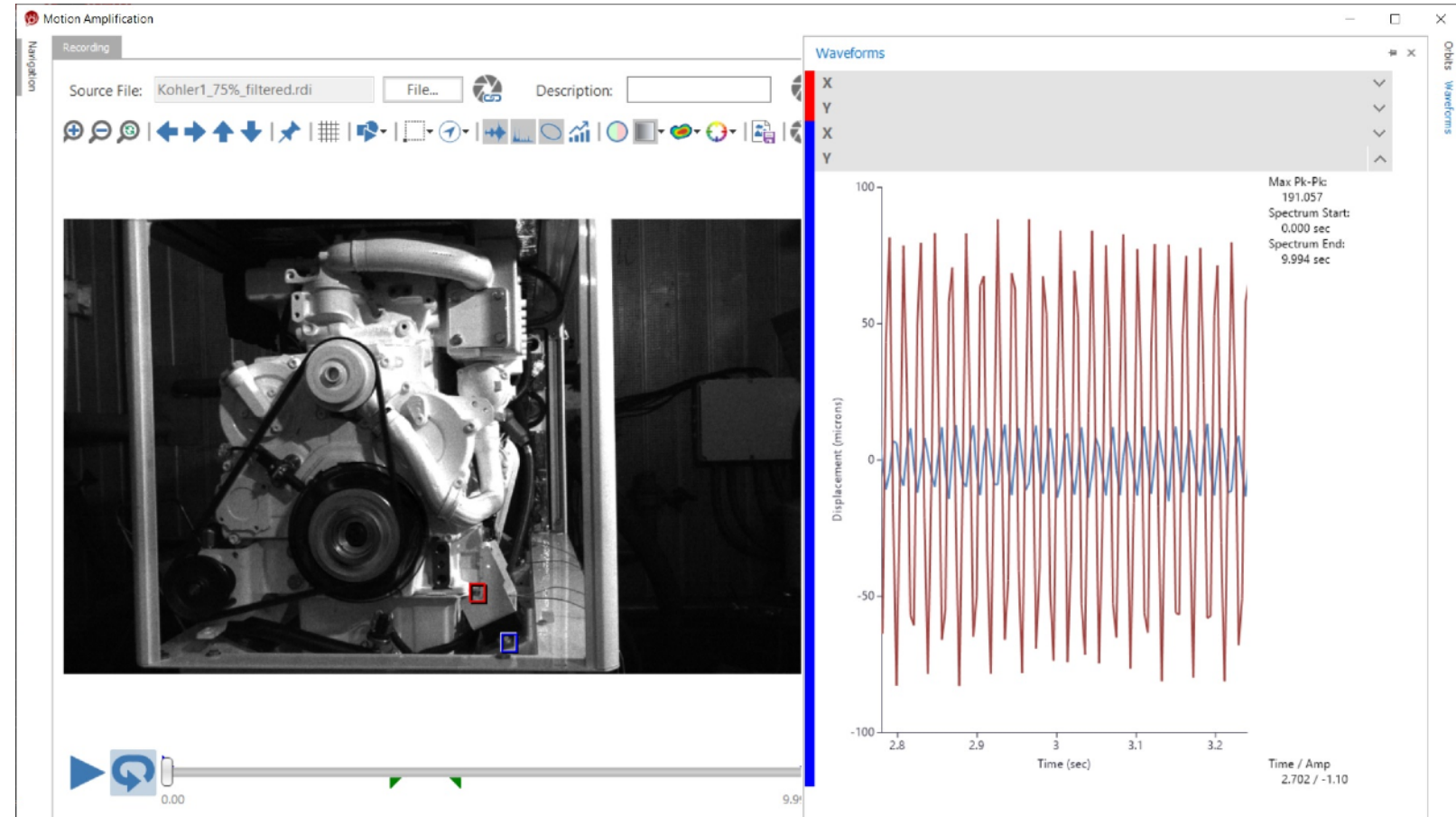
Analisi dei Risultati

L'analisi dell'efficacia del taglio dei resistenti e facilmente riscontrabile dall'analisi comparativa riportata nella immagine qui a fianco sia in termini di velocità che di spostamento

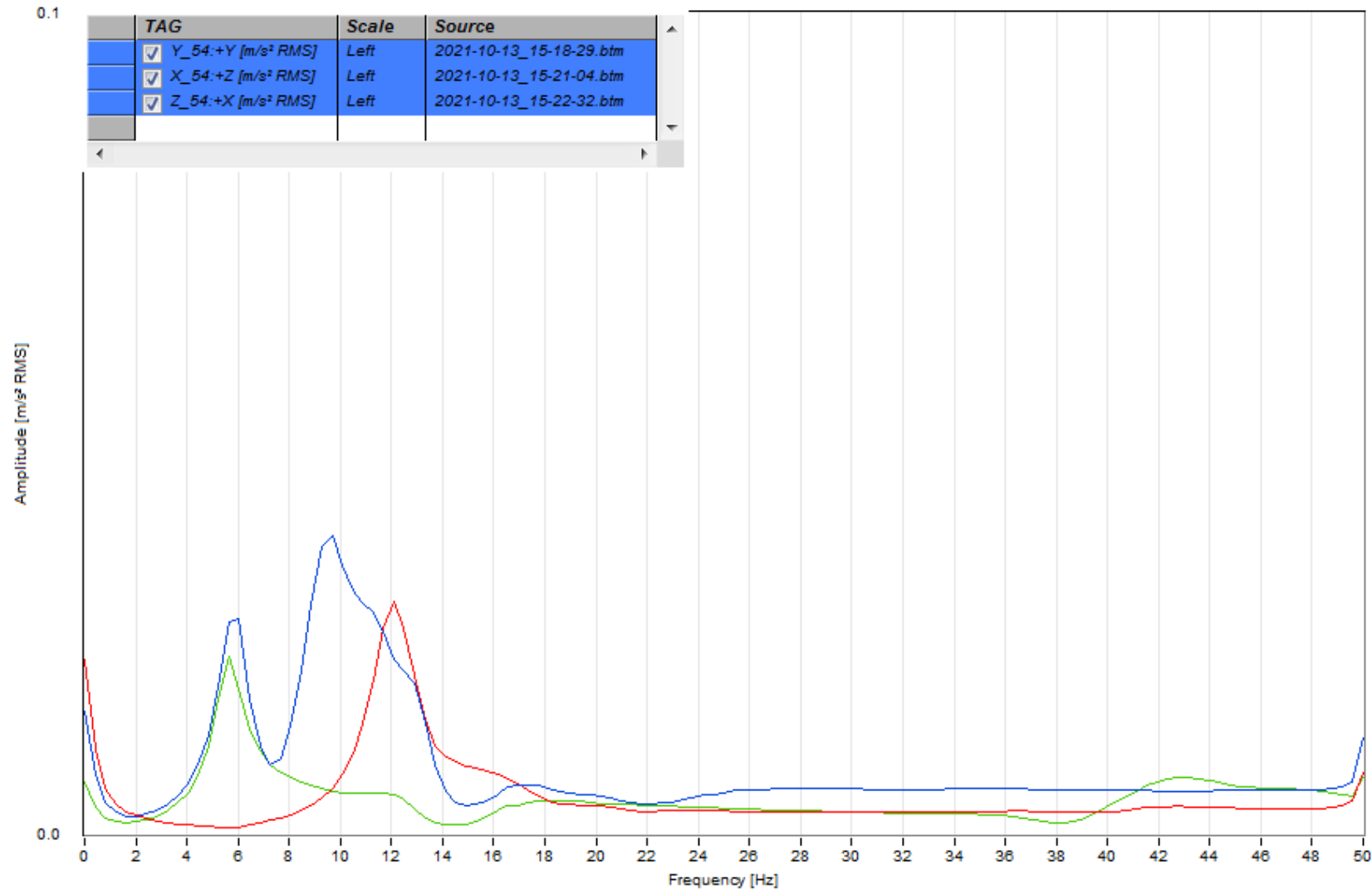


Analisi dei Risultati

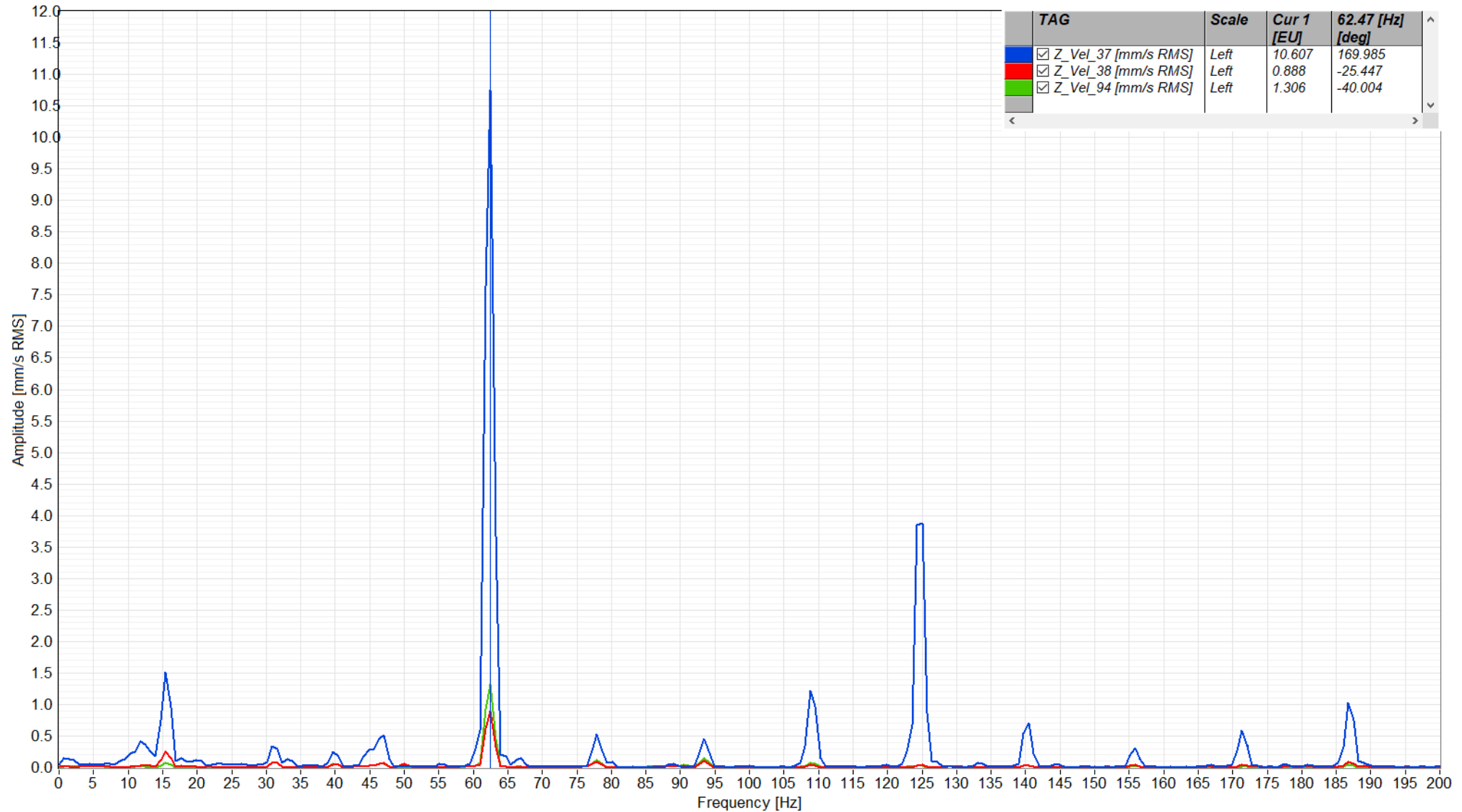
L'analisi dell'efficacia del taglio dei resistenti è facilmente riscontrabile dall'analisi comparativa riportata nella immagine qui a fianco sia in termini di velocità che di spostamento



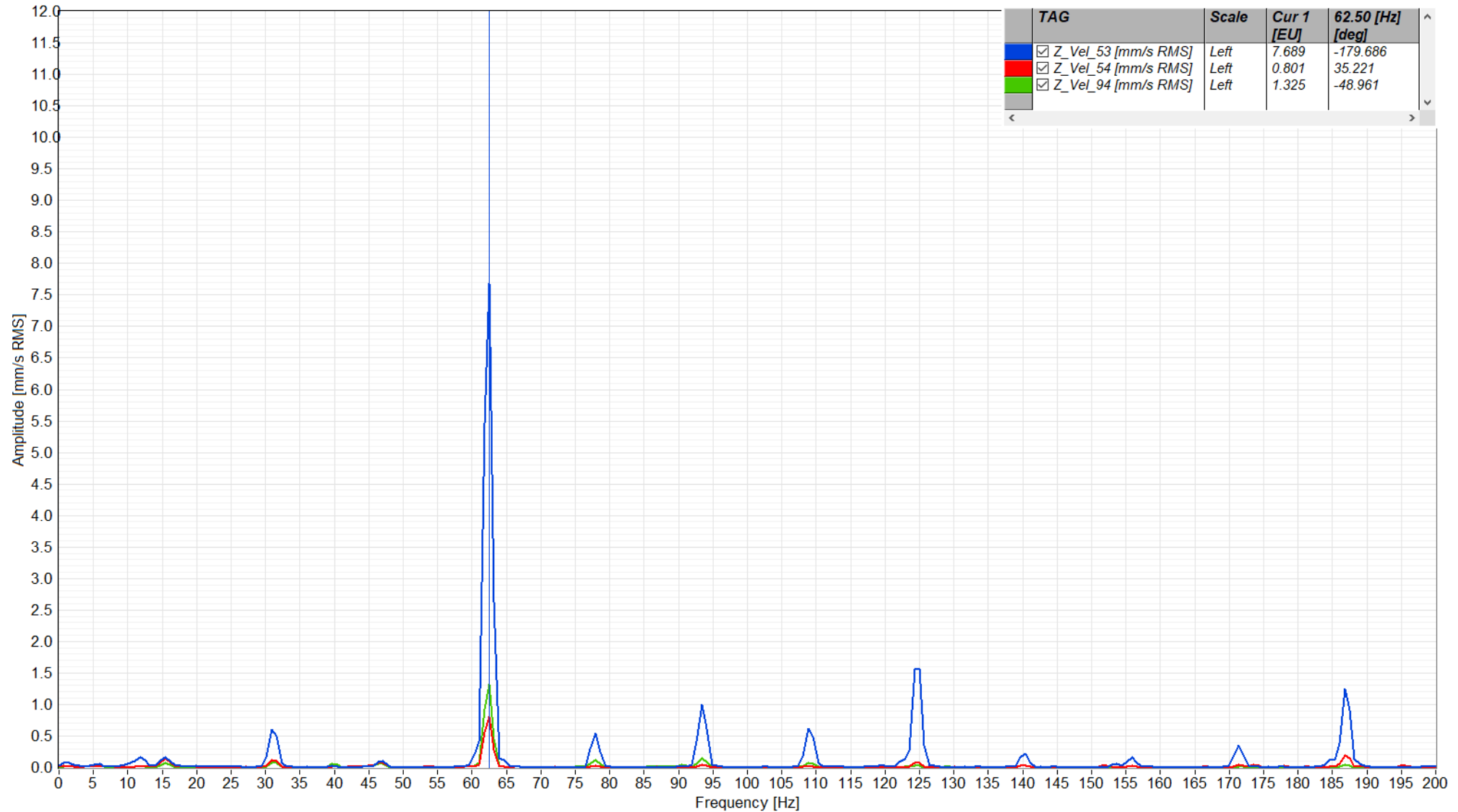
Frequenze Proprie sistema



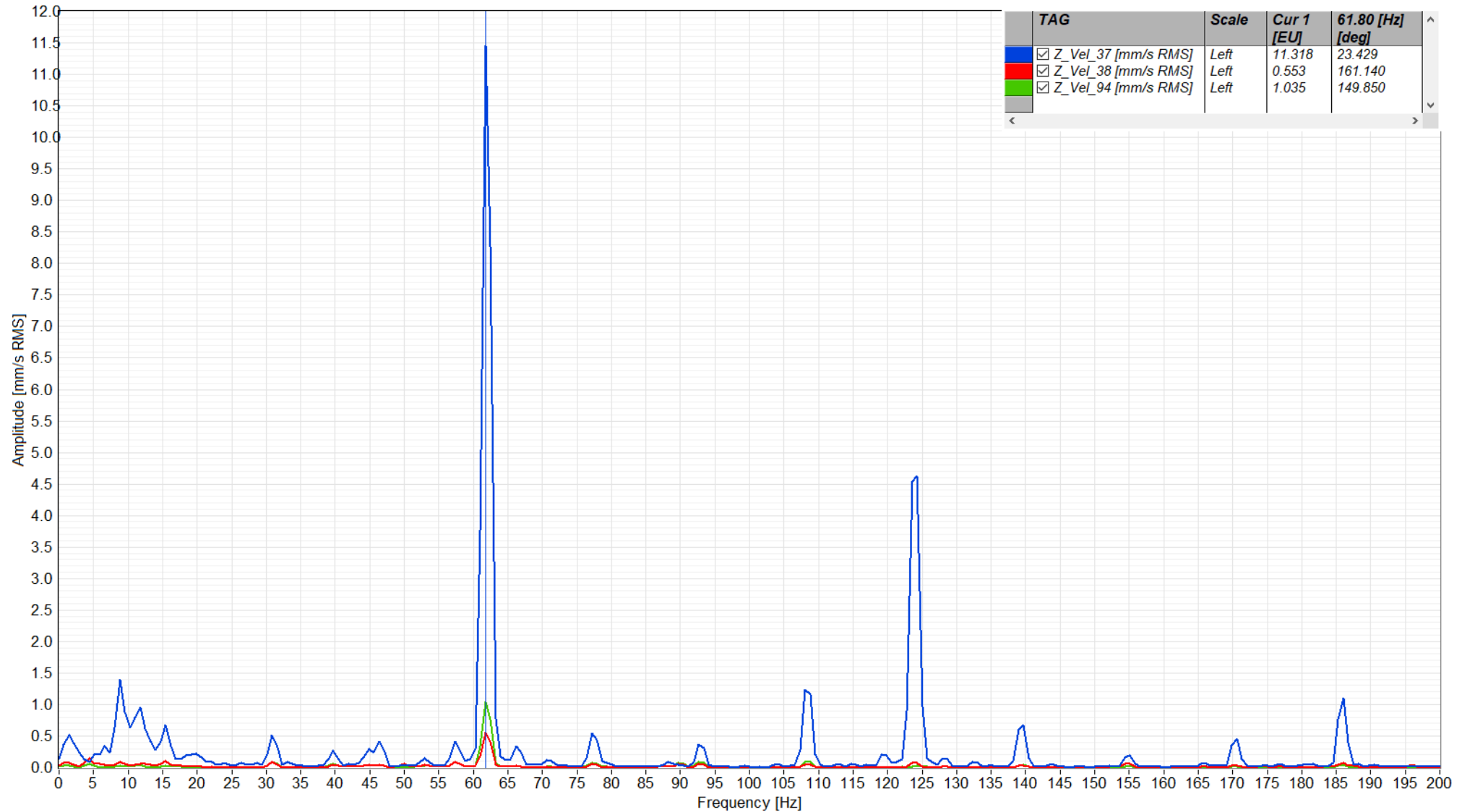
FFT Supporto 1 - IDLE



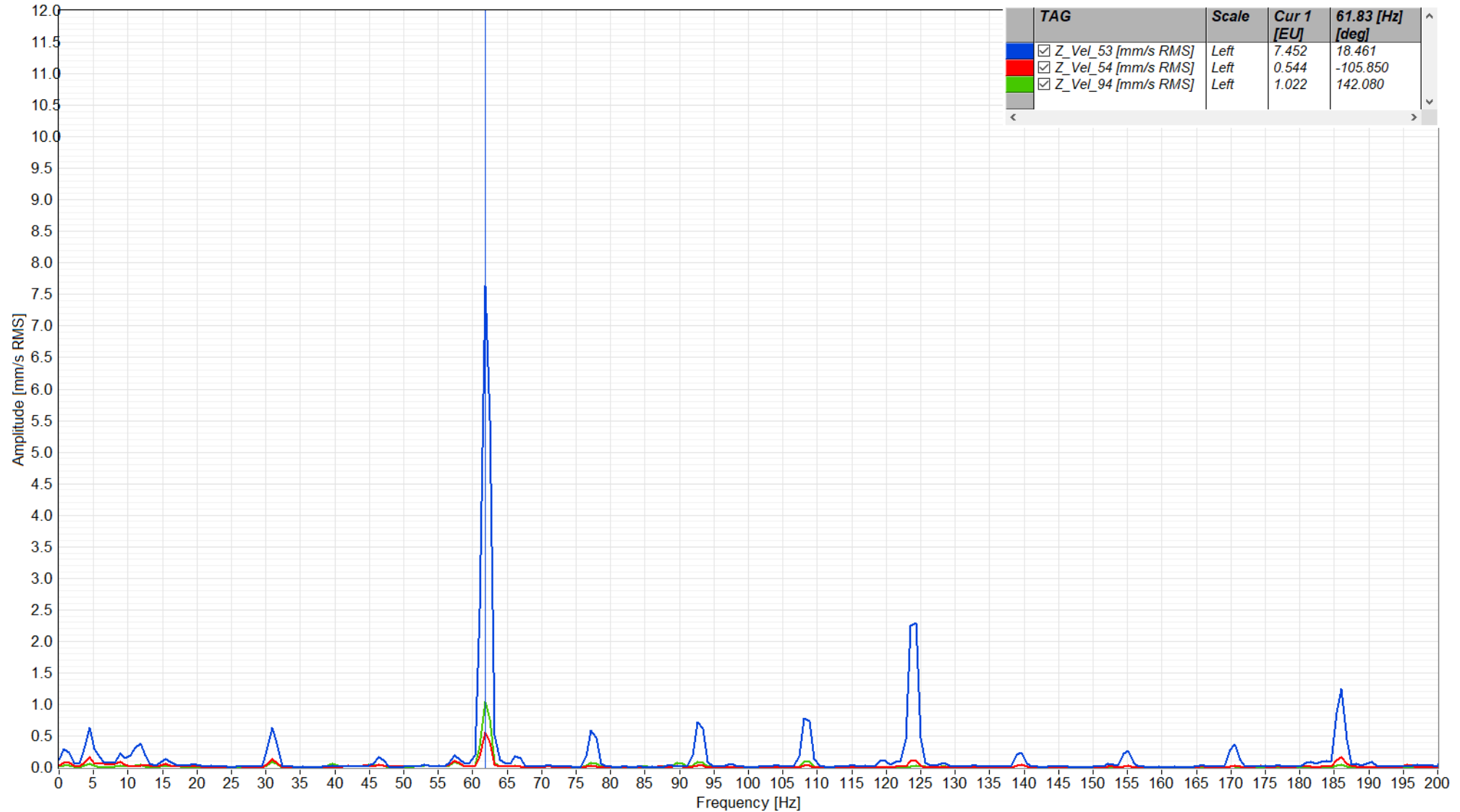
FFT Supporto 2 - IDLE



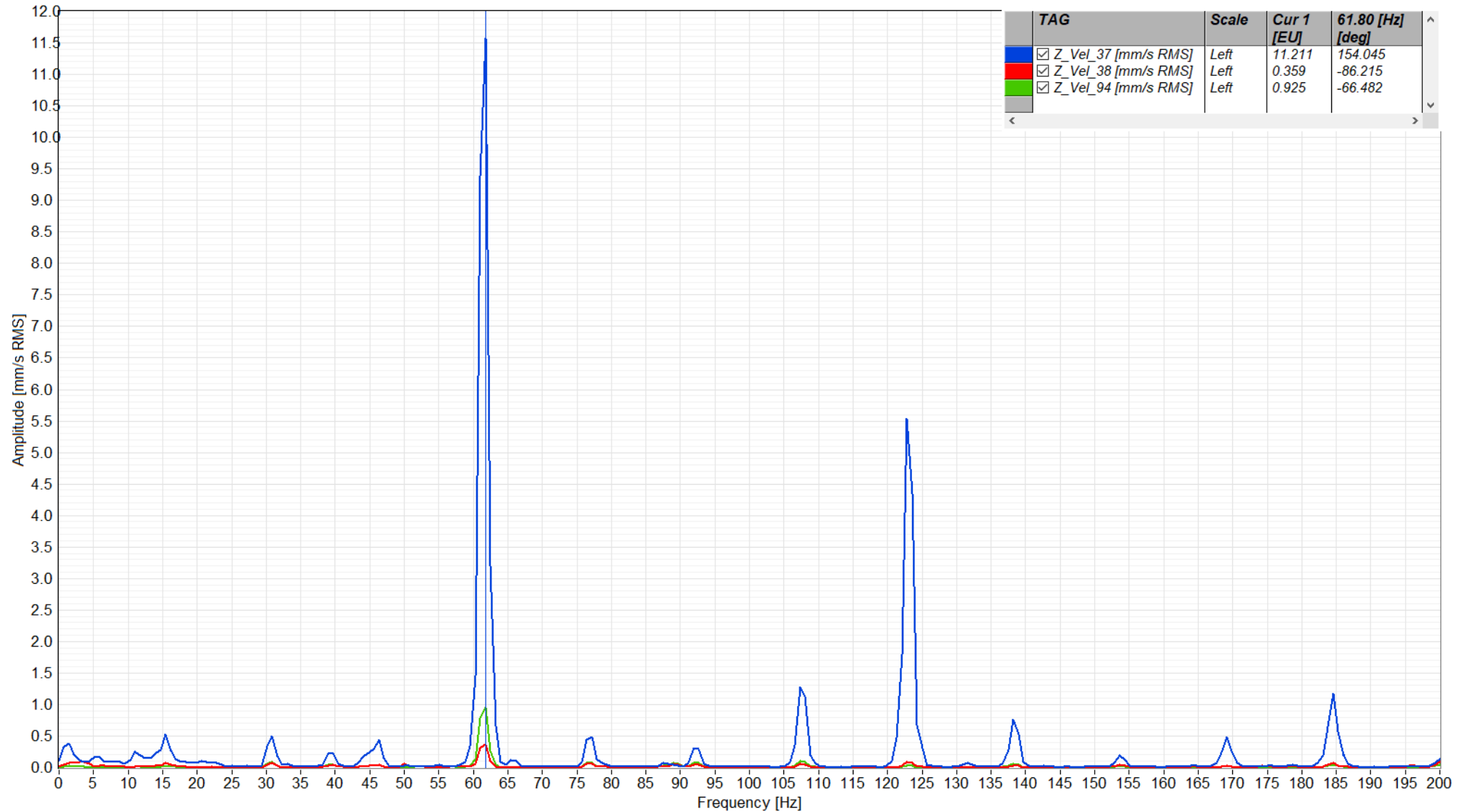
FFT Supporto 1 @ 4.5 kw



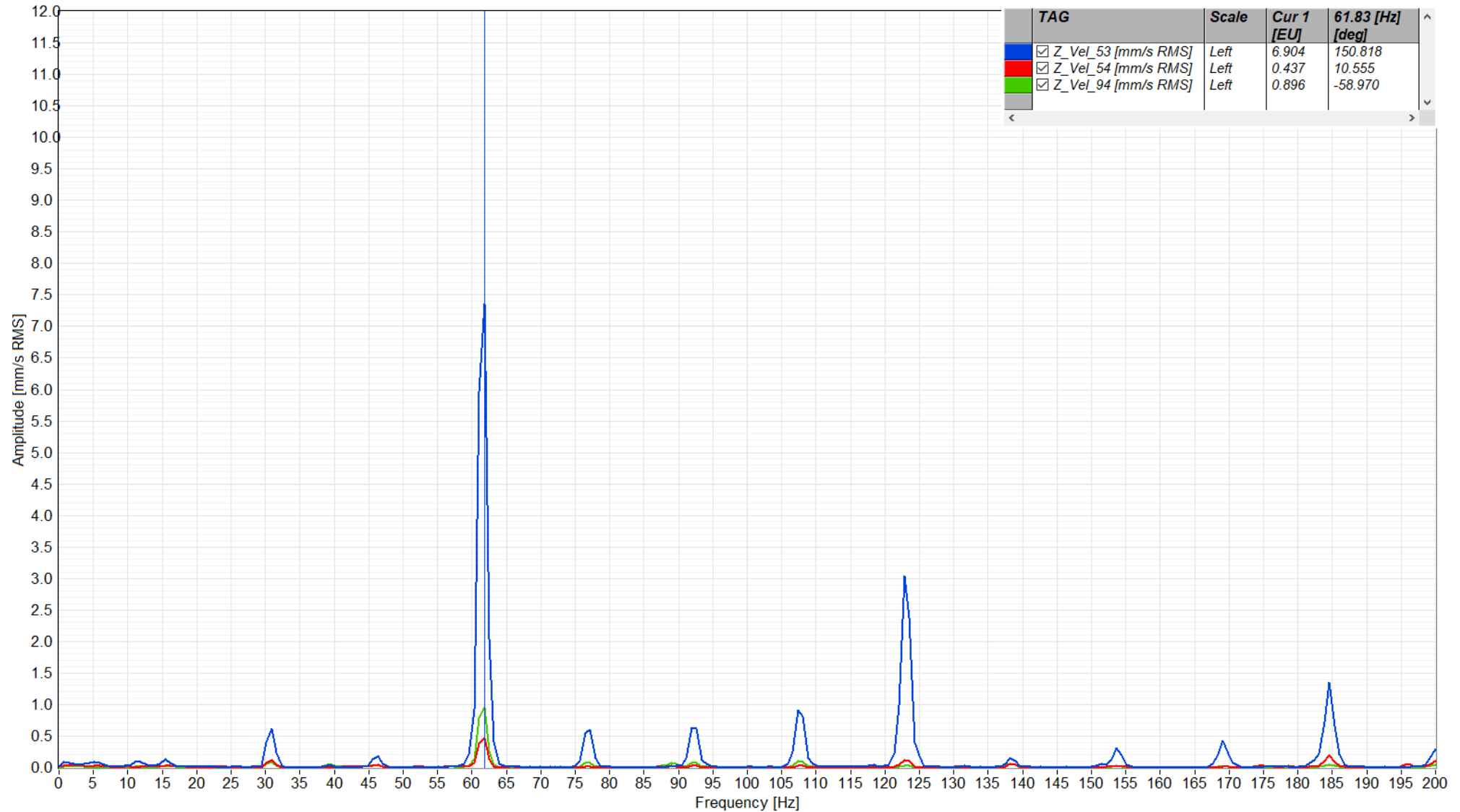
FFT Supporto 2 @ 4.5 kw



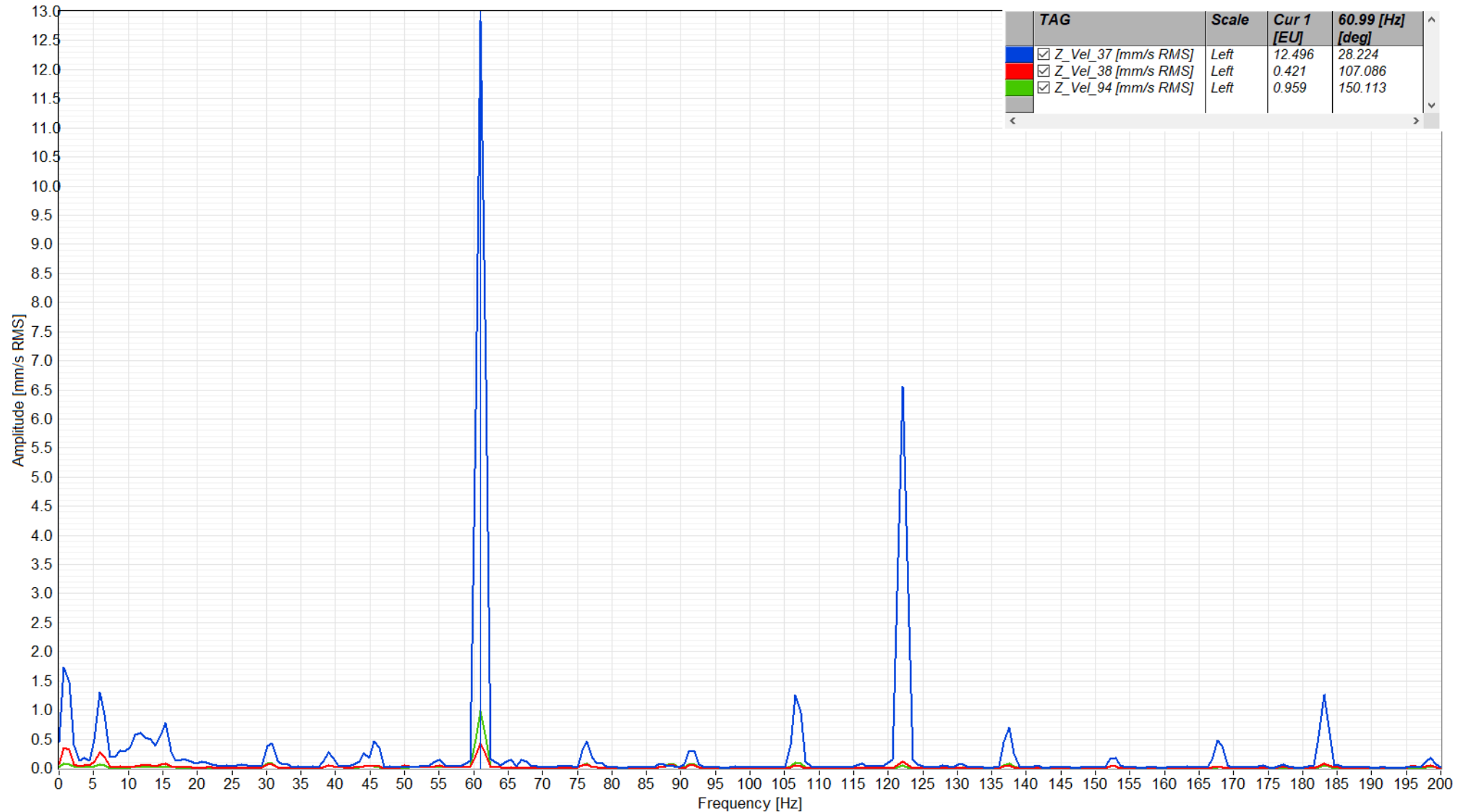
FFT Supporto 1 @ 8.2 kw



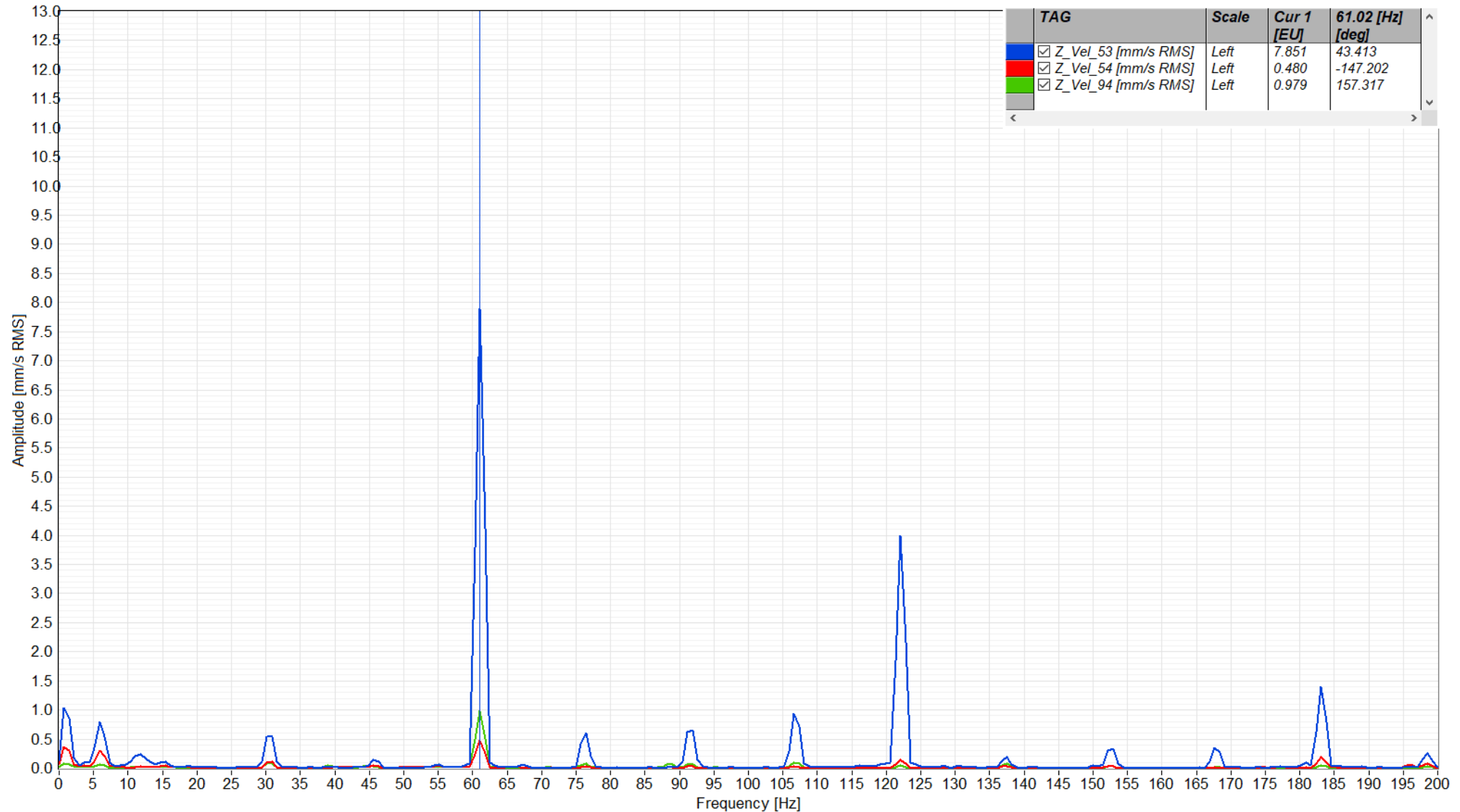
FFT Supporto 2 @ 8.2 kw



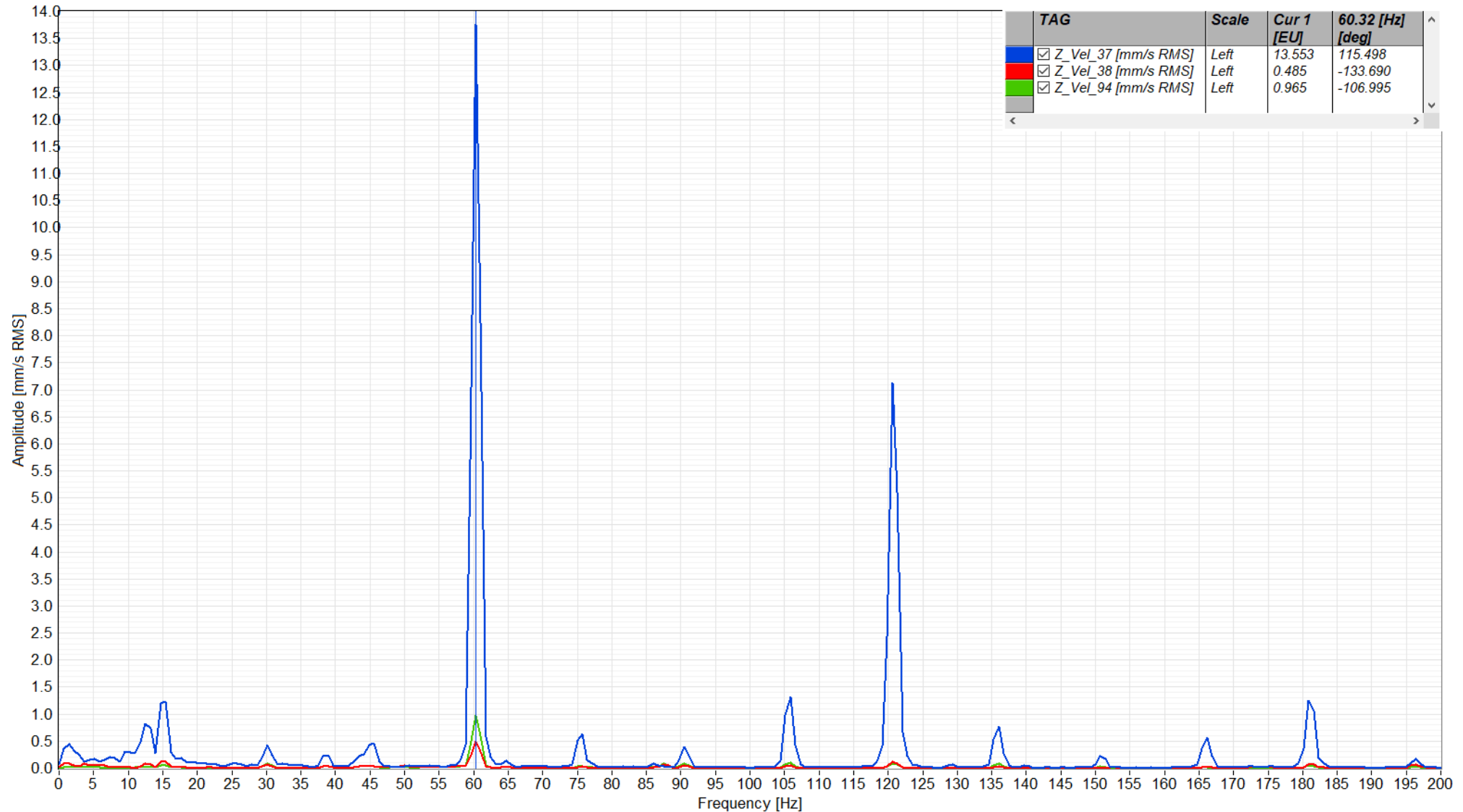
FFT Supporto 1 @ 14.7 kw



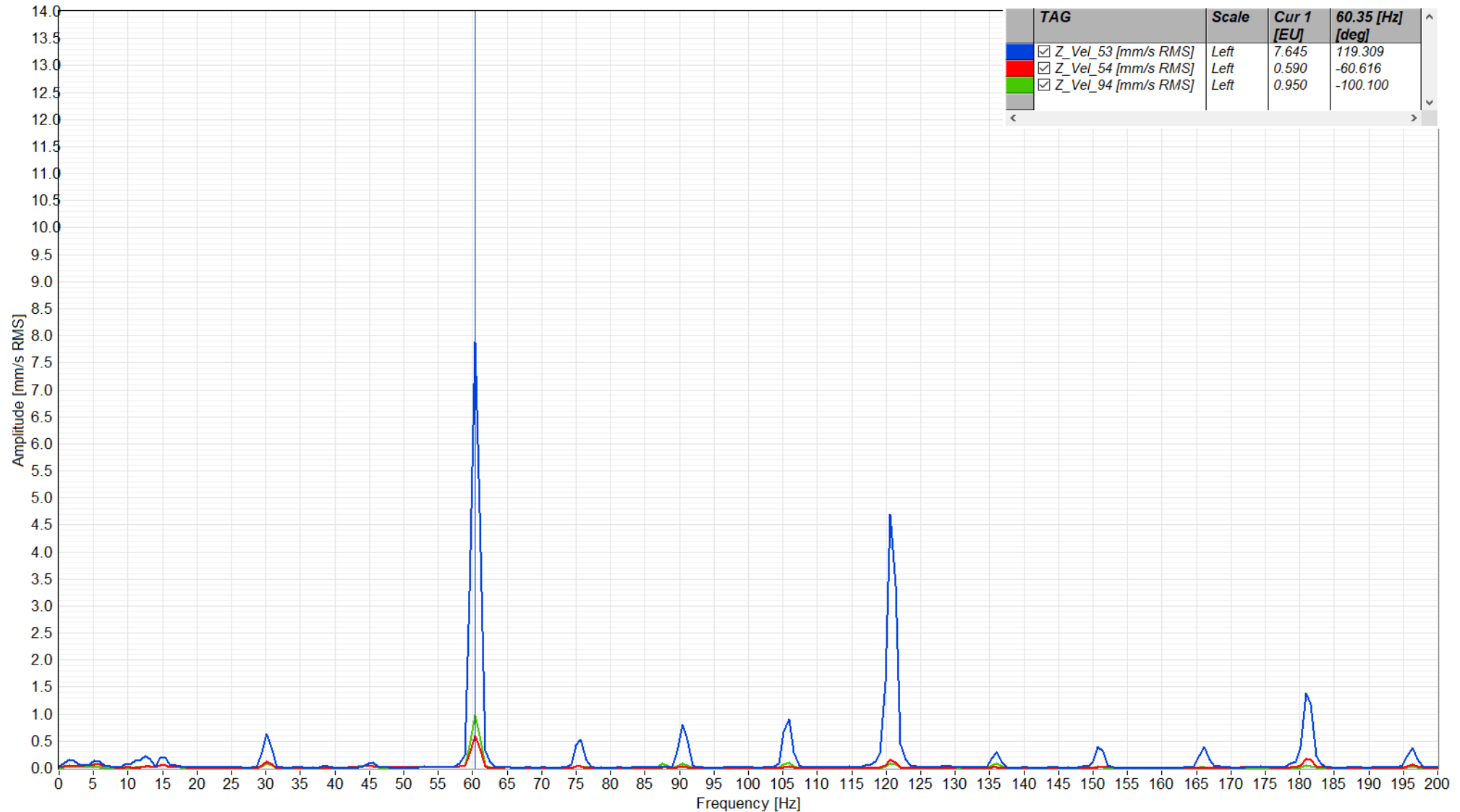
FFT Supporto 2 @ 14.7 kw



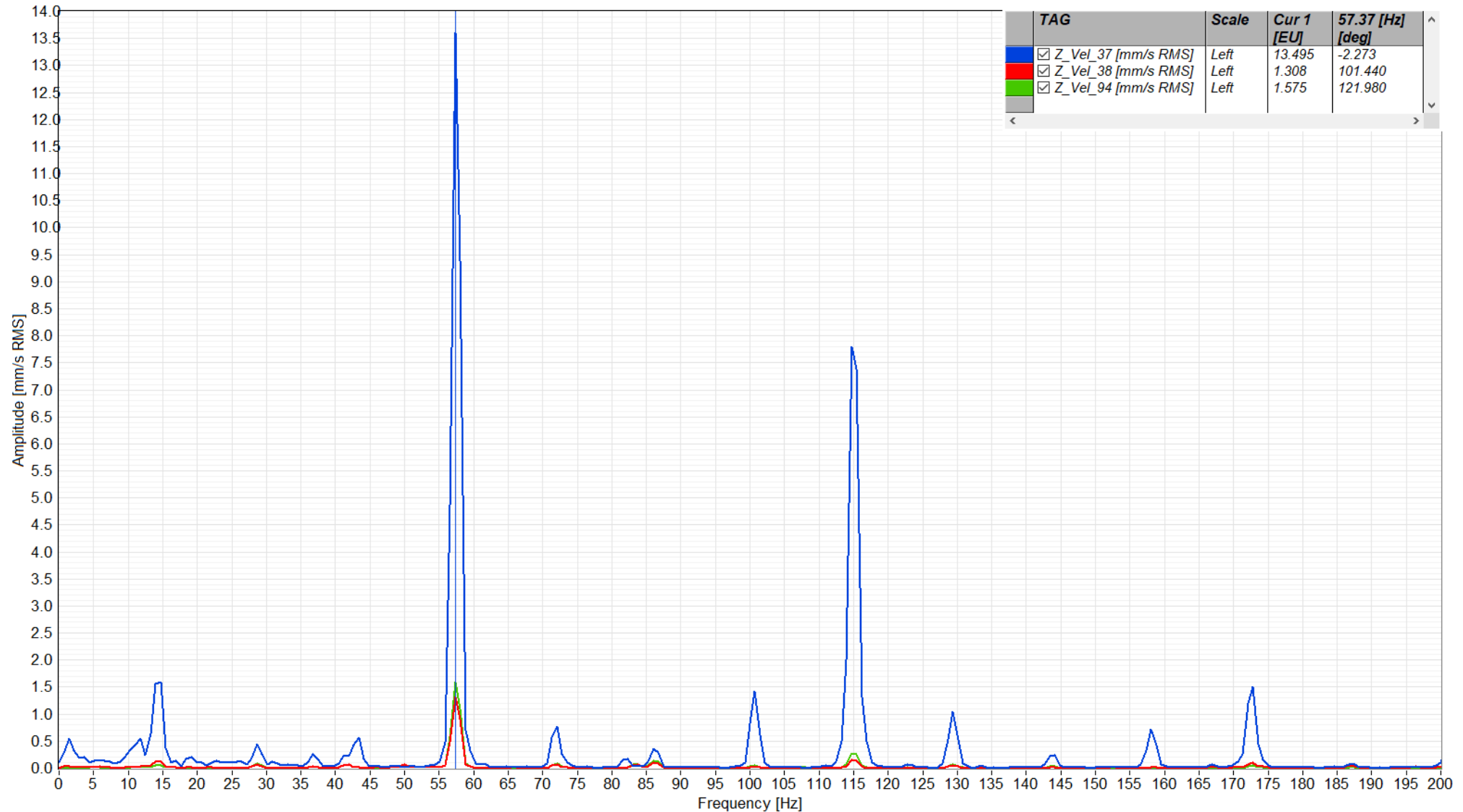
FFT Supporto 1 @ 19.2 kw



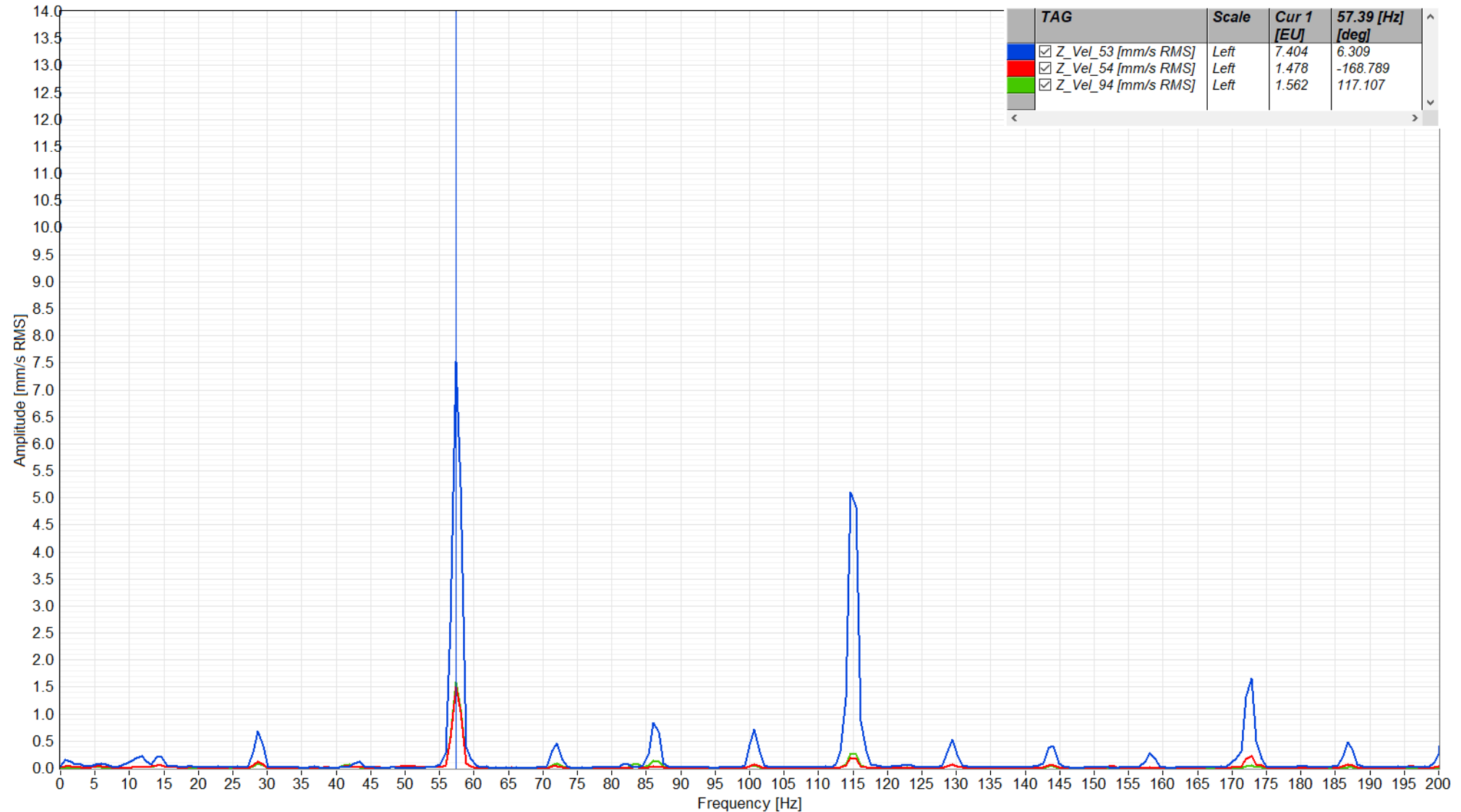
FFT Supporto 2 @ 19.2 kw



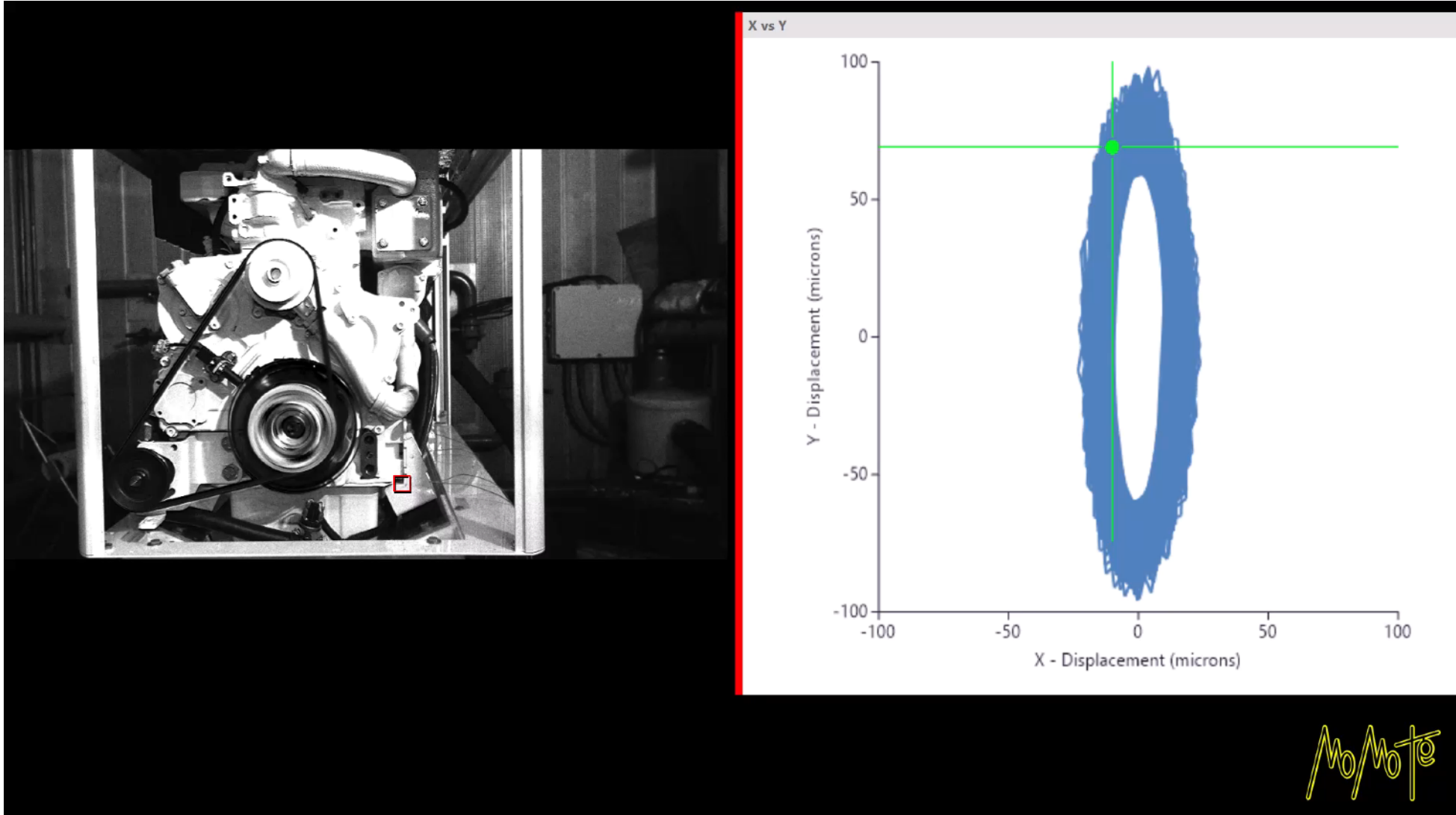
FFT Supporto 1 @ 22.2 kw



FFT Supporto 2 @ 22.2 kw

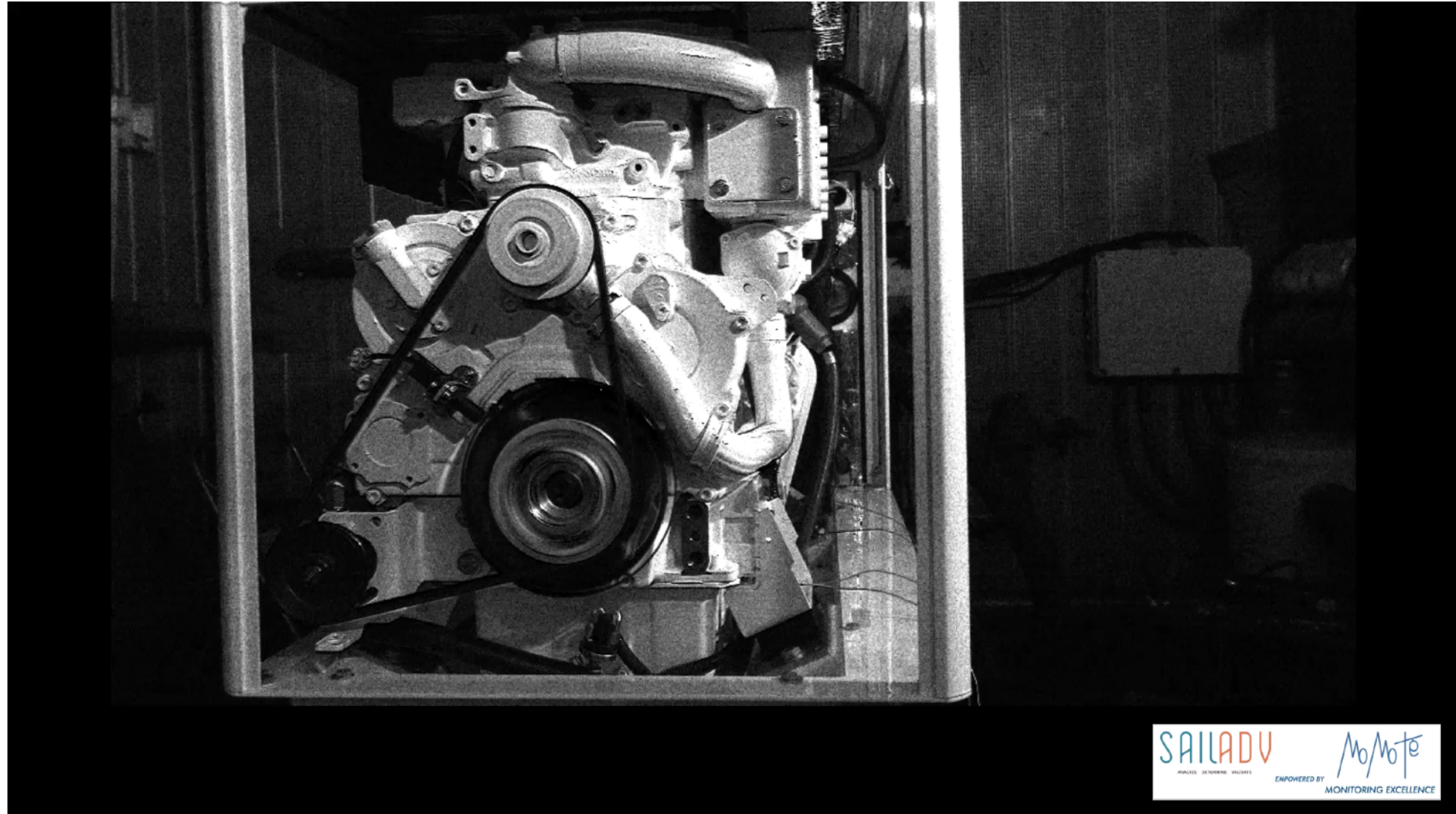


Frontal View @ IDLE

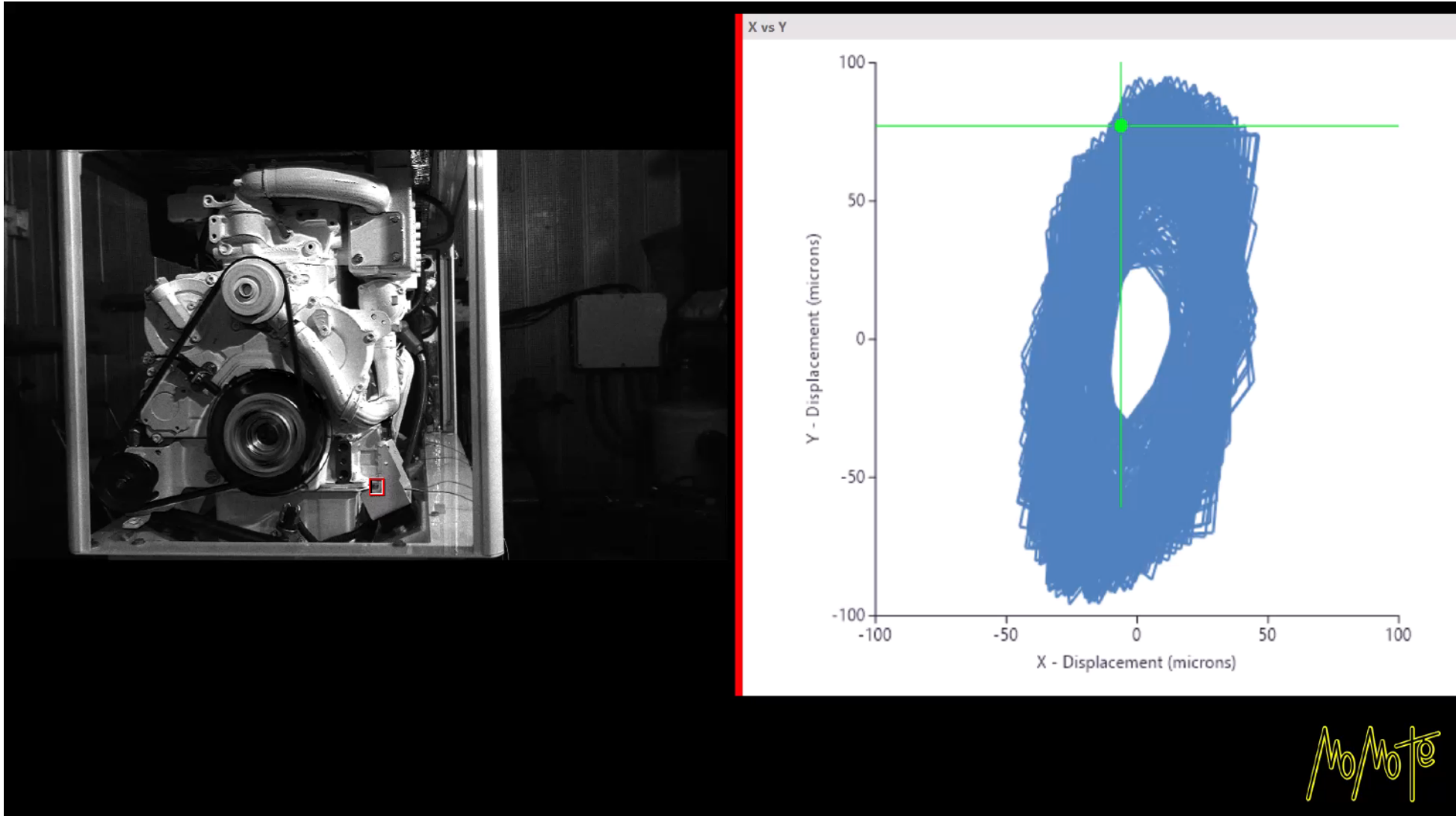


MoMote

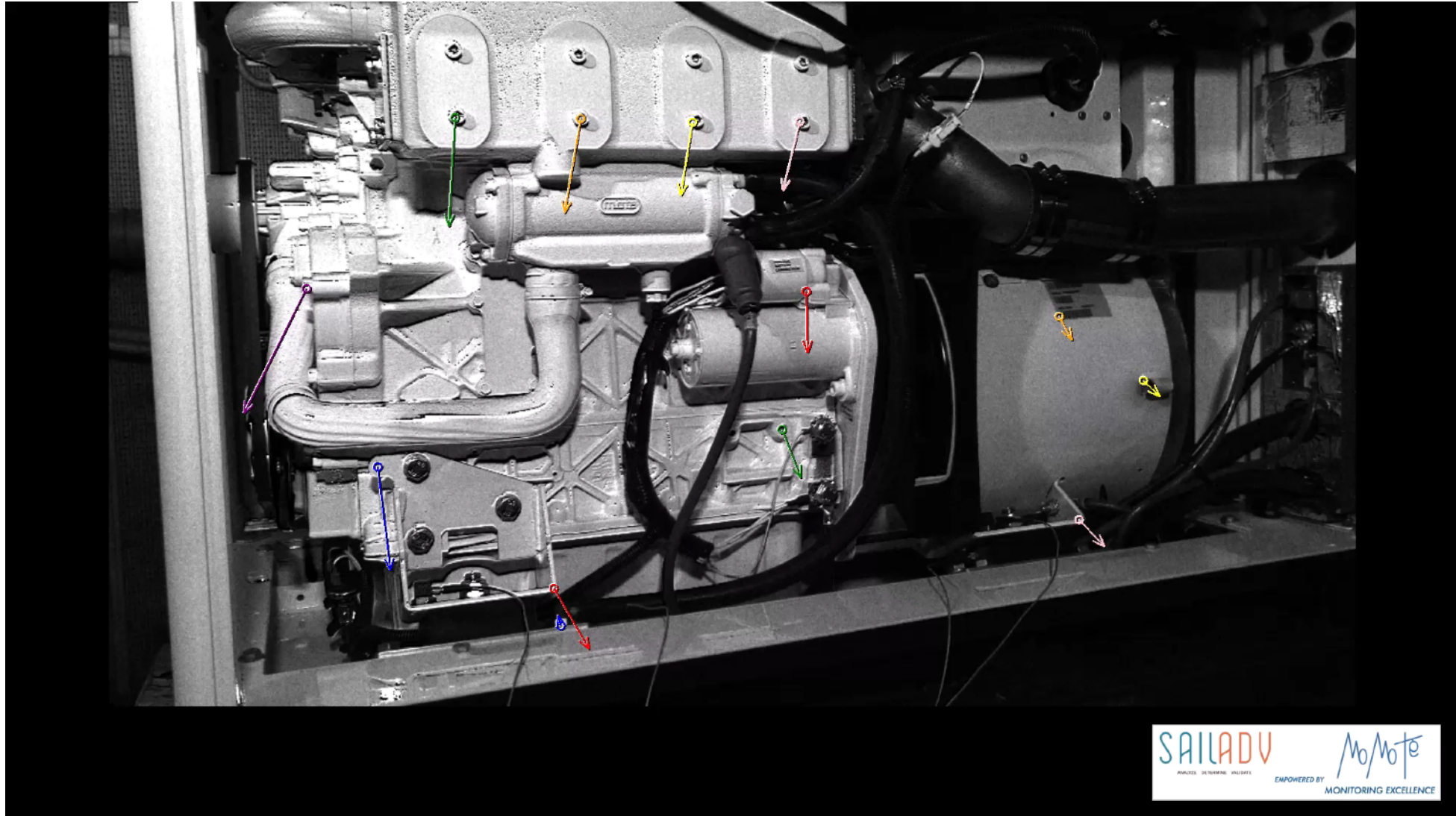
Frontal View @ 15 kw



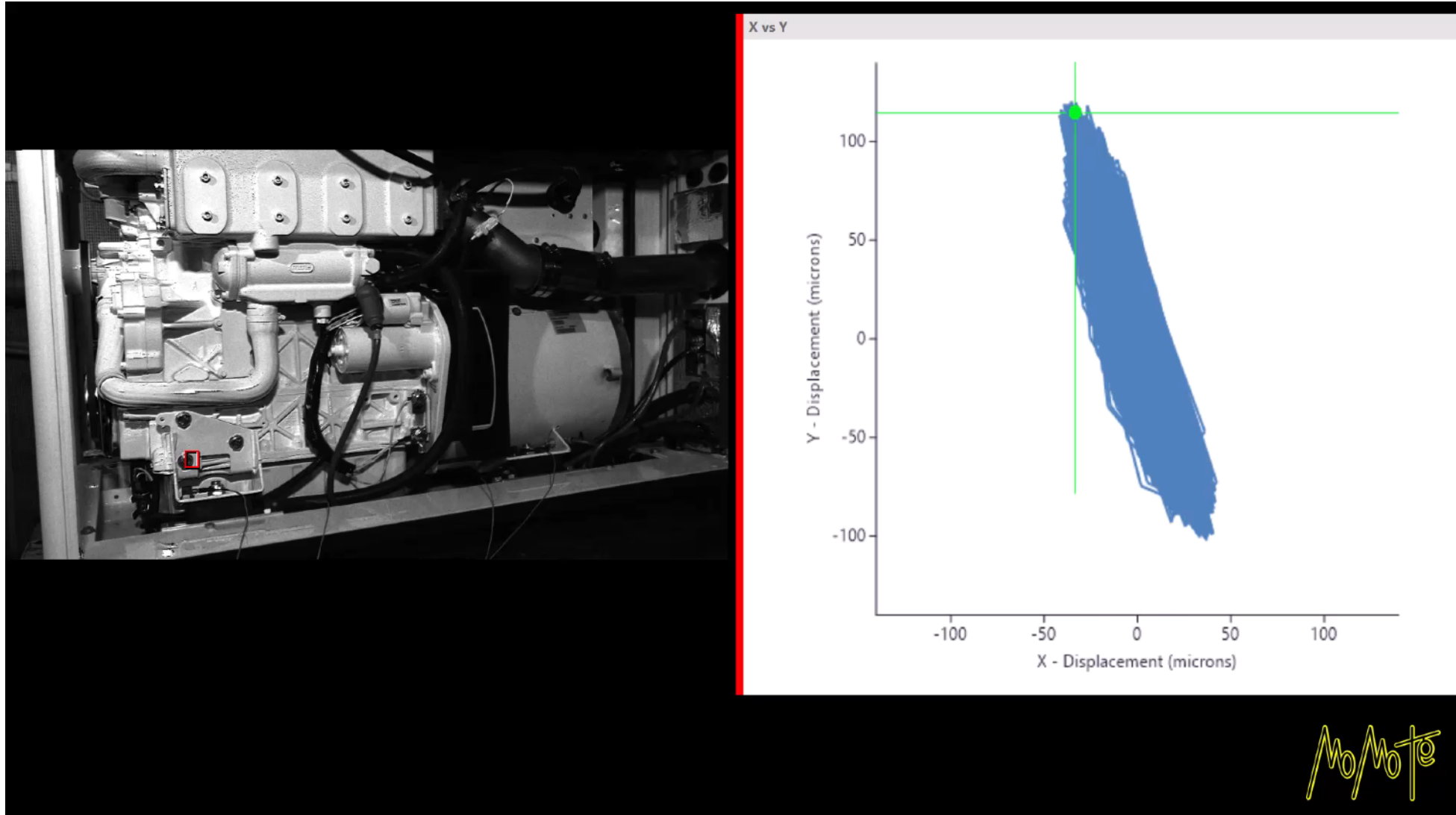
Frontal View @ 15 kw



Lateral View @ 15 kw



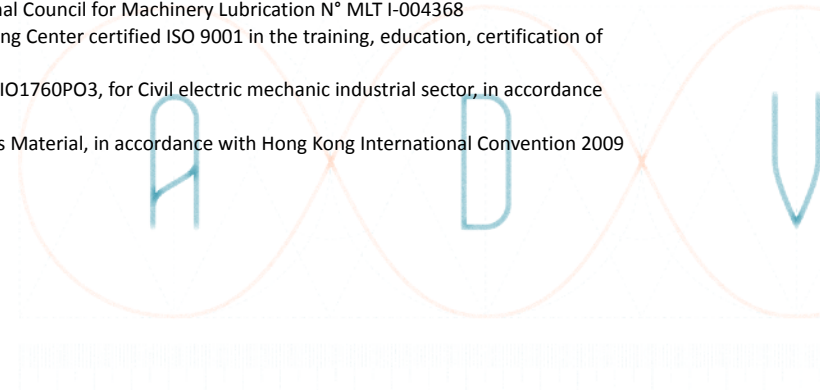
Lateral View @ 15 kw



Tecnici

Giovanni Palamà

- SNAME member
- Pisa CCIAA Register of Surveyors and Experts member n.399
- Strain Gauge Lev. 2, NDT Operator Certification N° 15FIO0333P01, for equipment, installations and facilities pre-service and in-service test, in accordance with the rule UNI EN ISO 9712: 2012, certified by RINA
- Vibration Analyst Technician Certification ISO 18436-2 Category II & ASNT Level II N° M-3363-01
- Machinery Lubrication Specialist Analyst Certification International Council for Machinery Lubrication N° MLT I-004368
- Thermography ITC Certification N° 2016IT21N003, Infrared Training Center certified ISO 9001 in the training, education, certification of professional users of thermal infrared systems
- Infrared Thermography Lev. 2, NDT Operator Certification N° 16FIO1760PO3, for Civil electric mechanic industrial sector, in accordance with the rule UNI EN ISO 9712:2012, certified by RINA
- Approved HazMat Expert Certification for Inventory of Hazardous Material, in accordance with Hong Kong International Convention 2009 and EU 1257/2013, certified by RINA



**MOBIUS INSTITUTE
BOARD OF CERTIFICATION**

certifies that

GIOVANNI PALAMÀ

has met the experience, training and examination requirements
for conformity to ISO 18436-2 as

VIBRATION ANALYST: CATEGORY II

ISO/IEC 17024 accredited in
accordance with ISO 18436-1

This certificate remains the property of
Mobius Institute Board of Certification.

www.mobiuscertification.org

Certification Number: M-3363-02
Date of Certification: 20 January 2014
Certification Renewal: 20 January 2019
Certification Expires: 20 January 2024


Jason Tranter, Founder, CEO
Mobius Institute Board of Certification



~ Calibration Certificate ~

Model Number: 394C06 Customer: _____
 Serial Number: LW17609 _____
 Description: Portable Handheld Shaker P.O.: _____
 Manufacturer: PCB Method: Back-to-Back Comparison (AT701-1)

Calibration Data

Operating Frequency: 159.2 Hz. Test Point Voltage: 100.2 mVAC
 Acceleration Level: 1.01 g's rms
9.895 m/s²
 Temperature: 76 °F (25 °C) Relative Humidity: 45 %

Condition of Unit

As Found: In Tolerance
 As Left: In Tolerance

Notes

1. Calibration is N.I.S.T. Traceable through Project 684(O-000000851) and PTB Traceable through Project 17016.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 10012-1, ANSI/NCSL Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for amplitude at operating frequency is +/-1.6%.

Equipment Used For Calibration

Manufacturer	Description	Model#	Serial No.	Cal Date	Due Date
PCB Piezotronics	Power Supply	480C02	CA380	11/8/2020	11/5/2021
National Instruments	Acquisition	PCI-6052E	NC015	3/10/2020	3/10/2021
PCB Piezotronics	Accelerometer	Y353B34	CA654	3/23/2020	3/23/2021

Technician: Fahad Muzahid FM Date: 02/24/21

Due Date: _____



3425 Walden Avenue
 Depew, New York 14043
 TEL: 888-684-0013 FAX: 716-685-3886 www.pcb.com hh1 2021142102.61

#1

CERTIFICAZIONI



Mobius Institute
Vibration Analyst Level II



Rina Certification
Strain Guage - UNI ISO 9712



Rina Certification
Infrared Thermographia - UNI ISO 9712



Lloyd's Register
Factual Statement Certification for H-BOX
Product



**International Council Machinery
Lubrication**
Certified Level I Machinery Lubrification
Technician



Infrared Training Center
Certified Level I Thermographer