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SAFER WORK CLOTHING FOR FISHERMEN

INGUNN HOLMEN GEVING [1], JARL REITAN [1], MARIANN SANDSUND [1],
HILDE FAEREVIK [1], RANDI EIDSMO REINERTSEN [1], HALVARD AASJORD [2]

ABSTRACT

The fisherman's work environment consists of many potential risks. A study of occupational accidents in the Norwegian fishing industry in the nine-year period from

[1] Ingunn Holmen Geving, M.Sc, Research Scientist, SINTEF, Trondheim
Jarl Reitan, M.Sc. SINTEF
Mariann Sandsund, Dr Scient, SINTEF
Hilde Faerevik, Cand. Scient. SINTEF
Randi Eidsmo Reinertsen, Professor, SINTEF
SINTEF Health Research, N-7465 Trondheim, Norway

[2] Halvard Aasjord, Dr.Ing. SINTEF Fisheries and Aquaculture, Trondheim
SINTEF Fisheries and Aquaculture, N-7465 Trondheim, Norway
The work has been carried out by:
SINTEF Health Research, N-7465 Trondheim, Norway
Corresponding author and contact regarding reprints:
Research Scientist Ingunn Holmen Geving,
SINTEF Health Research, N-7465 Trondheim, Norway
Tel. +47 4000 2590, fax +47 9307 0500
E-mail: Ingunn.Holmen.Geving@sintef.no
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1998 to 2006 shows that more than 3/4 of the deaths were caused by loss of fishing vessel or man-overboard accidents. Furthermore, the greatest risk of drowning is found in the smallest fleet.

The aim of our project was to develop safer work clothing and through this contribute to a reduction in work accidents and injuries in the fishing fleet. We considered that it is possible to produce protective work clothing that satisfies a specification of requirements covering the fishermen's needs for protection and comfort during work.

An end user-centred process including twenty-three personal interviews and a questionnaire was used to clarify the fishermen's needs and wishes before detailed design and product development. We identified an overview of all the fishermen's needs for protection during work, and produced a prioritised list of functional requirements for the clothing.

The results show that the clothing previously preferred by fishermen does not satisfy all the users' demands for safety, functionality and comfort. These demands have been taken into consideration when designing improved work clothing for the fishing fleet. A selected number of prototypes were developed on the basis of the established specification of requirements. The prototypes were evaluated according to the users' requirements through tests in SINTEF's Work Physiology Laboratory and on board fishing vessels. The results demonstrate that the new protective clothing satisfies the fishermen's requirements.

Keywords: protective work clothing, user requirements, product development, buoyancy aid, fishermen

INTRODUCTION

The fishing industry is the most risk-exposed occupation in Norway. The complexity of the fishing fleet, ranging from large, sea-going trawlers to one man operated smaller vessels in coastal areas, raises great challenges to improving the safety of fishermen. Only on rare occasions fishermen report that they wear buoyancy aids while working on deck, in spite of being exposed to a significant risk of falling overboard. During the period 1998- July 2006 a total of 85 deaths were reported in Norway (1). 26 deaths were caused by loss of the fishing vessel, 24 were due to man-overboard accidents and 22 to drowning in harbours. Similar occupational risk numbers are reported in other countries. Thus it seems to be a great life-saving potential in measures to prevent drowning.

Fishermen's working dress traditionally consists of inner and middle layers of cotton garments, a coverall (often with an insulating lining during the winter months) and an outer shell of heavy-duty rainwear (strap trousers and jacket). They also wear caps, boots (of various qualities) and gloves to keep their hand dry and ensure a good grip on the fish. Fishermen in most countries have easy access to practical lifejackets, but they usually do not use them at work. It was important for this project to look into the reasons for this.

The work environment, type of work and work load all influence the requirements for functional protective clothing. Exposure to cold, sea water, rain, wind and humidity may vary widely in the course of a single working day, and the fisherman is exposed to various climates in the course of the year. The work load and the body's heat production also vary in the course of the working day. Functional requirements and the need to feel comfortable during work determine what kind of personal protective clothing the fishermen wear.

The aim of our project is to develop safe and functional work clothing for fishermen and through this contribute to a reduction in work accidents and injuries in the fishing industry. Our hypothesis is that it is possible to develop protective clothing that satisfies a specification of requirements covering the fishermen's need for safety, protection and comfort during work.

MATERIALS AND METHODS

The implementation of the project was based on a concept development method known as Concept Engineering® (2), which is a user-focused method of systematically gathering and processing data for the development of functional requirements, products and services (3, 4). We conducted twenty-three personal interviews with fishermen, representatives of the fisheries' authorities and suppliers. We systematically gathered information about fishermen's needs for protection at work and their own requirements for functional and safe work clothing. Observations were conducted out at sea during fishing. The observations showed that today's preferred work clothing is inner and middle layers of cotton garments, a coverall and rainwear.

All interviews were recorded and every statement printed (altogether more than 800 statements). The most relevant statements were selected and developed into requirements for functional work clothing for fishermen.

This work resulted in thirty-one requirements which made the basis for a questionnaire sent to more than 1100 fishermen, ship-owners and other "stake holders". The respondents were asked to tick the 10 most important requirements from their point

of view. Background information was also recorded, e.g. type of work on board, size and type of vessel. The summary of all respondents' prioritisation results in a specification of user requirements.

To establish a final specification of requirements more input is needed. There are European and international standards for the certification of personal flotation devices which had to be considered. Possible constraints of the production process also had to be taken into consideration. Furthermore, to develop a work clothing which is preferred by fishermen more features have to be included in addition to safety. A study was conducted to identify important functionalities of comfortable sportswear. Good examples are paddle vests, which provide floating properties in combination with freedom of arm movements, and snowboard clothing, which is soft and comfortable to wear. We also got inspiration from bicycle helmets. The first helmets on the market were "just" safe, but modern bicycle helmets in addition to being safe have a cool design, provide ventilation and comfort.

Several concepts were developed based on a total specification of requirements, which are the sum of user requirements, requirements in the European standard EN 393 for 50 N buoyancy aids, product properties and production constraints. Special care was taken to find the optimal volume and placement of buoyancy elements to ensure the desired floating position in the water. A selected number of prototypes were manufactured and evaluated.

Thermal manikin tests were performed to measure the total thermal insulation of clothing (consists of underwear, middle layer and outer clothing – prototype or rainwear). Underwear and middle layer were chosen to give the same total insulation during the evaluation of prototypes according to user's requirements.

Both previously preferred clothing and the prototypes were tested in the climatic chamber of SINTEF's Work Physiology Laboratory with six male test subjects (average age 26±2 years, height 1.70±0.02 m, weight 77±3 kg). We designed a test protocol, total duration 80 minutes, to simulate the changes in work load on board a coastal fishing vessel, shifting between heavy (70 % of max load) or medium (50 %) working periods and rest. The environment was controlled to +2°C and 5 m/s wind. Several physiological parameters were recorded (skin and body core temperatures, sweat production, heart frequency). The moisture ventilation of the clothing was calculated on the basis of accumulated sweat in the clothing. Subjective evaluations of the functionality of the clothing were conducted both during the laboratory tests and on fishing vessels. The Ethical Review Committee of the Faculty of Medicine at the Norwegian University of Science and Technology approved the experimental procedure which is in accordance with the Helsinki Declaration of 1975. The subjects were free to withdraw from the experiment at any time.

RESULTS AND DISCUSSION

306 forms were completed and returned to us. Figure 1. shows the distribution of professions among the respondents. The majority of respondents (83%) were active in fishing.

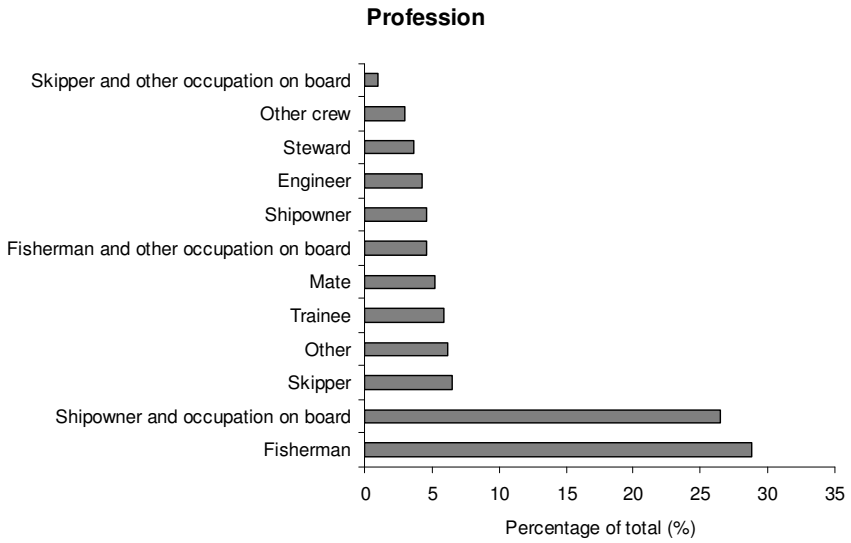

Figure 1. The distribution of professions among the 306 respondents to the questionnaire.

A summary of all 306 forms resulted in a prioritised list of user requirements for fishermen's work clothing. Table 1 shows the ten requirements which were regarded most important for safe and functional work clothing for fishermen. The table also lists the number (in percent) of the total group (n=306) who have prioritised each requirement. For instance: 59.2% of the respondents regarded water-proof to be one of the ten most important features of their work clothing.

Table 1 Prioritisation of user requirements for safe and functional work clothing (summary of n=306 responses). The column on the right lists the number (in percent) of the total group who have prioritised each requirement

	User requirement	% of total (n=306)
1	Water-proof	59.2
2	Reinforced on parts especially exposed to wear and tear	54.6
3	Keeps the body warm	54.2
4	Provides freedom of movement	53.9
5	Ensures good visibility	52.0
6	Withstands tearing by fishing hooks	50.3
7	Ventilates water vapour and sweat	48.4
8	Feels light when wearing	48.0
9	Reduces risk of getting caught in fishing equipment and installations	46.7
10	Integrated buoyancy aid	45.8

To prevent drowning, one important feature is integrated buoyancy aid. We chose 50 N buoyancy since this should not primarily be a lifejacket, but work clothing. The product was tested and approved according to the European standard EN 393 – 50N buoyancy aid. There are 50 N work suits on the market already, which gives the user a horizontal floating position. Our product ensures good visibility and control as it makes the user "stand" vertically in the water (Figure 2). Furthermore, integrating the buoyancy aid in the trousers automatically provides a crotch-strap.

Several concepts were developed and evaluated based on a total specification of requirements, which are the sum of user requirements, requirements in EN 393, desired product functionalities regarding user comfort and production constraints.

Figure 2 The designer demonstrates the vertical floating position of the work clothing (Photo: Regatta).

Analyses of the objective physiological data showed no significant differences in skin temperatures under clothing between previously preferred clothing and the prototype, which is as expected because the total clothing concept was chosen to give the same level of thermal insulation. Ventilation of moisture (sweat) is more efficient with the new product (Regatta Fisherman) thanks to integrated ventilation properties (Figure 3).

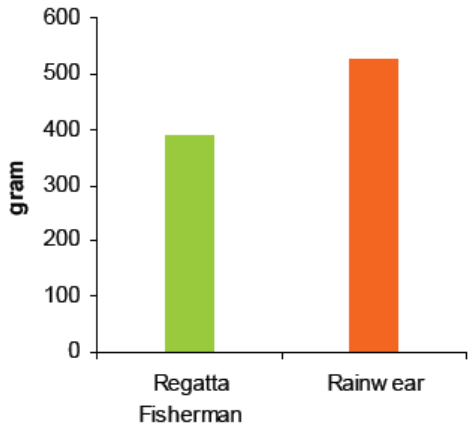

Figure 3 Comparison of total sweat production for six test subjects wearing the new clothing (Regatta Fisherman) or rainwear, measured as grams of accumulated moisture in the clothing ensemble.

Subjective evaluations were conducted on prototypes and previously preferred clothing (rainwear). The new product was rated equally as good or, for some features, better than rainwear.

Figure 4 shows the final concept named Regatta Fisherman by the manufacturer. The work suit consists of a rain coat and matching trousers. The buoyancy is integrated in the trousers around the upper part of the body. The prioritised user requirements (table 1) are integrated as indicated in the figure. We have given it a cool, new design, but kept the preferred functions from rainwear which is important to make the fishermen use the new clothing. The main colour of the suit is fluorescent yellow, and the work area in the front is grey.

Figure 4 Final concept for safer work clothing for fishermen – Regatta Fisherman.

CONCLUSIONS

The results show that the clothing previously preferred by fishermen (rainwear) does not satisfy all the users' demands for functionality and comfort. These demands have been taken into consideration when designing improved functional protective clothing for the fishing fleet. Evaluations and tests demonstrate that the newly developed protective clothing satisfies the fishermen's specification of requirements for protection and comfort during work.

Finally, the new clothing has already saved lives. A fishing vessel sank in northern Norway in June 2006. One of the two men on board unpacked his suit the same morning and dressed it before he went fishing. After the accident he explained that he felt safe because the buoyancy aid and the standing floating position made it possible to pick up the mobile phone and call for help.

ACKNOWLEDGEMENTS

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