

TITLE: EVALUATION OF MODERN EMERGENCY EVACUATION SYSTEMS

AUTHOR(S): M.A.F. Pyman, Ø. Bratsberg and D.M. Boulton

Technica A.S.,
PO Box 138,
Dusavik,
4001 Stavanger,
Norway.

ABSTRACT:

The use of risk analysis techniques has made possible the objective evaluation of platform emergency evaluation systems. New analysis methods allow the performance of evacuation systems to be broken down into individual steps - increasing the focus on the most important elements in the evacuation.

The paper describes the new methods and illustrates their use with reference to existing systems in the North Sea and new concepts being developed in Europe for use offshore.

1. INTRODUCTION

Present generation fixed and mobile installations in the North Sea have several means whereby people can leave the installation in an emergency. These normally include the following:-

- Helicopters (where available)
- Survival Craft (Totally Enclosed Motor Propelled Survival Craft)
- Liferafts
- Personnel baskets
- Knotted ropes
- Ladders to the sea

Evacuation by helicopter is the preferred means; it is well understood, frequently practised and generally accepted as safe.

If helicopter evacuation is not possible or available, then the preferred procedure is to remain on board, in one or more of the "shelter areas". Depending on the particular installation, other options may be available, such as transferring to adjacent platforms by bridge, personnel baskets to standby vessels, etc. Emergency evacuation is only ordered if these options become untenable. Survival craft are installed on all installations as the primary means of evacuation to the sea.

In recent incidents involving emergencies offshore, the standard evacuation equipment for offshore installations, namely Totally Enclosed Motor Propelled Survival Craft, have been seen as less effective than expected. In order to find improved solutions for the future, the authorities in various countries initiated record programmes to investigate alternatives. Foremost among these was the Norwegian programmes, under the heading "Evacuation of Personnel by Sea". This programme looked at numerous possible methods, such as gangways, cableways, new lifeboat designs etc. before finally concentrating on the freefall lifeboat. A whole range of survival systems have now been developed, as illustrated in Figure 1.

From the stimulus given by the Norwegian programme, alternatives have also been developed in other countries, most notably in Sweden.

In the U.K. a research programme was initiated by the Department of Energy on rather different lines. Because of the large number of platforms already in place, effort was concentrated on ways to improve TEMPSC and ways to evaluate improved assessment of existing evacuation systems already in place. As a part of the UK programme, a risk model was developed for the UK Department of Energy by Technica, with the objective of providing a tool for analysing evacuation system performance on a quantitative basis. The resulting model, described here, has since been developed further to apply to novel evacuation systems, such as freefall lifeboats and lifescape.

2. THE RISK MODEL FOR EVACUATION

The "model" that was developed is a mathematical description of the evacuation system, in which each factor that can affect the success of the evacuation is taken into account.

The model is a probabilistic one - which means that each of the factors are considered by asking "What is the probability that this factor will prevent successful evacuation using a particular system?". Thus, each factor has a certain probability of preventing evacuation under certain circumstances and by implication of causing casualties.

The outcome of each evacuation is expressed as a "Success Rate", defined as "the percentage of personnel on the installation who could expect to be successfully returned to shore after an incident had required evacuation by survival craft". Those who were not successful may have been fatalities, or had to evacuate by other means (e.g. liferaft), or may have been recovered by other means after their survival craft had failed them. Thus, a "Success Rate" of 80% means that on average 80% of those attempting to evacuate reached safety successfully through the use of survival craft (or whatever evacuation system is being studied).

There are four main elements to the risk model, which are shown diagrammatically in Figure 2, as follows:

- 0 Input Data
- 0 Incident Development
- 0 Detailed Evacuation Sequence
- 0 Output

These are described below, with reference to lifeboats as being the principal evacuation system.

2.1 Input Data

There are two types of input data required by the model. The first, of a rather general nature, determines the circumstances in which any particular type of lifeboat or evacuation system used. These input variables are:

- a) incident type
- b) wind speed, wave state, wind direction
- c) installation location
- d) installation design, location of lifeboats
- e) Lifeboat details

These are discussed below.

The second type of input relates to the detailed steps of the evacuation sequence. The probability of success for the entire evacuation is dependent on the factors which influence individual steps. Each of these factors, referred to as "failure modes", is allocated a probability figure. This second type of input is discussed under "Detailed Evacuation Sequence" in 2.3 below.

a) Incident Type

The number of incident types to be considered is categorised into six types of incident, which adequately cover all of the recorded incidents to date. These are:

- i) Blowout
- ii) Sea level fire
- iii) Vessel collision
- iv) Process events: severe explosion and fire or a large hydrocarbon release without ignition
- v) Structural failure
- vi) Storm

b) Weather Conditions

Weather severity. Here three easily distinguished weather severity conditions have been specified for the model. These are defined by the Beaufort scale and are as follows:

calm weather	- Force 3 and less
moderate weather	- Force 4 to 7
severe weather	- Force 8 and above

Wind direction. Wind direction is an important input to the model, because of the greater difficulty of clearing a craft on the windward side of the installation, compared to the leeward side. A simple classification of wind direction into 'North', 'South', 'East' and 'West' was used in the original model. The probability figures for each wind direction have been determined from wind roses for each North Sea area.

Tide. Tide is only really important in the Southern Sector installations, where spring tides can exceed four knots. Two tide directions are therefore considered: "Uptide" and "Downtide".

c) Location

Different areas are distinguished on the basis of the severity of the weather expected in those areas.

Thus the Northern part of the North Sea would be distinguished by the following set of weather condition frequencies:-

calm	28%
moderate	61%
severe	11%

See Figure 3 for the three main areas of the North Sea currently being distinguished.

d) Installation Design, Location of Lifeboats

The installation details required as input to the model are:

- Number of personnel on board
- Number of survival craft
- Location of craft
- Type and capacity of craft
- Size of clearance between craft drop and platform legs (see Figure 4)
- Number of liferafts

e) Lifeboat Details

Details of size, capacity, strength, craft acceleration, turning circle, etc. are required.

2.2 Incident Development

Three factors relating to the development of the incident are considered in the model. These are:-

- i) The number of lifeboats that are put out of action by the incident itself.
- ii) The likelihood that the majority of personnel can be taken off by helicopter (or other means) whilst the incident is still at an early, controllable, stage of development.
- iii) The scope available to the Offshore Installation Manager (OIM) to instruct personnel to use only those lifeboats that have the best chance of getting away.

2.3 The Detailed Evacuation Sequence

The evacuation of personnel by a particular lifeboat or evacuation system has to be split up into fourteen steps so that the failure modes that affect the evacuation can be categorised in detail. These steps are shown in Figure 5.

2.4 Sources of Data and Information

Various sources of data and information can be used.

For the study of survival craft from offshore installations data has been obtained from information generally available to the industry, the U.K. Department of Energy and Technica. In addition searches have been carried out to collect data on evacuation incidents worldwide, some 130 worldwide incidents having been examined in all the detailed available.

The causes of failure leading to mishaps occurring during lifeboat drills were identified from data collected by individual operators in the U.K. Sector of the North Sea for events up to February 1982. Information on reported mishaps has been examined, and this information has contributed to the definition and likelihood of distinct failure causes have been included in the model.

Research and development results from both operators and public agencies, particularly on model tests, needs to be used.

Several of the failure modes have to be studied through theoretical calculations and modelling - e.g. the clearance required between the lifeboat drops and the structure, or the loads imposed during towing.

3. EXAMPLE RESULTS (CONVENTIONAL SURVIVAL CRAFT)

Having developed the basis risk model, the original study examined in some detail the performance of survival craft in emergency evacuation. The findings of both the risk study and a parallel review of the historical record are shown below, grouped generally by the severity of the weather. (They start from the point where the incident has occurred and thus exclude the initial probability of needing to evacuate.) In all cases, the prime means of evacuation was by survival craft.

Weather Category	Success Rate (survival craft evacuation)		
	Merchant Ships (historical record)	Offshore Installations (historical record)	Offshore Installations (range from Risk Model)
Calm	Approx. 95%	Approx. 95%	61% - 96%
Moderate			22% - 82%
Severe	Approx. 71%	Approx. 45%	7% - 65%
Average Over all weather cate- gories	Approx. 86%	Approx. 70%	31% - 83%

The predicted range of results for the typical offshore installations analysed by the model can be seen to be consistent with the known historical record on emergency evacuation from offshore installations. For specific platforms, however, best estimates tend to be towards the lower end of the range, and are thus somewhat more pessimistic than the historical record to date. In addition to overall success rates, detailed predictions for individual steps in the evacuation enable the factors directly involved in determining the overall performance to be highlighted.

These figures give an idea of the summary results to be obtained from the risk model; the range gives a picture of how installations and detailed evacuation system design can lead to widely differing results.

In addition to statistical summary results, the model also produces graphical output for two of the key steps in the evacuation sequence reaching sea level without hitting the platform, and getting away from the structure against waves. Examples of typical output for each of these steps are shown in Figures 6 and 7.

The survival craft version of the model has currently been applied to some 20 offshore platforms. Use of detailed operator data for many of these, and interpreting the results in terms of possible practical improvements, has led to a good working "feel" of how best to use and interpret the model.

More recently, the model has been developed to look at newer evacuation systems.

4. NEW DEVELOPMENTS

Several novel ways of improving evacuation systems have been developed over the past 10 years. Some are designed to replace the existing craft, some to modify them, others to supplement the present facilities with an additional means of evacuation, and can be grouped under three main headings:-

- 0 Improvements to conventional lifeboats
- 0 Freefall systems
- 0 Transfer systems

Each of these is discussed briefly below.

4.1 Improvements to Conventional Lifeboats

Current developments on improvements to existing lifeboats take the form either of additional facilities to help get the craft away from the structure, or of improvements to the existing systems.

Two schemes for additional facilities that have reached an advanced stage of development are the 'PROD' system and a revolving davit arrangement. The PROD system (Watercraft Ltd, U.K.) consists of a 'fishing rod' that extends out normal to the platform, from which a "tagline" joins to the bow of the Survival Craft. As the Craft is lowered into the water, the tension on the tagline pulls the bow of the Craft away from the structure. Once fully extended, the tagline is automatically released. The revolving davit arrangement (Ankers A.S., Norway) is a means by which a craft hung parallel to the platform can be rotated to a direction normal to the platform before being lowered.

Besides PROD and the revolving davit, various changes to the existing systems have been proposed. Numerous minor changes have been made by operators to their lifeboats on the basis of training experience and feedback from accidents or mishaps elsewhere. Some larger changes are also being implemented, in the belief that they may give a significantly improved ability to get away from the platform structure. These changes include the following:-

- changing from offload to onload release gear (with safeguards against premature release)
- mounting the lifeboats further out from the installation, so that at sea level the craft is 8-10m or more from the structure
- placing the lifeboats near the end of each side of the installation

- placing the lifeboats normal to the installation rather than parallel
- installing top hatches to aid recovery of personnel from the craft to helicopters
- increasing the strength of the hull and canopy, installing padded seats with comprehensive seat belts, and other structural modifications.

4.2 Freefall Systems

Freefall lifeboats were first proposed for ships over twenty five years ago, and one or two prototypes were actually built in the 1950's and 1960's. However, the impetus for development came with the Norwegian research programme 'Evacuation of Personnel by Sea' in the 1970's, when Freefall lifeboats were developed successfully to full scale manned trials. After having been installed on ships in 1974 their application was developed to the offshore environment, the first systems being installed on the drilling semisubmersible Dyvi Delta in 1981.

Since that time development of freefall systems has been rapid and there are several products on the market. They fall into three categories:

- Purpose built lifeboats where sole function is to Freefall from the installation in an emergency.
- Lifeboats that are partially Freefall, partially lowered from davits.
- Retrofit kits to conventional lifeboats to allow them to Freefall.

4.3 Transfer Systems

Transfer systems have been the subject of considerable interest as an alternative mean of evacuating an installation. Their principal advantage is that they allow transfer of personnel direct to another 'dry' environment. Their principal disadvantages are that a suitable attendant vessel must be present, and that the transfer means must accommodate the motion of that vessel.

There have been numerous ideas and proposals for transfer systems, ranging from fabric chutes to hydraulic elevators, but there has not been any fully developed solutions as there have been with the Freefall projects (except for the rather special case of transfer between a semisubmersible (e.g. a flotel)) and an installation.

The principal developments have been with gangways, folding staircases, 'cable cars', and an unusual use of davit launched liferafts direct to an attendant vessel.

5. THE RISK MODEL APPLIED TO NEW DEVELOPMENTS

Since the original development of the risk model, it has been developed to apply to several of these new evacuation systems. Examples of application include the "PROD" system, Freefall Lifeboats, novel uses of liferafts, and the "Lifescape" concept.

In several cases the model has been used to pinpoint the dominant design weaknesses, which have then been corrected.

Examples of these applications will be given in the presentation.

6. AVAILABILITY OF THE MODEL

The risk model has been incorporated into a computer programme and is available from Technica to be run for individual installations and evacuation systems, to determine both present predicted performance and optimal means of improvement. The model will also be available from the Department of Energy, and is currently being made available on a commercial computer bureau, so that it can be used on a design tool by operator manufacturers and offshore contracts.

FIGURE 1 : RANGE OF SURVIVAL SYSTEMS EMPLOYED IN
EMERGENCY EVACUATION FROM OFFSHORE INSTALLATIONS

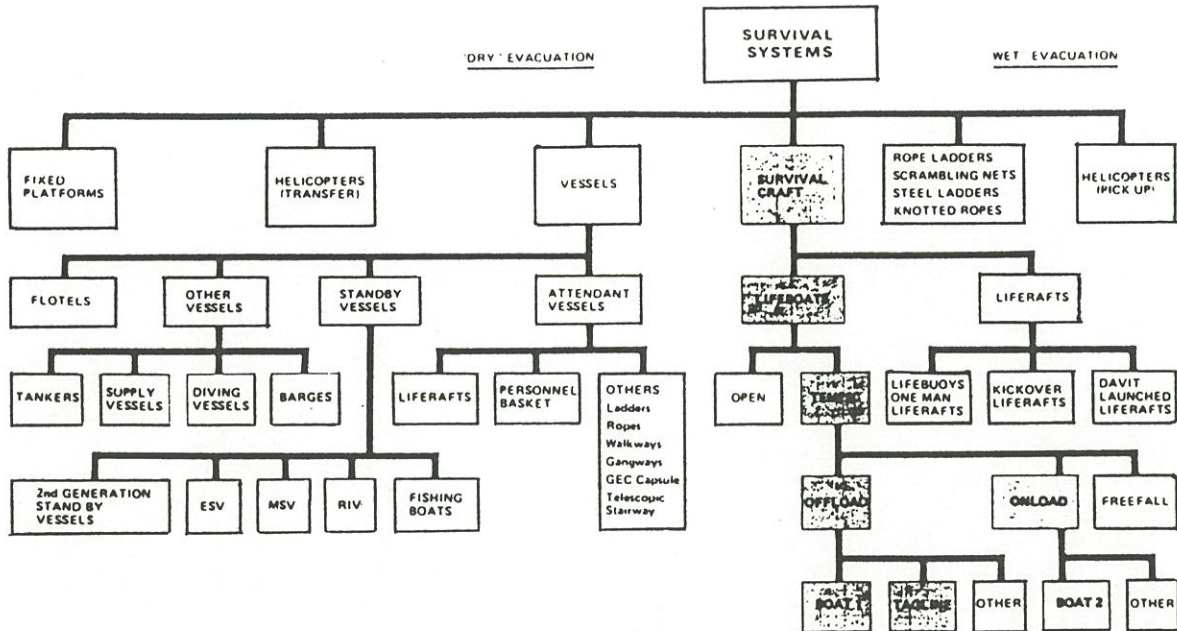


FIGURE 2 : FLOW DIAGRAM OF RISK MODEL

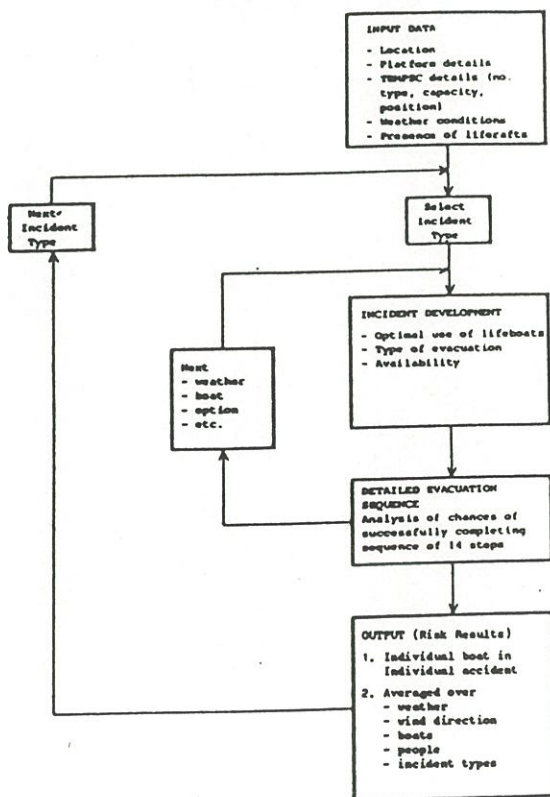


FIGURE 3 : WEATHER LOCATIONS IN THE NORTH SEA

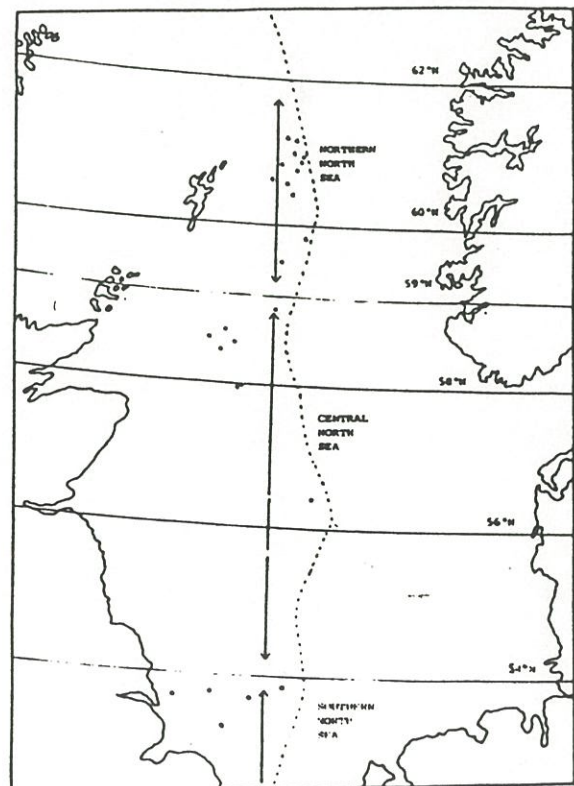


FIGURE 4 : CLEARANCE BETWEEN INSTALLATION LEGS
AND SURVIVAL CRAFT DROP

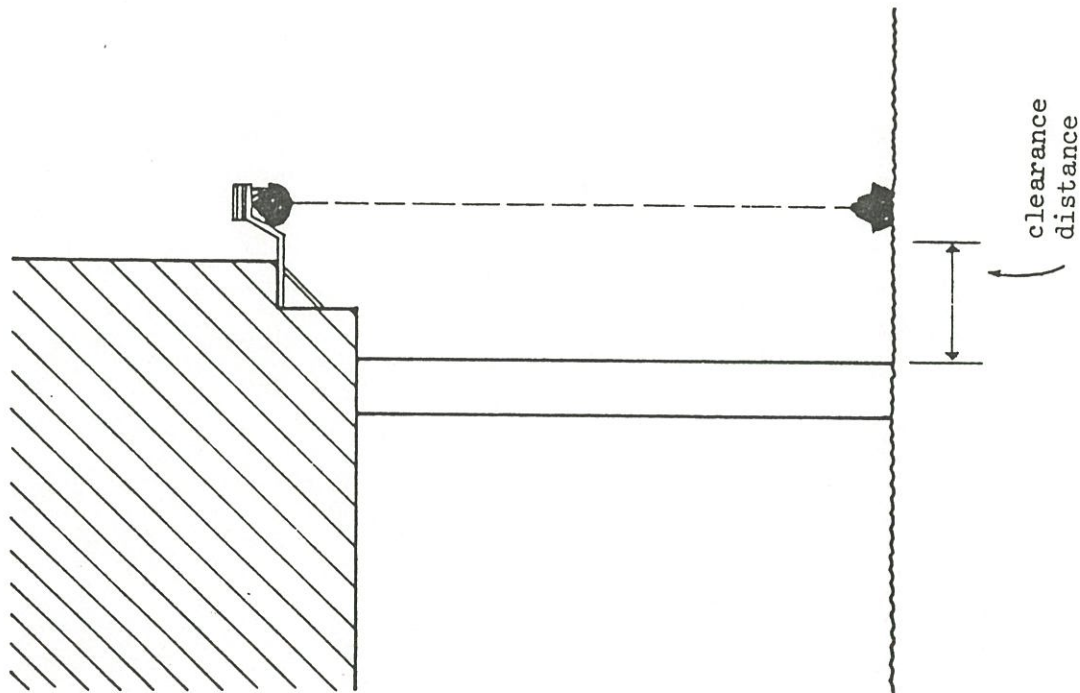


FIGURE 5 : DETAILED EVACUATION SEQUENCE
(for each individual craft)

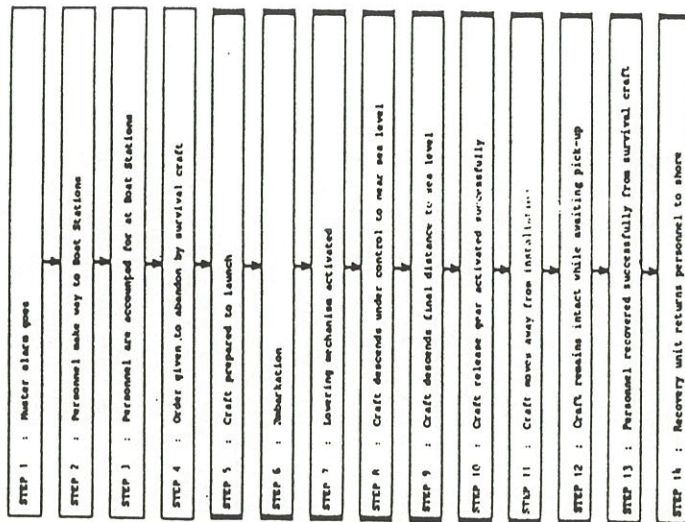


Figure 6 GRAPHICAL OUTPUT FOR STEP "LOWERING TO SEA LEVEL"
 AGAINST FAILURE MODE "HIT STRUCTURE DUE TO WIND FORCE"

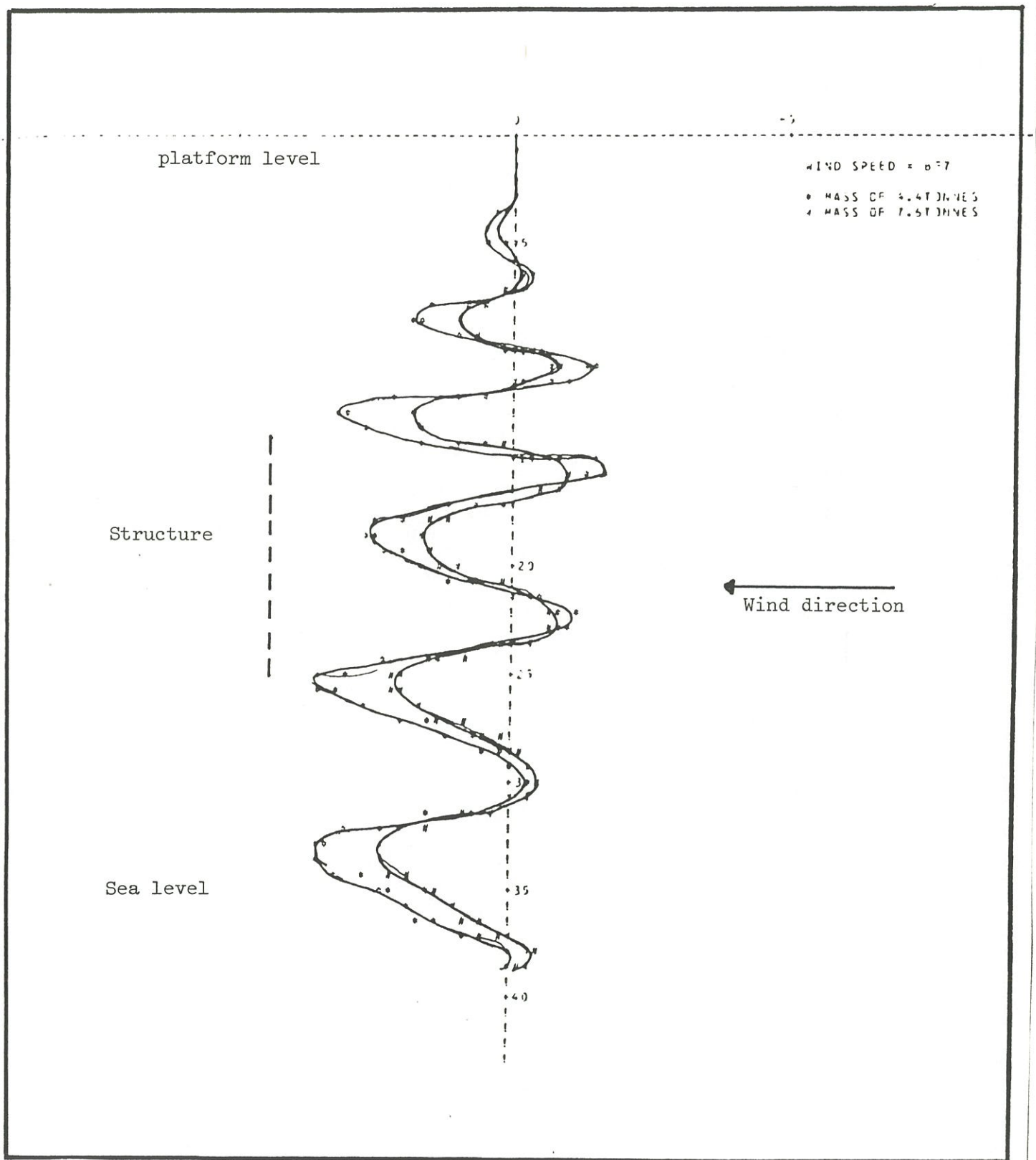


FIGURE 7 GRAPHICAL OUTPUT FOR STEP "LEAVING PLATFORM VICINITY SUCCESSFULLY" AGAINST FAILURE MODE "PUSHED BACK INTO STRUCTURE DUE TO WIND/WAVES"

