

Elevator Ride Quality

Definition & Measurement

An International Approach

EVA-625

PMT

***High Accuracy Instrumentation
for the Vertical Transportation***

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PMT

Why Measure Ride Quality?

- Evaluate Elevator Ride Comfort
- Improve Quality of:
 - Design
 - Installation
 - Maintenance
- Diagnosis (Trouble Shooting)
 - Reduce Time (Costs)

What Was Ride Quality?

- Qualitative
 - Method
 - Ride, Feel, Listen
 - Analysis
 - Compare Against Experience
- Flaws
 - Non-Repeatable/Non-Calibrated/Psychological

What is Ride Quality Now?

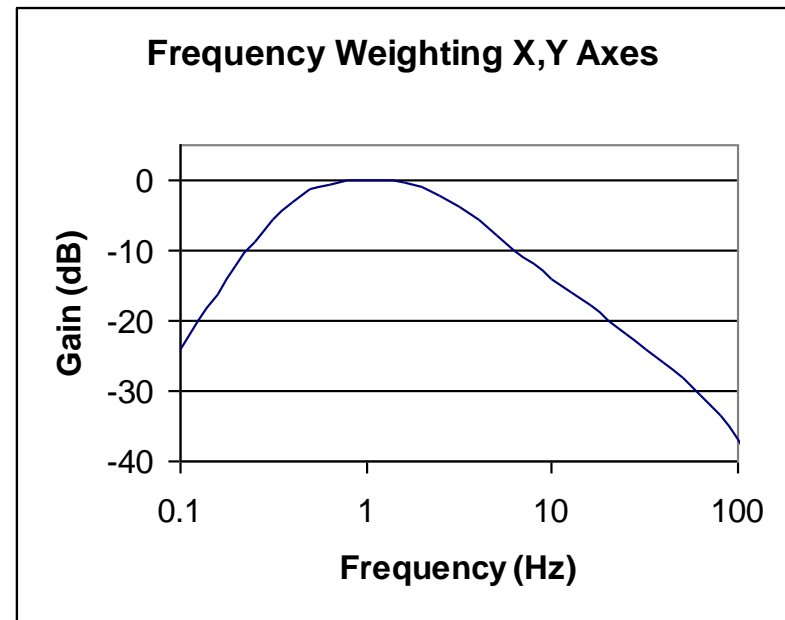
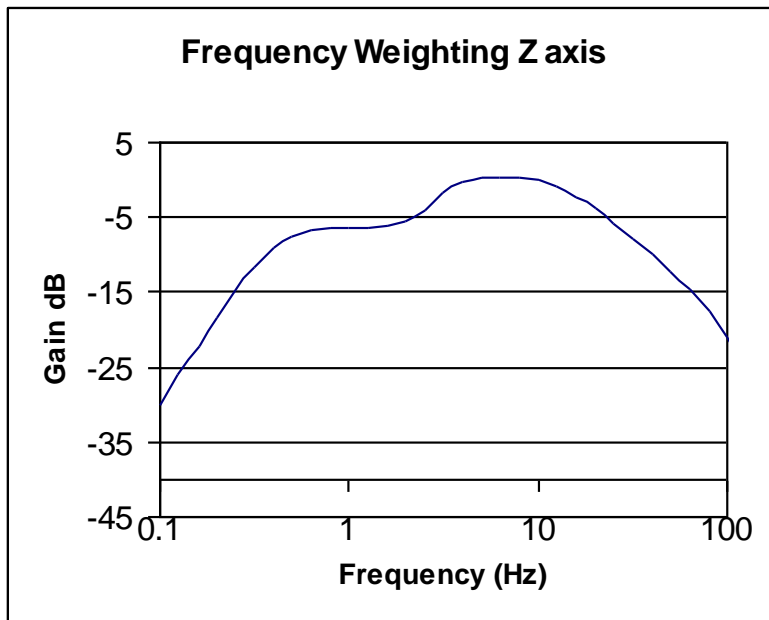
- Quantitative Measurement of Vibration (Motion) & Sound
 - Standardized Human Perception
- Measured in Standard Way
 - Standard Measurement Technique
 - Standard Processing Technique

New Standard

ISO/DIS 18738

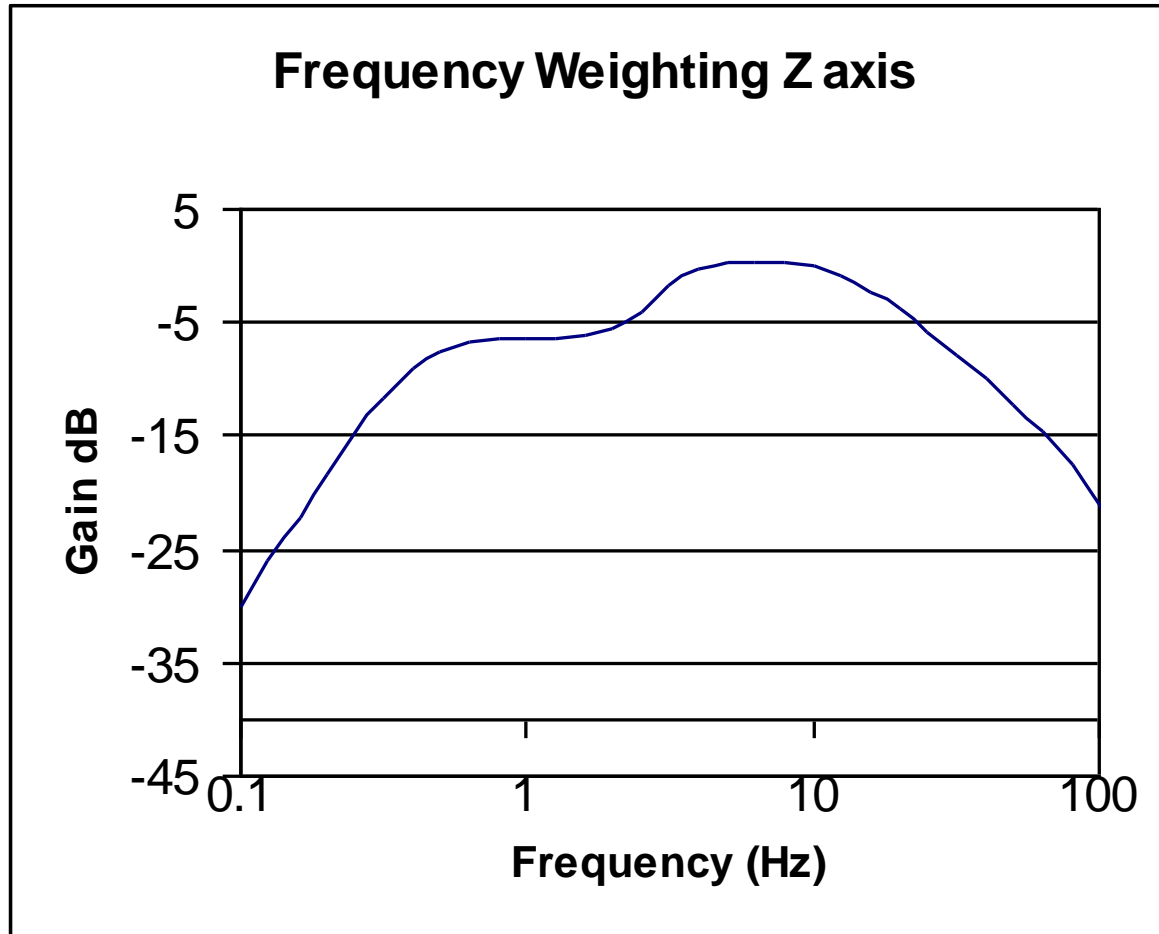
- Draws From
 - ISO2631
 - Human Response to Vibration
 - ISO8041
 - Instrumentation (ISO2631)
 - IEC651
 - Sound Level Measurement
 - Elevator Industry Experience

ISO2631/ISO8041

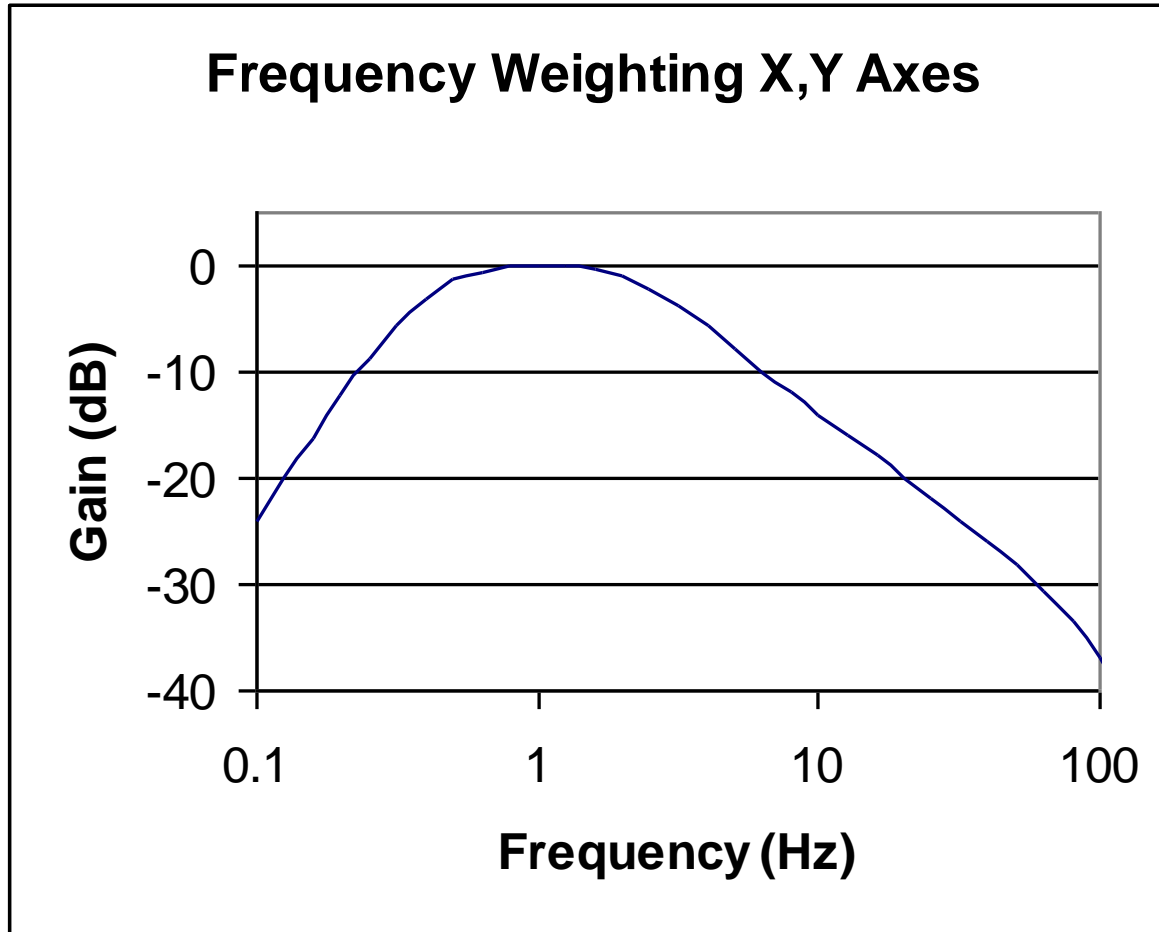


Human Response to Vibration 'ISO Filter'

ISO2631/ISO8041 Vertical Axis



ISO2631/ISO8041 Horizontal Axes



ISO/DIS 18738

- Defines Terminology
- Defines Field Measurement Method
- Defines Processing Techniques
- Defines Reporting

Units of Measure

Vibration Standard: m/s^2

Typical: milli(g)s, gals

Acceleration Standard: m/s^2

Velocity Standard: m/s

Distance Standard: m

Jerk Standard: m/s^3

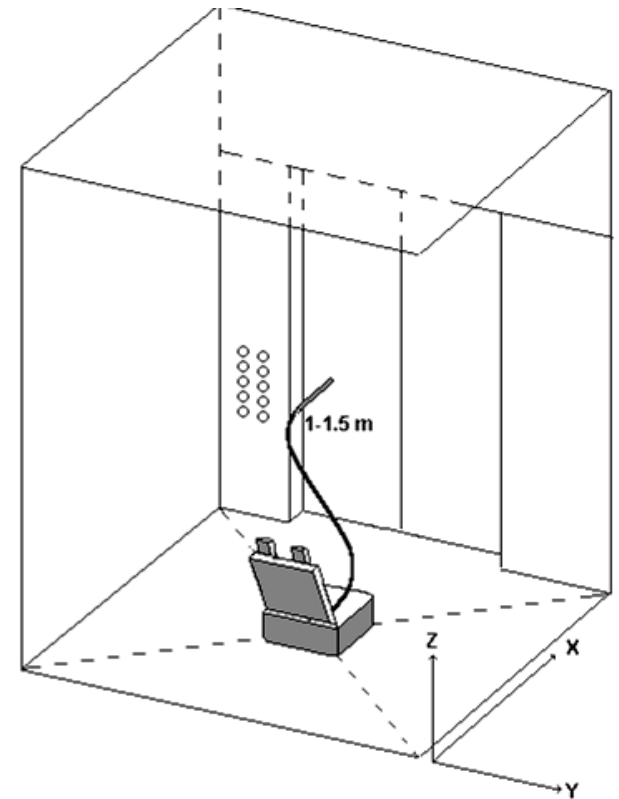
Sound Standard: dBA (decibels)

$$9.81 \text{ m/s}^2 = 1 \text{ g} = 1000 \text{ milli(g)s} \quad 1 \text{ g} = 981 \text{ gals}$$

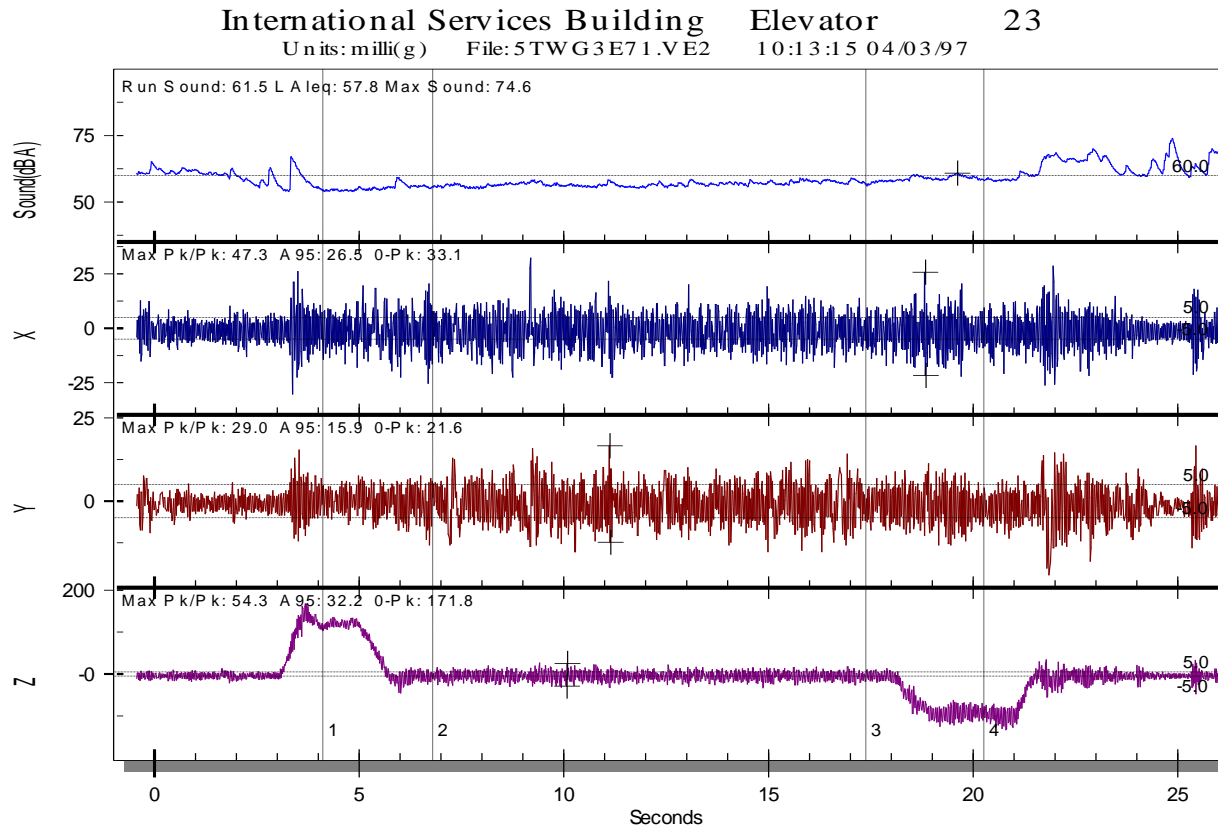
$$1 \text{ milli(g)} \cong 1 \text{ gal}$$

Field Measurement Method

- Ancillary Equipment Off
- Center of Car
- X Axis to Door, Z Vertical
- Microphone at 1 - 1.6 meters
- Agreed Upon Time of Day
- 2 People (Maximum) in Lift
- Measure Terminus to Terminus
- Begin Recording Before Doors Close
- Finish After Doors Open



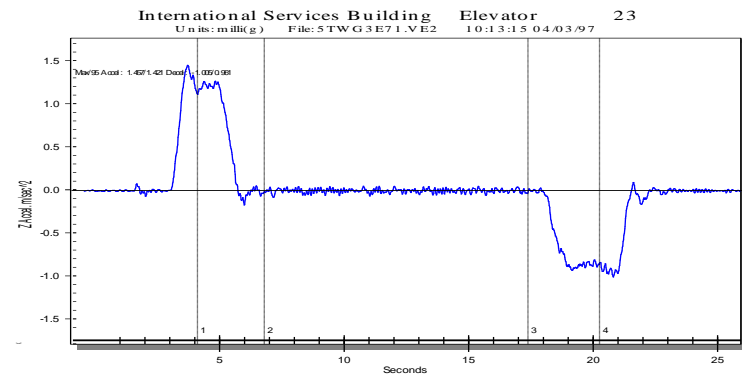
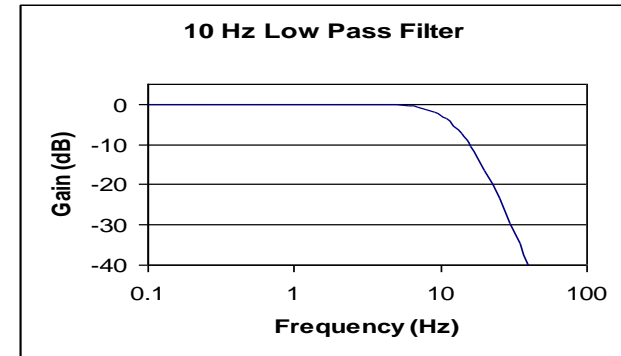
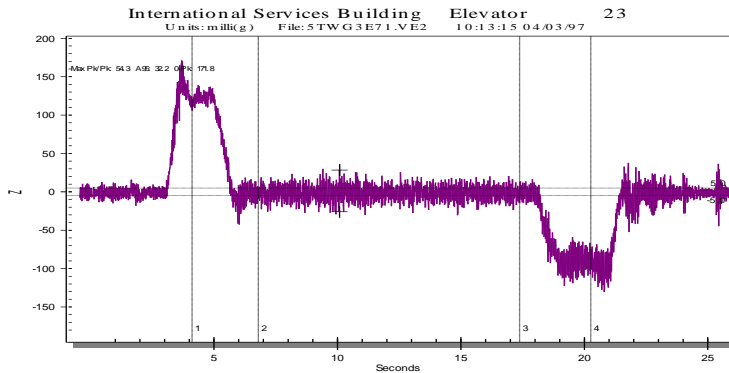
Collected Data (Unfiltered)



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Performance (Acceleration)



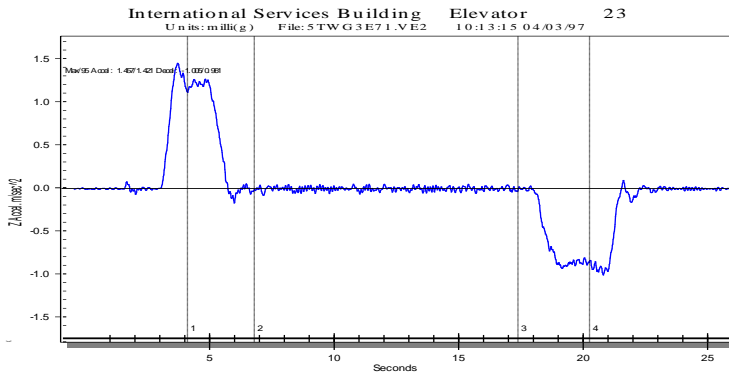
Report

- Maximum Acceleration
- A95 Acceleration
- Maximum Deceleration
- A95 Deceleration

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Performance (Velocity)

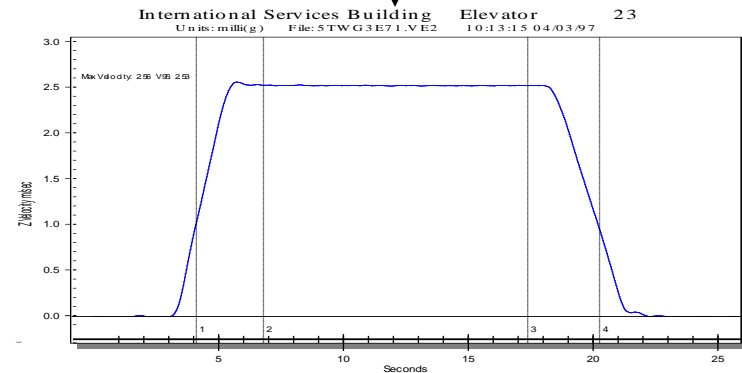


Report

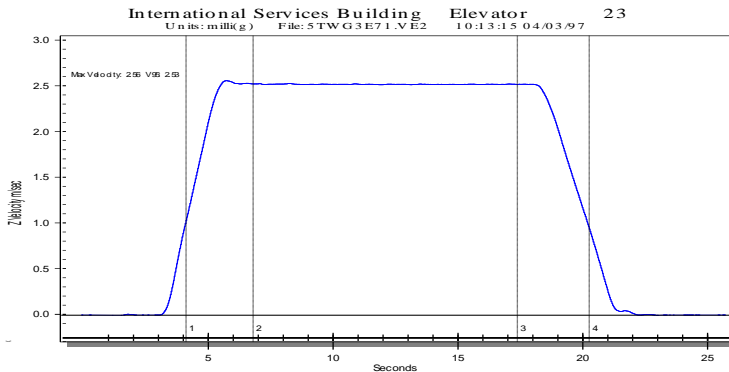
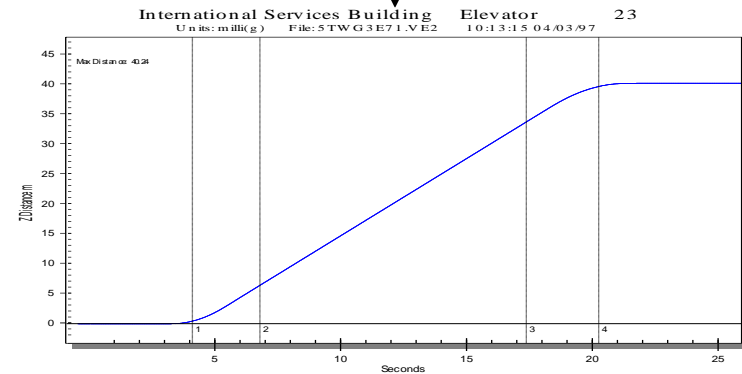
- Maximum Velocity
- V95 Velocity



Σ



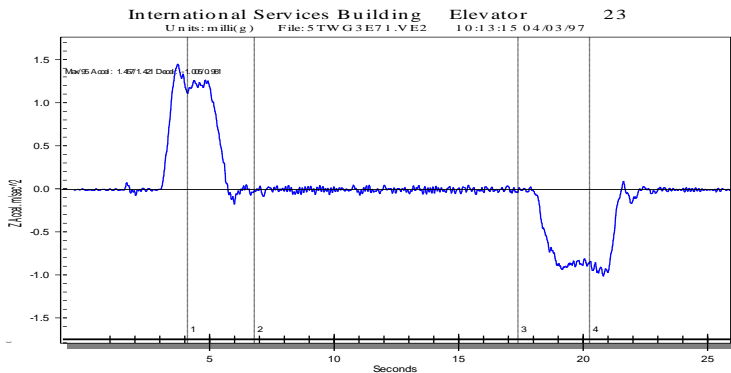
Performance (Distance)

 Σ 

Report

- No Reporting Requirement
- Used in Boundary Calculation
- Used for Diagnosis

Performance (Jerk)

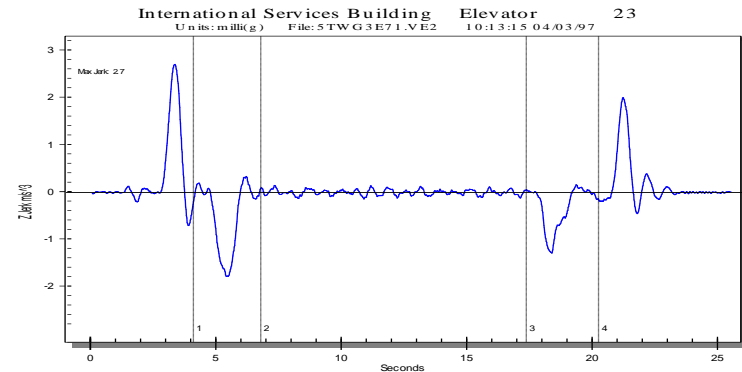


Report

- **Maximum Jerk**



**Running Slope
(Least Squares)**

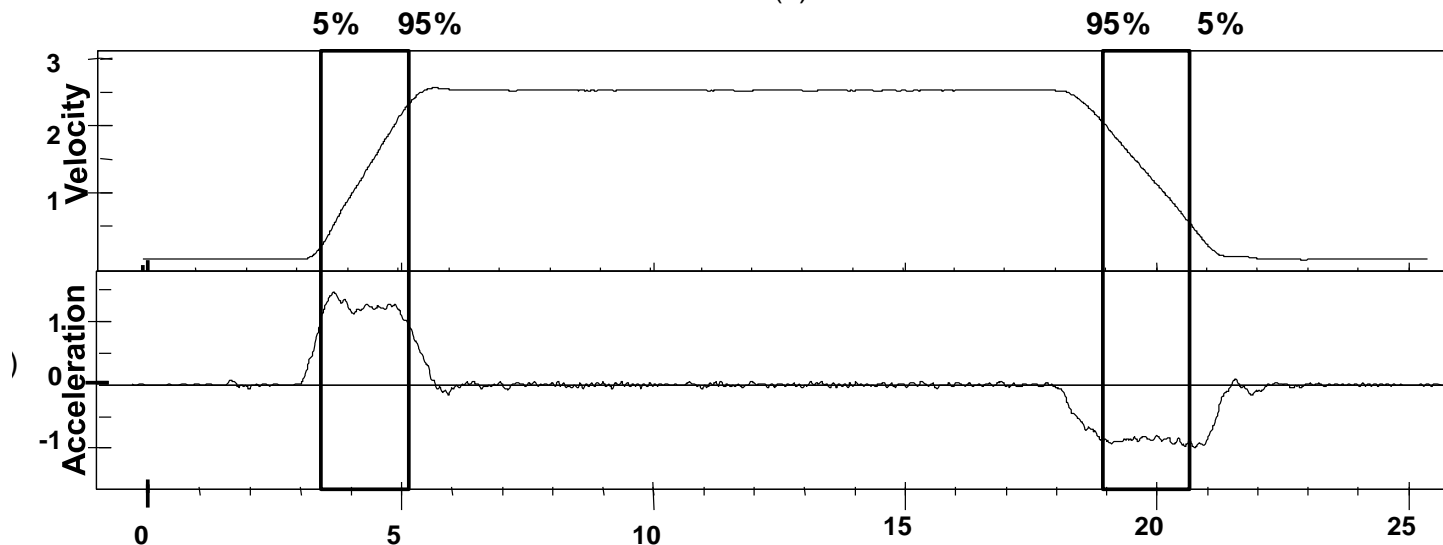


Performance Measurements

Acceleration/Deceleration Measurements:

Maximum: Greatest Acceleration Found Between 5% and 95% of Full Speed (Increasing) for Acceleration And Between 95% and 5% (decreasing) for Deceleration

A95: Typical Acceleration (Acceleration that 95% of all acceleration values are less than or equal to) Found Between 5% and 95% of Full Speed (Increasing) or between 95% and 5% of Full Speed (decreasing)



**High Accuracy Instrumentation
for the Vertical Transportation
Industry**

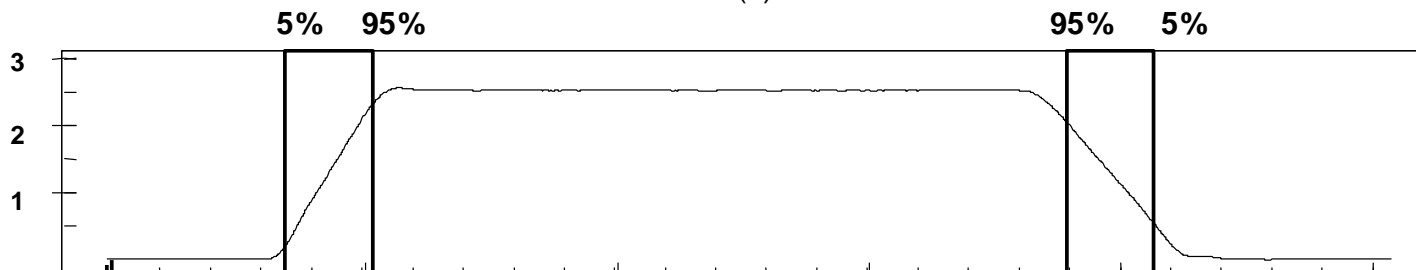
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Performance Measurements

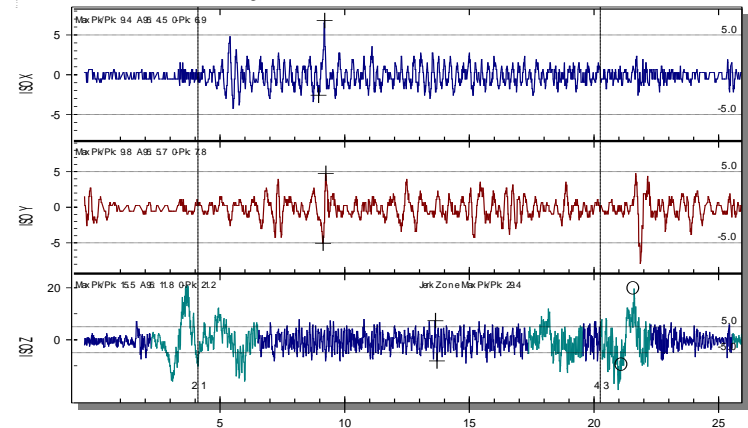
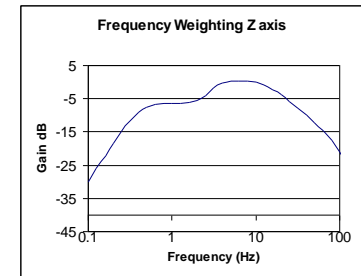
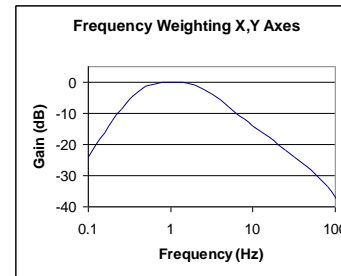
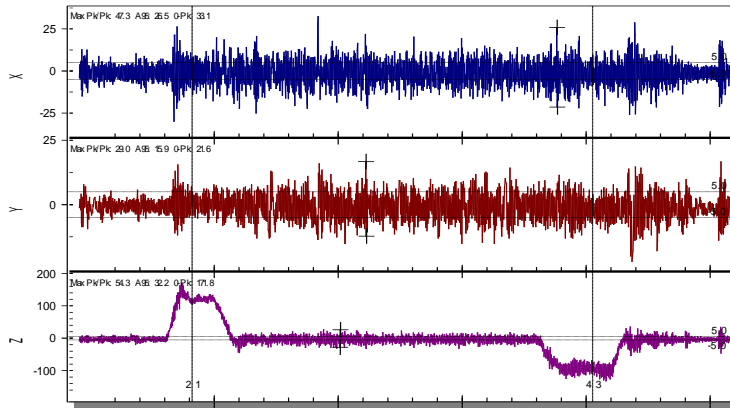
Velocity Measurements:

Maximum: Greatest Velocity Found 95% of Full Speed (Increasing) And 95% of Full Speed (decreasing)

V95: Typical Velocity (Velocity that is 95% of all acceleration values are less than or equal to) Found Between 95% of Full Speed (Increasing) and 95% of Full Speed (decreasing)



Vibration Measurements Ride Quality



Unfiltered (Raw) Data is Weighted
(filtered) According to ISO8041-1999
and Evaluated for Vibration Levels
(Maximum & A95)

Evaluating Vibration Level

- **Vibration Level Characterized:**

- **Maximum Adjacent Peak to Peak Vibration (Max Pk/Pk) for Each Axis**

- **Typical Vibration (A95) for Each Axis**

- **Vibration Evaluated Within Specific Boundaries**

- **For X,Y Axes (Horizontal)**

- **Max Pk/Pk & A95 Evaluated Between 0.5m From Lift Start Position to 0.5m From Final Position**

- **For Z Axis (Vertical)**

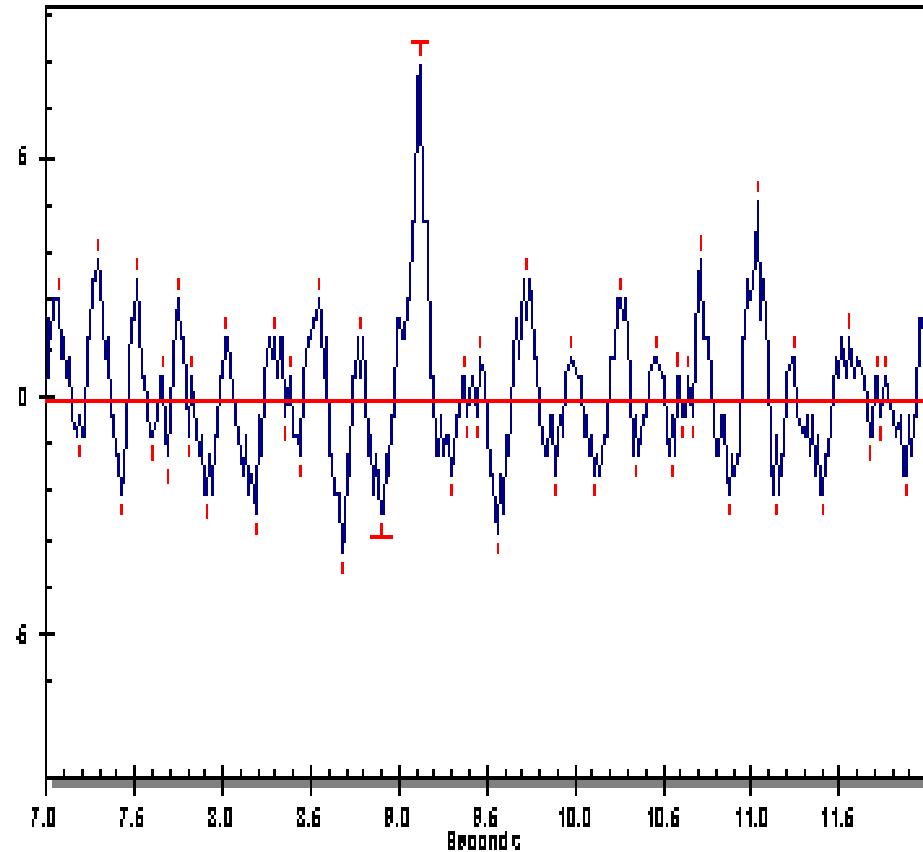
- **Max Pk/Pk & A95 Evaluated Between 0.5m From Lift Start Position to 0.5m From Final Position: Jerk $\leq 0.3 \text{ m/s}^3$ (non-Jerk Zone)**

- **Max Pk/Pk Evaluated Between 0.5m From Lift Start Position to 0.5m From Final Position: Jerk $< 0.3 \text{ m/s}^3$ (Jerk Zone)**

Evaluating Vibration Level

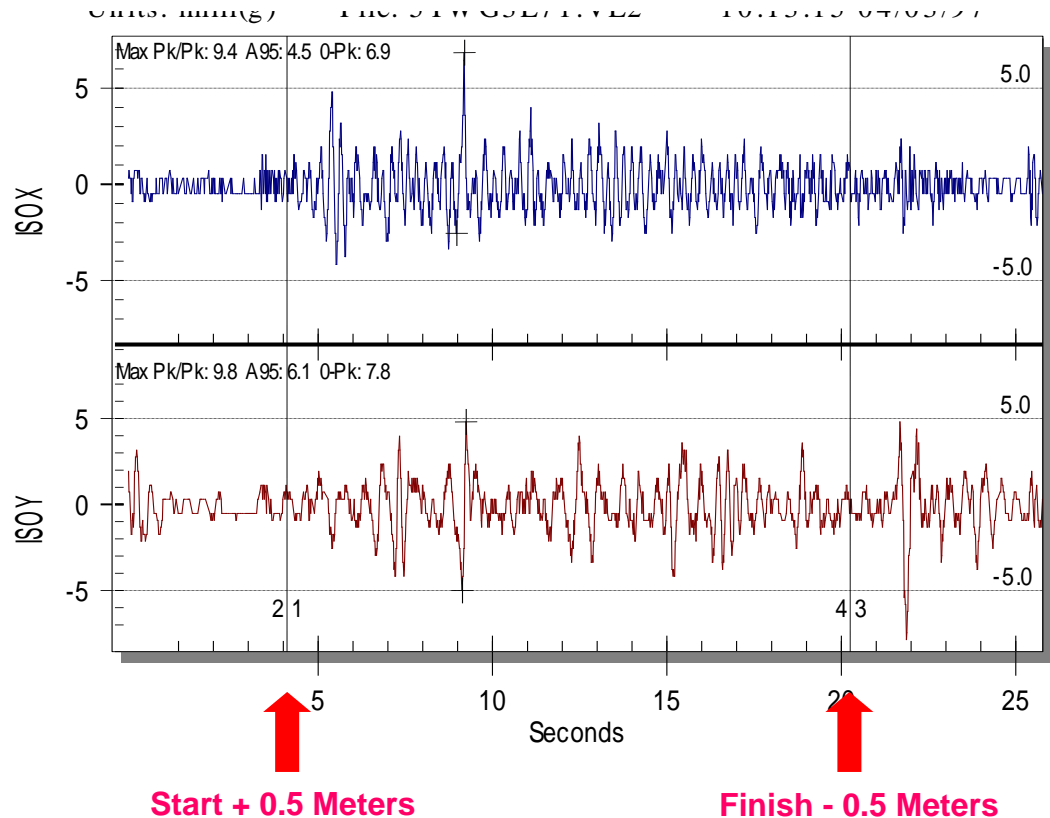
Adjacent Peak to Peak:
Local Maximum Values of
Opposite Sign, Separated by
Single Zero Crossing

A95 Peak to Peak: The Peak
to Peak Level That is Greater
Than or Equal To, 95% of All
of the Peak to Peak
Measurements Within A Data
Set



Evaluating Vibration Level Boundaries of Measurement

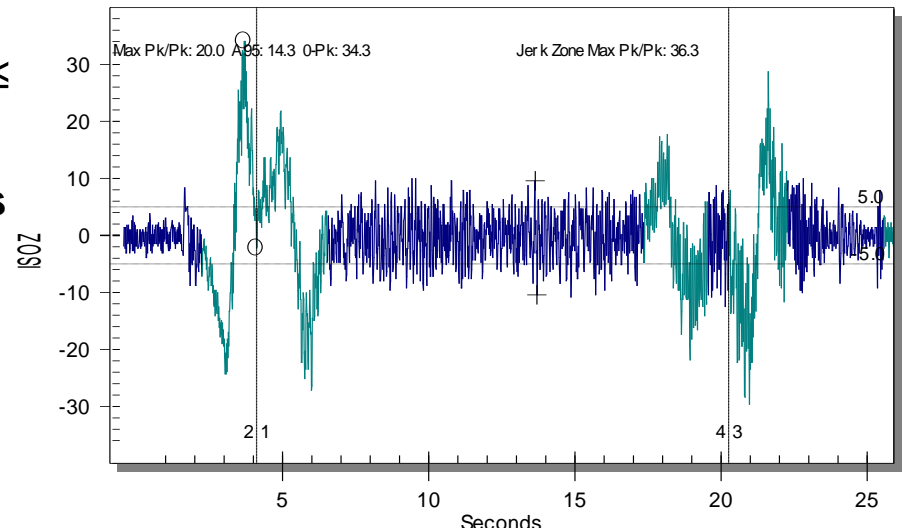
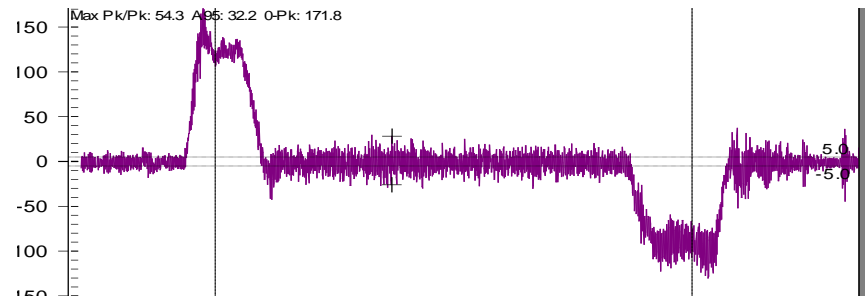
X,Y Axes (Horizontal)
Maximum Peak to Peak and A95 Vibration is Evaluated Between the Point at Which the Lift Has Moved 0.5 Meters From its Start Position to the Point at Which the Lift Has Moved to Within 0.5 Meters From its Final Position



Evaluating Vibration Level Boundaries of Measurement

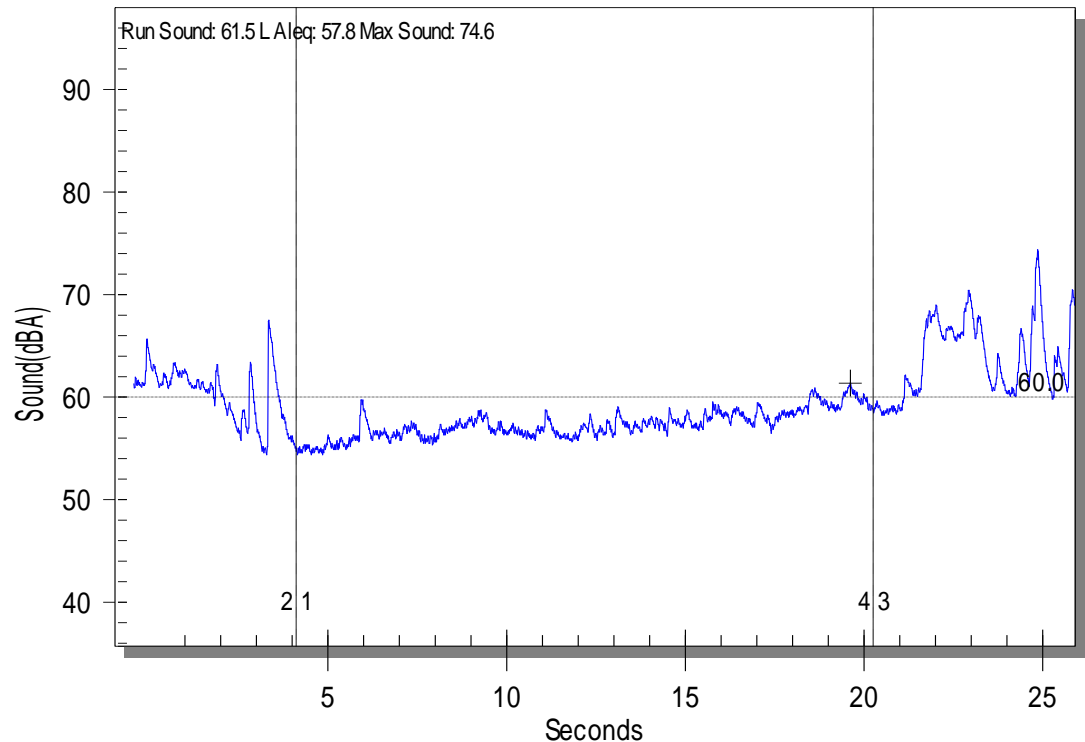
Z Axis (Vertical) Maximum Peak to Peak and A95 Vibration is Evaluated Between the Point at Which the Lift Has Moved 0.5 Meters From its Start Position to the Point at Which the Lift Has Moved to Within 0.5 Meters From its Final Position AND Where Jerk $\leq 0.3 \text{ m/s}^3$

Maximum Peak to Peak Vibration is Evaluated Where Jerk $> 0.3 \text{ m/s}^3$ and is Reported as Jerk Zone Maximum Pk/Pk



Evaluating Sound Level

Sound Level: Maximum A-Weighted, Fast Response, and L Aeq Sound Level is Evaluated & Reported Between the Point at Which the Lift Has Moved 0.5 Meters From its Start Position to the Point at Which the Lift Has Moved to Within 0.5 Meters From its Final Position



Ride Quality Reporting

Measurements

ISO Ride Quality (milli(g))*	X	Y	Z	Jerk Zone
Max Pk to Pk	9.4	9.8	15.5	29.4
A95	4.5	5.7	11.8	15.5

*ISO Whole Body X,Y,Z 1990

Sound Level dB(A)	Full Run	Pre-Run	Post-Run	Full Record
Max	61.5	67.7	74.6	74.6
L Aleq	57.8	61.2	65.8	61.5

Performance	Max	95	Average
Velocity (m/sec)	2.56	2.53	
Jerk (m/s ³)	2.7		
Acceleration (m/sec ²)	1.457	1.421	1.184
Deceleration (m/sec ²)	1.005	0.961	0.844
Distance Travelled (m)	40.24		

Analysis	Measured	Limit	% Limit
Max Horizontal Vib. ISO (milli(g))	9.8	10.0	97.96
Max Vertical Vib. ISO (milli(g))	15.5	10.0	155.10
Max Jerk (m/s ³)	2.7	2.8	99.0
Max Velocity (m/sec)	2.56	2.50	102.56
Max Acceleration (m/sec ²)	1.457	1.500	97.132
Max Sound Level dB(A)	61.5	60.0	+1.5 dB