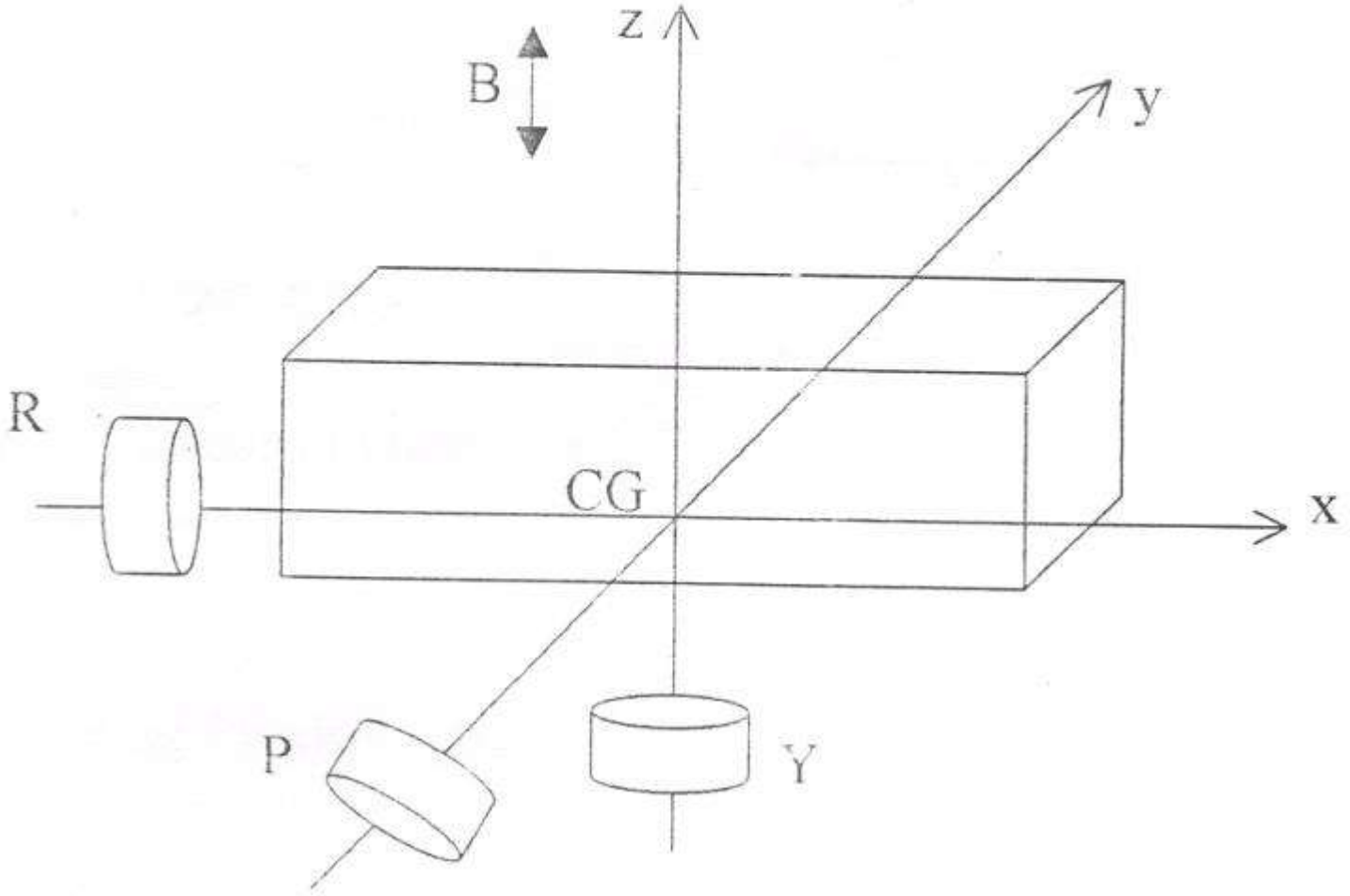
Testing of Coaching Stock

Need for Testing New Stock

- **Safe new design**
- Get natural frequency in various modes
- **Ensure level of comfort**
- Statutory requirements as per Policy Circular No 6 of Rly. Bd.

Modes of Oscillation



Policy Circular No 6

- No.92/CEDO/SR/4/0 dated 23/12/1999 issued by Member(Engg), Rly.Bd.
- Contains rules for certification of maximum permissible speeds for rolling stock
- Rly.Bd. is safety controlling authority for Indian Railways under Indian Railways Act
- Responsibility delegated to RDSO
  - Determine & recommend max permissible speed for new design rolling stock

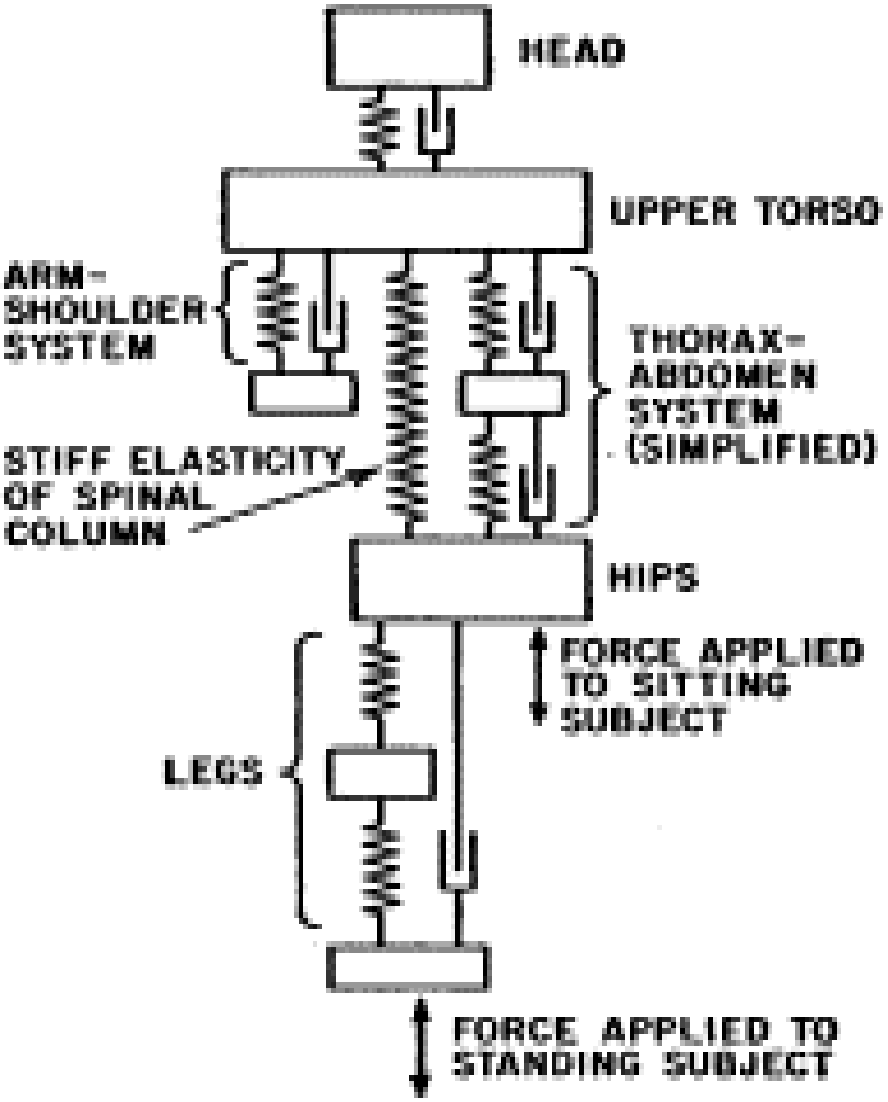
Policy Circular No 6(contd.)

- Definition of new rolling stock
  - Different principal dimensions
  - Different bogie design
  - New braking system
  - Change in axle load, track loading density, unsprung mass
  - Minor changes in design,internal layout(with sanction of CRS) only if leading to significant change in
    - C.G.,Weight distribution, ride behaviour

Types of trials

- Detailed oscillation trials
- EBD(speed >110 for passenger & 75 for goods) & Coupler force trials of trains
- Confirmatory oscillograph car run on tracks above 110Kmph
- Route Proving run between 105-110 Kmph by zonal Rly using portable accelerometers
  - Accel <.3 g or <.25 peaks/km for .3g < accel < .35g

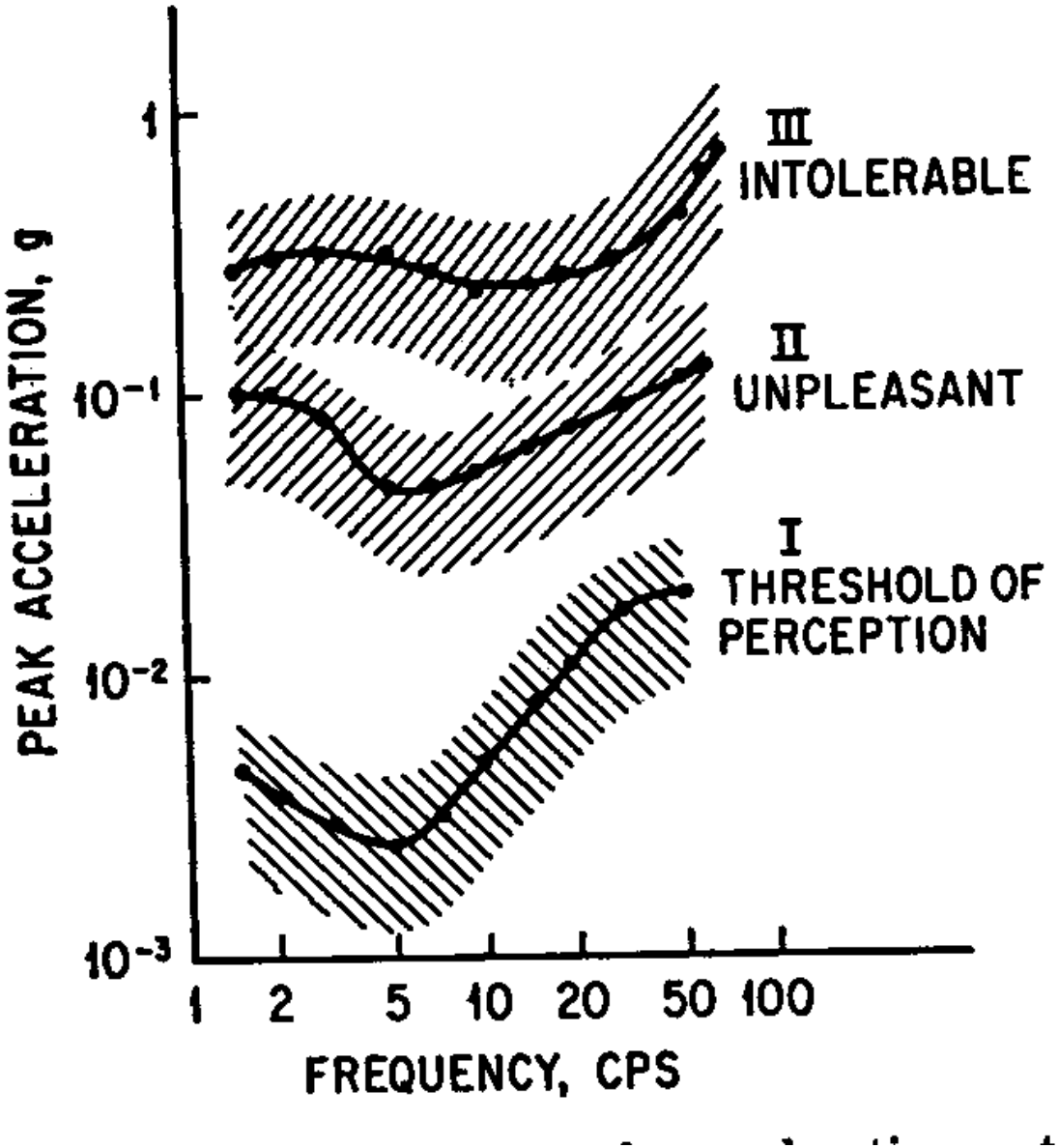
Effect of Vibration on Human Body


HEAD
UPPER TORSO
ARM-
SHOULDER
SYSTEM
THORAX-
ABDOMEN
SYSTEM
(SIMPLIFIED)
STIFF ELASTICITY
OF SPINAL
COLUMN
HIPS
FORCE APPLIED
TO SITTING
SUBJECT
LEGS
FORCE APPLIED TO
STANDING SUBJECT

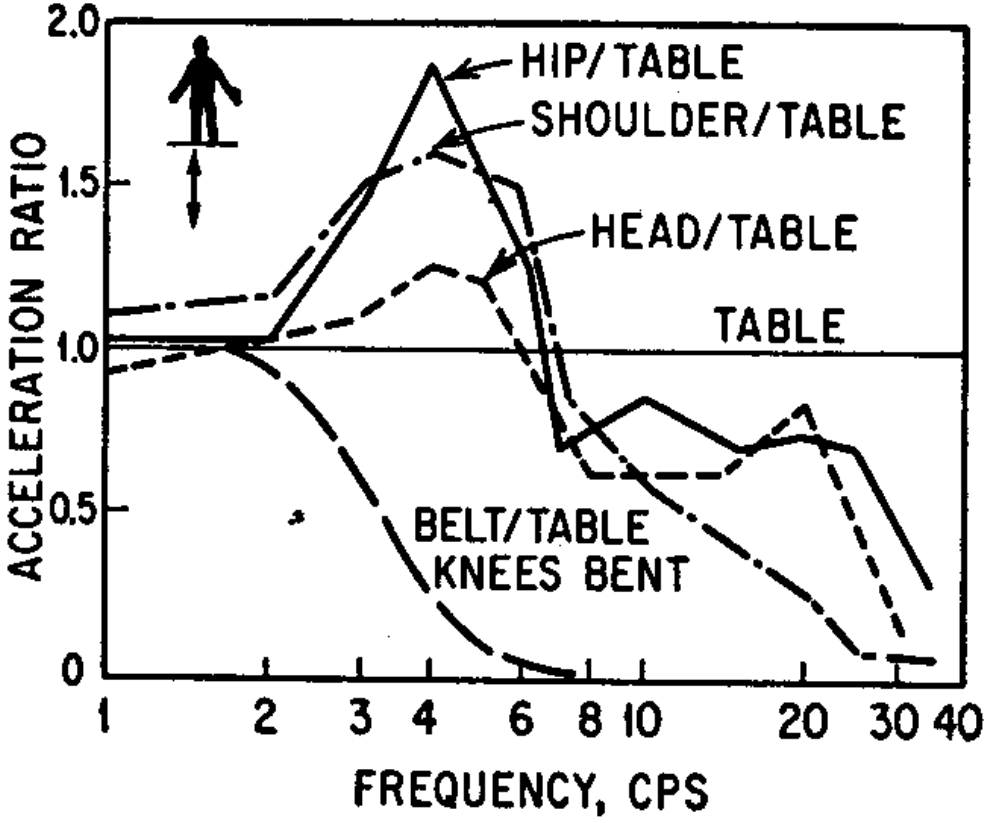
Effect of Vibration on Human Body

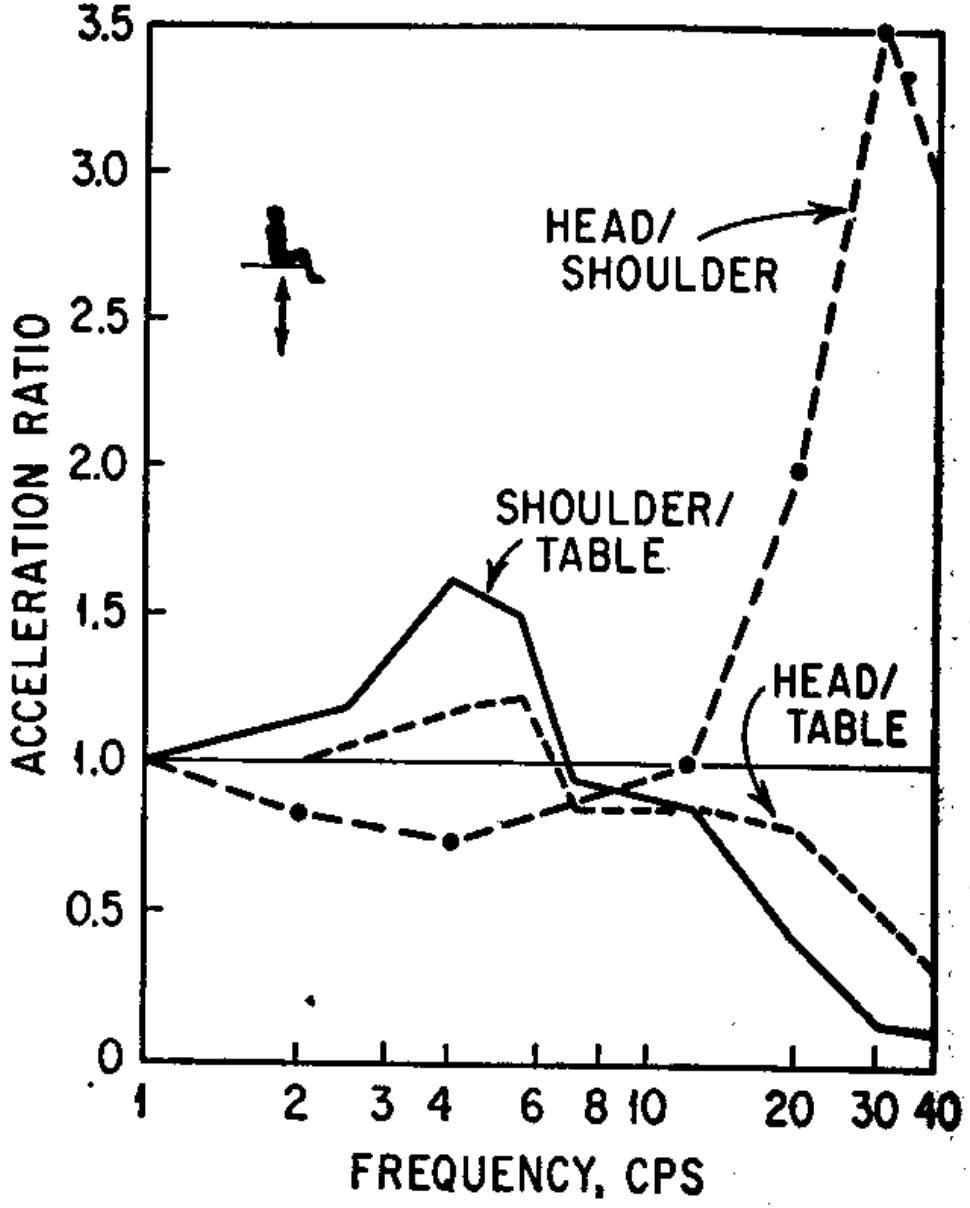
- Impulse/Shock in collisions
- Short term exposure
  - Unpleasant Sensation
  - Can withstand higher amplitudes
- Long duration exposure
  - Leads to fatigue after some time
- Function of Frequency, amplitude and posture

Effect of short duration vibrations

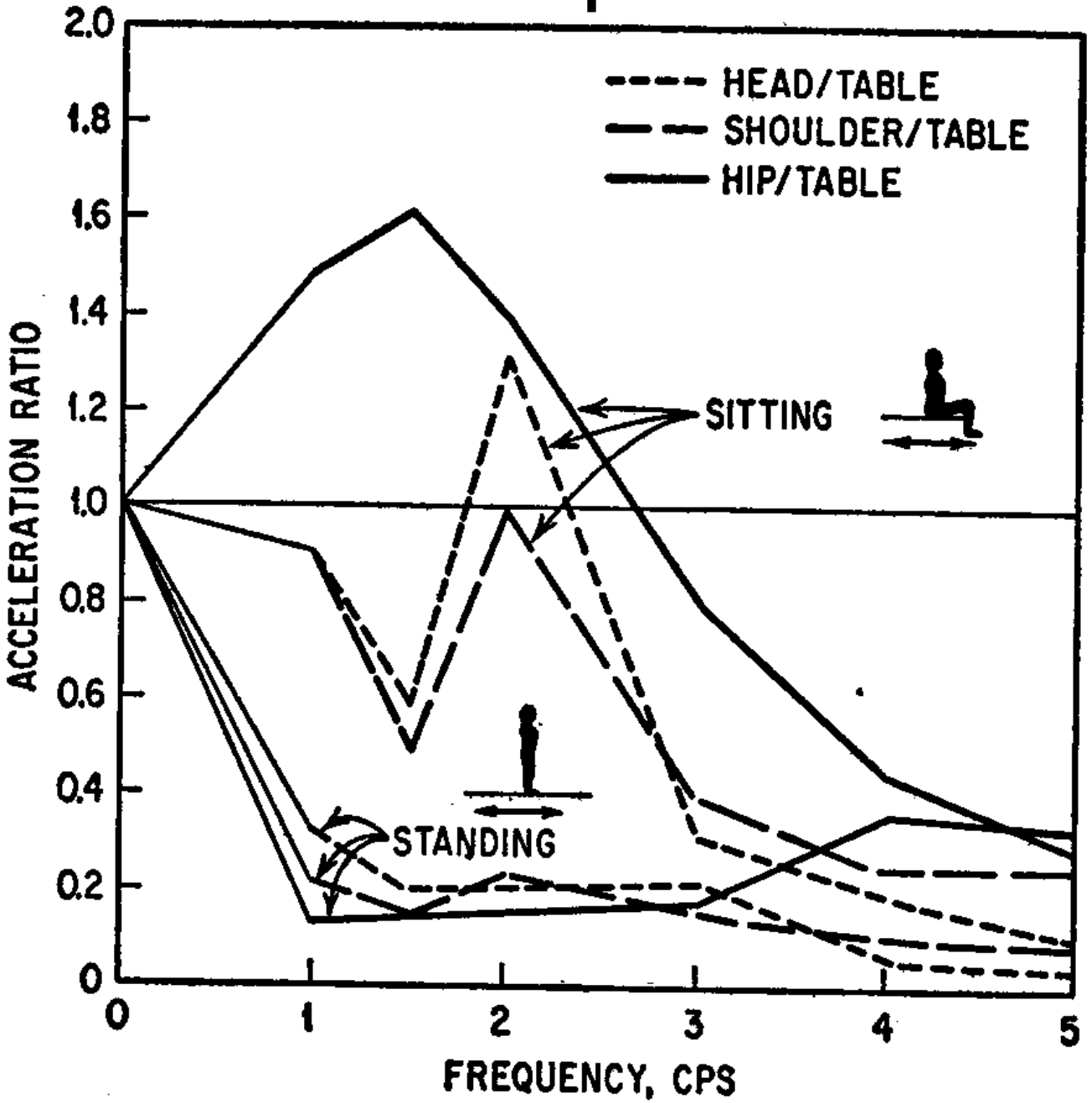


Transmission ratio of human body parts

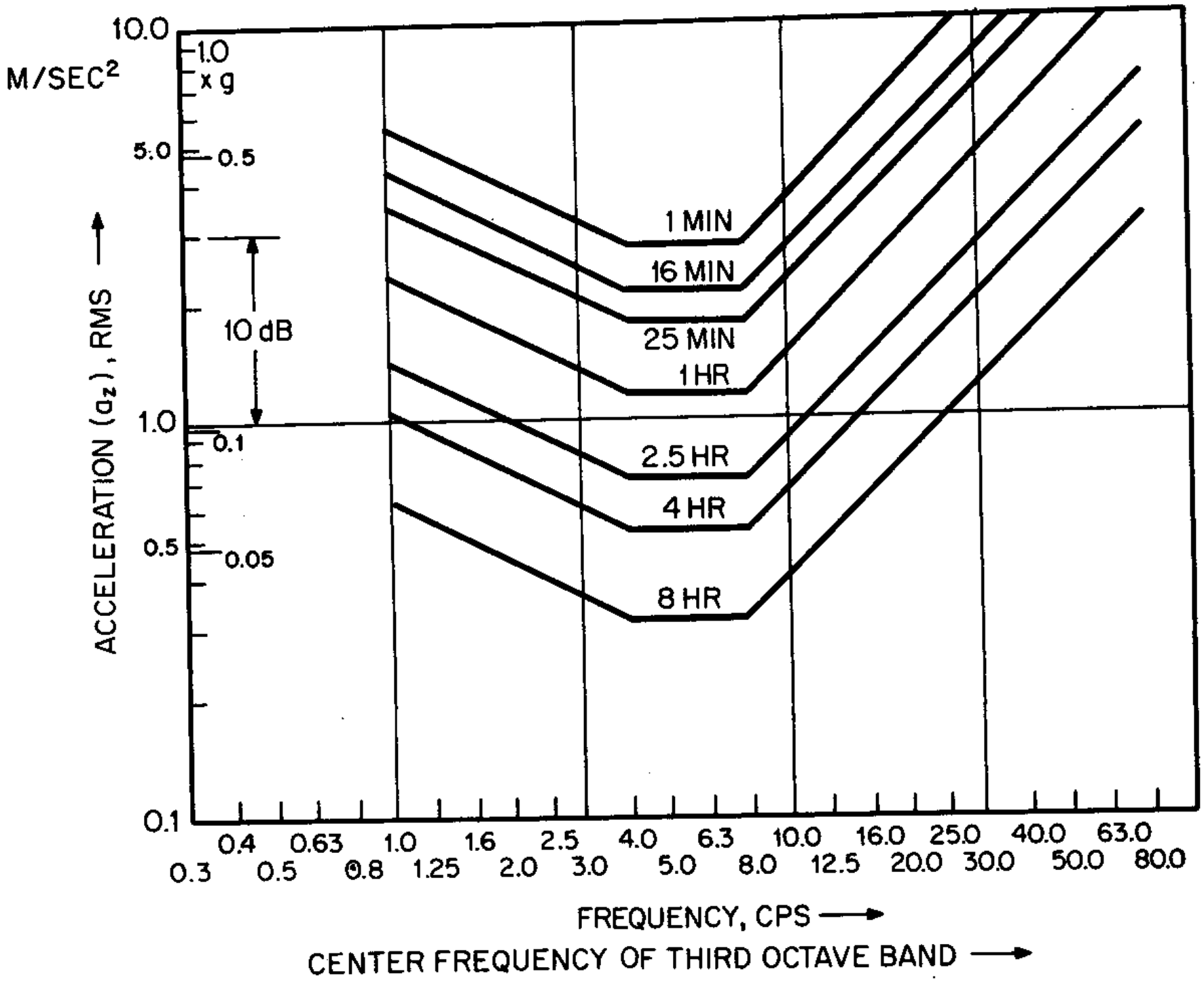


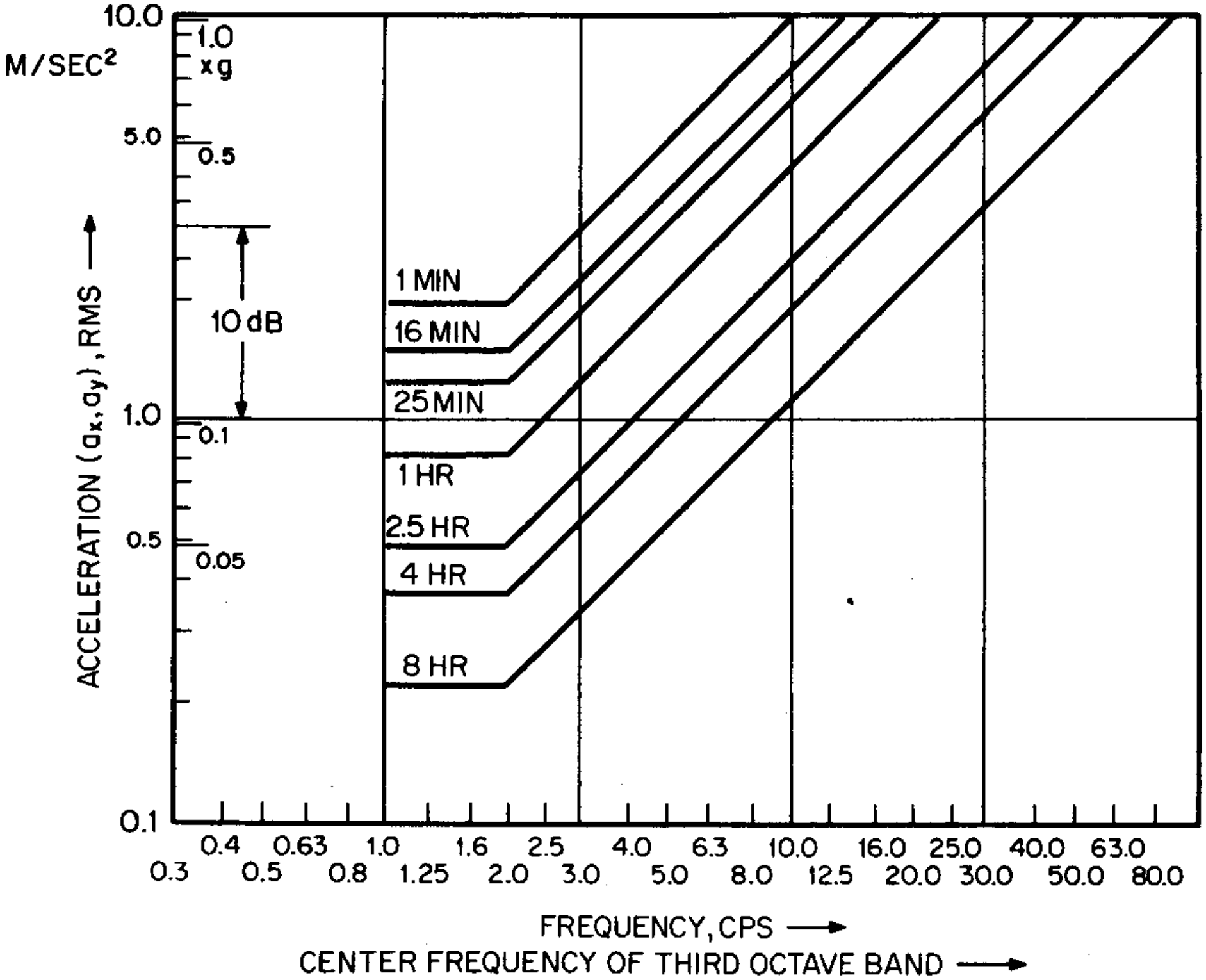


Transmission ratio of human body parts



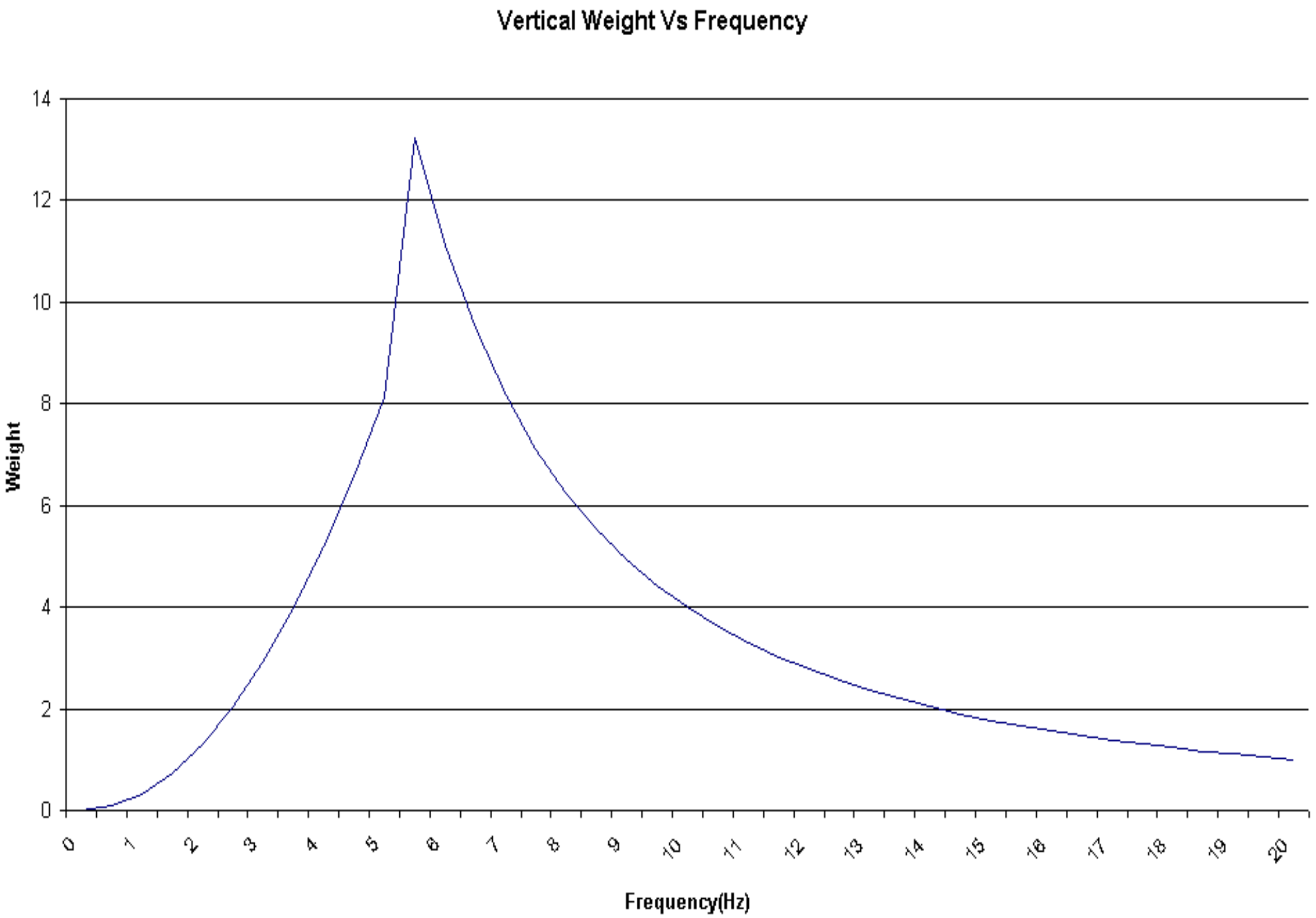
Effect of Prolonged Exposure to Vibrations on Humans

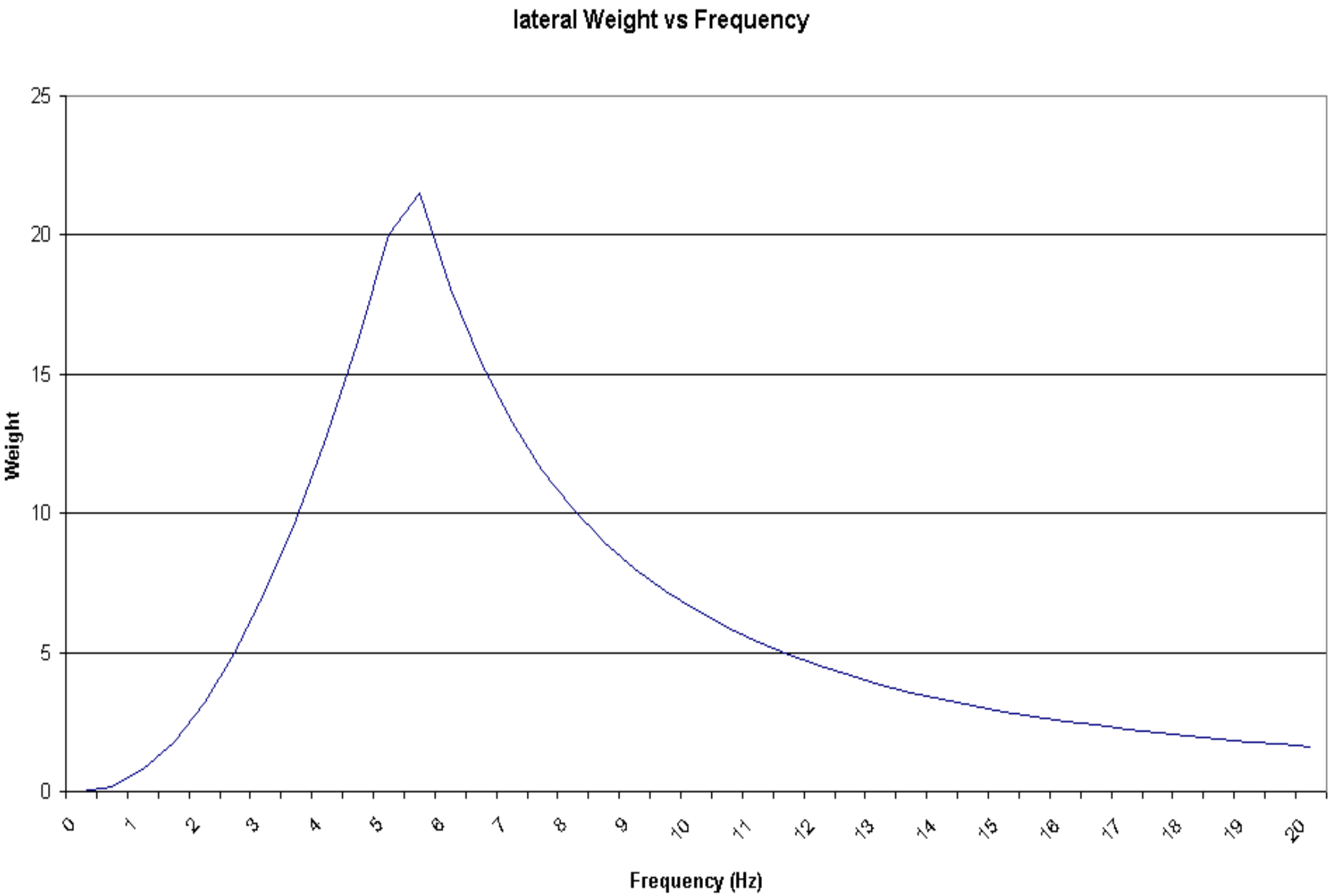

10.0
M/SEC²
1.0
x g
5.0
0.5
1 MIN
16 MIN
25 MIN
1 HR
10 dB
1.0
0.1
2.5 HR
4 HR
0.5
0.05
8 HR
ACCELERATION (az), RMS
0.1
0.4 0.63 1.0 1.6 2.5 4.0 6.3 10.0 16.0 25.0 40.0 63.0
0.3 0.5 0.8 1.25 2.0 3.0 5.0 8.0 12.5 20.0 30.0 50.0 80.0
FREQUENCY, CPS
CENTER FREQUENCY OF THIRD OCTAVE BAND


10.0
M/SEC²
1.0
x g
5.0
0.5
10 dB
1 MIN
16 MIN
25 MIN
1.0
0.1
1 HR
2.5 HR
0.5
0.05
4 HR
8 HR
0.1
ACCELERATION (a_x, a_y), RMS
0.4 0.63 1.0 1.6 2.5 4.0 6.3 10.0 16.0 25.0 40.0 63.0
0.3 0.5 0.8 1.25 2.0 3.0 5.0 8.0 12.5 20.0 30.0 50.0 80.0
FREQUENCY, CPS
CENTER FREQUENCY OF THIRD OCTAVE BAND

Sperling's Ride Index

- Human sensation of comfort proportional to
  - Displacement (sinusoidal)
  - Acceleration
  - Rate of change of acceleration
- $RI=.896(g(f)*b^3/f)^{0.1}$, b= acceleration amp
- Ride comfort correction factor $g(f) =kf^2$
  - k=.325 for vertical RI (0.5-5.4Hz)
  - k= .8 for lateral RI (0.5-5.4 Hz)
  - k=1 for goods stock


Vertical Weight Vs Frequency
Weight
0
2
4
6
8
10
12
14
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Frequency(Hz)


lateral Weight vs Frequency
Weight
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Frequency (Hz)

Track and Related Issues

Indian Railway Track

- Classified into two categories
- Main Line (speed <110 km/h)
- High Speed
  - For speed upto 150 Kmph
  - Based on Vol-I of Civil and Mechanical Engg Report No-I (C&M-I) dated May 1969 for “Increase of Speed on DLI-HWH Route Feasibility Study”

Track Recording Cars

- Recording speed 50 -100kmph
- Recording every .4m
- Self adjusting offset after some time
- Recording periodicity
  - Depends on track category

Derailment

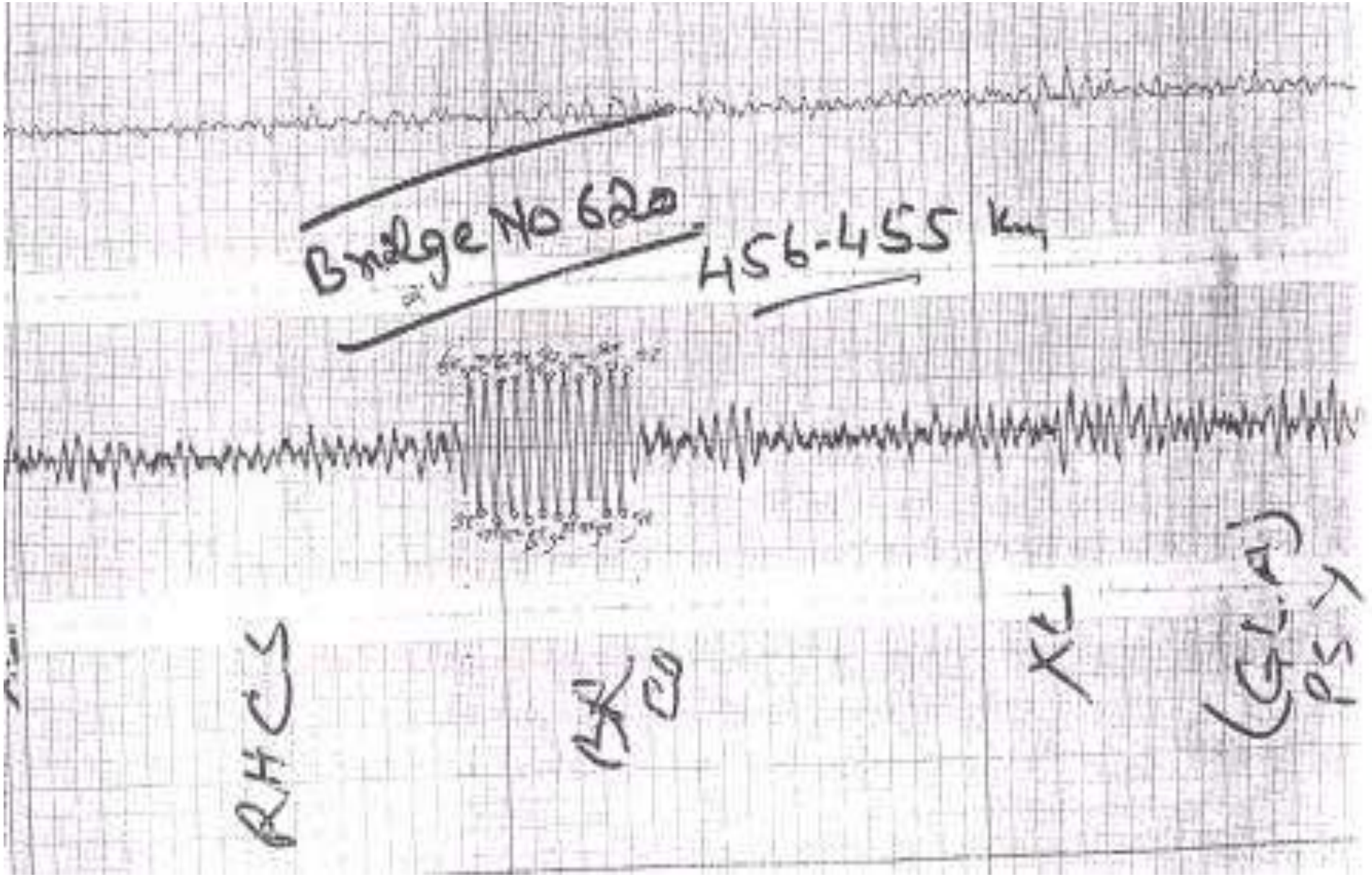
- Wheel climbing rail
  - Tight gauge
  - Due to excessive angle of attack
    - Sharp flange/Sharp curve -too much versine
  - Excessive lateral force- Nadal's formula
    - Hy/Q =(tanA-mu)/(1+mu tanA)= .997,

    where, A = flange angle wrt to horizontal ; mu=.27
    - Friction assists **only** if angle of attack causes rail wheel rubbing to be advanced

Derailment

- Wheel offloaded due to
  - Excessive spring deflection
    - Due to inadequate ballast
    - Unevenness of track
    - Poor quality ballast -caked up
  - **Resonance**
    - Poor damping
    - On multi-span bridges (more likely on steel girder type)

Resonance



Derailment

- Rail fractures due to
  - Inadequate stress relieving
  - Improper UFD
  - Inadequate ballast
  - Wheel flats?
- Shifting of sleepers
  - Prud Homme's Limit (wooden sleeper)
    - $Hy_{2m} < .85(1+P/3)$,
  - Wrong shape of ballast packing

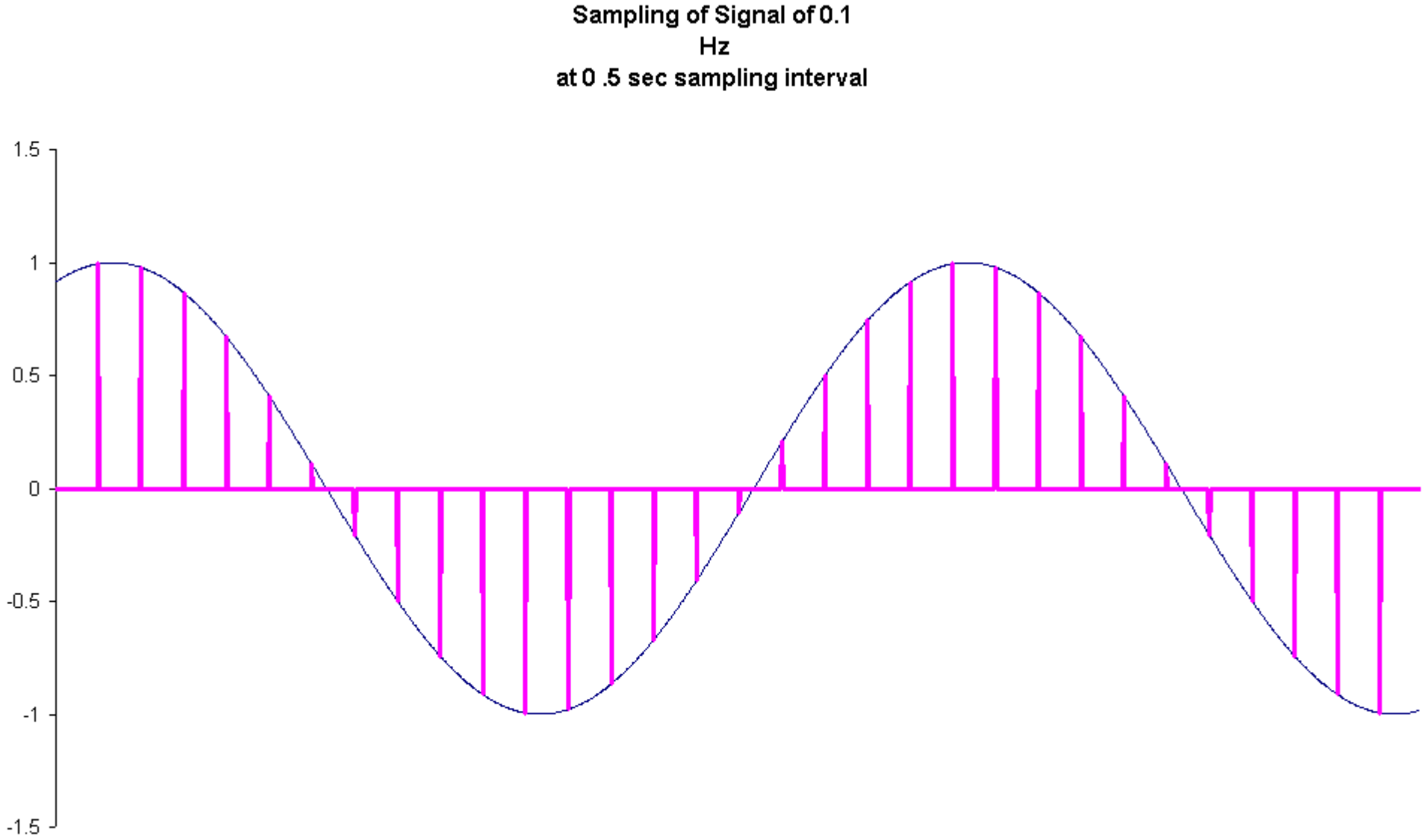
Signal Processing

Fourier Transformation

- Transformation of any time domain function into frequency domain
  - Sum of sin waves of various frequencies & phases
- Fast Fourier Transformation
  - Discrete data
  - Uses computationally efficient algorithm
  - Fundamental frequency =1/observation time
  - Usually sum of harmonics of sin wave of fundamental frequency
  - Highest frequency = ½ sampling rate (Nyquist

Important DAQ Parameters

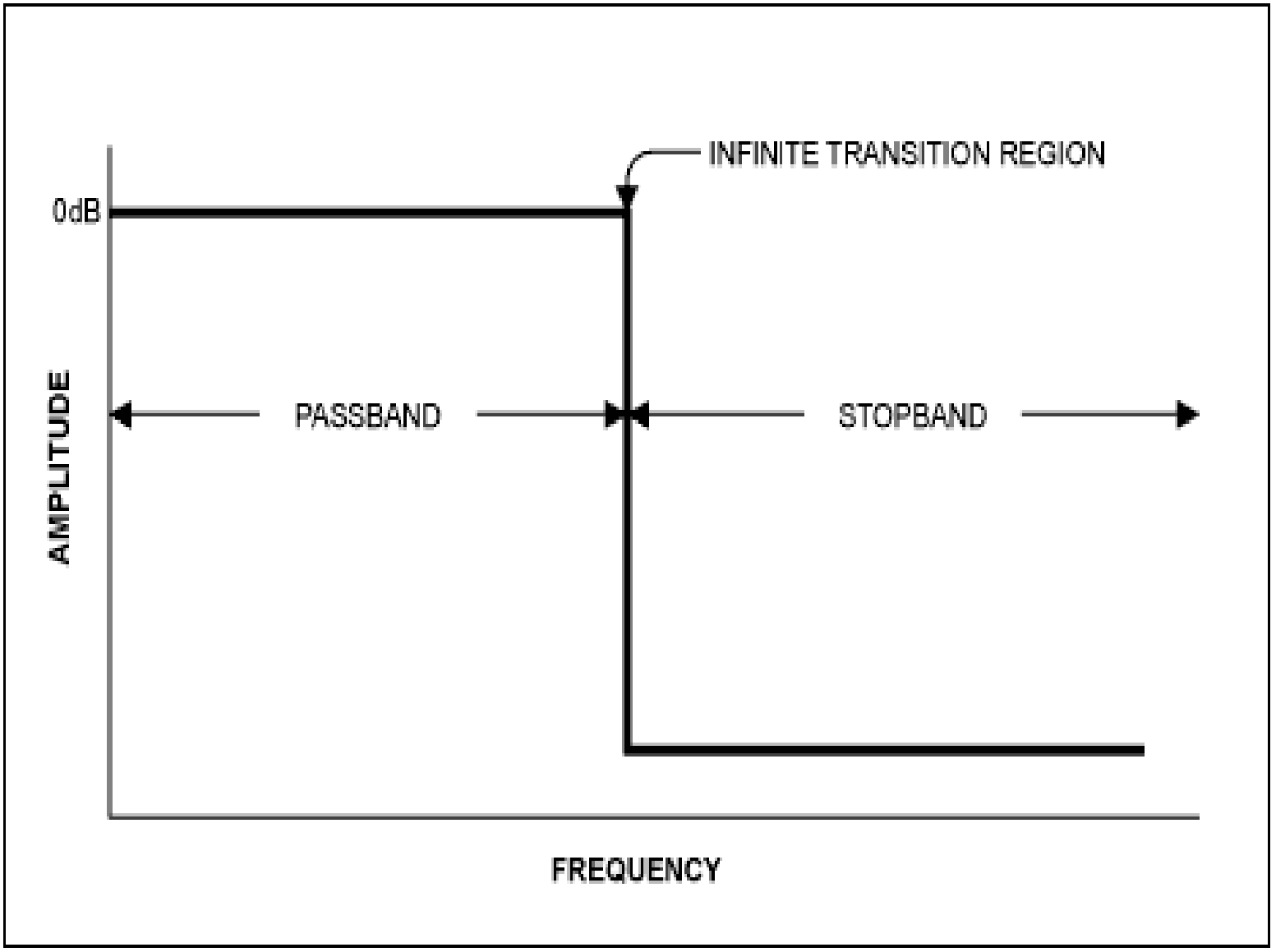
- Sampling rate
  - Min Nyquist limit
    - Usually 10 time highest signal frequency
  - Aliasing noise
    - Use of anti-aliasing filter
- Bit /sample
  - Higher value => lower digitizing noise
- Buffer size


Sampling of Signal of 0.1
Hz
at 0 .5 sec sampling interval
1.5
1
0.5
0
-0.5
-1
-1.5

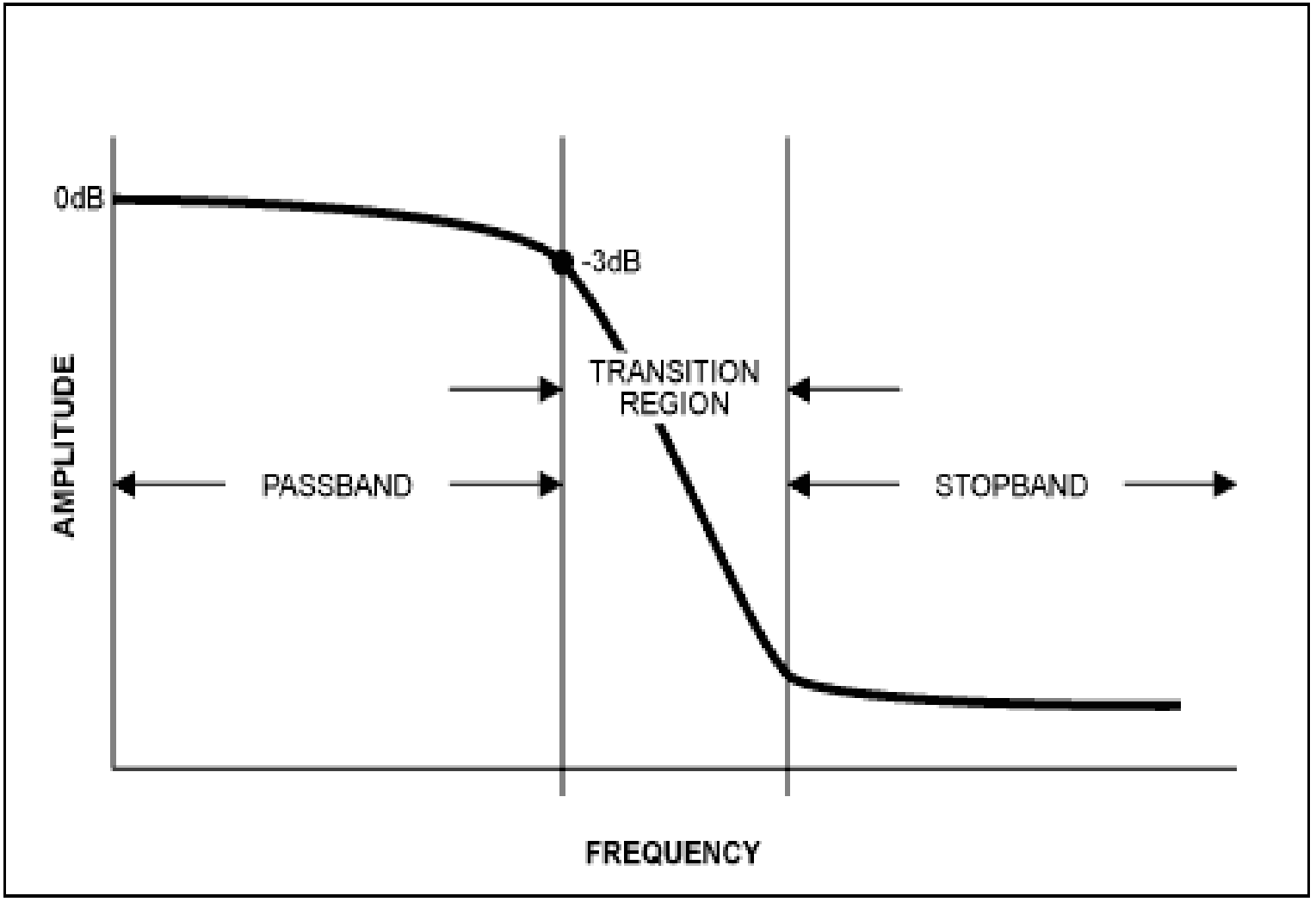
Filters

- Anti-aliasing to filter out frequencies above sampling rate
- Before ADC conversion
- Higher order filters cause phase shift

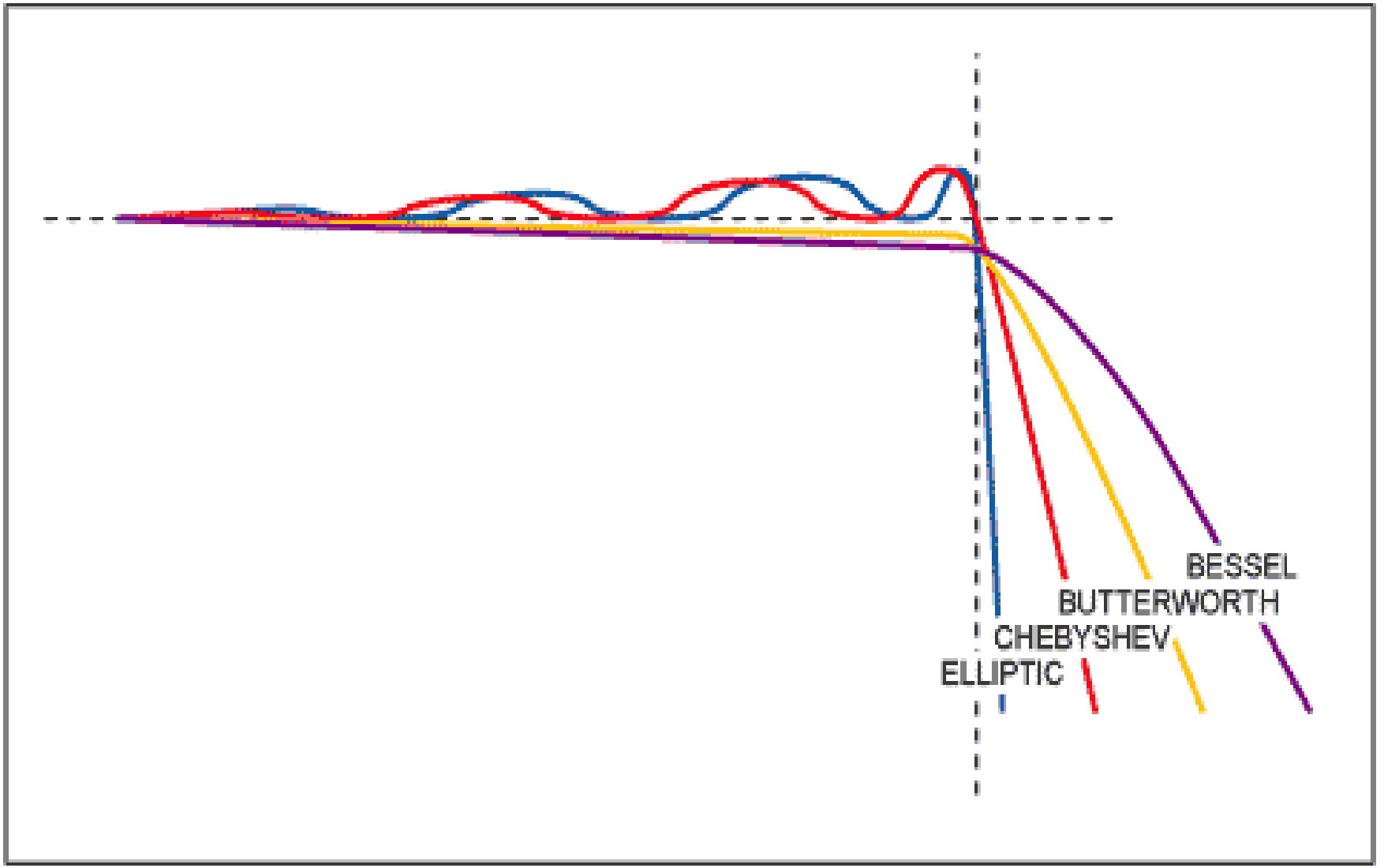
Ideal Low Pass Filter

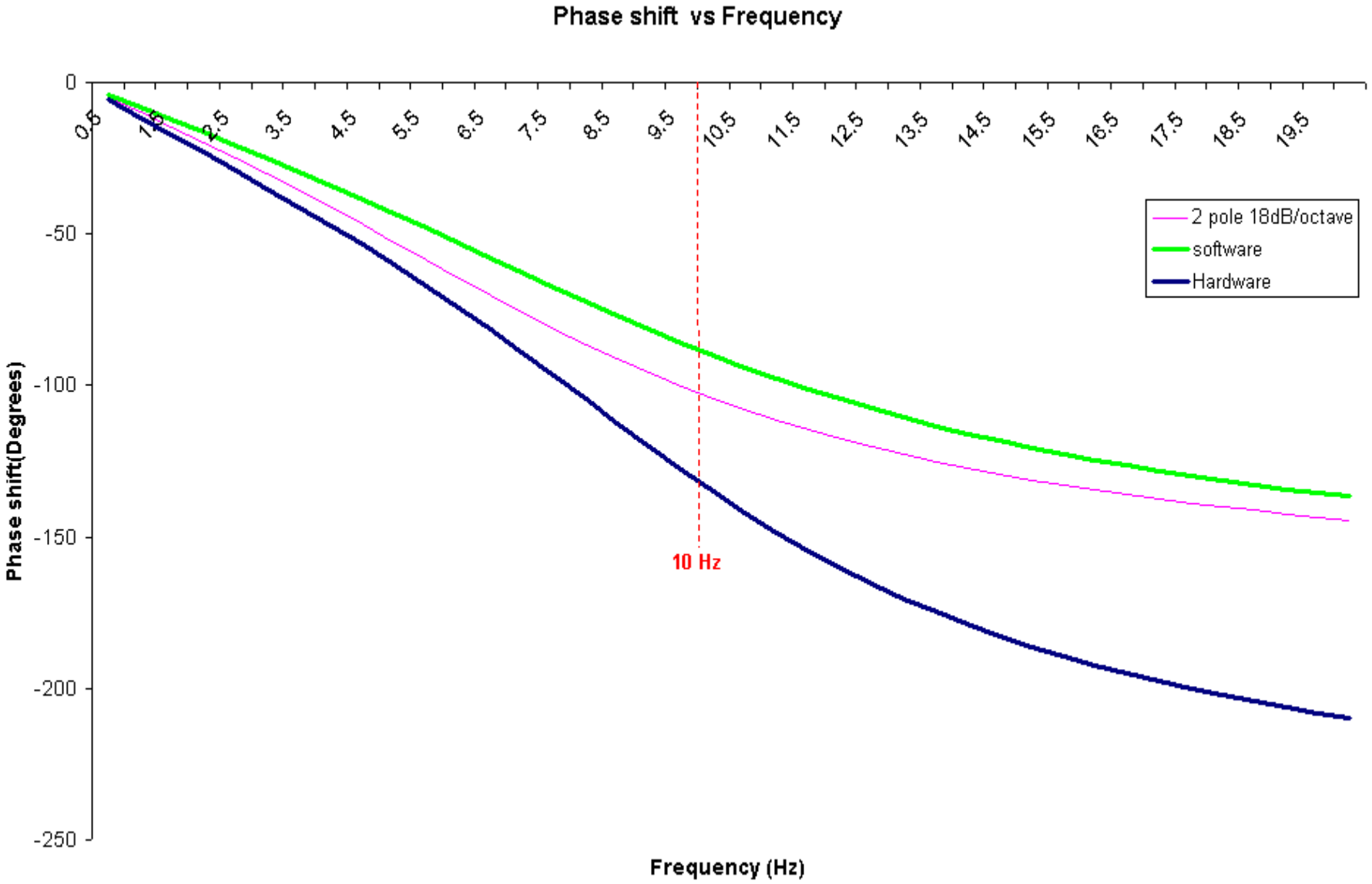


Desired Low Pass Filter

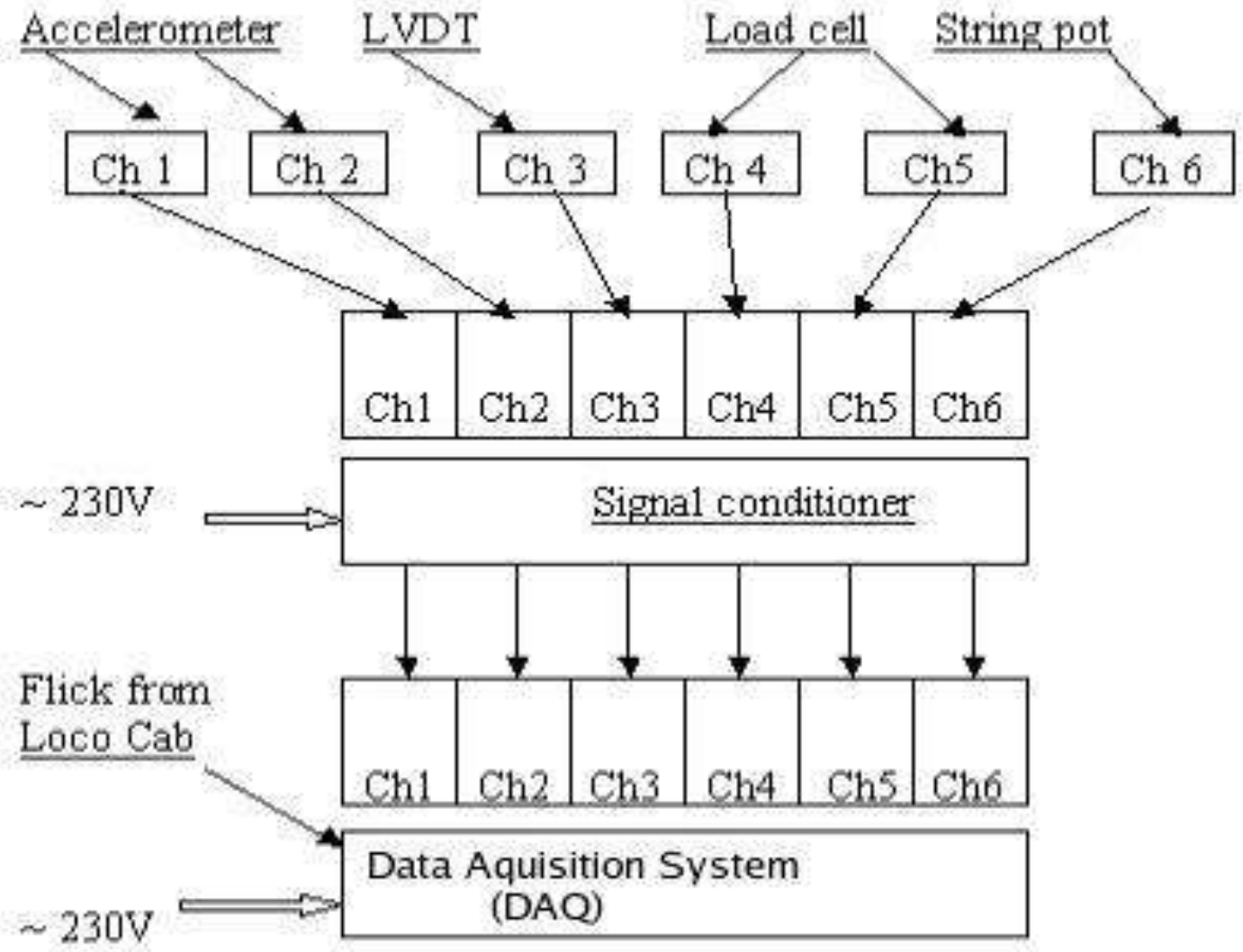


Low Pass Filters

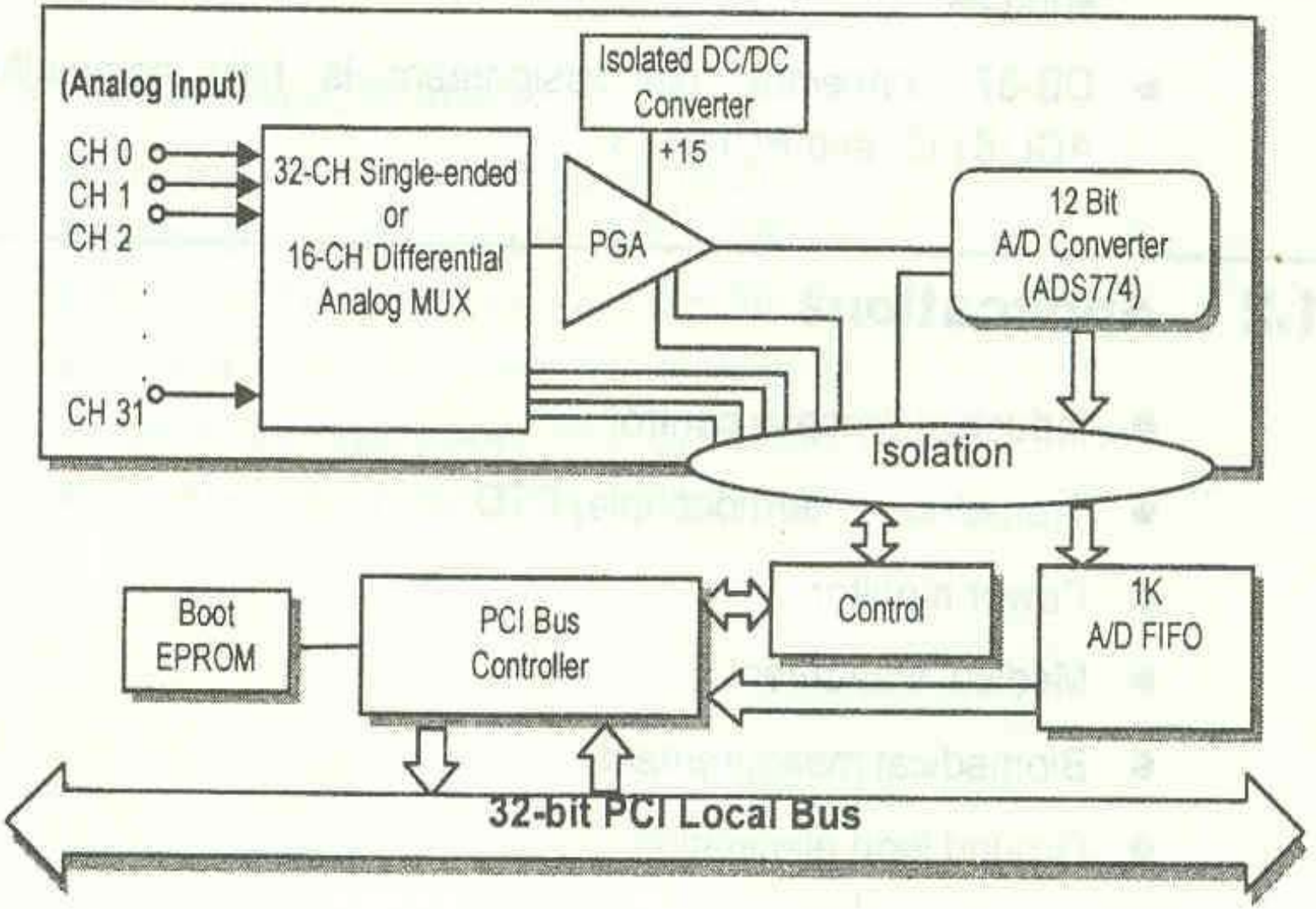



Phase shift vs Frequency
0
-50
-100
-150
-200
-250
Phase shift(Degrees)
0.5
1.5
2.5
3.5
4.5
5.5
6.5
7.5
8.5
9.5
10.5
11.5
12.5
13.5
14.5
15.5
16.5
17.5
18.5
19.5
10 Hz
2 pole 18dB/octave
software
Hardware
Frequency (Hz)

Data Acquisition System



Data Acquisition Card



Oscillation trials of Rolling Stock


WSCNEN
854?
LV

3rd Report of Standing Criteria Committee dated January 2000

- To evolve criteria for assessment of stability of rolling stock on IR,
- Composition
  - ED s RDSO
- Formulates oscillation trial procedure and Evaluation criteria

Test Track

- Straight 1 Km X 2
  - Station yard
  - 700-800 m Curve of about 2 degree
- Rundown track worse than 90% of IR track
- On main line track
  - Include high speed (C&M I vol I) for speed >110kmph
- Long confirmatory run for 10-50kms with resonance check on hard spots like L-Xing, Culverts, Bridges

Procedure

- Test Speed (Loaded & Empty)
  - Start with low speed (60kmph/80kmph)
  - Increase speed in increments of 5/10Kmph
    - Stop if any limit is exceeded
  - Max speed 10% higher than the proposed speed
- Test vehicle to be last vehicle (except loco)
- Free end bogie (leading bogie for loco) usually instrumented
- Data acquisition system usually in oscillograph car


G CAPACITY
TONNES
BEML TREASURY VAN
OSCILLATION TRIALS
BY
RDSO TESTING Dte
OT-III UNIT


1. 11. 2002

RIDE INDEX CALCULATION

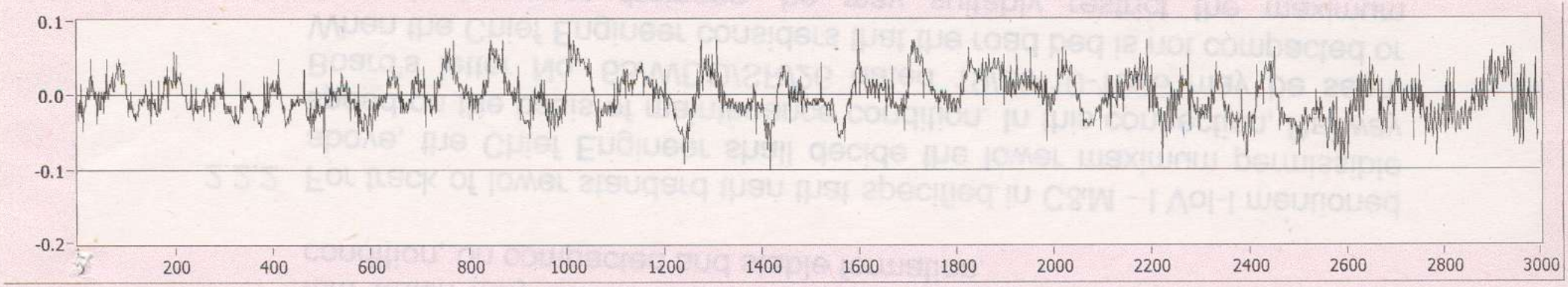
Calculation for samples from 18553 to 21549

Channel	DC Offset	Conversion Factor	Scan	Type of Vehicle	Mode
3	0.0000	1.0000	100	Loco/Carriage	Lateral

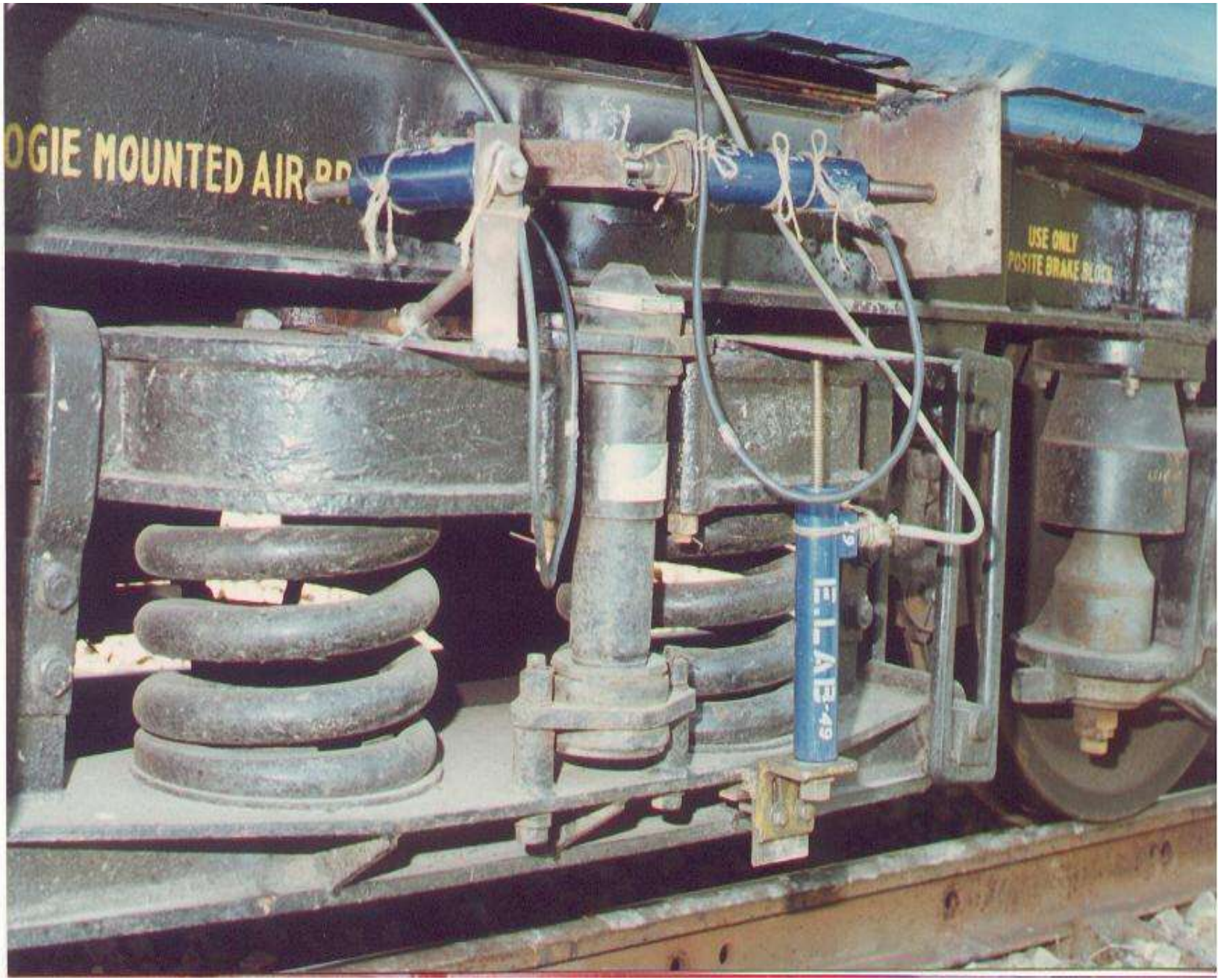
Mean Acceleration	0.022
Standard Deviation	0.017
RMS Acceleration	0.028
Percentile Max. 99.85/0.15	0.093
Max. Acceleration	0.102
Average Ride Index	2.729

UIC Percentile Values

99.85%	50.00%	0.15%
0.073	-0.005	-0.093



BACK


OGIE MOUNTED AIR
USE ONLY
E-LAB-49


40
29. 10. 2002


1. 11. 2002

Criteria for Carriage

- Ride index <3.5,
  - preferred 3.25
  - upto 4 for EMU/DMU
- <.3g accelerations in vertical & lateral directions
- Isolated peak upto .35g if no resonance

Criteria for wagons

- Hy_{2m}<.85(1+P/3),P= axle load (Prud Homme's limit)
- Hy/Q (for >1/20 sec) <1
- In case Hy cannot be measured,
  - Ride index < 4.5, preferred 4.25
- General stable running characteristics based on
  - Accelerations
  - Spring deflections

Other Tests Related to Coaches

- Squeeze test
  - Check buffing /pay loads
  - Measure deflections, stresses and permanent sets
- Crash worthy tests
  - Withstand impact at 60 km/h
  - In passenger area
  - Actual crashes carried out

Example of Squeeze Test

- BG BEML shell (model 816)
- Requirements
  - Max stress 90% of lower YP
  - No permanent set at 102 mT load
  - Max shell deflection (lateral & vertical)
    - 10 mm at centre
    - 6 mm at ends
  - No weld failure

Test Fixtures

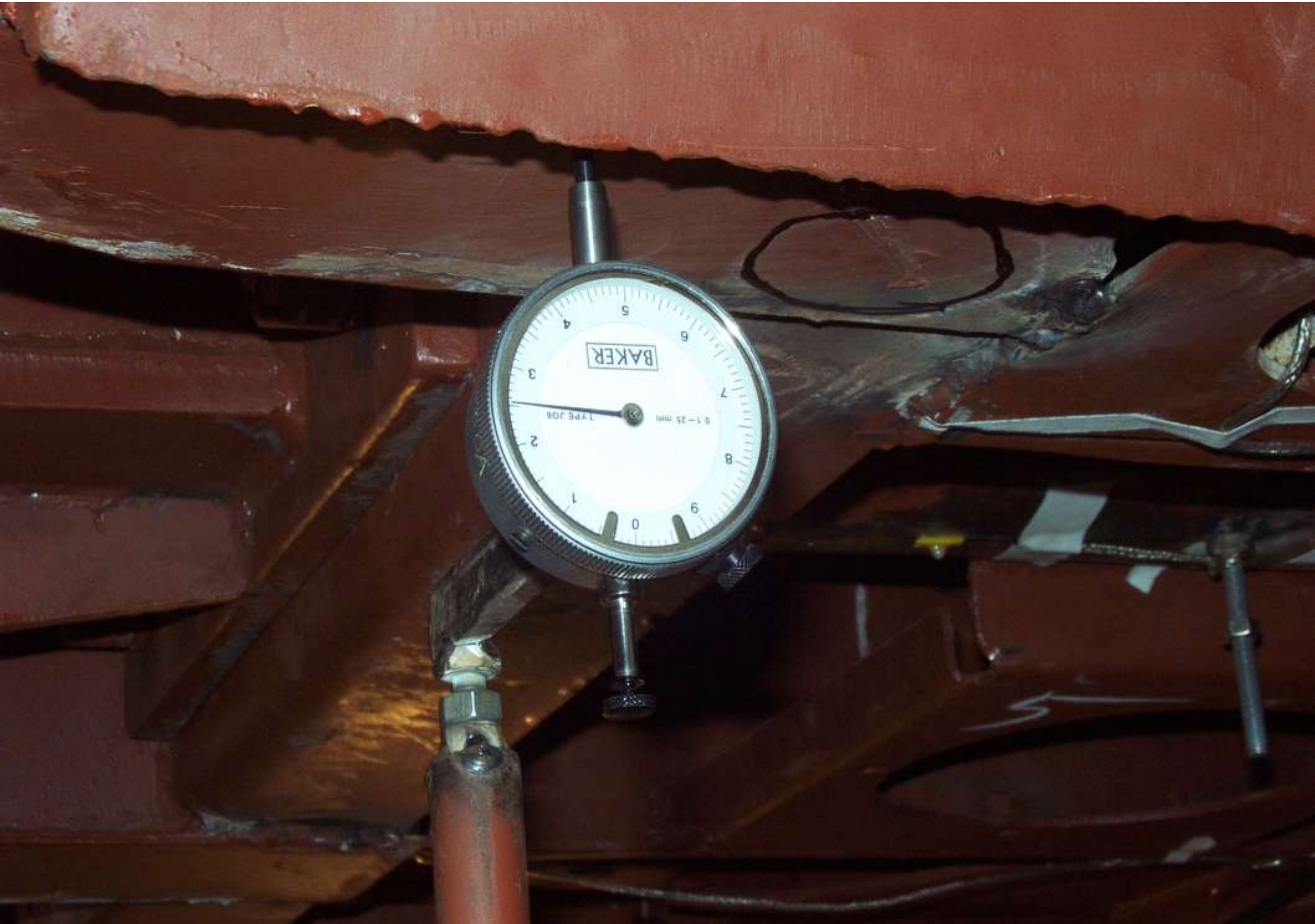

SQUEEZE TEST
OF 816 MODEL
RDSO
TESTING DATE


NMP
94
90
95
91

Loading Devices

Deflection Measurement


109
114
116


BAKER

Stress Measurement

Crash Test video

Thank You!!!