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Separation shocks

Easier specified than tested?

Mikael Tibbing M.Sc. Spec. Env. Engineering
Saab Surveillance, Environmental Qualification



Saab business areas

- Aeronautics
- Dynamics
- Kockums
- Combitech
- **Surveillance**



Saab Surveillance

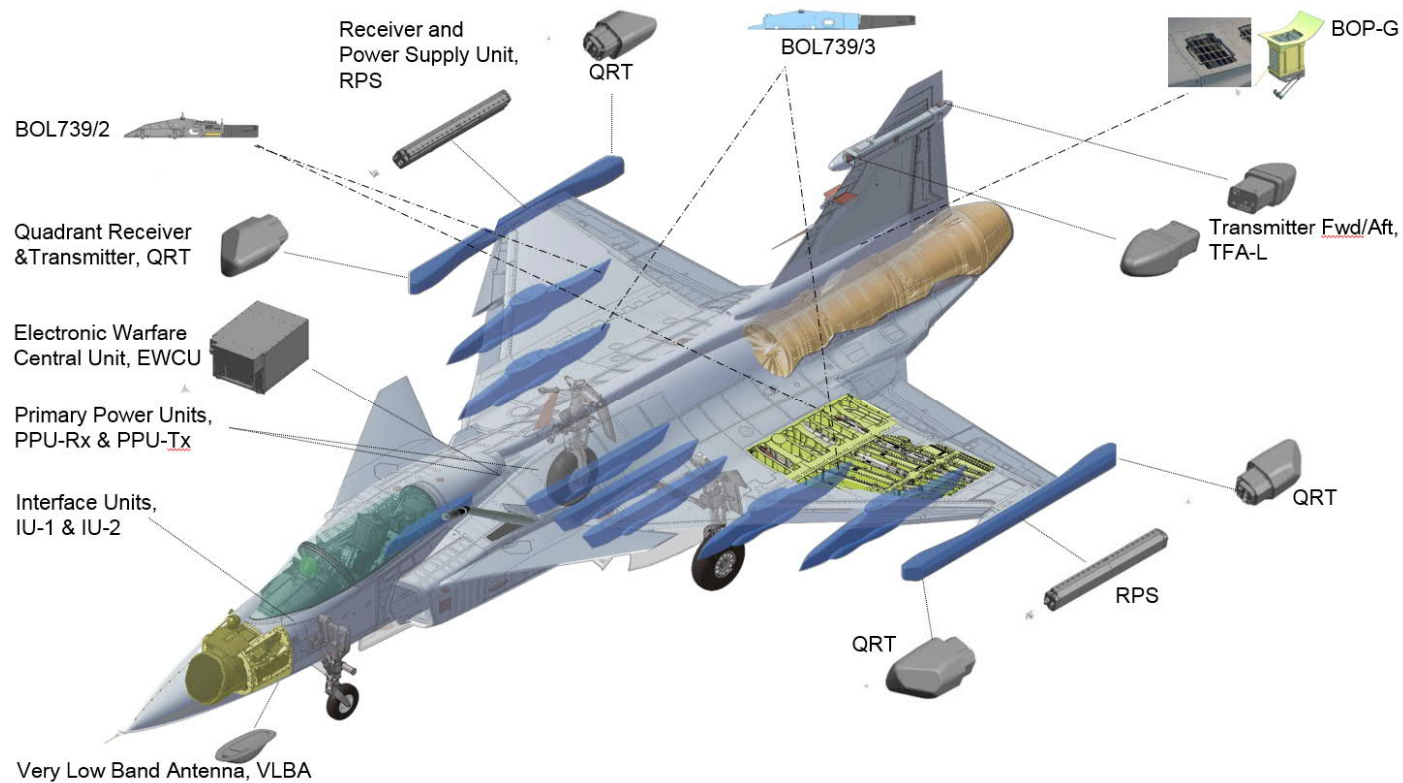
- Combat Systems
- Radar Solutions
- Traffic Management
- **EWAS**



EWAS - Electronic Warfare and Aircraft Systems

- CAS (Countermeasures and Aircraft System)
- ES (Electronic Surveillance)
- Saab Grintek Defence (SGD)
- Saab Sensor Systems Germany (S3G)
- **EW (Electronic Warfare)**

Saab Gripen EW



Environmental Qualification

Mech/Clim.
Steady-State Acceleration
Bench handling
Shock
Bump
Angular acc.
Angular velocity
Vibration
Acoustic noise
Low air pressure
Pressure change
Low temperature
High temperature
Rapid temperature change
Gradual temperature change

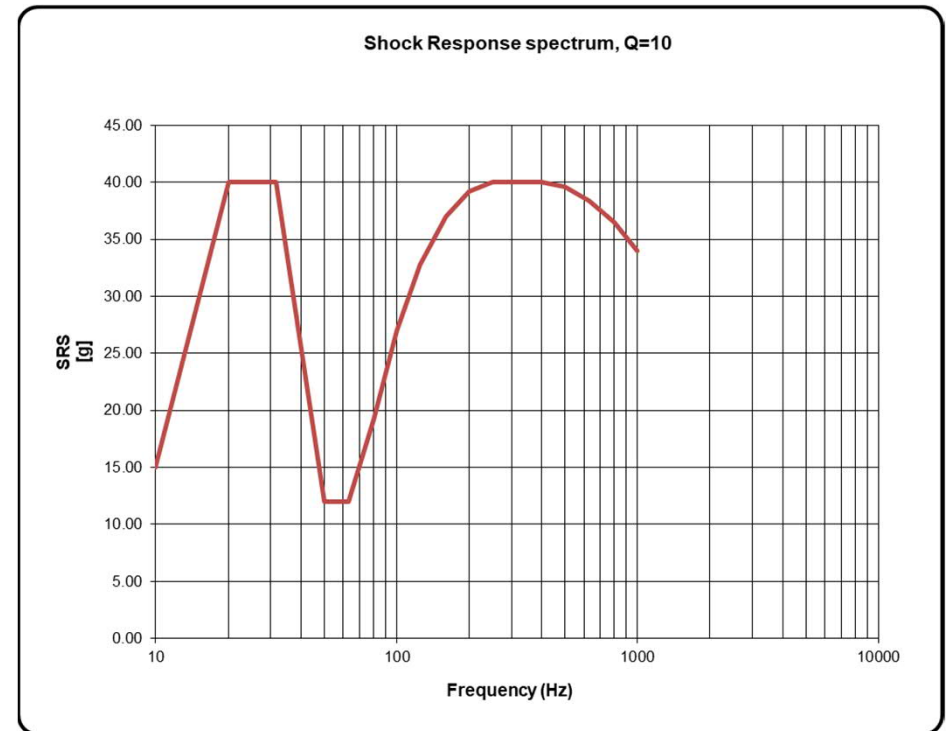
Mech/Clim.
Damp heat
Water
Sand and dust
Corrosive atmosphere
Explosive atmosphere
Solar radiation
Fungus
Ice/Freezing rain
Rain erosion
Fire resistance
Contamination by fluids
Rain impact
Hot Jet

EMC
CE102
CE106
CS101
CS103
CS104
CS105
CS114
RE102
RE103
RS103
RS105
Lightning Indirect Effects
Lightning Direct Effects

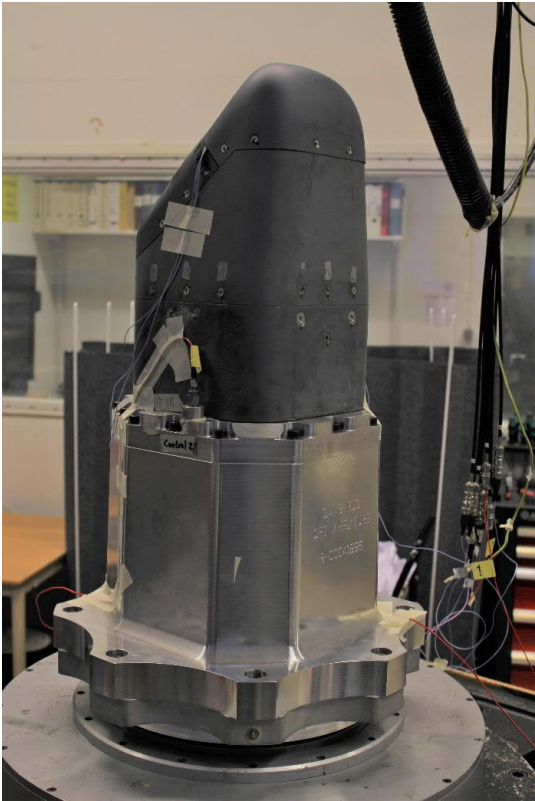
"Normal" shocks

- Hard landings
- Separation of adjacent stores

[F/A-18 Hornet Drop test – 20ft!](#)



Wingtip unit for Gripen E/F



Dispensers for Gripen E/F, pylon 2&3



Gripen aircraft with some stores



Weapon separation – Possible shock sources

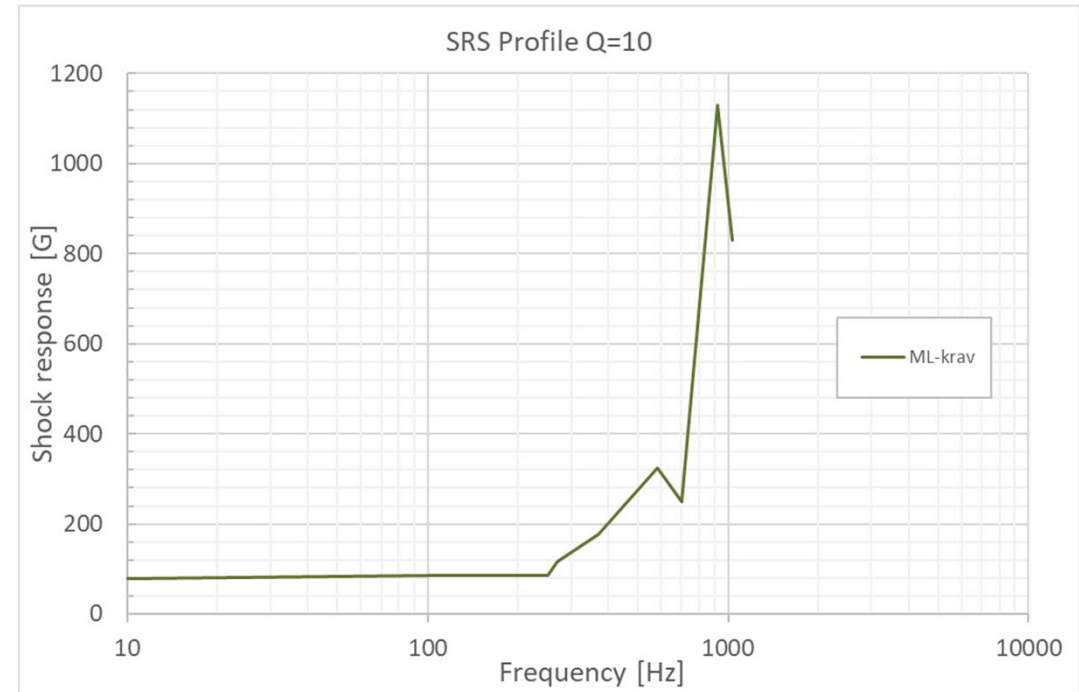
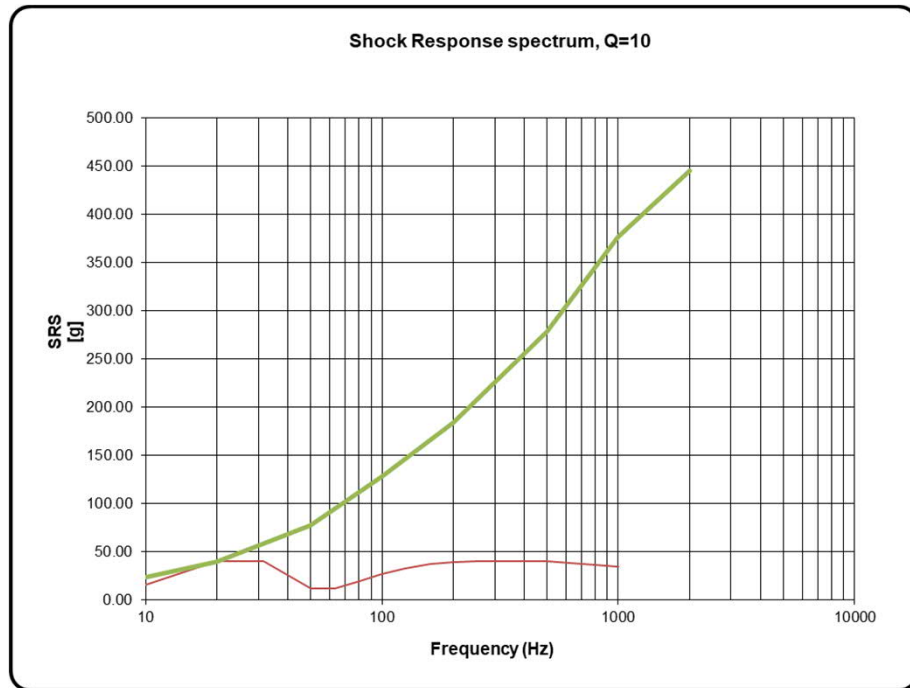
- Explosive bolt release
- Compressed air piston
- Piston reaction
- Wing rebound
- Missile lock passage



Separation problems

[Aircraft Store Separation Incidents](#)

Weapon separation shock requirements



Electrodynamic shakers

Maximum Force Ratings for System Configurations

	Sine Force (peak)		Random Force (rms)*		Half-sine Shock Force*	
	V8-440	V8-640	V8-440	V8-640	V8-440	V8-640
with SPA40K Amplifier	42.00 kN (9 442 lbf)	42.00 kN (9 442 lbf)	47.14 kN (10 598 lbf)	39.72 kN (8 929 lbf)	84.54 kN (19 005 lbf)	84.70 kN (19 042 lbf)
with SPA48K Amplifier	50.40 kN (11 330 lbf)	50.40 kN (11 330 lbf)	56.57 kN (12 718 lbf)	47.66 kN (10 714 lbf)	101.45 kN (22 806 lbf)	101.64 kN (22 850 lbf)
with SPA56K Amplifier	57.83 kN (13 000 lbf)	55.60 kN (12 500 lbf)	66.00 kN (14 837 lbf)	55.60 kN (12 500 lbf)	118.35 kN (26 607 lbf)	118.59 kN (26 660 lbf)

* Random and shock ratings assume a payload approximately twice the mass of the armature. Half-sine shock force is calculated with the standard payload, 2 ms pulsewidth, 10% pre/post pulse.

V8 Shaker Specification

LDS Shaker Model	V8-440	V8-640
Armature Diameter	440 mm (17.32 in)	640 mm (25.20 in)
Usable Frequency Range	dc to 2500 Hz	dc to 2300 Hz
Armature Resonance (fn)	2000 Hz	1900 Hz
Acceleration (sine peak)†	1370 m/s ² (140.0 gn)	392 m/s ² (40.0 gn)
Acceleration Random (rms)†	980 m/s ² (100.0 gn)	392 m/s ² (40.0 gn)
Effective Mass of Moving Elements (Armature with Raised Inserts)	42.0 kg (92.6 lb)	47.0 kg (103.6 lb)
Suspension Rotational Stiffness	387 kN m/rad (286 000 lbf ft/rad)	538 kN m/rad (397 000 lbf ft/rad)
Suspension Cross-axial Stiffness	27.6 kN/mm (158 000 lbf/in)	29.0 kN/mm (166 000 lbf/in)
Stray Magnetic Field§	Base-mounted Shaker: < 1.6 mT (16 gauss) — Trunnion-mounted Shaker: < 1.0 mT (10 gauss)	
Suspension Axial Stiffness	20 kN/m (114 lbf/in)	
Velocity (sine peak)†	1.8 m/s (70.9 in/s)	
Displacement (peak-peak)‡	63.5 mm (2.5 in)	
Internal Load Support Capability	700 kg (1540 lb)	
Body Mass	Base Mounted: 3050 kg (6724 lb) — Lin-E-Air Trunnions: 3250 kg (7165 lb)	
Body Suspension Resonance	Lin-E-Air Suspension: < 5 Hz — Air Isolaton Mounts: < 10 Hz	
Ambient Working Temperature	+7 to 30 °C (+45 to 86 °F)	
Maximum Dimensions (H x W x D)	Trunnion-mounted Shaker: 1320 x 1693 x 1138 mm (52.0 x 66.6 x 44.8 in) Base-mounted Shaker: 1225 x 1103 x 1341 mm (48.2 x 43.4 x 52.8 in)	

Test sites in Sweden

Testplats	Kraft sinus	Kraft random	Kraft shock	Slaglängd	Vikt glidbord	Vikt övrigt	Delning	Glidbord	Expander	Temporråde	Kontakt
Intertek Jfa											Håkan Mårtensson 070 8750075
Ling V8	57.8kN	66kN	118.4kN	+/-31.75mm	144.6 41.6kg	81.5kg	70x70mm	1340x1216 920x600	610x610 57.4kg	RT	
Ling V954	40kN	32.7kN	?	+/-12.5mm	37.6kg	46.4kg	70x70+cirke	500x700		RT	
S Gbg											Jan Schloenzig +46 31 794 88 66
Ling V875-LS	35.6kN	35.6kN	106.8kN	+/-25.4mm	137.4 28.9kg	63.5kg	69.85x69.85mm	1220x1200 660x600	680x630 45kg		
Ling V824-LS	26kN	24kN	48kN	+/-25.4mm	27.4kg	37.4kg	69.85x69.85mm	600x600	D585 54kg		
AN Linköping											Christina Johansson +46 102163352
Ling 954LS	34kN	27kN		+/-24mm			70x70mm	1000x1000 600x600	350x600	RT	
Ling 964LS	80kN	57kN	99kN	+/-24mm			70x70mm	1000x1000 600x600	600x600 600x1000	-50 -- +85C	
BTC Karlskoga											Gustafsson Per-Åke <perake.gustafsson@testcenter.se> 058684023
ETS H1248A	120kN	120kN	235kN	+/-31.5mm	?	85 kg armatur	70x70mm	1300x1000 800x800	D800	-55 -- +100C	
Ling954LS	40kN	?	?	+/-25mm	?	?	70x70mm	1265x1216	D585	-46 -- +100C	
Ling954	40kN	?	?	+/-10mm	?	?	70x70mm	1265x1216	D585	-55 -- +100C	
Innventia/RISE Kista (Packforsk)											Akrediterat lab Torben Jacobson 076-8767059 torben.jacobson@ri.se
Ling 964-LS	71kN	60kN	100kN	+/-25mm	?	?	70x70mm	910x980	D815		
Ling 964-LS-2	89kN	80kN	160kN	+/-25mm	?	?	70x70mm	900x900	D815		
Ling 964-LS-2 Klimat	89kN	80kN	160kN	+/-25mm	?	?	70x70mm	-	D560	-45 -- +90C	
Ling 875-LS	35kN	31kN	107kN	+/-25mm	?	?	70x70mm	750x750	D645		
Schenck bi-ax	80 kN V			+/-100mm V						1-200Hz	
Schenck single-axis	30 kN H			+/-125mm H			100x100mm	1100x1101		1grms	
SP/RISE Borås											Andreas Anderson 010-516 53 53
LDS v894-440		55.6	50	25			70x70mm	ca900x900	knapp 900x900		
ETC M		68.7	137	31.8			70x70mm	ca900x900	knapp 900x900		
LDS 826-LS		14.2	50	25			70x70mm	ca900x900	knapp 900x900		
Servo-hydraulisk 4-ax, 5ton	35/60kN										Martin Olofsson 010-516 53 10
<i>Kommande</i>		74	222/180	76			70x70mm	Flexibelt	?	Klimatskåp	
Saab Training Huskvarna	?										Håkan Hedbjörk 036 38 84 17
LDSV864 Combo	39800			+/-25mm				750x750	D800		
MWL KTH											Stefan Jacob <sjacob@kth.se> 0721486242.
Ling 964	?	?	?	39mm			70x70mm	Ur funktion	-		
Pyroshockmaskin!?											
Delta / FORCE Västerås/DK											Akrediterat lab https://se.madebydelta.com/tjanster/vibrationsprovning/ infose@delta.dk
IMV??	54kN	54kN	108kN	+/-50mm				Stort			

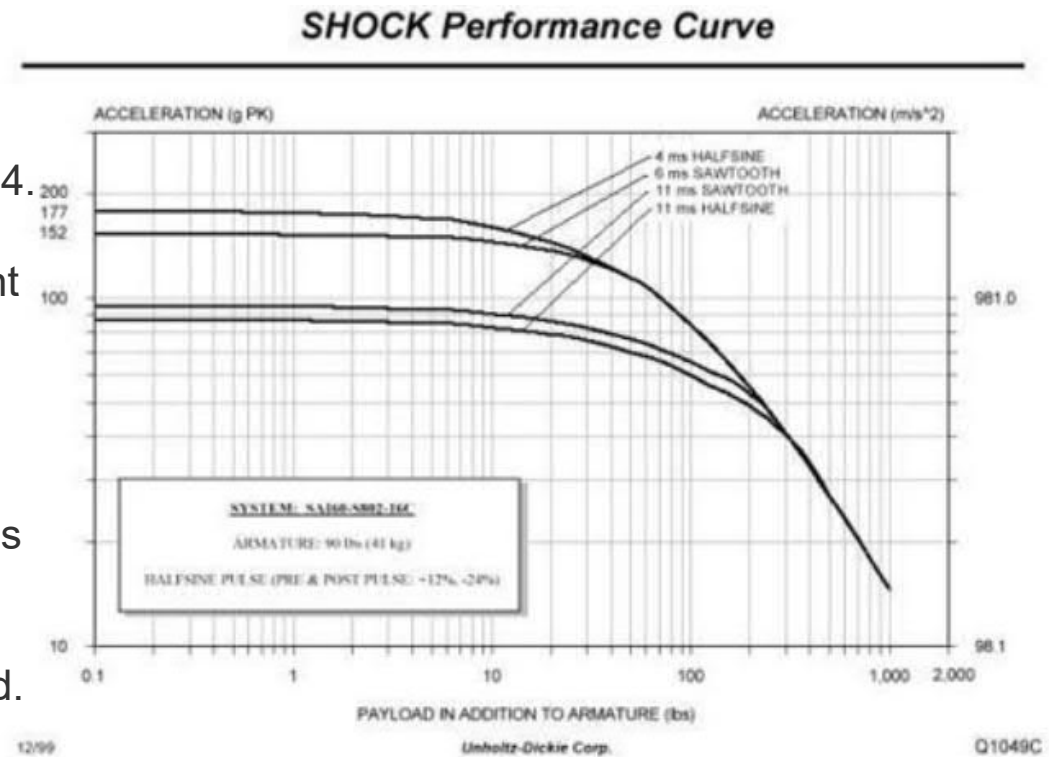
But...

Performance *should* be specified according to ISO 5344.

The Shock performance is dependent on many different variables including pulse shape (half-sine, trapezoid, sawtooth, etc.), pulse peak amplitude, pulse duration, test load weight and load dynamics.

Furthermore, the specified shocks were not specified as classical shock pulses, but as SRS.

Different control systems push the limits differently hard.



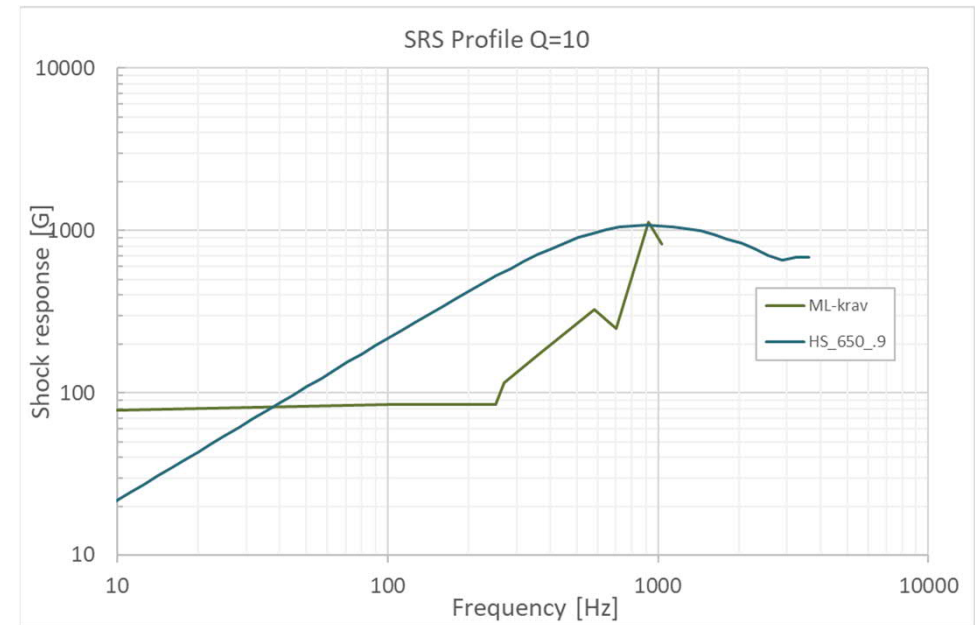
=> Comparison of shock test performance is difficult without actual pre-testing!

Shock test machine testing?

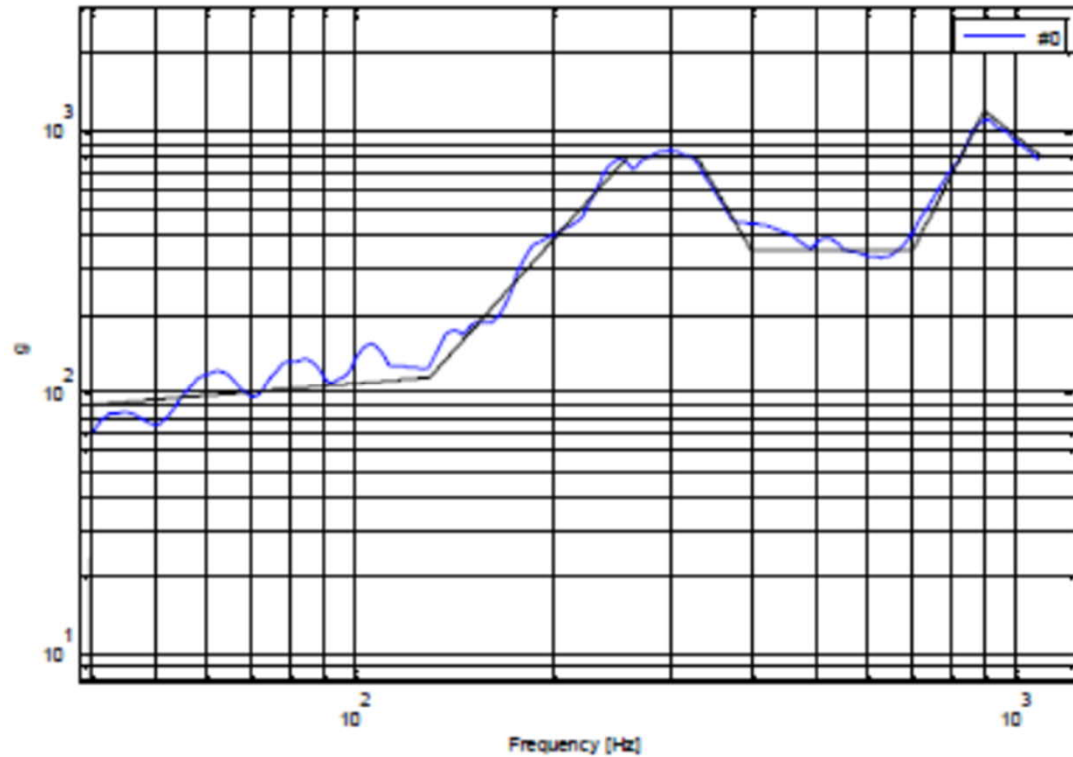
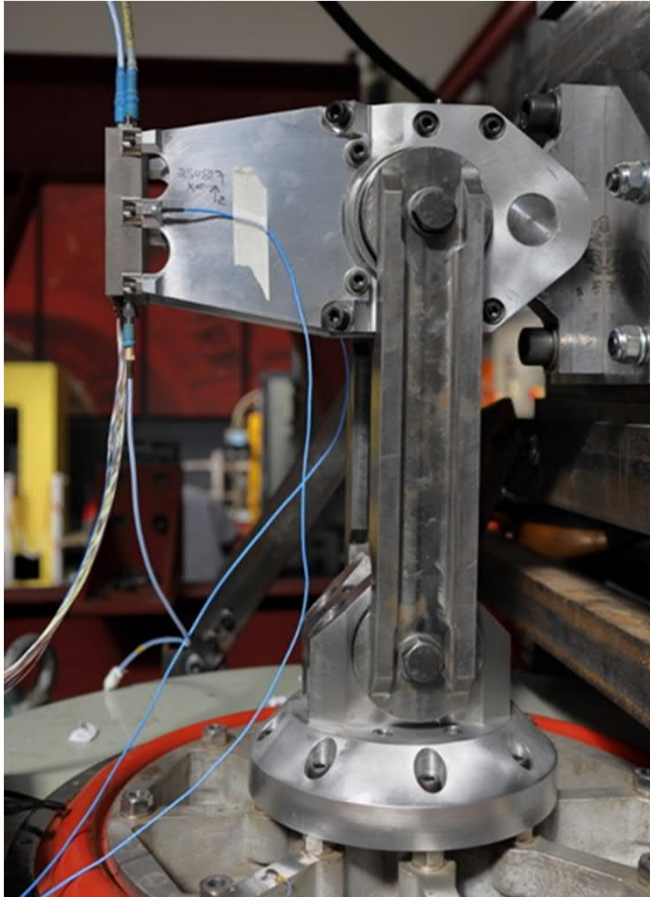
Mechanical Environment Shock test machine AVEX SM 110 MP



Max. load:	90 kg
Velocity at impact	
without load:	10 m/s
70 kg load:	7 m/s
Max. acceleration:	3000 g
With shock amplifier:	30000 g
Pulse duration:	0.1 – 24 ms
Pulse form:	Half sine
Table size:	405 x 405 mm
Hole spacing:	70 x 70 mm, M10
Max. Stroke:	430 mm



Component testing with shock amplifier



University of Pretoria
www.structest.co.za

www.saab.com

