Dynamic Response of Wheelchair Cushions to the ISO Impact Damping Test

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Abstract

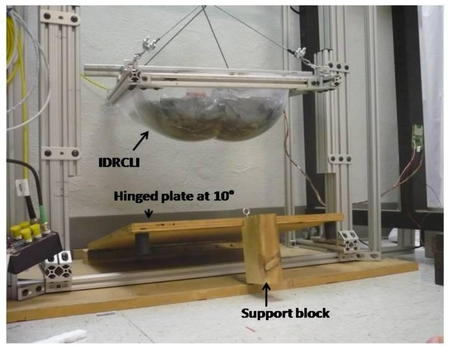
Selecting an appropriate wheelchair cushion is not a trivial process. A wheelchair cushion must be able to optimize the load distribution as well as to minimize peak pressure which is crucial to pressure ulcer prevention. In addition, a wheelchair cushion has to provide adequate supportive properties to the user. The International Organization for Standardization (ISO) has been developing wheelchair cushion standards and tests to characterize physical and mechanical properties of such cushions. One of these tests, the impact damping test (IDT), characterizes the abilities of a wheelchair cushion to reduce impact loading on tissues and to help maintain postural stability. The objectives of this project are to evaluate the methodology described in the ISO standard, determine the repeatability of the accelerations resulting from the ISO test method and assess the test method's ability to distinguish the impact damping performance of different cushions. A small cohort of 5 cushions was selected to represent variability in material and design of wheelchair cushions.

Aims

1. Evaluate a cohort of 5 wheelchair cushions using the IDT
2. Assess the feasibility and pertinence of ISO IDT for characterizing the impact damping characteristics of the wheelchair cushions

Methods

Test Rig



Wheelchair Cushions

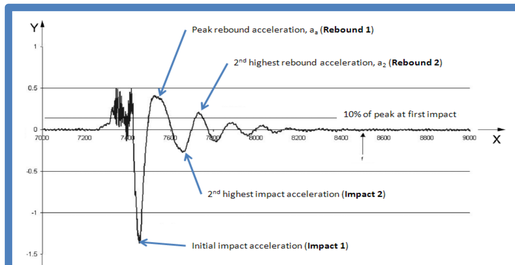
Cushion	Manufacturer	Material
3" flat HR 45 Foam #1	Hibco Plastics, Inc; Yadkinville, NC	Urethane foam with *45* IFD
3" flat HR 45 Foam #2	Hibco Plastics, Inc; Yadkinville, NC	Urethane foam with *45* IFD
Cloud	Otto Bock USA, Minneapolis, MN	Viscous fluid bladders within elastic foam base
Dream	Allegro Medical, Meza, AZ	Viscoelastic foam
Roho HP	The Roho Group, Belleville, IL	Single valve adjustable air cushion

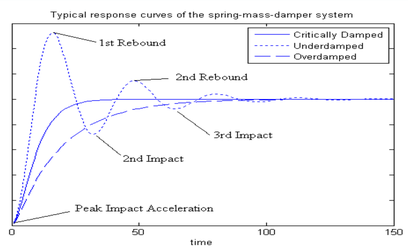
Note: - 2 samples of the same flat foam were used
HR=high resiliency; IFD=indentation force deflection; HP=high profile

Experimental Protocol

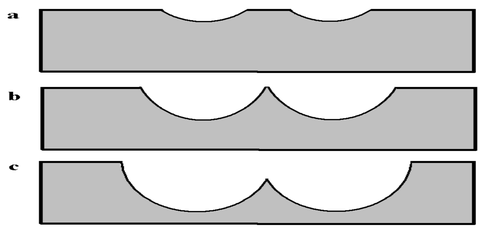
1. Test procedures performed after ISO 16840-2, chapter 11.2
2. 3 operators tested all cushions on 3 different days
3. Each cushion was tested 6 times per day for a total of 18 tests per cushion

Results and Discussions

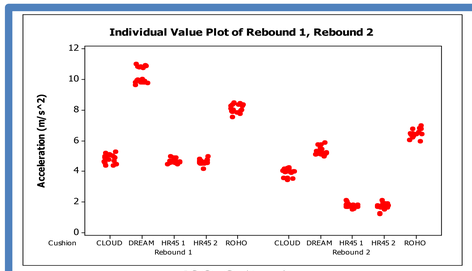




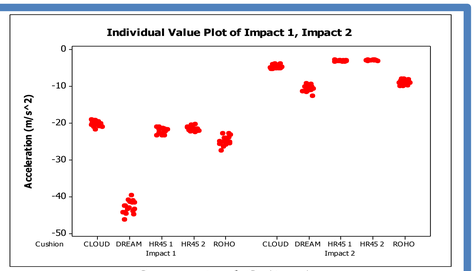
Typical result for impact damping test with the parameters



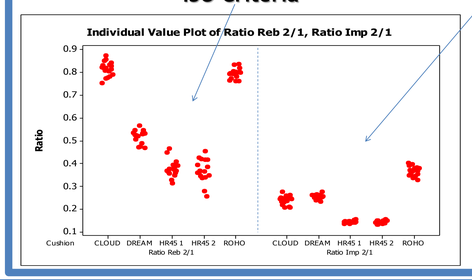
Expected contact area during the rebound
a) at the rebound
b) a midpoint between the rebound and the impact
c) at the impact



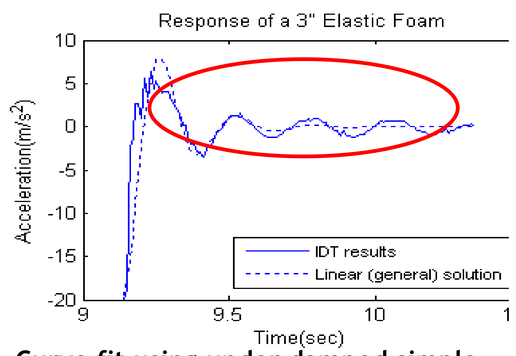
ISO Criteria



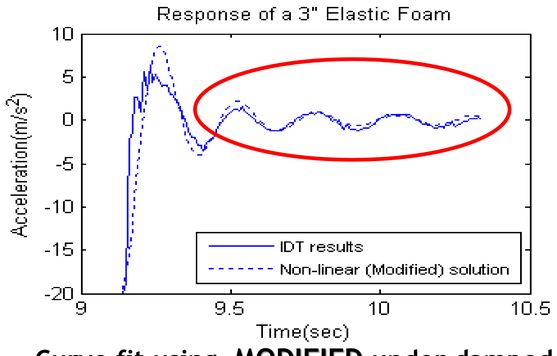
Suggested Criteria



- results of both ratios were repeatable, but indicated differences between rebound & impact ratios
- differences indicate that cushion responses are not reflected by a simple harmonic response
- impact acceleration occurs during greatest contact between indentor & cushion, insuring most linearity & consistent response



Curve fit using under damped simple harmonic solution



Curve fit using MODIFIED under damped simple harmonic solution

Curve Fit Parameters

x(0) peak impact acceleration
ζ damping ratio
ω_n natural frequency

Parameters used in curve fit

	3" Elastic Foam	
	General Solution	Modified Solution
x(0)	-20	-20
ζ	0.28	0.28 - (0.00130) * t
ω_n	0.25	0.25 - (0.00008) * t

$$x(t) = x(0) \cdot e^{-\zeta \cdot \omega_n \cdot t} \left(\frac{\zeta}{\sqrt{1-\zeta^2}} \sin \omega_n \sqrt{1-\zeta^2} \cdot t + \cos \omega_n \sqrt{1-\zeta^2} \cdot t \right)$$

Conclusion

1. ISO test method for impact damping is reliable and can distinguish performance across cushions
2. We suggest to provide an explicit distance between accelerometer and axis of rotation
3. We suggest the use of a mechanism such as our frame with adjustment arms to ensure a fixed distance between accelerometer and axis of rotation
4. We that the magnitude of the initial impact and the ratio of the 1st and 2nd impact should be reported as results of the test.

Acknowledgements

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