Performance of Marine Evacuation Systems in Rough Conditions

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Canadian Ferry Operators Association
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About NRC

- NRC total expenditures: $1B
- Approximately 3600 employees
NRC’s unique value proposition

- Specializing in state of the art technology
- Drawing expertise and know-how from across NRC for multidisciplinary solutions-tailored to the needs of our clients
- Combining NRC strategic R&D, tech capabilities with innovation support and specialized infrastructure to provide a powerful mix of research & technology operations for Canada

Solving innovation and competitive technology problems. Developing, adapting and transferring technology.
NRC business lines

- Strategic Research & Development
- Technical Services
- Industrial Research Assistance Program (IRAP)
- National Science Infrastructure
NRC organizational structure

DIVISIONS

Emerging Technologies
- Information and Communications Technologies
- Measurement Science and Standards
- National Science Infrastructure
- Security and Disruptive Technologies

Engineering
- Aerospace
- Automotive and Surface Transportation
- Construction
- Energy, Mining and Environment
- Ocean, Coastal and River Engineering

Life Sciences
- Aquatic and Crop Resource Development
- Human Health Therapeutics
- Medical Devices

Industrial Research Assistance Program
- Pacific Region
- West Region
- Ontario Region
- Quebec Region
- Atlantic & Nunavut
- National Office

Common Services to support portfolios and IRAP
Ocean, Coastal and River Engineering

- Staff of 120+ with locations in Ottawa and St. John’s
- Extensive experience in advanced engineering for harsh environments
- Collaboration with other NRC portfolios (Construction, EME)
OCRE Facilities

- Offshore Basin
- Ice Tank
- Tow Tank
- Large Area Basin
- MWB
- Flume Tanks
EXPERTISE IN
Harsh Environments
Ocean, Coastal and River Engineering

PROGRAMS

Marine Vehicles

Arctic

Marine Infrastructure, Energy and Water Resources
Programs are key operational units

- Designed to meet an industrial need drawing on resources from across NRC and externally.
- Have a clear objective, composed of projects designed to meet that objective.
- Time-limited and end when the deliverables are achieved or the strategy changes.
- The basis for investment decisions by NRC.
Arctic Program

Research thrusts:

• Resource development

• Northern transportation

• Marine safety technologies

• Community infrastructure

OBJECTIVE

Ensure sustainable, low-impact development of the North while increasing the quality of life for Northerners
Research Thrusts:
• Marine infrastructure
• Renewable energy
• Water resources

OBJECTIVES
Optimize the design of marine infrastructure
Improve the management of water resources
Accelerate the commercial viability of Canadian marine renewable energy technologies
Research Thrusts:
• Reduced cost of marine operations
• Safe and economic Arctic and offshore O&G operations
• Building a sustainable, competitive Canadian shipbuilding industry

OBJECTIVES
Reduce fuel consumption
Reduce vessel design costs
Maximize the value of capital investment
Reduce risk
NRC/OCRE Methodologies

Numerical Modeling

Physical Modeling

Field Data (Full Scale)
Performance of Marine Evacuation Systems (MES) in Rough Conditions - Background

- MES often used on high capacity vessels.
- Designed to egress large number of people from a ship quickly.
- Usually take the form of a slide or chute system.
• International Maritime Organization (IMO) Life Saving Appliance (LSA) code (2010):
  • 30 minutes to evacuate ship using MES – passenger vessel.
  • Capable of providing satisfactory means of evacuation in Beaufort 6 sea state.
  • Evaluation for capacity by deployment tests in a harbor.
Research Objectives

• Goal of the research was to compare the performance of MES in both calm and rough weather conditions.

• National Research Council of Canada (NRC) performed two series of tests:
  1. Performance of MES at model scale (1:7).
  2. Performance of MES at full scale using volunteers.

• At model scale:
  • How do deployment conditions and positions affect performance?

• At full scale:
  • How do wind and waves affect the ability of volunteers to use MES?
Model Scale Tests

• 1:7 scale models of a marine evacuation chute and slide were built by NRC.

• Attached to a large model to simulate a vessel with a high freeboard.

• Normal and “damaged” conditions.

• Tested in the offshore engineering basin (OEB) – facility capable of generating wind and waves.
## Model Scale Test Conditions

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Beaufort Equivalent</th>
<th>Full Scale Wind Speed (knots)</th>
<th>Full Scale Wave Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weather 2</td>
<td>4</td>
<td>11 - 15</td>
<td>1</td>
</tr>
<tr>
<td>Weather 3</td>
<td>5</td>
<td>16 – 20</td>
<td>2</td>
</tr>
<tr>
<td>Weather 4</td>
<td>6</td>
<td>21 – 26</td>
<td>3</td>
</tr>
<tr>
<td>Weather 5*</td>
<td>7</td>
<td>27 – 33</td>
<td>4</td>
</tr>
</tbody>
</table>

* Higher sea states were tested in order to determine performance beyond approval requirements.
Model Scale Results

• Model slide: Deployment on windward side resulted in catastrophic damage in a lower weather condition.

• Model chute: Deployment on windward side resulted in greater decreases in performance compared to leeward.
Model Scale Recommendations

• Deploy evacuation systems on leeward side to reduce performance decrease.
• Knowledge gap: Effective deployment in weather conditions to ensure good performance.
• IMO LSA Code (2010): “..capable of providing a satisfactory means of evacuation in a sea state associated with a wind of force 6 on Beaufort scale”.

[Image of a model scale evacuation system]
Full Scale Trials

- Full scale tests of evacuation slide and chute performed with young, healthy volunteers
- All volunteers gave their informed consent to participate.
## Anthropometrics and Full Scale Test Conditions

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Wind Speed (knots)</th>
<th>Significant Wave Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BF 3</td>
<td>7.17</td>
<td>0.30</td>
</tr>
<tr>
<td>BF 4 (Irregular)</td>
<td>8.24</td>
<td>0.67</td>
</tr>
<tr>
<td>BF 4 (Regular)</td>
<td>9.82</td>
<td>0.69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slide ((n=15))</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Body Fat %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>179.2</td>
<td>85.3</td>
<td>23.7</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>9.5</td>
<td>10.4</td>
<td>6.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chute ((n=19))</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Body Fat %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>178.6</td>
<td>86.3</td>
<td>21.6</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>8.3</td>
<td>19.6</td>
<td>7.4</td>
</tr>
</tbody>
</table>
Results

• Total time to use system, cross collection platform and enter liferaft was recorded.

• Times:
  • Slide: 12.6 s in calm; 12.7 s in 0.69 m waves (learning effect).
  • Chute: 9.9 s in calm; 12.4 in 0.69 m waves.
Number of Slides Required for 30 Minute Evacuation
Number of Chutes Required for 30 Minute Evacuation

Simultaneous Number of Chutes

Number of People

Calm
Wind and Waves
Number of Slides for 30 Minute Evacuation + 30%
Number of Chutes for 30 Minute Evacuation + 30%

The graph shows the relationship between the number of people and the simultaneous number of chutes needed for evacuation. There are two lines on the graph:

- The blue line represents the base time (W+W).
- The red line represents the base time + 30%.

The x-axis represents the number of people, ranging from 0 to 1800. The y-axis represents the simultaneous number of chutes, ranging from 0 to 16. The graph demonstrates how the number of chutes required increases with the number of people and the added 30% evacuation time.
Conclusions

• Side of vessel of MES is deployed will impact performance:
  • On weather side: greatest decrease in performance.
  • On leeward side: smaller decrease in performance.
• Recommended to always deploy on leeward side if possible.
• MES use: wind and waves will increase total evacuation time.
  • Increased transit time across collection platform.
  • Increased difficulty in entering liferaft.
• If passengers have pre-existing physical conditions:
  • Can they use the MES?
  • If so, how much extra time will it take?
  • > 30%?
Thank you

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