Shock-Mitigating Suspension Seats for Marine Vehicles

An update on performance measurements and scientific research.

Tim Rees, Ph.D.
An Overview of Mechanical Shock
What is Mechanical Shock?
A survey of U.S. Navy special boat operators was conducted (Ensign et al, 2004), and found:

### Effects of Mechanical Shock

**Occupation**  | **SBU** | **Navy**
--- | --- | ---
Hospitalizations per 100,000 man-years | 2687 | 479

<table>
<thead>
<tr>
<th>Injury Location</th>
<th>Injury Rate</th>
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<tbody>
<tr>
<td>Lower back</td>
<td>33.6 %</td>
</tr>
<tr>
<td>Knee</td>
<td>21.5 %</td>
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<tr>
<td>Shoulder</td>
<td>14.1 %</td>
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Only 18% of injuries occurred during unusual sea-states.
What is Shock Mitigation?

![Graph showing seat and deck accelerations.](image)
How is Shock Mitigation Achieved?
The Challenges of Assessing Acceleration Severity
Which Acceleration is Most Severe?
You may have heard things like:

- “...our seats achieve 70% shock mitigation.”
- “...our seats don’t bottom-out in the most severe conditions.”
- “...our seats are scientifically proven to be the best.”
ISO 2631 TC108/SC4 WG18 is developing a laboratory drop-test standard for evaluating marine seat shock mitigation performance.

Participants include U.S. Navy, UK MOD, Canada’s DND, industry and academics. SHOXS is a member and an active contributor.

Developing a robust shock-mitigation metric is a key focus.
A Drop-Testing Platform
Why Focus on Laboratory Drop-Tests?

- Repeatability
- Fair head-to-head comparisons
- No reliance on weather/sea-state
- Economical
The UK MOD has recently awarded a large contract to BAE Systems for sixty PAC 24 boats with SHOXS seats.
The Science of Measuring Shock Mitigation
So, How is Shock Mitigation Measured?

- **Step 1:** filter the signals
- **Step 2:** feed filtered signals into severity algorithm
- **Step 3:** calculate ratio of severities (MR)
Performance Metrics: P-P, VDV, & SRS

- **P-P MR**: take ratio of peak acceleration values
- **VDV MR**: calculate vibration dose values
- **SRS MR**: calculate the effects of acceleration on a simple physical model
SRS: The Setup
Solve: \( z''(t) + 2\zeta\omega z'(t) + \omega^2 z(t) = -a(t) \)
SRS: Another Example

P-P: 1.0
SRS: 1.0

P-P: 0.8
SRS: 1.0193

P-P: 1.05
SRS: 0.85919
Myths and Misconceptions
Some Misconceptions

- Fallacy #1: On-water testing is the best/only way to assess shock mitigating performance
- Fallacy #2: Comparing unfiltered peak accelerations provides accurate indications of shock-mitigating performance
- Fallacy #3: Complex adjustments are required to achieve high-performance shock mitigation
- Fallacy #4: Comfort determines shock-mitigating performance
Comfort vs Safety

- Comfort and shock mitigation are **not** the same
- Seat cushions can amplify shocks
- Seating decisions should not be based purely on comfort
Conclusions

CUSHION HEIGHT
13.5 - 16.5
8.25
Summary

- A new standard for evaluating shock-mitigating performance of marine seats is under development.

- The methods required to accurately measure shock-mitigating performance are sophisticated.

- The cost of not using shock-mitigating seats should be carefully considered.
Useful References


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