



Like a fish in water

Building confidence in children's flotation devices

by Rolf Popp, Sue Coleshaw and Ingunn Holmen Geving

Drowning is one of the leading causes of accidental deaths of children in many countries, killing more than 175 000 a year – in the USA, drowning is second after road accidents. Up to three million children survive a drowning incident each year. Due to brain damage in some survivors, non-fatal drowning has the highest average lifetime health and economic impact of any injury type (statistics from *The World Report on Child Injury Prevention*, UNICEF 2008).



Donning test with a nine-month-old infant.
Photo owned by SINTEF/ M.Sc. Ole Petter Naesgaard

ISO technical committee ISO/TC 188, *Small craft*, working group WG 14, *Personal safety equipment*, has concentrated on protective equipment against drowning since 1989.

This includes a variety of products, from personal flotation devices (PFDs) and buoyancy aids for white water canoeing, to immersion suits and harnesses. WG 14 deals with a wide range of applications on and in water, with products intended for use in both leisure and commercial applications.

The work programme covers the set of standards for personal flotation devices, ISO 12402, *Personal flotation devices*, Parts 1 to 10, published in 2007. In Europe, these standards replaced European standards EN 393 to EN 396 and EN 399.

ISO 12402 specifies various performance levels, from buoyancy aids to offshore lifejackets (Parts 1 to 5); products for special applications (Part 6 in correlation with one of the first five parts); requirements for material and component testing; additional items and performance testing (Parts 7 to 9), plus a guidance paper for application and use (Part 10).

Other key safety standards developed by the working group include ISO 15027, *Immersion suits* (Parts 1 – 3), which covers abandonment suits and constant wear suits/winter gear (currently under review), ISO 12401:2009, *Deck safety harness and safety lines*, and ISO 10862:2009, *Quick release system for trapeze harness*.

The standards are being continuously improved by working group members, which comprise manufacturers, consumers' representatives, test bodies and representatives of regulating organizations.

For every situation

The most important goal of the work group is to reduce the risk of drowning. All standards aim to improve the performance of water safety devices, without differentiating between leisure and commercial applications, onshore or offshore, surfboard or cruise ship, passenger or master mate. Safety specifications must meet the needs of all situations.

ISO 12402 aims to ensure safety, while maintaining wearer comfort during

use on, and in, water or onboard a craft. Comfort, sizing and fit requirements are important, with special attention paid to devices for children.

The size of adult devices is mainly determined by user height, body mass and chest sizing, with constant relationships between measures across age ranges. As every parent knows, body shapes vary significantly from baby, to toddler, to a five-year-old child. This means that careful consideration must be given to the size and buoyancy distribution of flotation devices designed for small children or babies.



Child mannequin representing 18-month-old child. (SRK ColeshawPhoto)

Targeting children

An important issue is the question of when a child is capable of taking his or her own safety precautions. This would establish thresholds for considerations such as requirements for mandatory automatic lifejackets, or when buoyancy aids would be acceptable for canoe training under the supervision of a trainer.

Most manufacturers have traditionally created children devices by simply down-

sizing adult models. But after evaluating anthropometric data, the working group quickly concluded that the design of these devices required more thought. For example, the head of a baby accounts for almost one-third of his body mass, so head support must be adapted accordingly.

In the early 1990s, test houses were reporting problems when testing PFDs on children. For example, it was impossible to assess whether the device would stay correctly fitted after a jump into water. Small children and babies do not relax in water, tending instead to kick and splash. This makes it very difficult to determine the correct performance of a device, whether it will correctly turn the child face-up, and whether there is sufficient buoyancy to support the head.

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To address these issues, the European Commission's Standards Measurement and Testing Programme initiated a research effort aimed at developing mannequins that would simulate small children in water. The mannequins would provide a standard test tool to improve the approval of children's devices designed for the European market. A consortium of five research and testing organizations, one consumer organization and one mannequin manufacturer carried out the what was known as the BAMBI project.

The project took into account the experience of test bodies, market research on PFD use in children, the incidence of drowning, and specific boating accidents involving children (although in this case, little useful data was found). Target age groups were established, with mannequins developed to simulate children of 18 months (9.4 kg body weight) and three years (14.5 kg body weight), using 50th percentile anthropometric data drawn from a number of sources.

Modified crash-test dummies

The original mannequins were based on established child crash-test dummies, but were then highly modified to suit the needs of marine mannequins, with a solid trunk, flexible limb joints, a specially designed neck joint, and all body segments designed to specific density values.

Concerted effort

ISO technical committee ISO/TC 188 specifications and guidelines often take into account the Recreational Craft Directive (a European New Approach to Technical Harmonization of Standards directive).

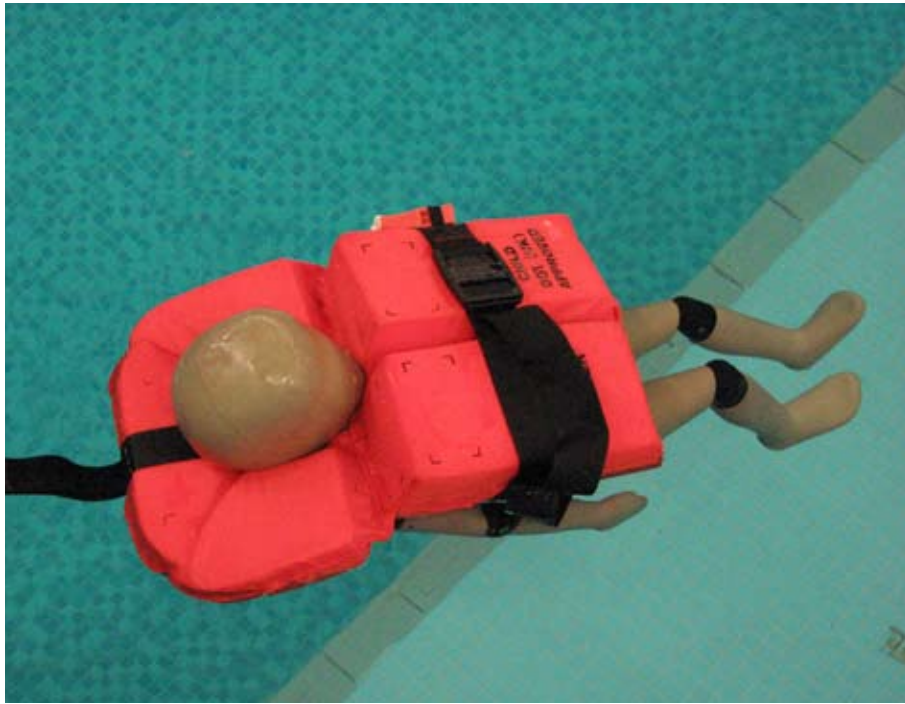
From its inception, the working group has maintained close cooperation with the European Committee for Standardization CEN/TC 162/WG 6, *Personal protective equipment against drowning*.

ISO 12402, *Personal flotation devices*, Parts 1 to 10 replaced the European standards EN 393 to EN 396 and EN 399.

Most members participate in both working groups; the convenor holds both chairs and all papers are elaborated under the Vienna Agreement. More than 50 experts from 27 countries participate.



18-month-old mannequin wearing SOLAS-style lifejacket.



18-month-old mannequin wearing SOLAS-style lifejacket, in relaxed floating position.

These alterations reproduced the correct floating position in water. The mannequins were validated by motion analysis and comparison with child swimmers. They proved successful at identifying good and poor device design. Moreover, some of the problems recognized had not been seen during the simple observation of children wearing a device in water.

Once the design was finalized, new test procedures were written to be used with mannequins. Test methods and requirements were then incorporated into relevant parts of the ISO 12402 PFD standard. These additional tests help improve

the quality of information gained on the safety and performance of new products.

The development of BAMBI has provided a tool for manufacturers to test certain properties of life-saving appliances without exposing children to potentially hazardous tests such as falls from heights. However, complete evaluation of a PFD's performance requires water testing with a representative selection of children.

The ISO 12402 series calls for evaluation of self-turning properties, stability, the distance from the water surface to the mouth (freeboard), and face and body angles when floating in a face-up posi-

tion. Protocols also include observing the child's comfort and behaviour wearing the lifejacket while moving in the water, as well as entering and climbing out. A donning test (children can be assisted by an adult) must also be performed – a well-designed PFD should enable donning within one minute.

Testing must be fun

Experience shows that it can be a challenge to conduct tests with babies, toddlers and older children, but care is always taken to ensure that they feel safe and remember the test as a fun experience in the pool.

A child is never pushed to repeat exercises it does not feel comfortable with. The tests require that the child is willing to properly don the PFD before entering the water and that he or she relaxes in the water. A parent is allowed to stay in the water close to the child.

ISO 12402 also spells out that the procedures may be adapted to each child's performance level in the water. Evaluation of PFDs for children thus comprises observations of children playing, jumping and floating in the pool.

However, certification must also be based on accurate measurements of the basic functionalities of the PFD and, in this respect, mannequins can be used as a supplementary tool to provide reproducible test results.

ISO 12402 supports the development of PFDs that are safe at a high performance level, and also comfortable for children to wear. ■

About the authors



Rolf Popp holds degrees in mechanical engineering, naval architecture and offshore engineering from the Technical University Aix la Chapelle. Since

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