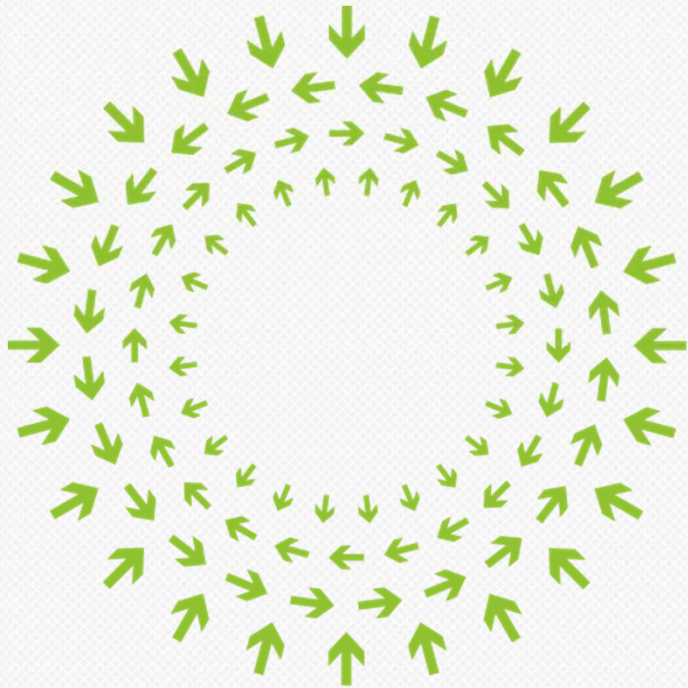




OPEN

Compute Summit

Engineering Workshop

October 30-31, 2014

Paris





Rittal Open Rack Solution

Andy Gill & Paul Clements

Rittal

VP Engineering (Andy), Lead Design Engineer (Paul)



Rack - Overview



Front Isometric View

Key Rack Features Include : -

- Loading to 1400KG
- 2 Power zones
- E.I.A. Adaptors, in top of rack(3), can be installed in any position.
- Dimensions 2210H x 600W x 1067D



Rear Isometric View



Rack – Including Equipment Installed



Front View

(Standard Config.) Maximum Installable Equipment Includes: -

- I.T. Equipment, 16 Shelves (16 x 20U)
- Power Equipment, 2 Shelves (2 x 30U)
- E.I.A. Equipment, 3 Adaptor (3 x 10U)
- Total 41 x OU



Rear Isometric View



Rack including Kits

Kits Include (Visible) : -

- Side Panel Kit
- Hot Aisle Baffle
- Seismic Bracing (Partial)



Front Isometric View

Rear Isometric View

Rack – Features – Bus-bar Assembly



Bus-Bar Assembly
2 separated zones



Bus-bar convertor kit.
Some low power configurations require single power zone bus-bars, this is achieved by connecting upper bus-bar to lower bus-bar. Sold as a accessories kit.





Transport testing

Rack Test Information

Rack Model:	Facebook V2 Open Rack, Single Rack with Bus Bar, 2 Power Zone 2,210H, 600W, 1067D (mm) to Facebook Specifications 06-000060 & 27-000416 Rev 2
Build Version:	P.V.T. (Rittal C23670 Rev 1)
Test Specification:	Open Rack V2 Specification Rev 7 Rittal Product Testing Specification (Ver.3)
Rack weight:	180 kg (396.8 lbs)
Load weight:	1400 kg (2755.8 lbs) Distribution: Separate Document
Crate / Pallet Type:	Cushioned Shock to TransPak San-De-0015 RevA
Inserts & other components:	- 3 x Wooden (Width) Brace to Rittal Drawing "Brace_Wood" Mounted in front of rack, per image
Performed by	Paul Clements (Design Engineer)
Witnessed by	Tom Shingleton (Design Manager)



Tests Performed

<u>Palletised Product Test</u>	<u>Notes</u>
Flat Drop (6")	Facebook standard
Rotational Flat Drops (6" on both long sides)	Facebook standard
Rotational Corner Impact (6" on 2 corners raised by 4")	Facebook standard – <i>Not completed, safe method to be defined at Rittal</i>
Rotational Edge Drop (6" on both long sides raised by 4")	Rittal Standard, Rack toppled on Initial drop, considered un-safe, so No further Tests completed.
Transportation (Lorry)	Facebook / Rittal

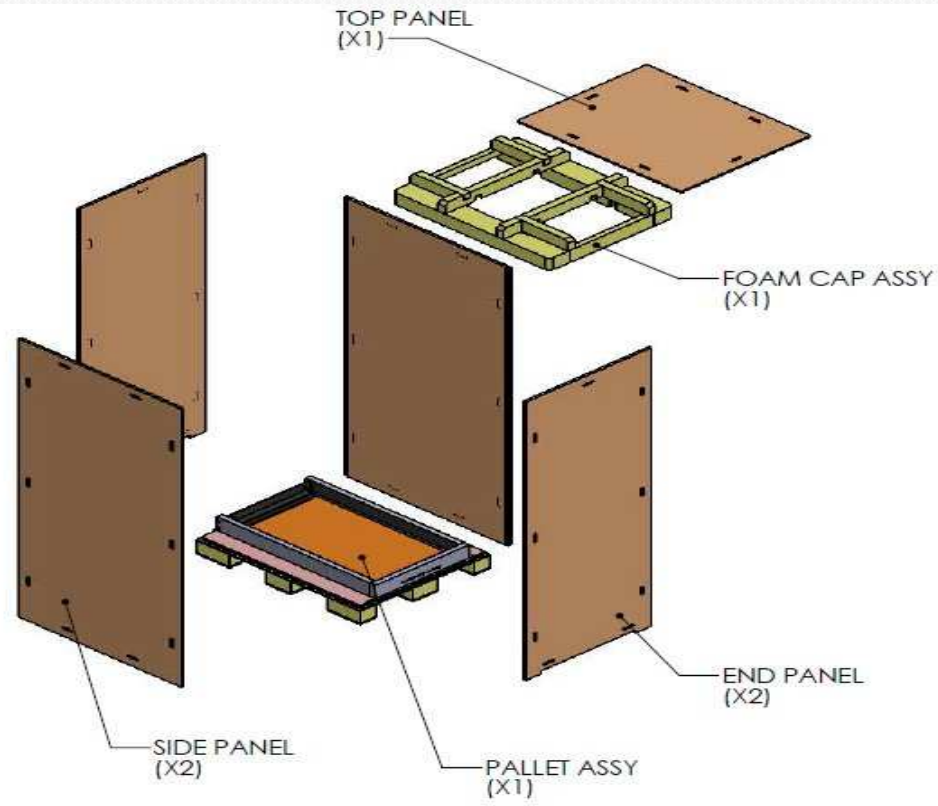
The Flat drop & Rotational drop tests were initially completed, then the packaging removed and inspection performed, include dye penetrant N.D.T. on the weld corner regions.



Rack and Packaging



Rendered view of Rittal
V2 Open Rack



Exploded view of Transpak / Crocodile Shock Pallet /
Crate



Loaded Rack in
Crate (Front / Rear
removed

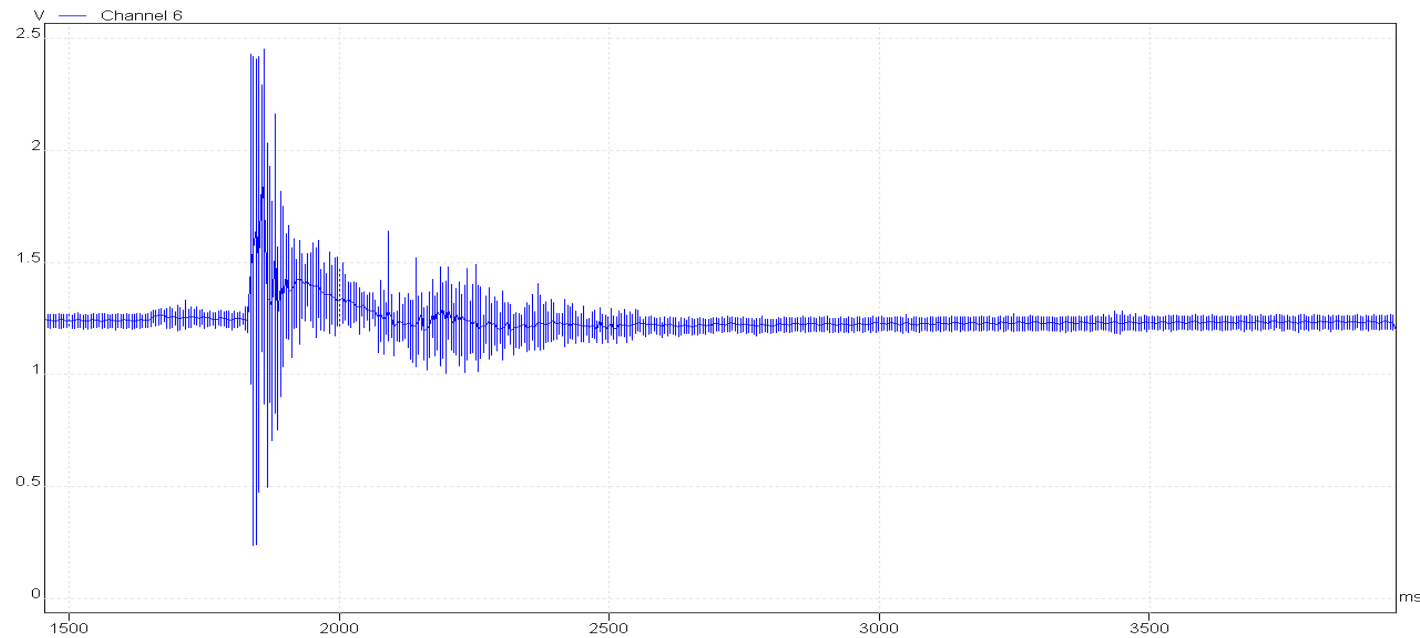
Monitoring Equipment



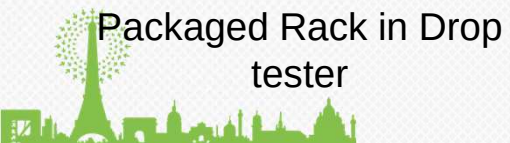
Accelerometer is mounted in the base tray, at the front for the rack.
Accelerometer is a uni-axial type, calibrated to 50g



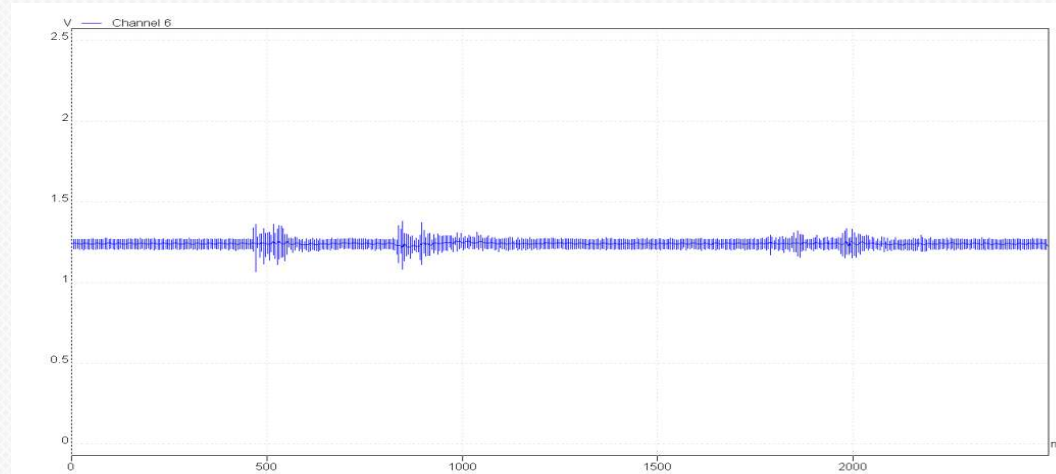
Flat Drop (6")



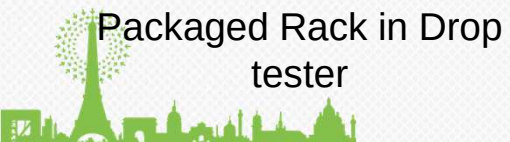
Accelerometer Trace (Unfiltered) – Y value in volts – convert to acceleration (g) by subtracting 1.24, then multiplying by 40
Giving a maximum of 48g



Rotational Flat Drop (6")



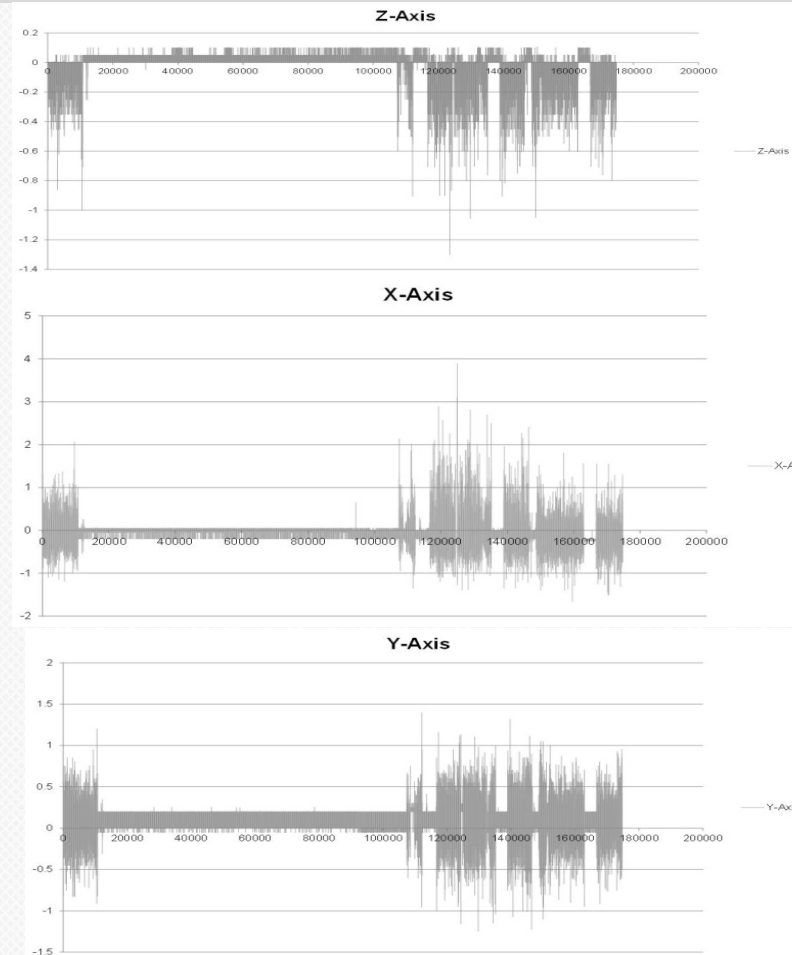
Accelerometer Trace (Unfiltered) – Y value in volts – convert to acceleration (g) by subtracting 1.24, then multiplying by 40
Giving a maximum of 7g



Transportation Testing



Data-logger in rack



Graph shows measure accelerations (g) in the Vertical direction.
Maximum of 1.3g measured

Graph shows measure accelerations (g) in the Width direction. (Braking / acceleration of lorry)
Maximum of 3.85g measured

Graph shows measure accelerations (g) in the Depth direction. (Cornering of lorry)
Maximum of 1.4g measured



Transportation Testing – Rack Movement.

Test / Task	Pull Force Measured			Pull force to total Load	Loading	
	Configuration	Measurement				KG
		(N)	KG			
Measure Force	Static	520	53.0	3.38%	Rack	170
	Dynamic	280	28.5	1.82%	Load	1400
400M Roll (0.8M/S)					Total	1570
Measure Force	Static	560	57.1	3.64%		
	Dynamic	260	26.5	1.69%		
1" Gap x3 Times						
Measure Force	Static	550	56.1	3.57%		
	Dynamic	250	25.5	1.62%		
200M Roll						
Measure Force	Static	490	49.9	3.18%		
	Dynamic	350	35.7	2.27%		
1" Gap x2 Time						
Measure Force	Static	610	62.2	3.96%		
	Dynamic	350	35.7	2.27%		
200M Roll						
Measure Force	Static	630	64.2	4.09%		
	Dynamic	300	30.6	1.95%		
6mm Step x5 Times						
Measure Force	Static	680	69.3	4.42%		
	Dynamic	220	22.4	1.43%		
				4.42%		
				Maximum		

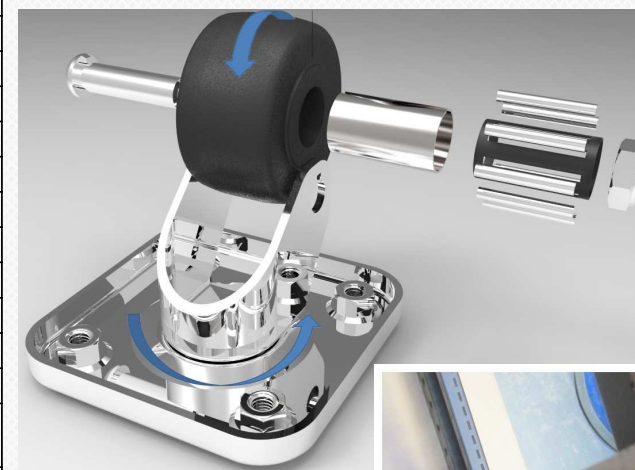
Series of transportation tests completed, with the (static & dynamic) pull force measure between each step.

Slight degradation was measured over the complete tests, however all measurements were within the requirement of 5.0%.

Post Test

All Swivel castors were free to rotate in both directions (Wheel rotation and Castor Horn Rotation)

(Open Rack V2 specification Rev 7)



Base tray remained Flat, in all directions

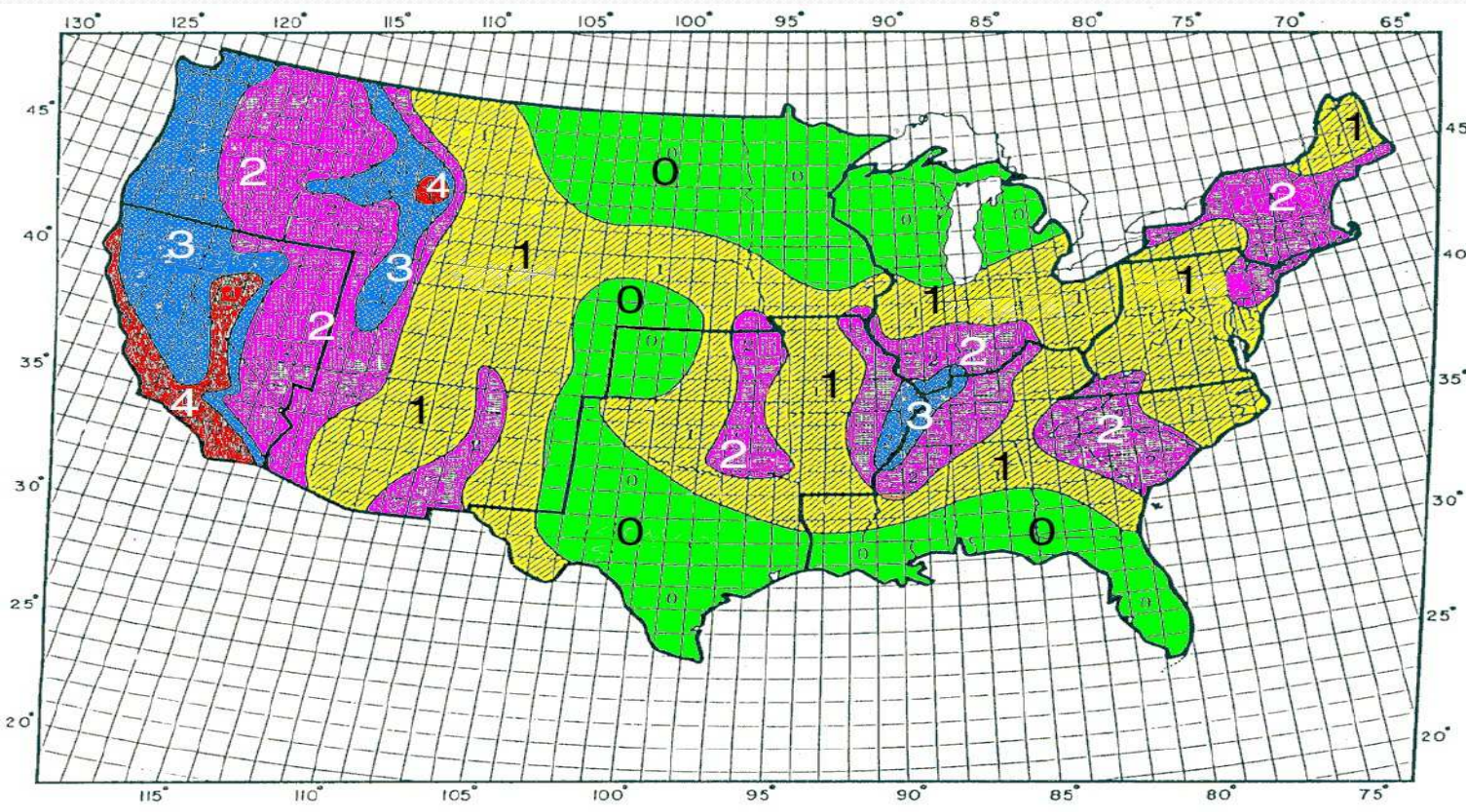


A decorative graphic on the left side of the slide features a collection of white arrows of varying sizes and orientations. These arrows are scattered across a green rectangular area that occupies the left half of the slide. The arrows point in various directions, including up, down, left, and right, creating a sense of movement or flow. The text 'Seismic Simulations' is centered horizontally and partially overlaps the green area and the arrows.

Seismic Simulations

GR-63-Core Seismic

The loaded rack is required to withstand NEBS GR-63 zone 2 Seismic Testing



North America – Earthquake Risk Zones

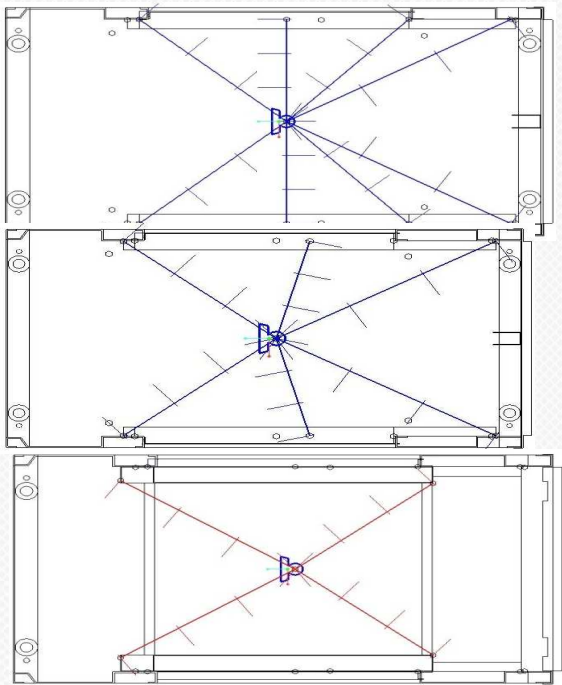
4 – Zone 4, Highest risk area

0 – No Substantial earthquake risk.



Rack Loading

The Rack is loaded with masses detailed per table, the Horizontal position is Mid-way in the Depth and the Width. The masses are connected to the frame members per details below: -



I.T. Shelf Mass: - Connected to I.T. Shelf in three locations (per side) + connection to Rear member.

Power Shelf Mass: - Connected to Power Shelf in three locations (per side)

E.I.A. Mass: - Connected to E.I.A adaptors in two locations (per side)

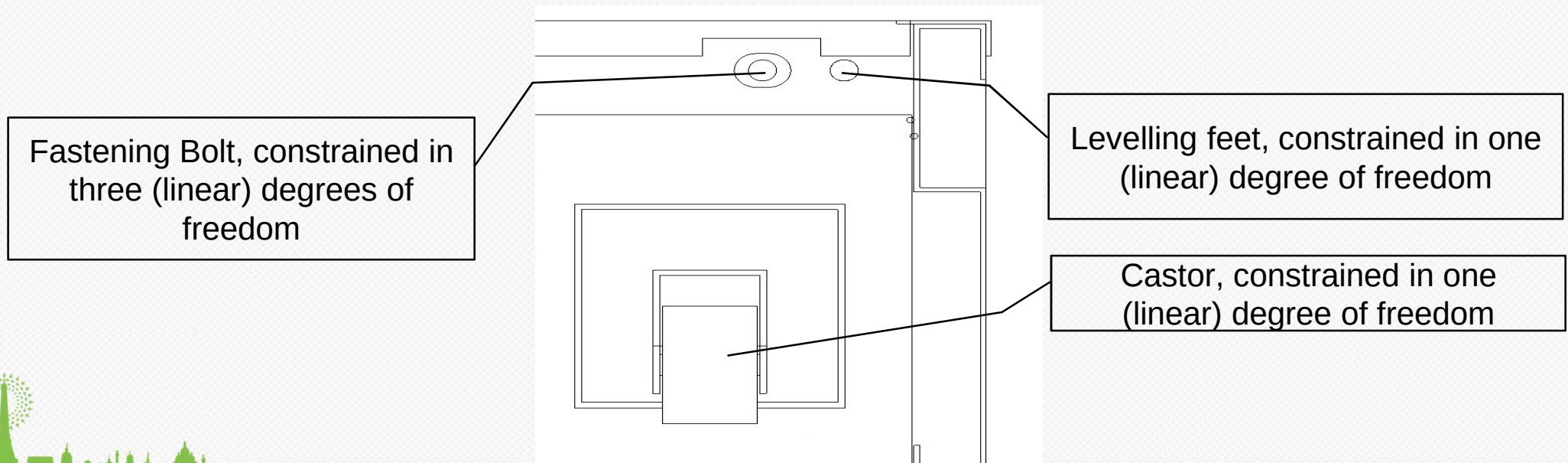
Distribution throughout Rack		
Vertical positioning in Rack	Description	Load for Max 1400kg (kg)
	E.I.A	12.0
	E.I.A	12.0
	E.I.A	12.0
	IT	78.25
	IT	78.25
	IT	78.25
	IT	78.25
	Power	56
	IT	78.25
	IT	78.25
	IT	78.25
	IT	78.25
	IT	78.25
	IT	78.25
	IT	78.25
	Power	56
	IT	78.25
	IT	78.25
	IT	78.25
	IT	78.25
	Total	1400.0



Constraints

Constraints are applied in three regions, detailed below: -

- Fastening Bolts – Surface at floor level, constrained in three degrees of linear freedom
- Castors – Surface at floor level, constrained in one degrees of linear freedom, vertically locking wheel to floor.
- Levelling Feet – Surface at floor level, constrained in one degrees of linear freedom, vertically locking wheel to floor.



Analysis Configuration Details

The Analysis is Linear Transient and consists of a Restart between the Modal and the Dynamic Analysis.

Rack Analysis has been completed in the following order: -

- Single Rack – No Shear Plates. Modal Analysis ONLY
- Single Rack – + 2 x Shear Plates in the Upper and Lower Positions. Modal Analysis ONLY
- 3 x Bayed Ganged Pod – + 2 x Shear Plates in the Upper and Lower Positions.
- 3 x Bayed Ganged Pod – + 2 x Shear Plates in the Lower Positions.
- 3 x Bayed Ganged Pod – + 2 x Shear Plates in the Upper and 1x in the Lower Positions.

Modal Analysis

The lowest eight Natural Frequencies are analysed. Convergence level set at 5%, with a maximum Polynomial Order set to 9

Dynamic Analysis

The analysis initially is completed with a time step of 0.075 seconds, a secondary analysis is to be completed, with the resolution increased around the Maximum deflection region.





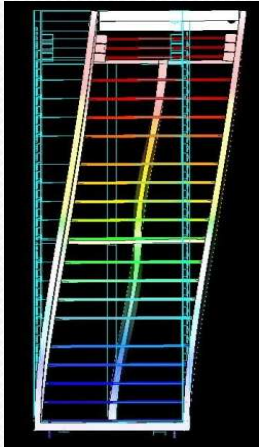
Single Rack



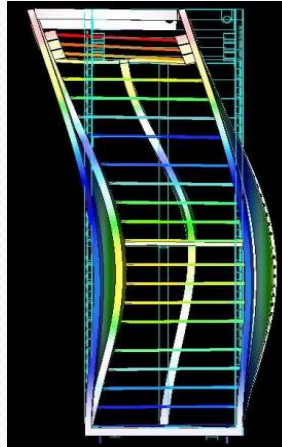
Engineering Workshop

Modal Analysis — Single Rack

In Accordance with G3-Core R4-70, Frame-level equipment shall have a frequency greater than 2.0Hz



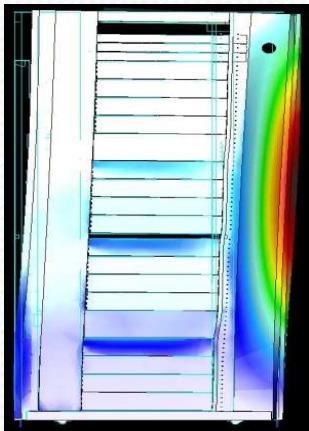
First Natural Frequency at 3.18Hz



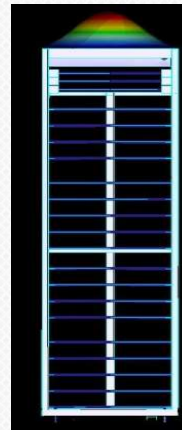
Second Natural Frequency at 13.26Hz



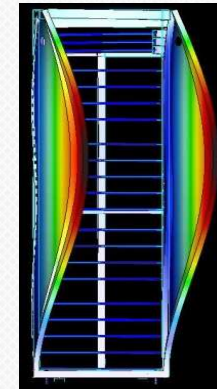
Third Natural Frequency at 31.38Hz



Fourth Natural Frequency at 37.51Hz



Fifth Natural Frequency at 44.10Hz



Sixth Natural Frequency at 45.65Hz

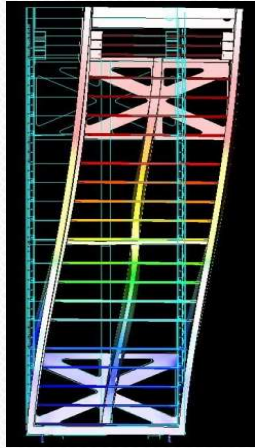


Single Rack + 2 x Shear Plates in the Upper and Lower Positions

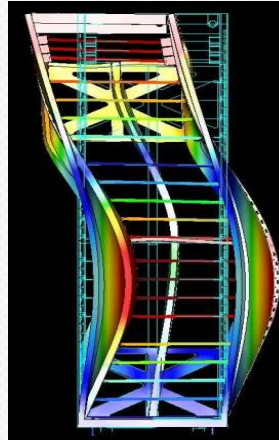


Modal Analysis — Single Rack

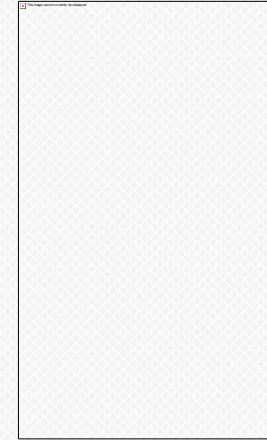
In Accordance with G3-Core R4-70, Frame-level equipment shall have a frequency greater than 2.0Hz



First Natural Frequency at 4.31Hz



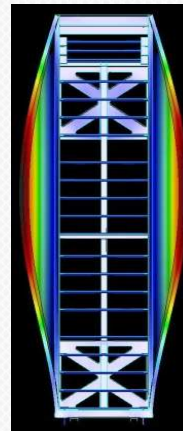
Second Natural Frequency at 18.63Hz



Third Natural Frequency at 21.77Hz



Forth Natural Frequency at 35.09Hz



Fifth Natural Frequency at 42.79Hz

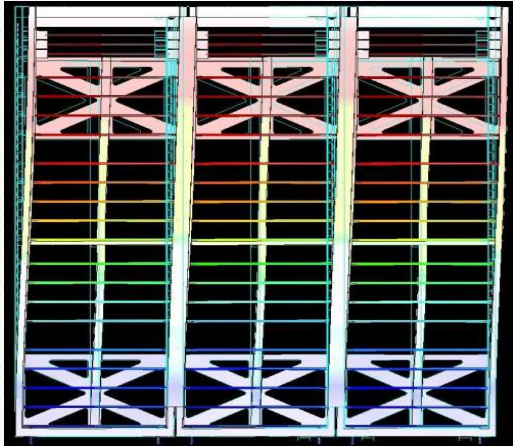


3 x Bayed / Ganged Pod + Shear Plates in the Upper (1 x) and Lower Positions (1 x)



Modal Analysis — Three Bayed racks, Shear Plate high / Low Positions

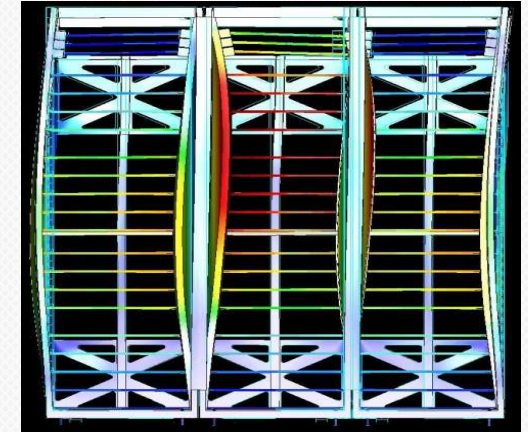
In Accordance with G3-Core R4-70, Frame-level equipment shall have a frequency greater than 2.0Hz



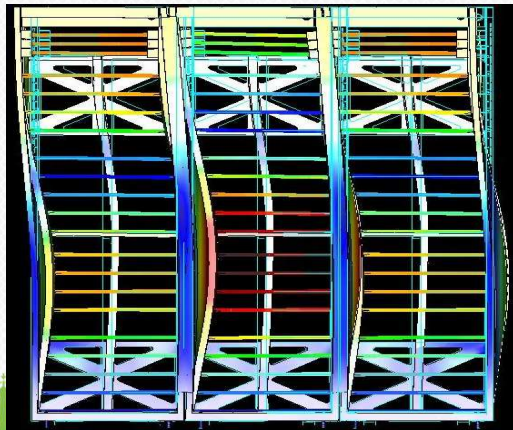
First Natural Frequency at 5.29Hz



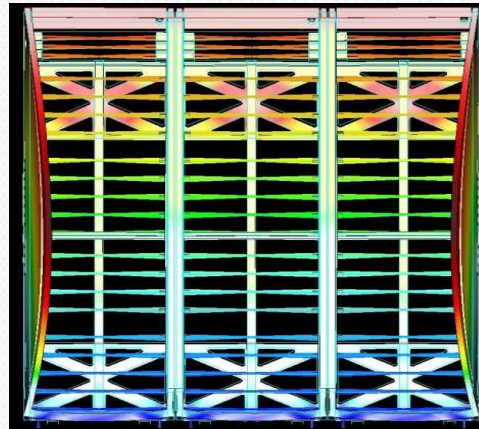
Second Natural Frequency at 18.06Hz



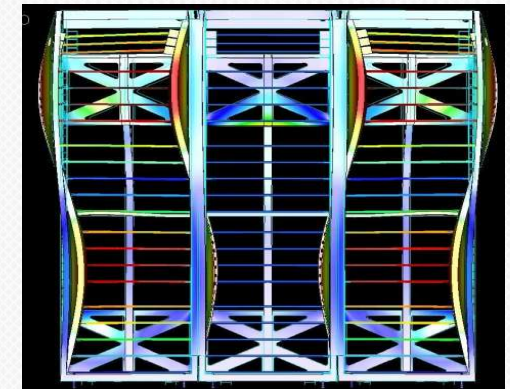
Third Natural Frequency at 19.79Hz



Fourth Natural Frequency at 22.00Hz



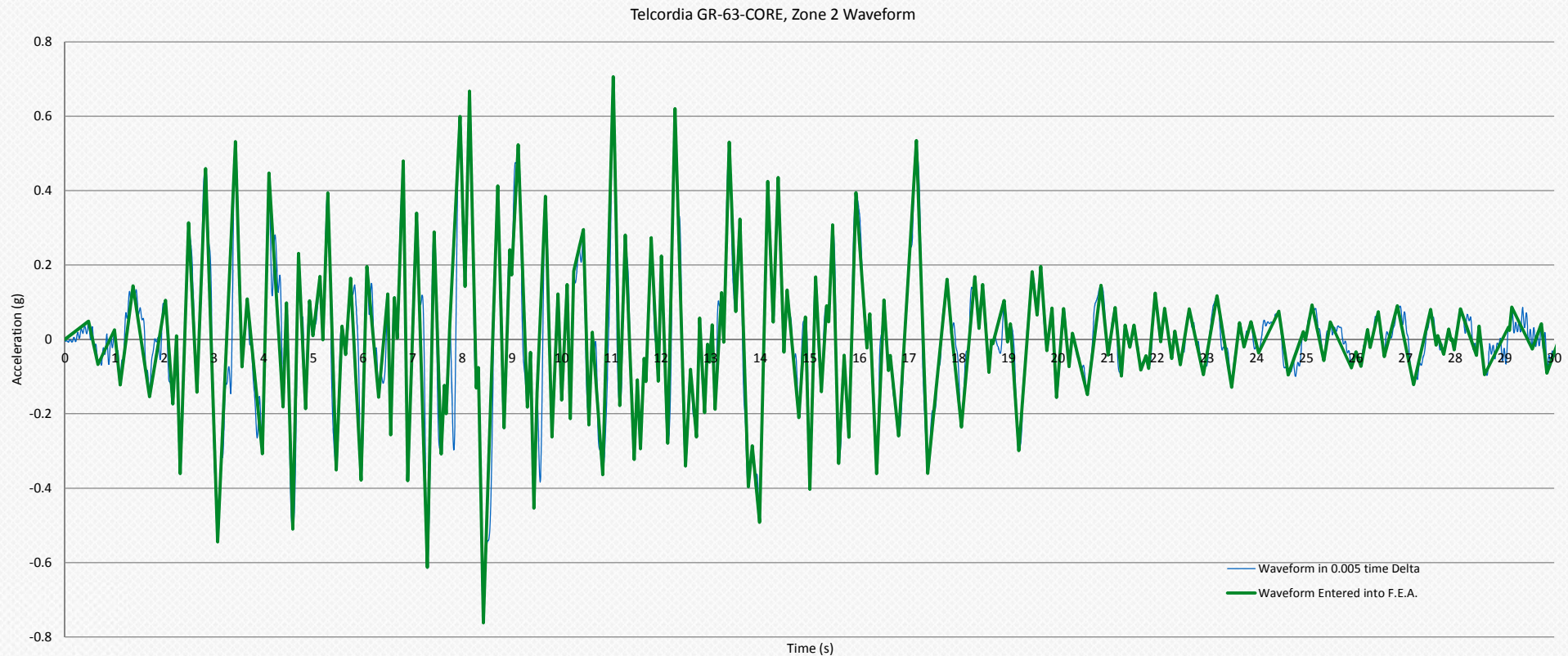
Fifth Natural Frequency at 22.80Hz



Sixth Natural Frequency at 27.23Hz

Base Excitation Input – Zone2

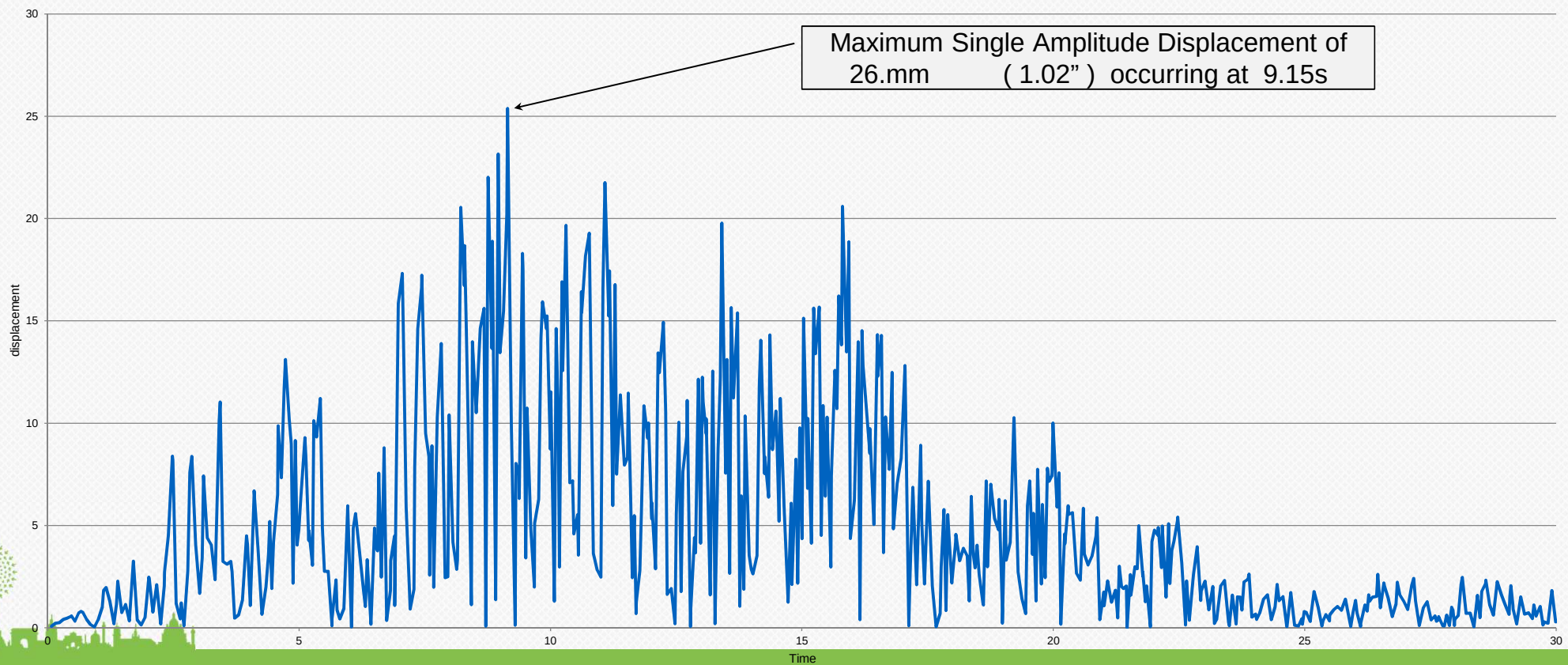
The Base of the rack is excited, in each of the three orthogonal directions, in accordance with Telcordia GR-63, Zone 2 Waveform



Displacement Resulting from Base Excitation in the X-Axis (Width) – Three Bayed racks, Shear Plate high / Low Positions

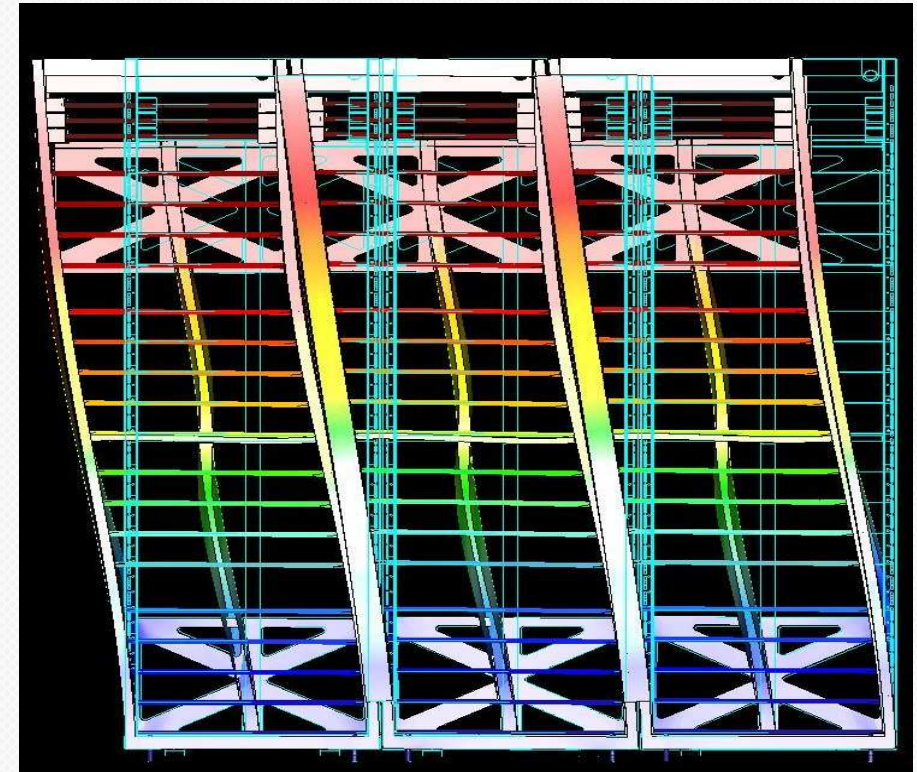
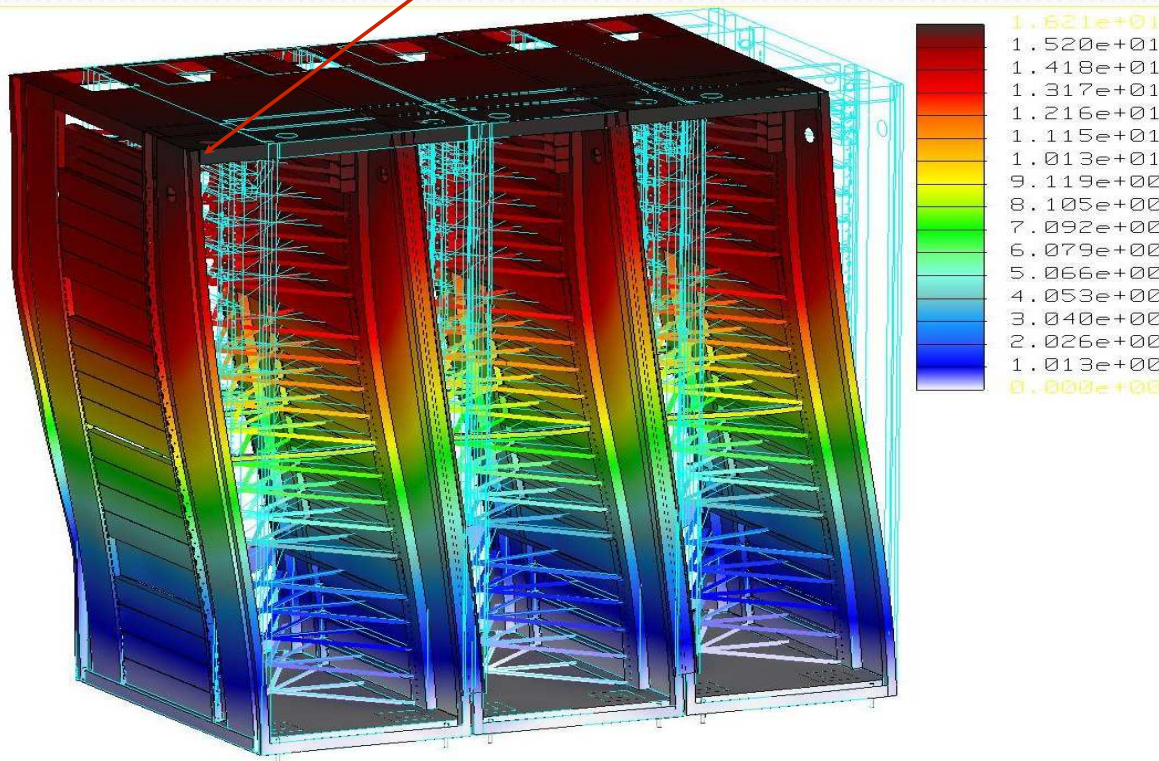
In Accordance with GR-63-Core R4-69, the Maximum Single amplitude deflection at Top of frame work, relative to base does not exceed 75mm

Displacement



Displacement Resulting from Base Excitation in the X-Axis (Width)

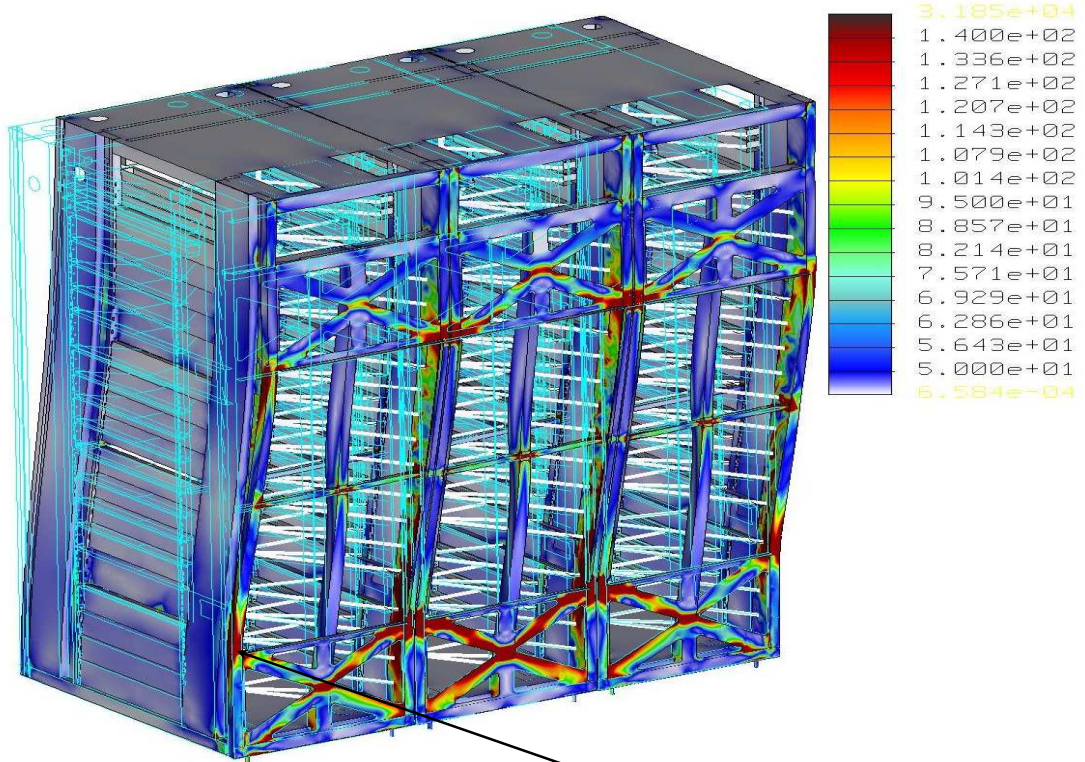
Maximum displacement of Rack 26mm



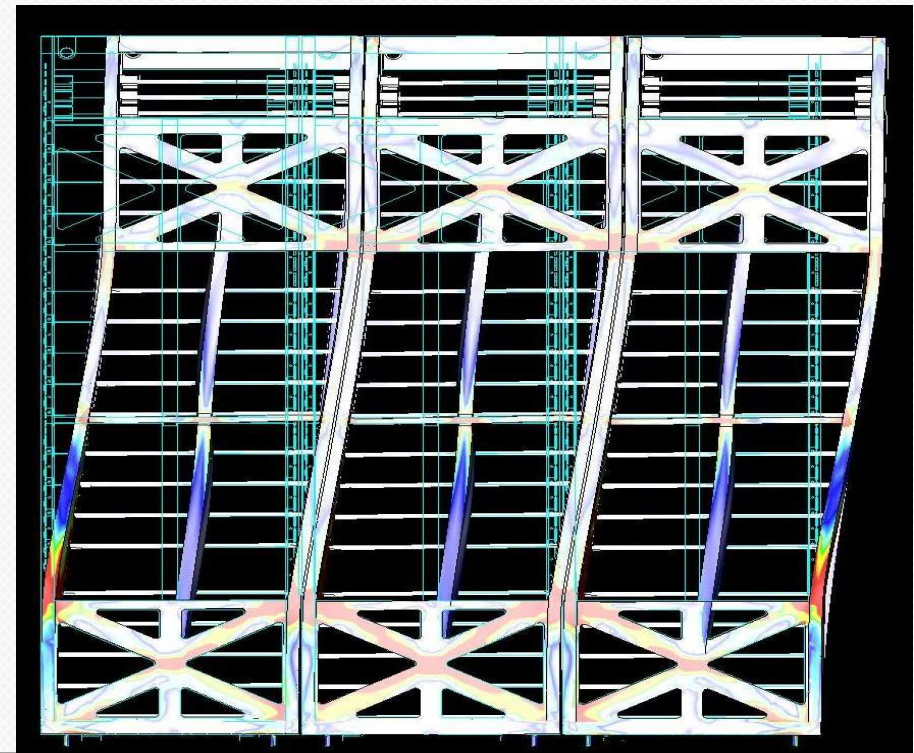
Displacement Generated in the rack at 9.15s

Stresses Resulting from Base Excitation in the X-Axis (Width)

In Accordance with G3-Core R4-68, all equipment shall be constructed to sustain the waveform testing, without permanent structural or mechanical Damage



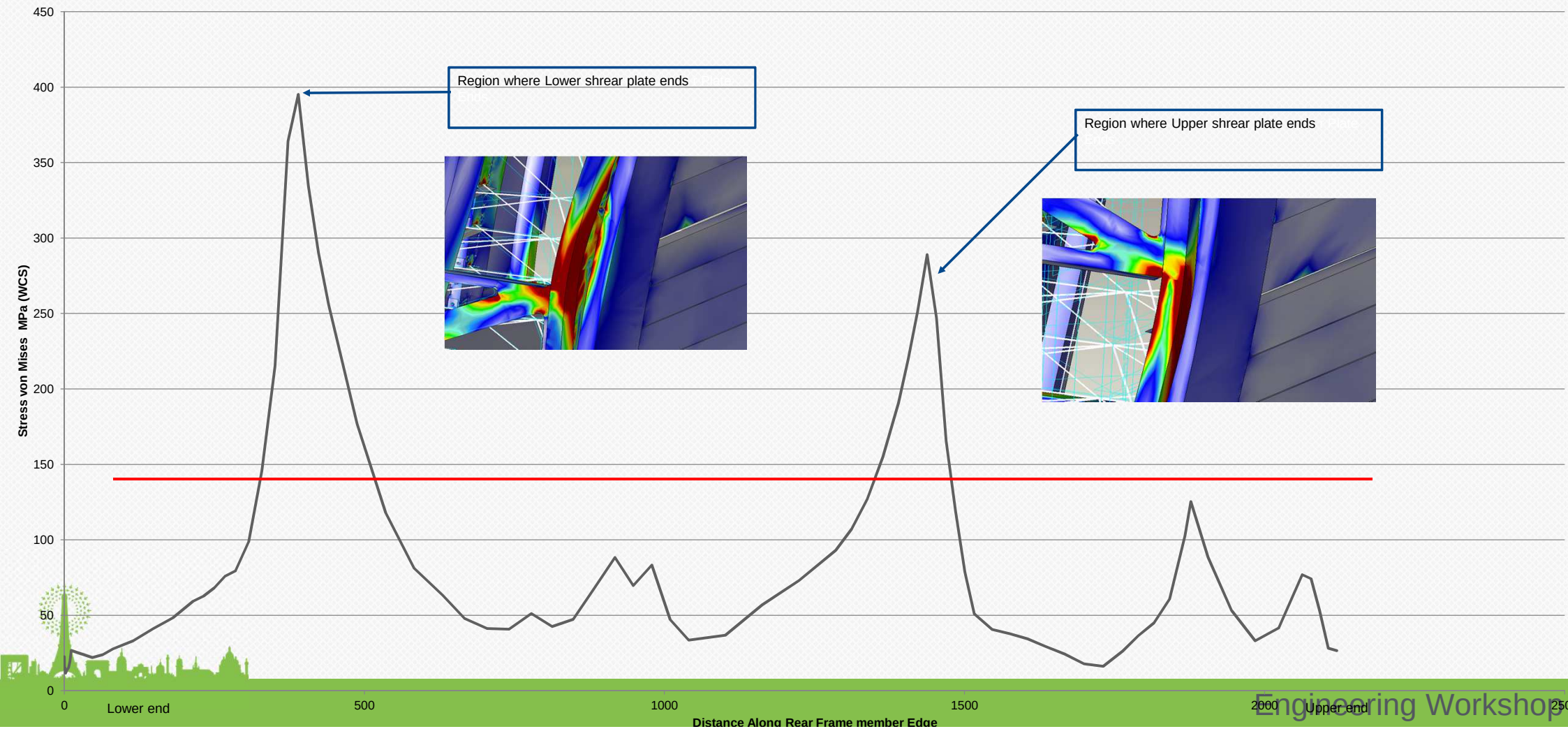
Stresses are generated in the Rear Frame members & Shear Brackets, which exceed the Lower Yield range for the material



Stresses Generated in the rack at 9.15s

High Stress Regions resulting from Base Excitation in the X-Axis (Width)

Stress von Mises (WCS) Progressing Up Rear Frame Member at 9.15 into Zone 2 Simulation



Analysis Result Details

Modal Analysis

The analysis Converged to within 10% on frequency, individual modal convergence listed below: -

Mode	Frequency (Hz)	Convergence
----	-----	-----
1	5.28e+00	2.6%
2	1.81e+01	3.1%
3	1.98e+01	3.2%
4	2.20e+01	2.4%
5	2.28e+01	0.9%
6	2.72e+01	2.8%
7	2.92e+01	2.6%
8	3.76e+01	1.5%
9	3.91e+01	1.4%

Dynamic Analysis

The analysis initially is completed with a time step of 0.075 seconds, a secondary analysis is to be completed, with the resolution increased around the Maximum deflection region.

The Target of 80% + Mass Participation was achieved, below is the participation factor for each mode

Mode	Part. Factor	Eff. Mass Tot. Mass
----	-----	-----
1	68.1%	68.1%
2	0.0%	68.1%
3	1.0%	69.1%
4	12.2%	81.3%
5	0.0%	81.3%
6	0.0%	81.3%
7	0.0%	81.3%
8	1.6%	82.9%
9	3.2%	86.1%

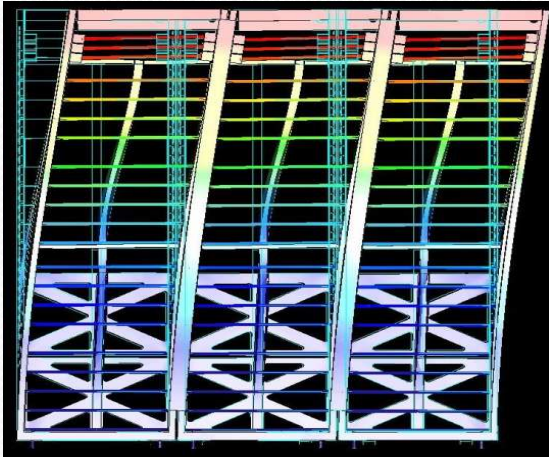


3 x Bayed / Ganged Pod + 2 x Shear Plates in the Lower Positions

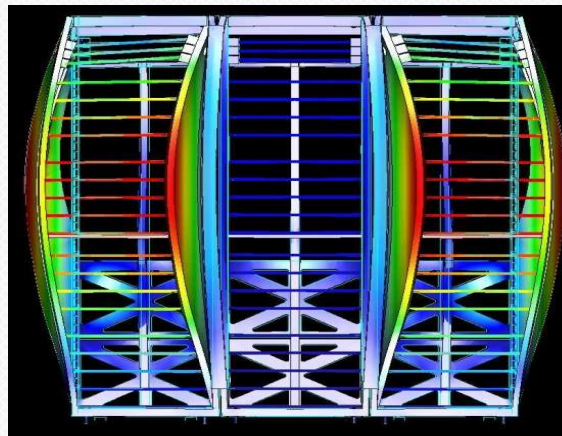


Modal Analysis — Three Bayed racks, Shear Plate 2x Lower Positions

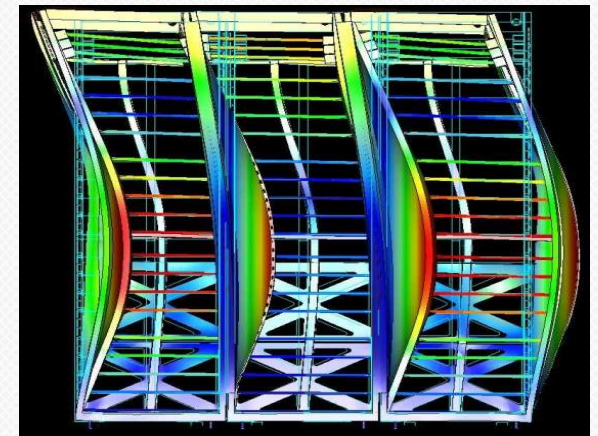
In Accordance with G3-Core R4-70, Frame-level equipment shall have a frequency greater than 2.0Hz



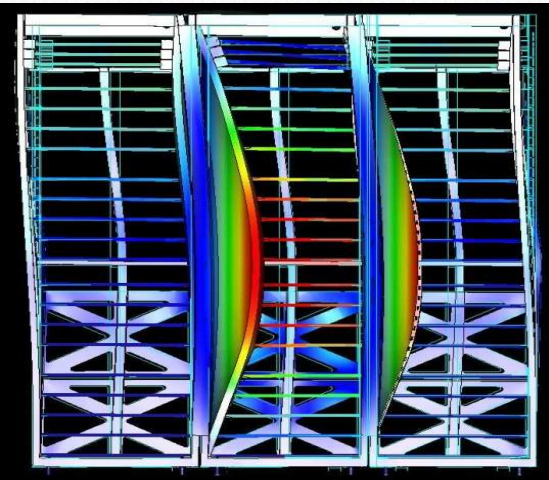
First Natural Frequency at 6.38Hz



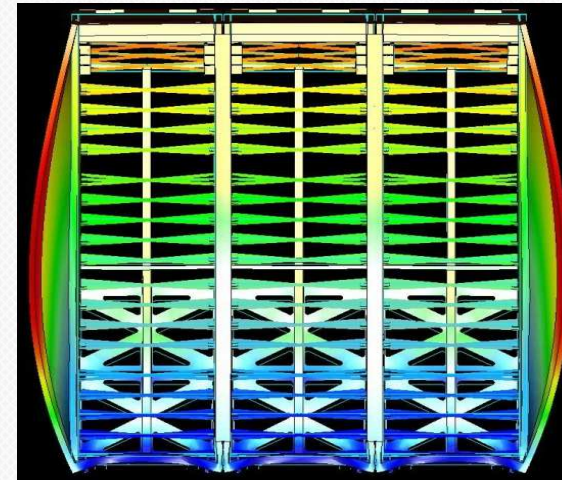
Second Natural Frequency at 17.30Hz



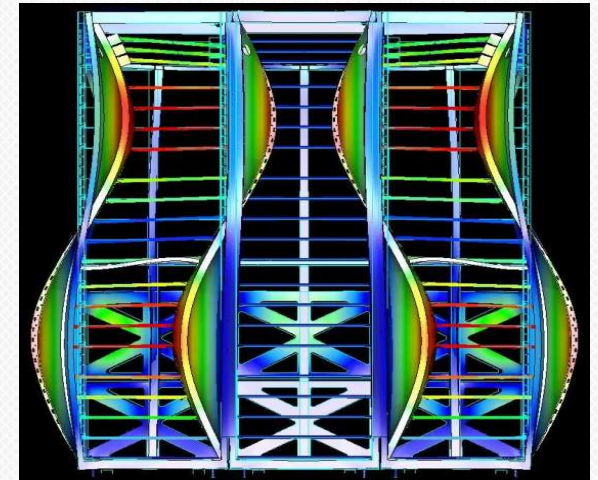
Third Natural Frequency at 18.50Hz



Forth Natural Frequency at 20.01Hz



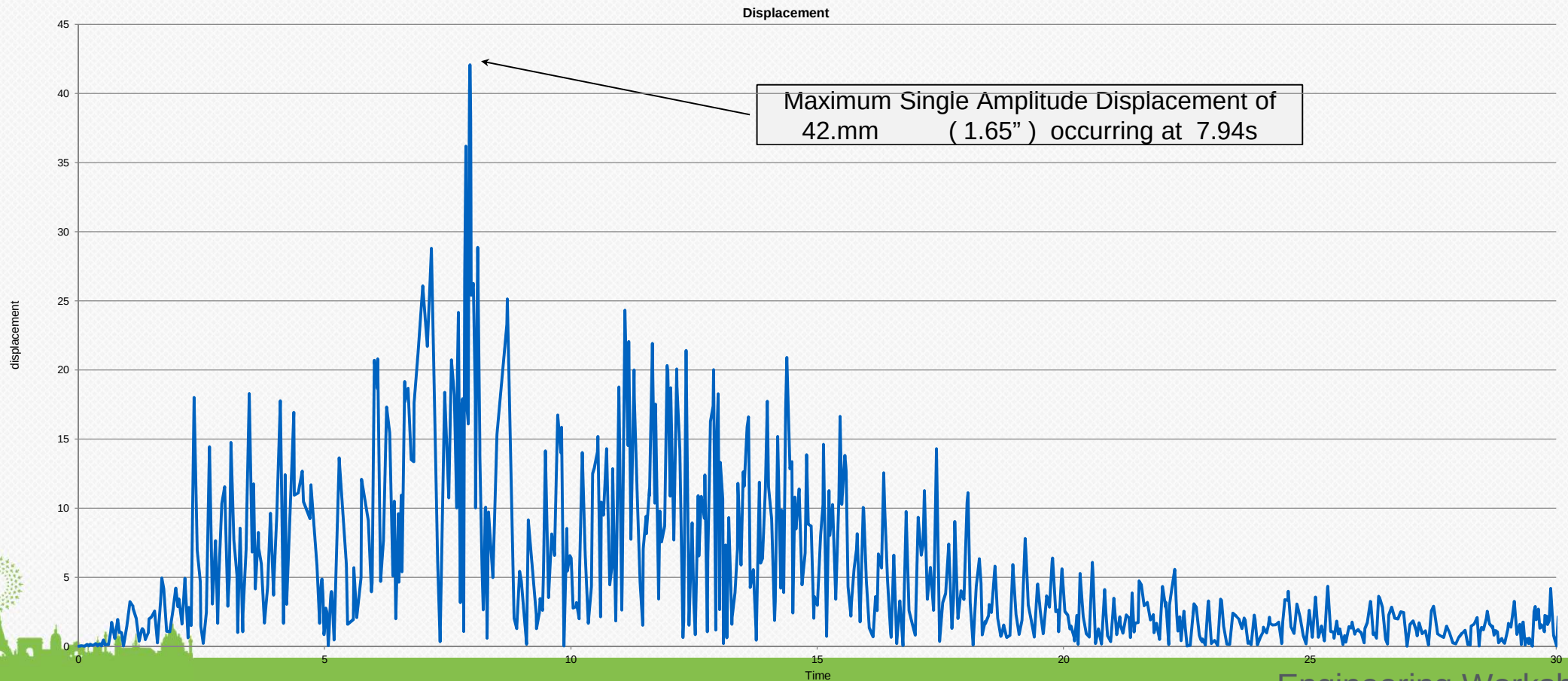
Fifth Natural Frequency at 22.720Hz



Sixth Natural Frequency at 26.940Hz

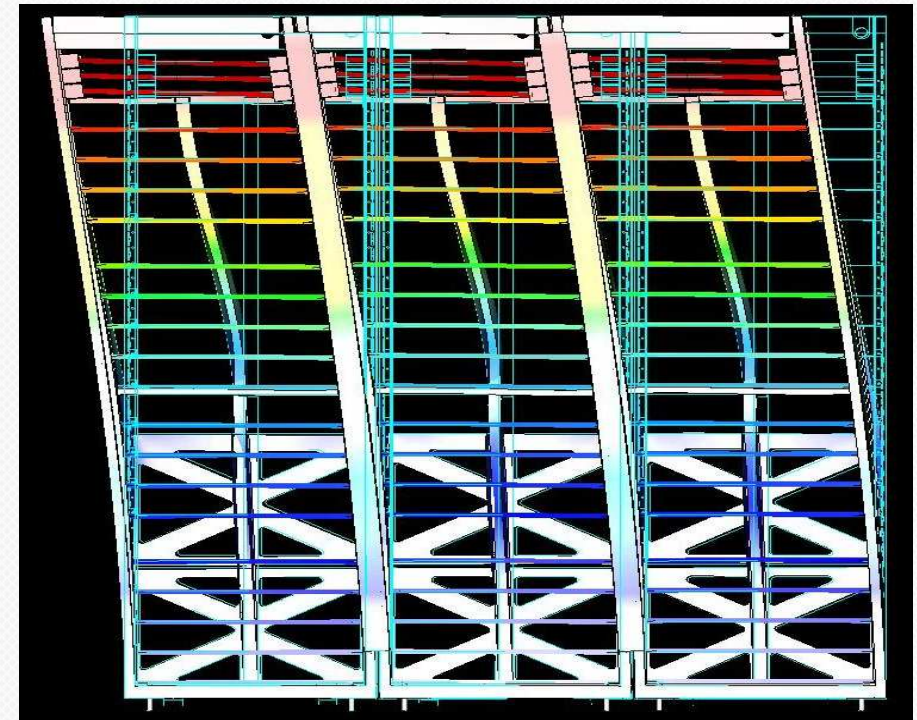
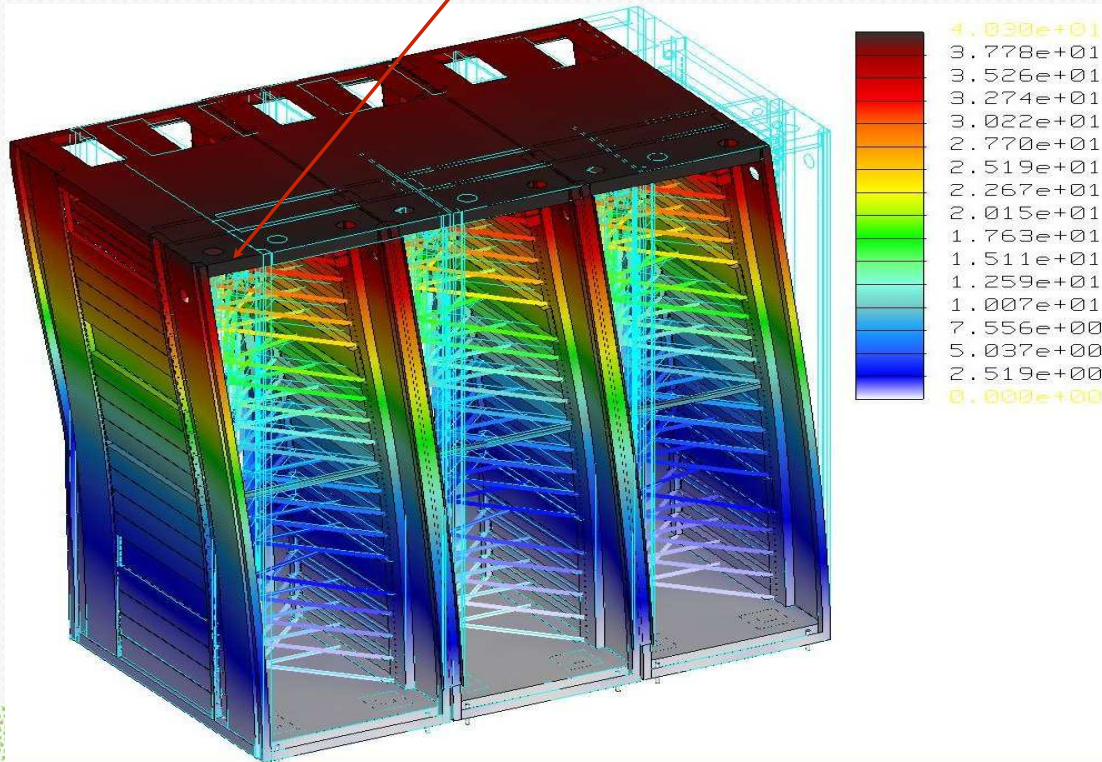
Displacement Resulting from Base Excitation in the X-Axis (Width) – Three Bayed racks, Shear Plate Low / Low Positions

In Accordance with G3-G3-Core R4-69, the Maximum Single amplitude deflection at Top of frame work, relative to base does not exceed 75mm



Displacement Resulting from Base Excitation in the X-Axis (Width)

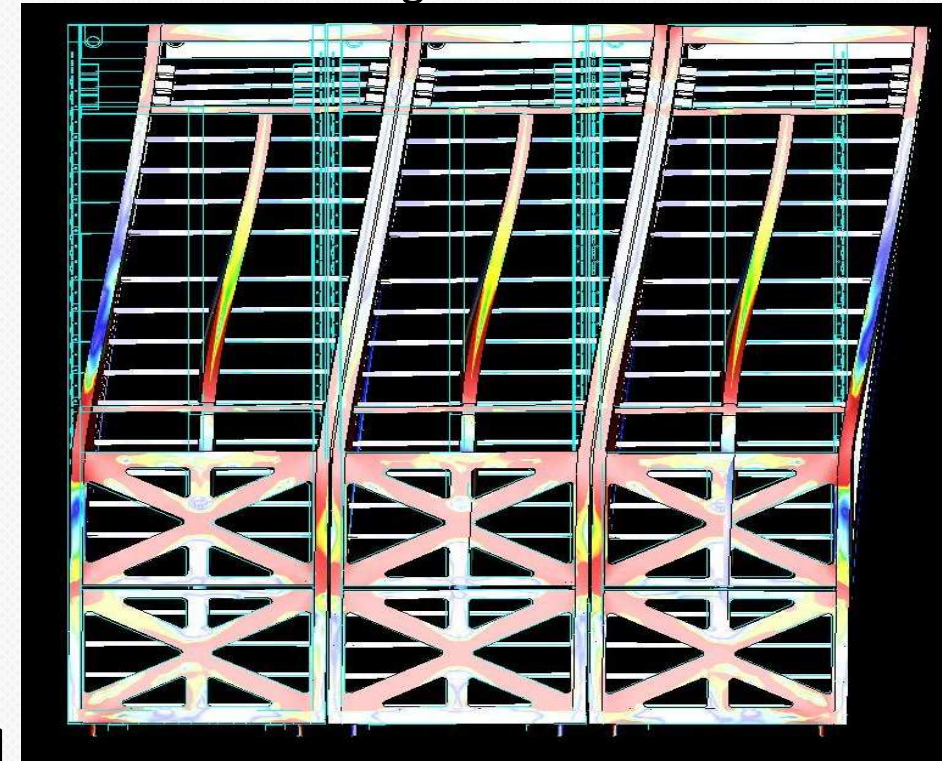
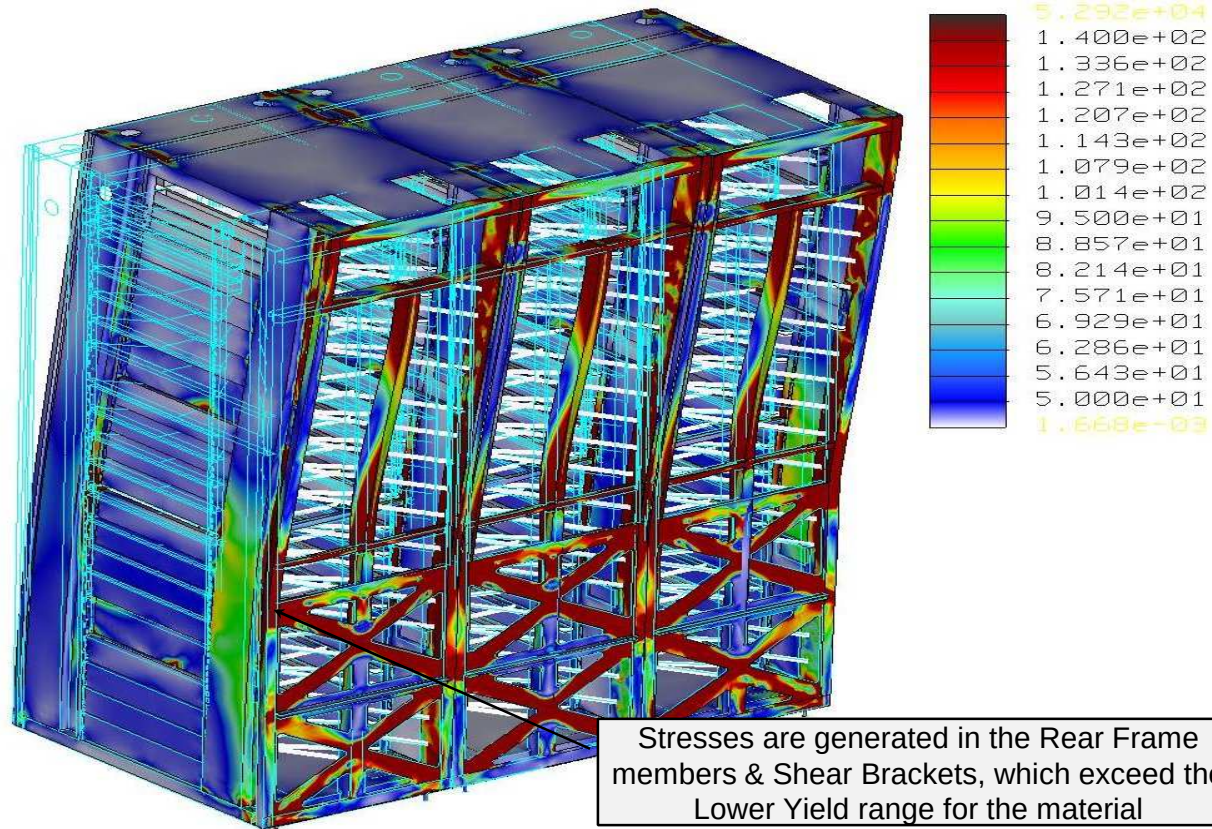
Maximum displacement of Rack 42 mm



Stresses Generated in
the rack at 9.15s

Stresses Resulting from Base Excitation in the X-Axis (Width)

In Accordance with G3-Core R4-68, all equipment shall be constructed to sustain the waveform testing, without permanent structural or mechanical Damage





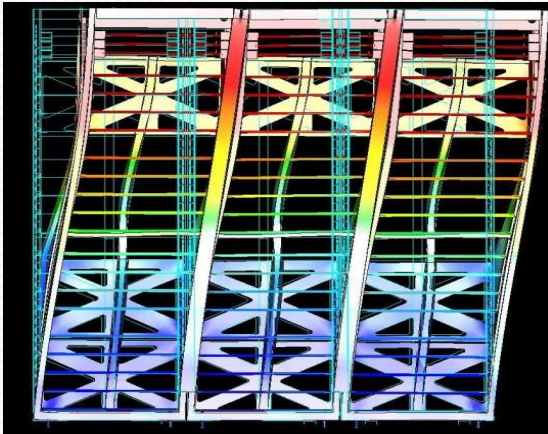
OPEN
Compute Summit

3 x Bayed / Ganged Pod
+ 1 x Shear Plates in the
Upper and 2x in the Lower
Positions

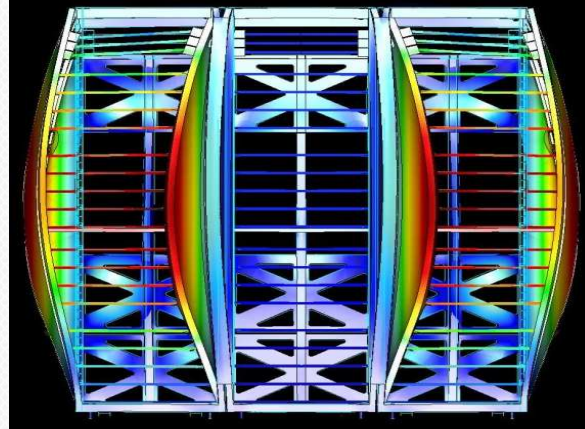


Modal Analysis — Three Bayed racks, Shear Plates 2x Lower+ 1 x Upper Positions

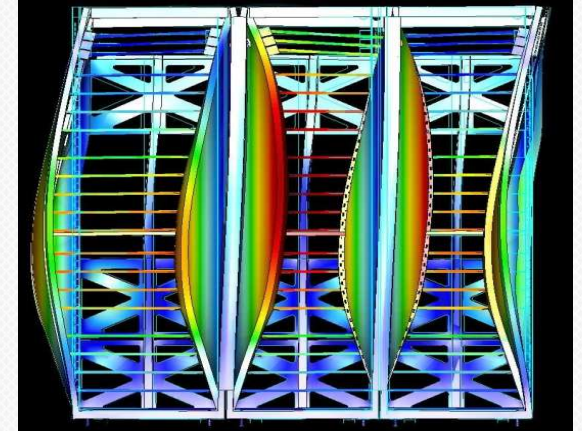
In Accordance With G3-Core R4-70, Frame-level equipment shall have a frequency greater than 2.0Hz



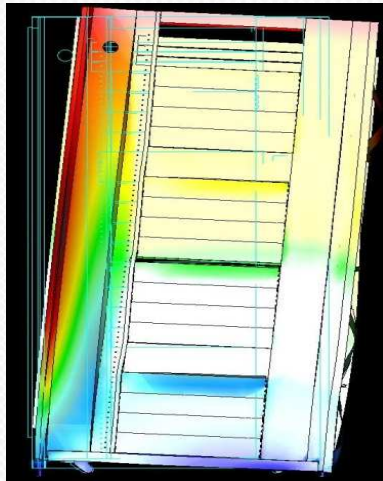
First Natural Frequency at 8.97Hz



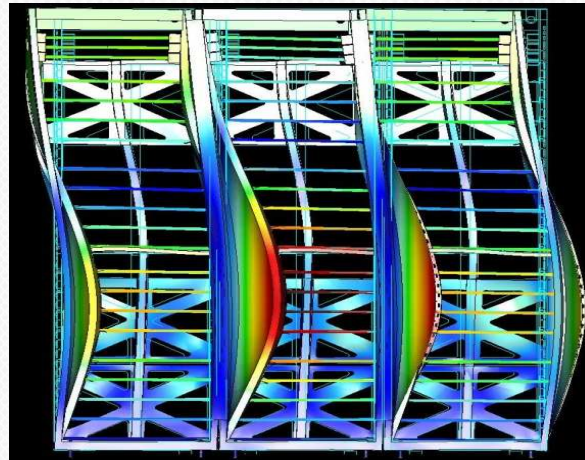
Second Natural Frequency at 18.49Hz



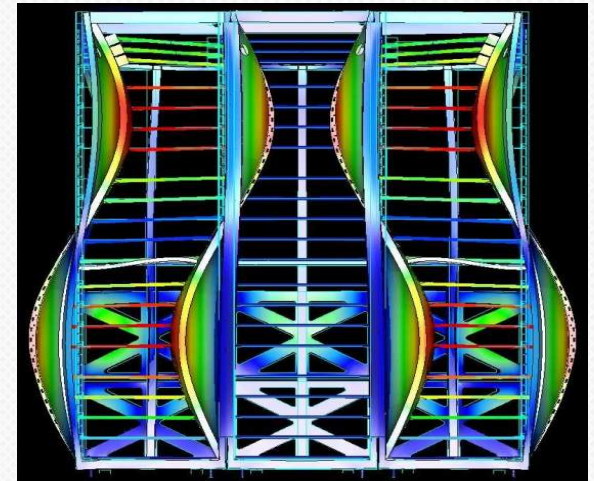
Third Natural Frequency at 19.95Hz



Fourth Natural Frequency at 22.81Hz



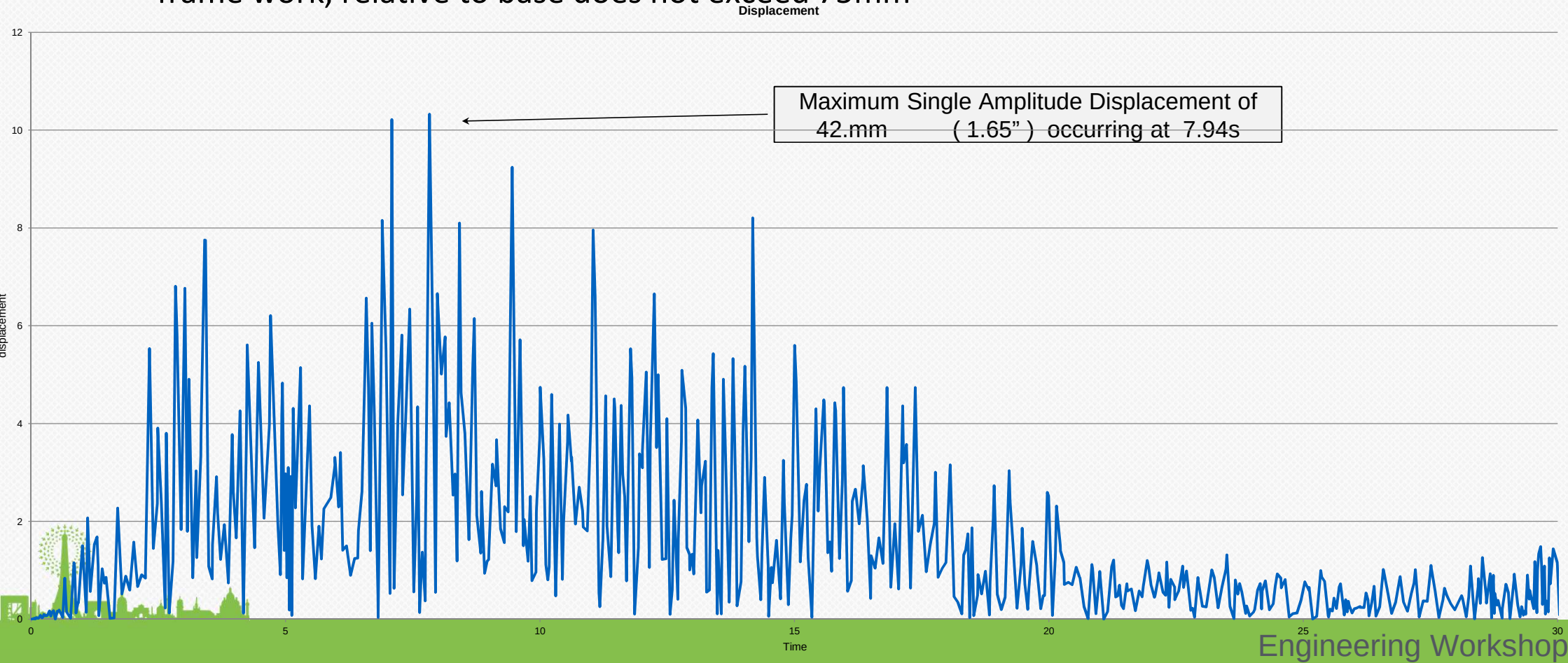
Fifth Natural Frequency at 22.97Hz



Sixth Natural Frequency at 28.360Hz

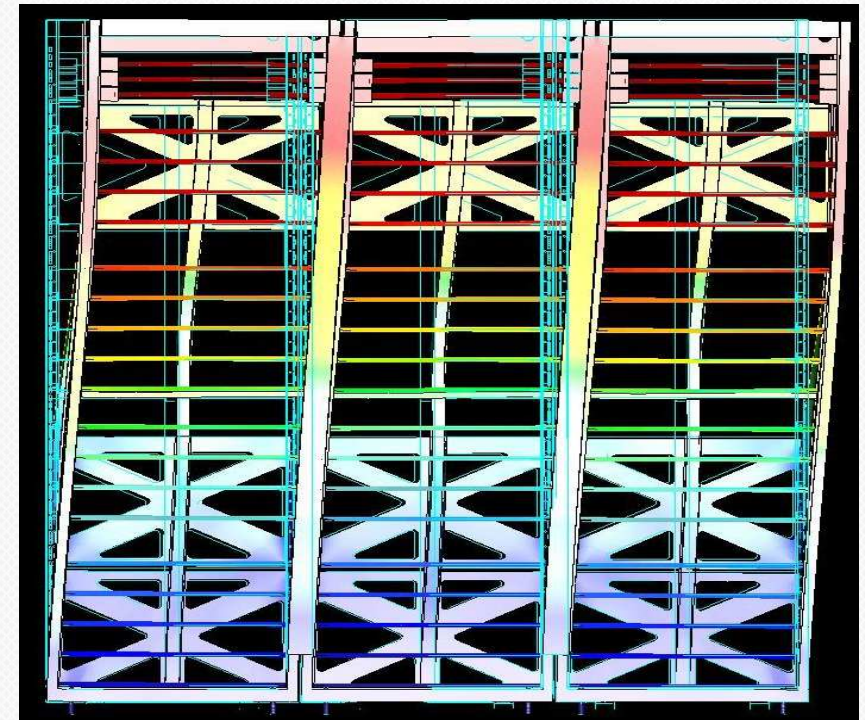
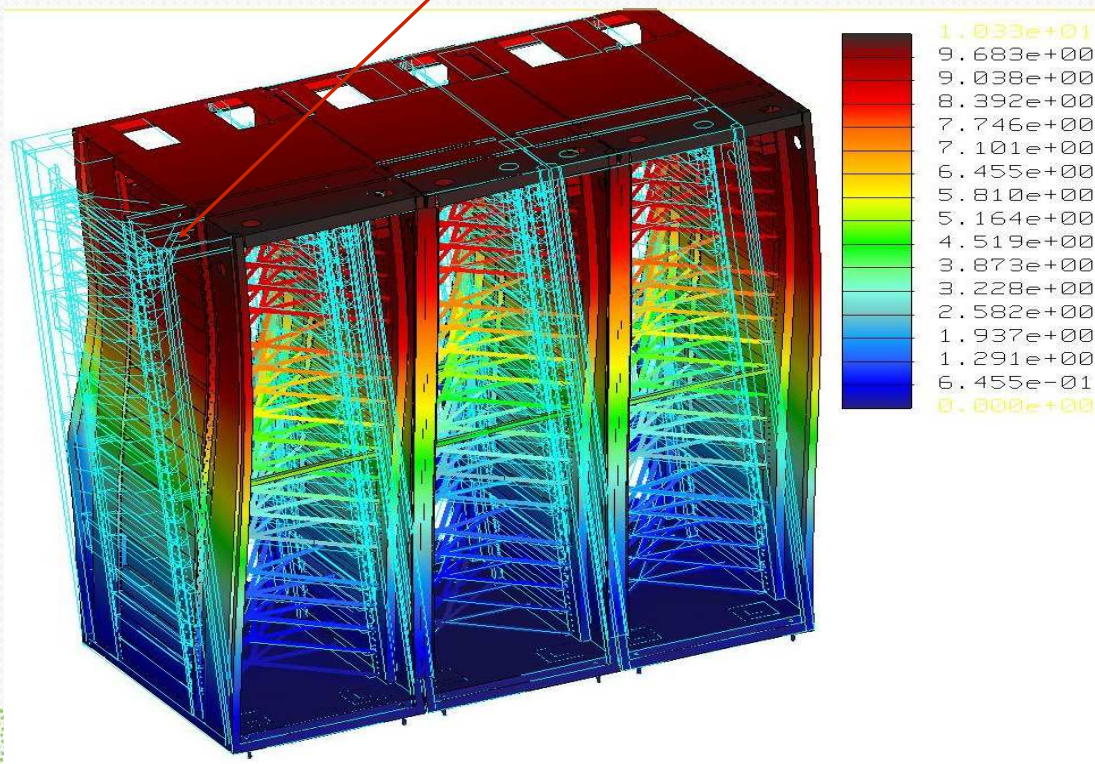
Displacement Resulting from Base Excitation in the X-Axis (Width) – Three Bayed racks, Shear Plate Low / Low + Up Positions

In Accordance with G3-G3-Core R4-69, the Maximum Single amplitude deflection at Top of frame work, relative to base does not exceed 75mm



Displacement Resulting from Base Excitation in the X-Axis (Width)

Maximum displacement of Rack 10.33mm

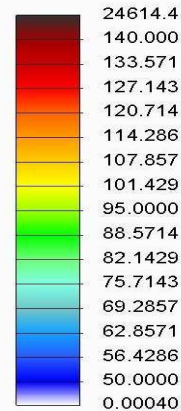
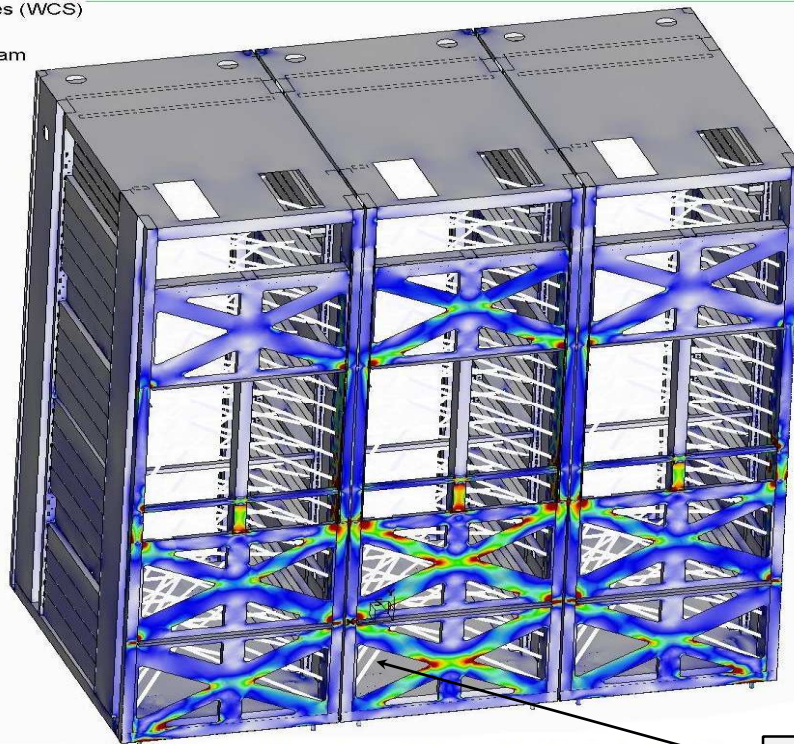


Displacement at 7.83s

Stresses Resulting from Base Excitation in the X-Axis (Width)

In Accordance with G3-Core R4-68, all equipment shall be constructed to sustain the waveform testing, without permanent structural or mechanical Damage

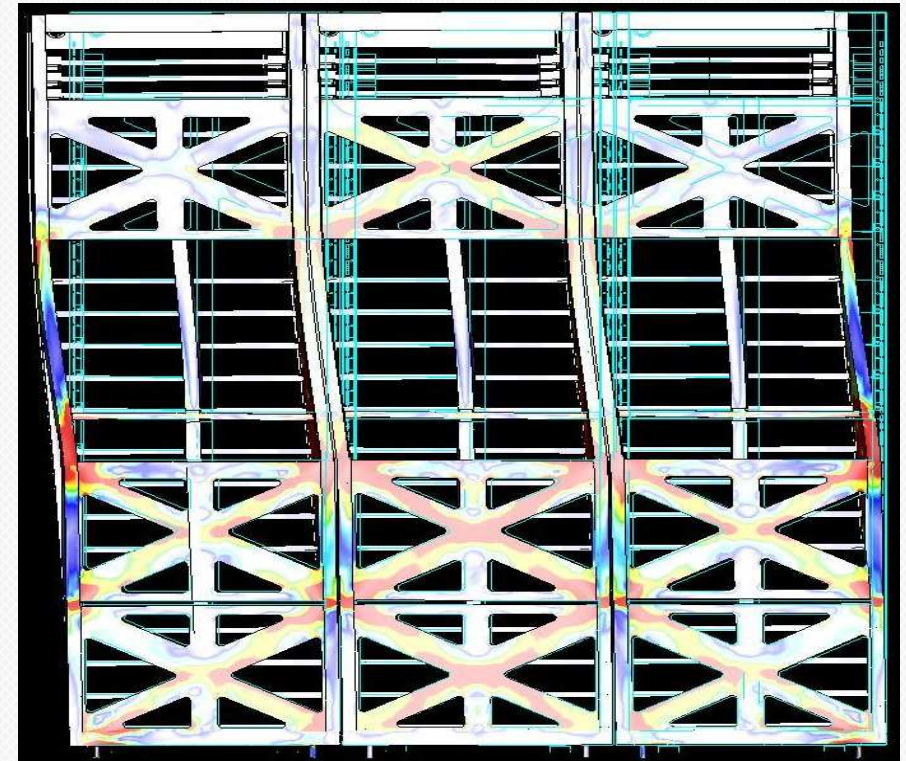
Stress von Mises (WCS)
Top of shell
Maximum of beam
(MPa)



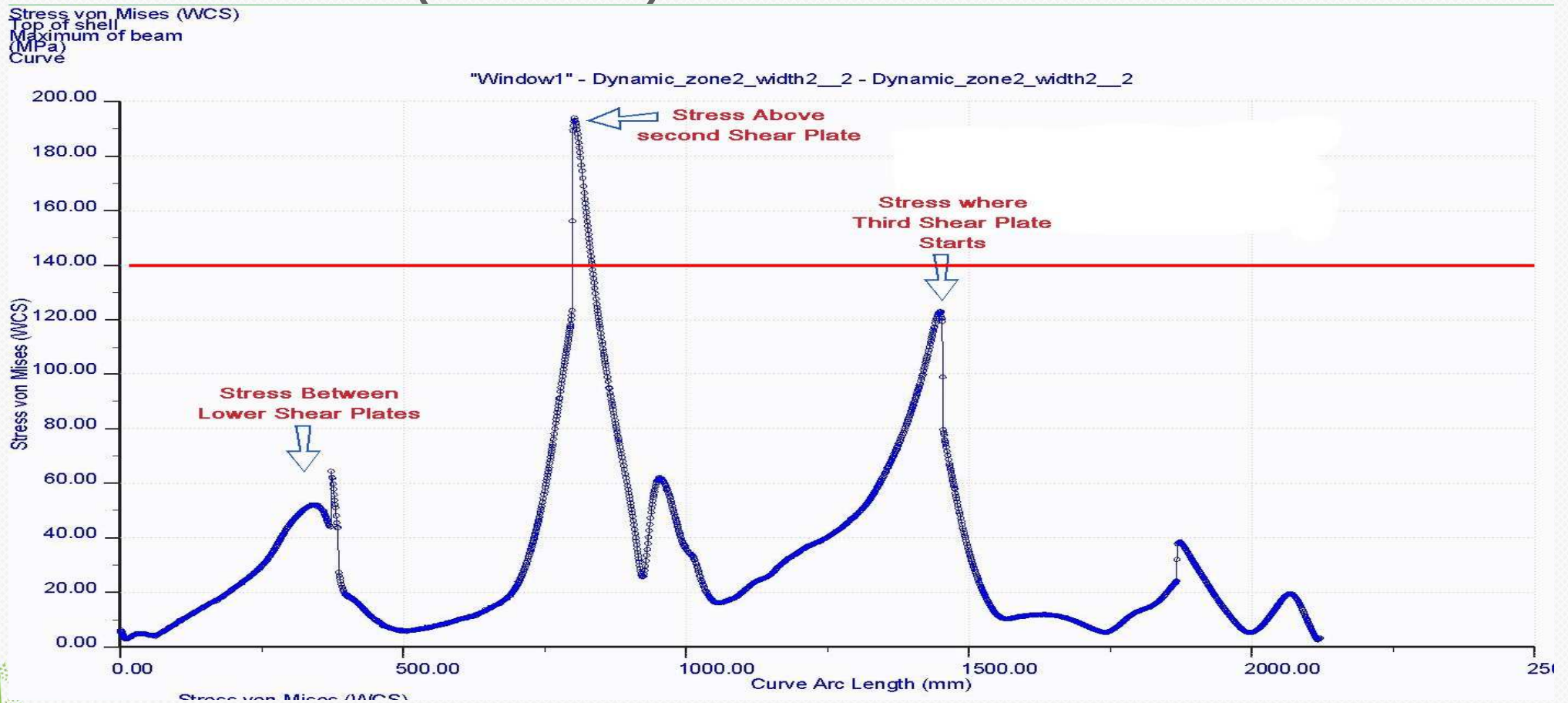
Stress (Von mises) When rack subjected to Zone2
Base Excitations, Maximum deflections at 8.43seconds
Legend Max 140MPa (Per DC01 Design Limit)

Stresses are generated in the Rear Frame
members & Shear Brackets, which exceed the
Lower Yield range for the material

Stresses Generated in
the rack at 8.43s



High Stress Regions resulting from Base Excitation in the X-Axis (Width)





Alternate Solution to Facebook Interpretation

Open compute – Alternative Solution



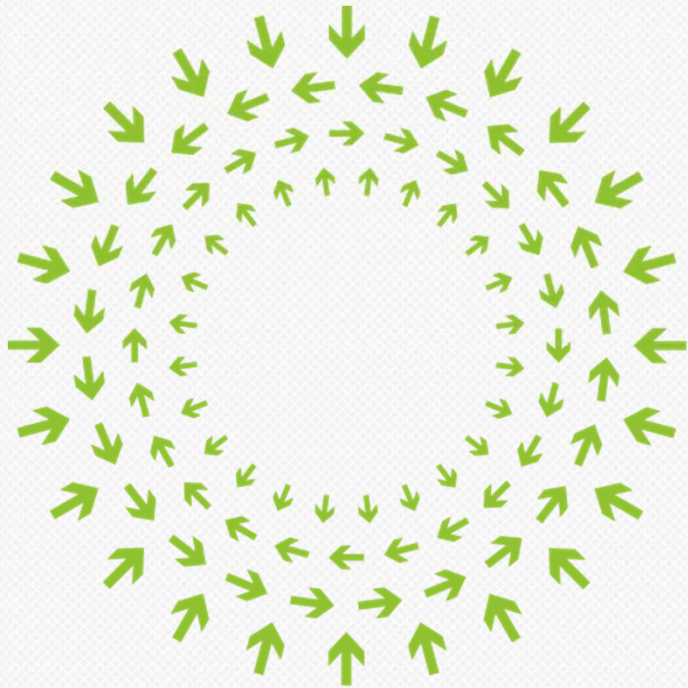
Key Rack Features Include : -

- 19 I.T. Shelves accessible
- 1 Power zone.
- Bus-bars 3 full height in rear
- Dimensions 2210H x 600W x 1067D



 Front Isometric View

Rear Isometric View



OPEN

Compute Summit

Engineering Workshop

October 30-31, 2014

Paris

