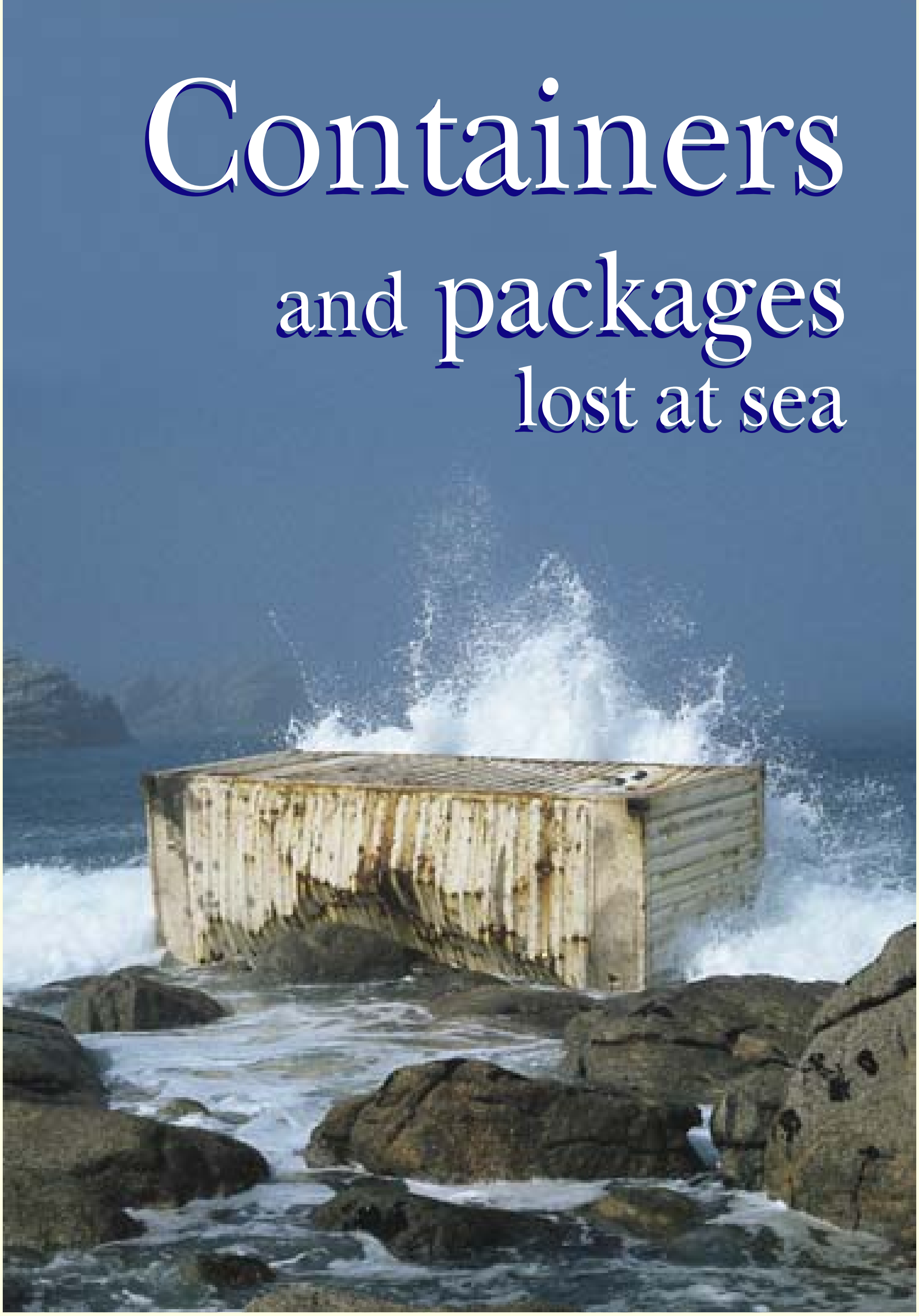
Containers and packages lost at sea



OPERATIONAL GUIDE

Cedre

Cover photo: a container stranded on the Brittany coast.

Containers and packages lost at sea

OPERATIONAL GUIDE

Information

Decision

Action

Guide compiled by *Cedre* with financial support from the French Navy and Elf Aquitaine.
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The poorly-secured cargo of Julia del Mar - 1989
(photo SAVR: Service Audiovisuel Régional).

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Detailed contents

Preamble

The aim of this operational guide is to provide the information necessary for an initial decision to be taken even before any precise information from the shipping companies involved is available.

Under the conditions prevailing at the beginning of a crisis, a hurried assessment of the situation and of the dangers involved is a potential source of blunders and errors that may lead to an aggravation of the situation.

General information about the containers and their contents is easily accessible and reference to it may enable major mistakes through undue haste, negligence or ignorance to be avoided. The initial assessment will naturally develop gradually as the information becomes more precise following investigations carried out by the response authorities in charge.

This guide is intended mainly for:
- personnel on board ships involved in taking action;
- personnel, on board or not, responsible for airborne operations;
- any official responsible for operations dealing with packages lost at sea.

Introduction

The loss of packages at sea is something that affects all European coasts, but especially those of the Atlantic, the English Channel and the North Sea, regions where navigation is difficult and the traffic is dense.
The primary characteristic of operations relating to packages lost at sea (drums, containers, etc.) is that they are very often undertaken before the exact nature of the substances being transported is known.
The dangers presented by such operations are therefore unknown to those taking action and making decisions but they have, nevertheless, to cope with the situation.
Thus, to instruct personnel to take on board a container holding a highly toxic product may have catastrophic consequences for the salvage vessel and its crew. The same may occur with a decision to tow a container of toxic products into a harbour in an urban area or into an environmentally sensitive estuary.
It is therefore essential to have a thorough knowledge of the mechanical strength of the containers, their hydrodynamic properties, the risks created by the substances they contain and the behaviour of pollutants.
This guide is based on the principle of achieving the greatest possible safety. It takes into account the fact that the information available develops with time and, with these aspects in mind, it proposes a dynamic methodological approach involving the following five stages:

Warning, notification, initial steps
These three aspects are closely related and may have a decisive effect on later operations. The declaration of the loss or discovery of a package lost at sea should initiate the procedures of warning, of notification, and of taking protective and safety measures as if they were instinctive reactions.

Assessment of the situation
Added to the complexity of a situation related to the behaviour and effect of a chemical pouring into the water are the uncertainties about the behaviour of the package in the sea, particularly those associated with the effect of the environment. At this stage in the approach, information on the maritime weather conditions, the sensitivity of the environment, the resources available for taking action and the protection of personnel must also be sought.

Decision-making
Once in possession of the information gathered in the previous stage, the potential effects can be estimated with a confidence interval whose magnitude depends on the precision with which the information is known. This analysis will lead to an assessment of the level of threat and will thus make it possible to determine the chances of a successful intervention.

Action
This stage of the operation consists of putting into practice the decisions made about intervention: searching, marking, recovery or destruction.

Monitoring developments
Faced with a situation liable to change very quickly, particularly under the effect of the maritime weather conditions, such an approach is only realistic if it is dynamic. Continuous monitoring of the evolution of all the factors is necessary so as to be able to reassess the situation and relaunch the decision process.

To underpin the various stages of such a widespread methodological approach, the information contained in this guide has been assembled into chapters dealing with the following subjects:

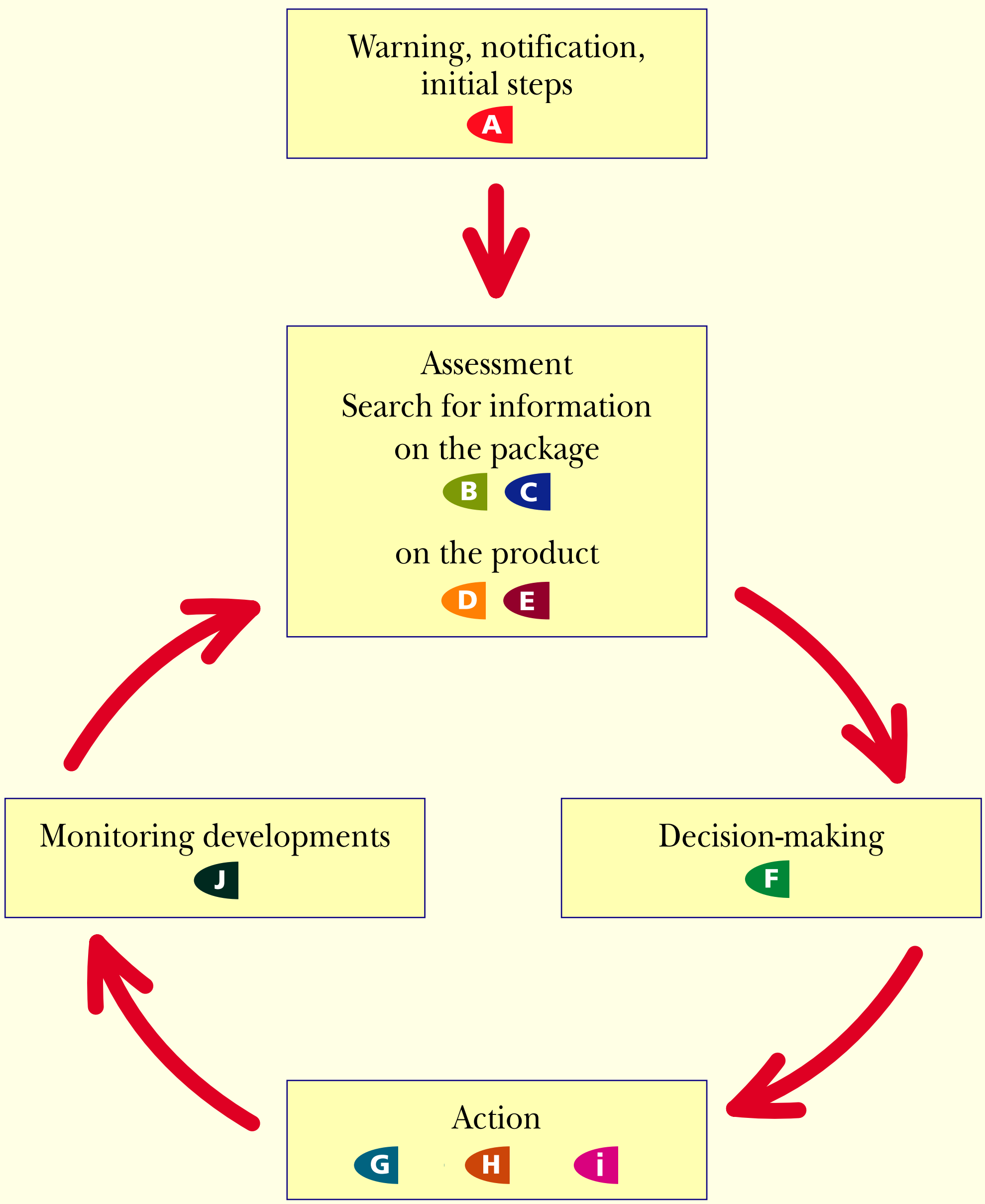
A - Warning, notification, initial steps;
B - Description of packages;
C - Behaviour of packages;
D - Products transported;
E - Risk profiles;
F - Decision-making;
G - Searching;
H - Marking, beaconing;
I - Recovery, destruction;
J - Monitoring developments.

The reader may access any of these ten chapters directly by using the coloured labels at the edge of the pages. In each chapter, practical information is presented in the form of operational data sheets. The latter are designed to respond quickly to any concrete questions the reader may have.

Towed side-scan sonar DUBM42 being lowered into the water (photo : DGA France).

Grounding of the container ship Valdès on the Chaussée de Sein - 1989 (photo : French Navy).

Response to packages lost at sea: actions to be undertaken



A

Warning, notification, initial steps

Reported loss of package: 3 cases, 1 notification

Loss reported by the ship where the incident occurred

Any accident involving a ship transporting dangerous substances or any situation occurring on board such a ship must be immediately brought to the notice of the maritime authority in accordance with the international provisions in force.

Information to be requested from the ship

What?

- What substances are involved?
- Are these substances dangerous?
- What types of package have been lost?

How many?

- What number of packages are involved?
- What quantity of the substances do they represent?

When?

- At what time did the incident occur?
- If an exact time cannot be given, during what period of time did the incident occur?

Where?

- At what points did the loss occur (exact or estimated)?
- What route was the ship taking at the time of the loss or during the period of the loss?
- What were the conditions in the region (swell, wind) at the time of the loss?

How?

- What are the circumstances surrounding the incident?
- Is the ship in difficulty?

Validate the information by confirming it.

A2

Unknown package located by chance

Information to be requested from the locating ship or aircraft

First approach

- Position
- Time of discovery
- Type of package B
- Shape, size
- Colour
- Markings
- Depth of immersion
- Apparent conditions
- Weather in the area

Second approach

- Labelling D2
- Identification of the substance E

Unknown package recovered accidentally

A3

When a drum is accidentally recovered by a fishing vessel, warn the geographically competent national reporting authority (e.g. coast guard) and follow this procedure:

Drums presumed to be intact

- Cover up completely with an oilskin, donning boots and gloves, goggles if possible, in order to remove the drum from the fishing gear.
- Communicate all items of information making identification possible — A1 / A2
- If a dangerous nature is probable or possible:
  - put the drum back into the water with the catch of fish, avoiding any contact and proceeding as if it were a damaged drum (see the section on damaged drums below).
  - mark the drum with a buoy or beacon. — H
- If the drum is clearly harmless:
  - lash it down securely on the deck in a well-ventilated and sheltered spot, handling it with great care.
  - on arrival at the quayside, hand over the drum to the maritime authorities or, failing that, to the fire service.

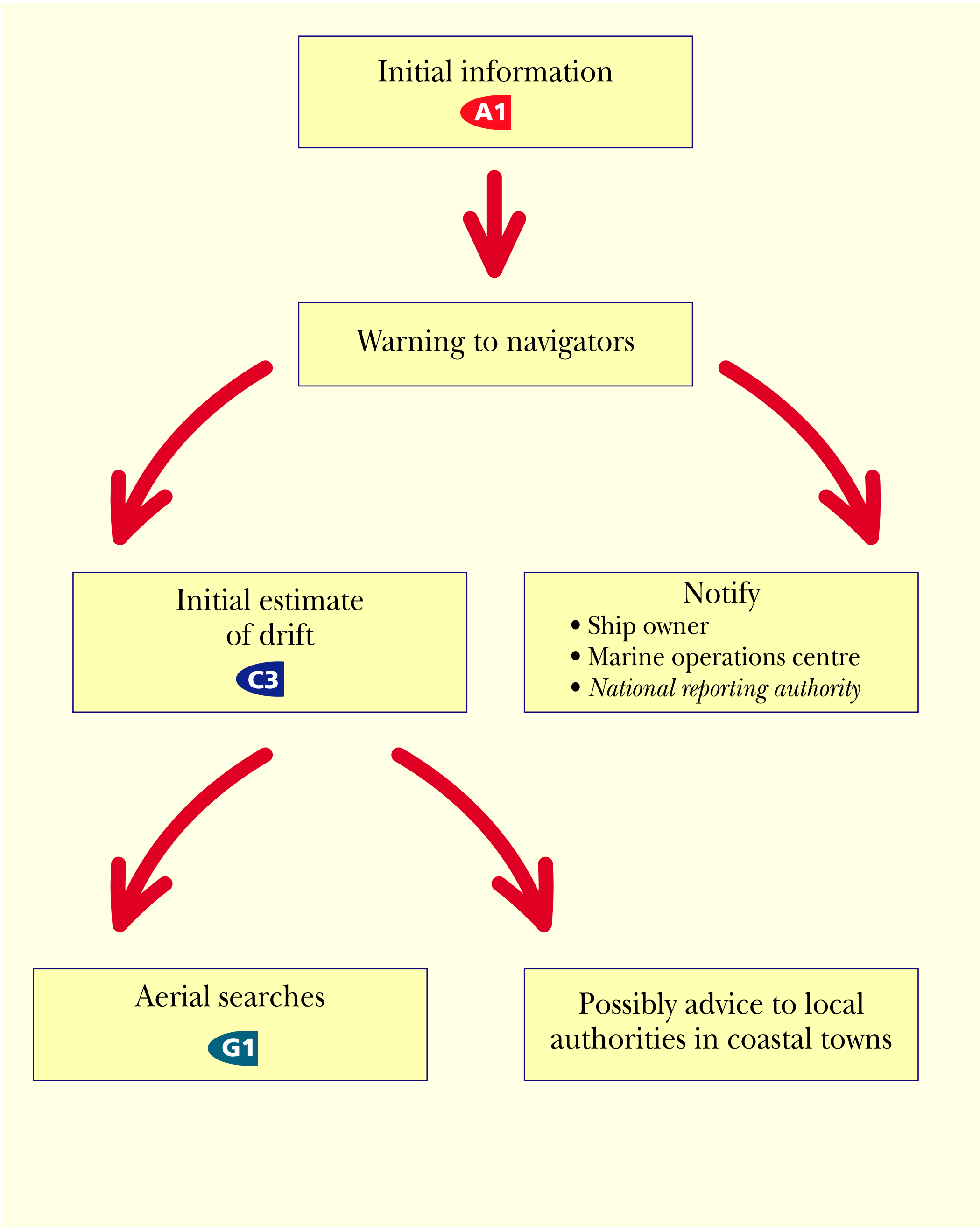
Damaged drums

- Release the drum and the catch of fish, avoiding any contact with the object (protecting oneself against noxious fumes, protecting the eyes and skin)
- Note all items of information making identification possible — A2
- Warn the maritime authorities and obey the directives given — B1
- Depending on what is feasible and at the request of the authorities, **mark the object with a buoy or beacon with a view to its later retrieval** — H

Stand permanently windward of the drum to avoid inhalation of toxic fumes.

A4

Notification, initial steps



Validate the information by confirming it.

Description of packages

B

The nature of the packages is known

Ascertain the characteristics

- Drums B1
- General-purpose containers B2
- Tank containers B3

The nature of the packages is unknown

Question

- The ship owner
- The owner of the cargo
- The port where loaded (declaration of dangerous merchandise)
- Those responsible for loading the container (in the case of a bulk container)

Drums

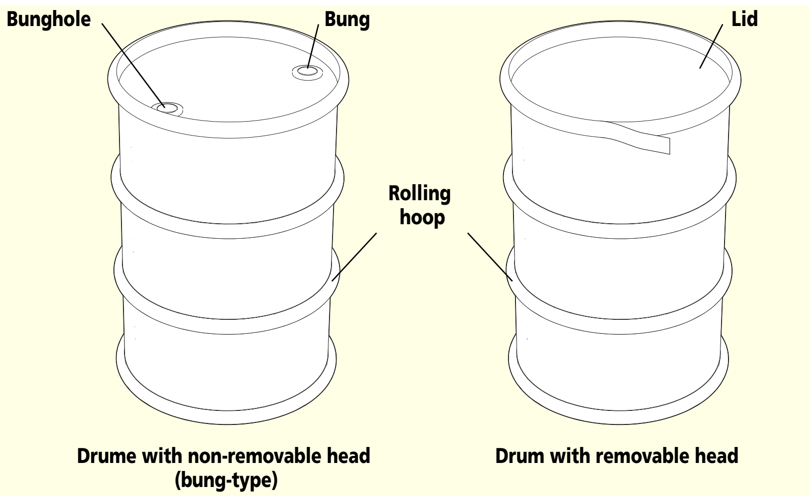
B1

Several types available

- Plastic (high density polyethylene) B1a
- Steel B1b
- Kraft B1c

Volumes: from 15 to 250 litres

Configuration of metal or polyethylene drums (figure 1).



Transport

■ **As deck cargo:** increasingly rare, generally in containers, mounted on pallets or unmounted.
■ **In 20-foot containers:** between 78 and 82 drums each of 225 litres maximum per 20-foot container.
■ **On pallets:** may be strapped and wrapped in a polyethylene sheet (a pallet base weighs between 7 and 10 kg).

Authorisation of dangerous materials

The IMDG Code (Annex 1) specifies the following three categories of authorisation. The category must be indicated on the drum:

• **Packaging Group I (denoted X):** authorised to transport goods presenting GREAT DANGER;
• **Packaging Group II (denoted Y):** authorised to transport goods presenting MEDIUM DANGER;
• **Packaging Group III (denoted Z):** authorised to transport goods presenting MINOR DANGER.

These labels are printed or inscribed in the material of the drum.

Drums: high density polyethylene (HDPE) or plastic drums

Goods regularly transported

Acids, alkalis, peroxides, alcohols, fatty acids, dyes, herbicides …

There are two types of drum

■ Drums with removable head, incorporating an internal bag of polyethylene film: powders, crystals, pastes,

■ Bung-type drums for liquids.

Average characteristics

External volume (litres)	**Tare** (kg)	**Volume of contents** (litres)	**Number of drums per pallet**
215 to 225	8 to 10.5	200	4
125 to 130	3.5 to 4.5	120	5
65 to 68	2 to 3.5	60	8
32 to 33 (casks)	1 to 1.6	30	12

Properties

■ **Bulk colour:** generally blue but other colours are also found: black, orange, white, green.

■ **Drums highly resistant to impacts and pressure.** Bung-type drums withstand up to 20 bars for at least 48 hours.

■ If ruptured, they split from top to bottom.

■ **Take care: drums with removable head lose their impermeability upon suffering impacts.**

■ Drums with external volumes of 125, 60, 30 and 15 litres generally have handles on the side at the upper end or recesses. Drums with an external volume of 220 litres may have rolling hoops.

Steel or lacquered iron drums

B1b

Goods regularly transported

Alcohols, animal and vegetable oils, aromatic compounds, glycols, lubricants, styrene, white spirit.

These exist as

- Drums with removable head, having internal bag of heat-sealed or laced polyethylene;
- Bung-type drums for liquids.

Average characteristics

External volume (litres)	**Tare** (kg)	**Volume of contents** (litres)
225	15 to 20	200 to 210
120	12 to 15	110
60	4 to 6	55
30	2.5 to 4	27

Properties

Bung-type drums have high resistance to impacts and pressure.

They are highly resistant to corrosion (several months). The thickness of the metal varies from 1 to 1.5 mm for category I, and from 0.6 to 1 mm for those of category II.

Apart from casks, metal drums generally have no handles and are manipulated by means of drum grips.

Drums with removable heads (photo Cedre).

Kraft drums

Goods regularly transported

Only removable-head kraft drums exist and they only transport solid substances in the form of powders, crystals and pastes.

The following substances are generally packed in kraft drums: adhesives, pigments, agri-food products including plant-care materials such as pesticides.

Average characteristics

Kraft drums have highly variable nominal capacities. The following table, however, gives some idea of the weights to be taken into account:

External volume (litres)	**Tare** (kg)
220	6.8
120	3.5
60	2.4

There are two large categories of kraft drum:

■ Conventional drums consisting of successive windings of sheets of kraft paper;

■ Drums treated to make them impermeable, also called "tempest drums". Apart from sheets of kraft paper, polyethylene or aluminium sheets are also incorporated to strengthen the drum and enable it to withstand adverse weather conditions.

The substance being transported is accommodated in a heat-sealed or laced polyethylene bag.

Immersion resistance:

• after an hour in contact with sea water, conventional drums lose their mechanical strength.

• tempest drums are stronger but are tricky to handle since their stiffness and mechanical strength are greatly diminished after several hours in contact with sea water.

The internal polyethylene wrapping plays a very important part in keeping the substance confined, although water does penetrate into the wrapping.

Handling this type of drum is still very tricky and great precautions must be taken at sea due to the high risk of the wrappings getting torn.

Kraft drum after spending 48 hours at a pressure of 20 bars (photo Cedre).

B2

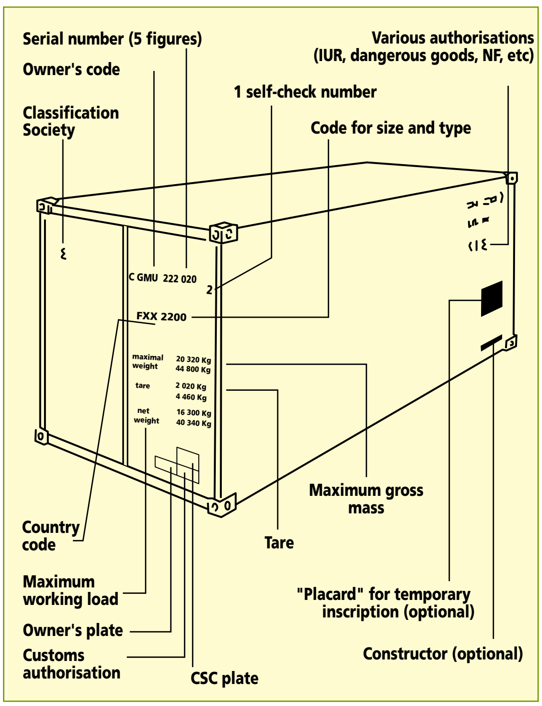
General-purpose containers

Types of container encountered

These containers are standardised at international level. Two main types of container are used: 20 feet and 40 feet in length.

	Mean external dimensions			Capacity	Type
	Length	Width	Height	Maximum gross mass maximale	
20′ (20-foot)	6.058 m 19′10″5	2.438 m 8′	2.438 m 8′	20 320 kg	General purpose Refrigerated Isothermal Tank Platform Open roof
	6.058 m 19′ 10″5	2.438 m 8′	2.591 m 8′6″		
40′ (40-foot)	12.192 m 40′	2.438 m 8′	2.438 m 8′	30 480 kg	General purpose Refrigerated Isothermal Platform Open roof
	12.192 m 40′	2.438 m 8′	2.591 m 8′6″		
	12.192 m 40′	2.438 m 8′	2.676 m 9′6″		

General purpose container (figure 2).



Structure of the container

Only the corner castings, the floor and the corner posts have an appreciable strength. The tare of a 20-foot container varies between 2 tonnes and 2.3 tonnes, depending on the size and structure of the floor.

Marking of containers:

The following must appear on each container:
- the owner's code: 4 letters;
- the serial number: 6 figures;
- the self-check number: 1 figure;
- the country code: 2 or 3 letters;
- the code for size and type: 4 figures.

Tank containers

This type of container is intended for the transport of liquids or gases without any other internal container.
It consists of two basic components: the tank and the framework.

Definitions

There are more than 60 000 tank containers worldwide, about a third of which are managed and monitored by the Bureau Veritas (BV).
The IMO (International Maritime Organization) considers four types of tank container defined as follows:

- Portable tank, IMO type 1: a tank provided with decompression devices whose authorised Maximum Service Pressure (MSP) is equal to or greater than 1.75 bar (90% of these tanks have a MSP equal to or less than 6 bar);
- Portable tank, IMO type 2: a tank provided with decompression devices whose authorised Maximum Service Pressure (MSP) is equal to or greater than 1 bar but less than 1.75 bar;
- Portable tank, IMO type 4: road vehicle whose tank is permanently secured and which is provided with decompression devices.

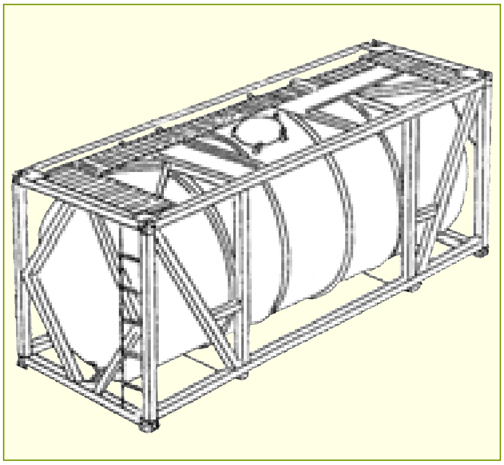
The diversity of tanks installed on road vehicle chassis is greater than that of containers because of the great variety of conditions under which they are used;

- Portable tank, IMO type 5: tank provided with decompression devices and intended for the transport of gases.

Characteristics of the containers

Weight and volume: highly variable.
An identification tag for each tank container is available from Classification Societies: ask the owner of the container first. It is generally very easily identifiable.

Tank container (figure 3).



Behaviour of packages

Predicting the behaviour of packages that fall into the sea will determine the estimate made of the risks to humans (salvage crews and the general population) and to the environment.

C

The questions to be asked are as follows

Resistance to environmental attack

Resistance to impacts, to pressure, to corrosion

General points

The impacts that packages may suffer, either by bouncing on the deck of the ship or on the surface of the water, will produce stresses that may make the impermeability of drums and the integrity of general-purpose containers doubtful.

Impermeability

A general-purpose container is not impermeable. An empty container in good condition fills with water and sinks in about 30 minutes. Tank containers, on the other hand, are impermeable. If they sink, the valves (safety valve and decompression valve) will balance the external and internal pressures.

Drums

Drum		Drop	Pressure	Corrosion	Wettability
Steel drum	Bung-type	+	+	++	n/a
	Removable-head	–	–	++	n/a
HDPE drum	Bung-type	++	++	n/a	n/a
	Removable-head	+	–	n/a	n/a
Kraft drum	Removable-head	+	– –	n/a	–

Table : strength of drums under external attack
++ *very high strength*
\+ *correct strength*
– *loss of impermeability*
– – *drum considerably damaged*

Containers

It is not possible to predict the resistance of a container to physical attack. Its behaviour under the initial impact depends on which part of the container comes into contact with the water. The corners, edges and floor will withstand impacts while the sides and the roof may be opened and allow the packages inside to escape.

Steel drum after 6 months immersion in sea water (photo Cedre).

Determination of the buoyancy of an object

A few reminders of some concepts in physics.

Mass

The unit of mass is the kilogramme. The mass represents the quantity of material or the number of molecules in the object.

Weight

A mass of 80 kg has a weight of 80 x 9.81 = 784.8 newtons (N). The weight takes into account the acceleration due to gravity at a given place, which has an average value of g = 9.81 N/kg, often rounded off to 10.
Weight is often more easily expressed in decanewtons (daN) = 10 N.
It is then a simple matter to change from a mass to a weight by replacing kg with daN.

Density φ (phi)

This is the mass per unit volume, expressed in kg/m^3 or in grammes/litre (g/l). For sea water, we have chosen a density of 1025 g/l, but this varies from one sea area to another.

Relative density d

The relative density (formerly the specific gravity) of a body is the ratio between the density of the body and the density of pure water at 20°C (if water is taken as the reference material).

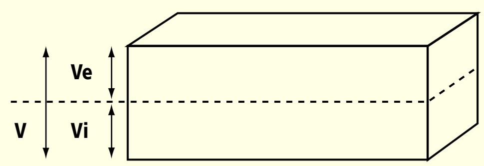
Archimedes Principle

Any body immersed in a fluid receives an upward thrust equal to the weight of fluid displaced and applied at the centre of gravity of the displaced fluid.
Thrust = φ (water) x V(volume displaced) x g.

The buoyancy of a body of relative density d and total volume V

Weight $P = \varphi Vg$
Let φo = mass of 1 m^3 of water
d = relative density of body
V_e = volume above waterline (emergent volume)
V_i = submerged volume
Then the upthrust = $\varphi_o Vg$
Apparent weight, $P_a = \varphi Vg - \varphi_o Vg$
If the body floats, the Archimedean thrust is equal to the weight of the volume of fluid displaced byV_i. So that $\varphi Vg = \varphi_o V_i g$, or $\varphi / \varphi_o = V_i / V = d$.

Floating container.



To determine the buoyancy of an object of non-uniform density that has fallen into the water (this is the case for containers and drums), the "equivalent" density of the body must therefore be found.

For the loss of a package at sea, two situations may occur:

Impermeable objects: drums and tank containers

V = external volume of the object
Gross weight = net weight of the product + weight of packaging
Density of the drum = φ = gross weight/Vg
Apparent weight:
$P_a = \varphi Vg - \varphi_o Vg = Vg(\varphi - \varphi_o)$
The body sinks if $P_a < 0$, and hence if $\varphi < 1025$ kg/m^3.

To a first approximation, **a drum will sink** if the volumic mass of the product transported is greater than 1060 kg/m^3 (i.e. a relative density of about 1.06).

As regards **tank containers**, their buoyancy depends on the type of container (mass of metal) for a given mass of the product.

The following values are averages for the weight of the product transported, beyond which the tank container sinks. These values are to be taken as default values when accurate data are lacking.

IMO 1 : 17 400 daN, or a mass of 17.4 tonnes of the product;

IMO 2 : 18 800 daN, or a mass of 18.8 tonnes of the product;

IMO 4 : 23 900 daN, or a mass of 23.0 tonnes of the product;

IMO 5 : 13 350 daN, or a mass of 13.35 tonnes of the product.

Non-impermeable objects: general-purpose containers

This type of container is not impermeable. An empty general-purpose container fills with water and sinks approximately 20 to 30 minutes after falling into the sea.

To determine the buoyancy of a loaded container (it is not always filled with goods), the total volume displaced must be found, i.e.:

• the volume occupied by the goods transported (the sum of the external volumes of the cases or drums);

• the volume of the securing devices and any pallet bases (lacking this, a volume of 500 to 1000 litres should be taken for a weight of 250 to 500 daN).

• the volume of steel in the container. The weights when empty have the following approximate values:

• 20-foot: 2 100 daN, or a mean mass of 2.1 tonnes;

• 40-foot: 4 000 daN, or a mean mass of 4 tonnes, for volumes of steel amounting to 270 litres and 500 litres respectively.

The apparent weight $P_a = Vg(\varphi - \varphi_o)$,
where φ = total mass/total volume
and φ_o = 1 025 kg/m^3.
If $\varphi < \varphi_o$, the container sinks.

The emergent volume of a floating container is given by the formula $V_i/V = \varphi/\varphi_o$, where V_i = submerged volume and V = total volume.

C3

Estimation of drift

Modulus of the speed

V = 100% of the speed of the body of water
(tides, currents due to sloping seabed, etc.)
+ 3% of the wind speed
+ thrust on the emergent part.

Thrust of the wind on the emergent part

Values of the wind speed to be taken into account:

- container with 80% emergent: 4%
- container with 60% emergent: 3%
- container with 40% emergent: 1.5%
- container with 20% emergent: 0.5%

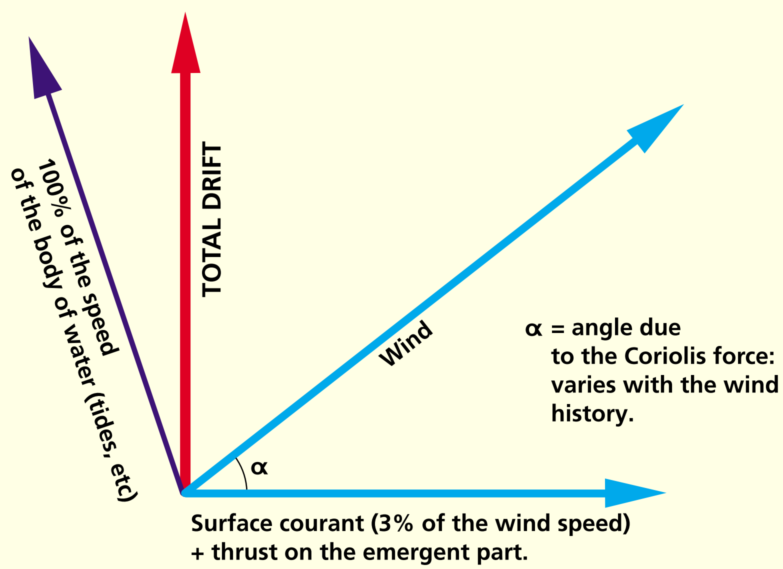
Modulus of the direction

In the northern hemisphere the drift zones to be taken into account vary between 10° and 45° to the right of the direction from which the wind is coming.

Important note

From an operational viewpoint, it is rare that the wind over the zone is known. While waiting for data from a meteorological organisation, values reported by ships in the zone and by coastal stations will have to be used.
Winds given by meteorological organizations are generally measured or estimated at 10 m from the ground. The effective wind at the surface of the sea is about 3/4 of this value.

Example of vector calculation of the surface drift as used by Cedre (figure 4).



C4

Estimation of motion produced on the sea-bed

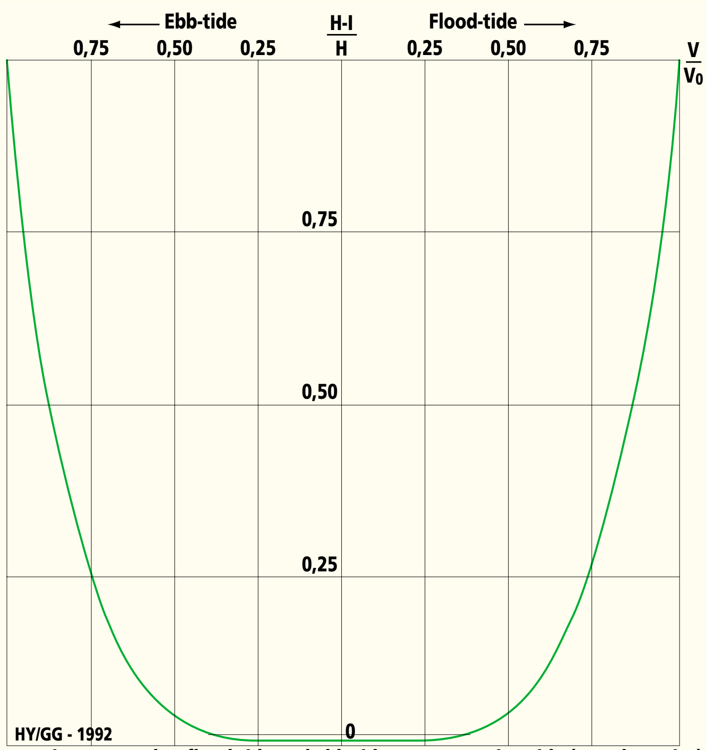
The speed of drift on the sea-bed is very difficult to evaluate. Here, we propose a method for determining the threshold for induced motion of the package.

Parameters to be used to evaluate the drift on the sea-bed:
• apparent weight of the object;
• value of currents due to swell;
• value of sea-bed currents (tide);
• nature of the sea-bed;
• topography of the sea-bed.

The direction of drift will be that of the resultant current and may be affected by the slope and nature of the bottom. A zone with a wealth of fallen rocks and crevasses will discourage drift on the sea-bed.

The speed of the tidal current on the sea-bed is estimated using a Cartwright diagram (figure 5). Example of the calculation for a depth 1 m above the sea-bed and a total depth of 20 m:
If H = total depth of water;
I = depth at point of evaluation;
V = speed of current at point of evaluation;
V_O = speed of current at the surface, excluding the effect of the wind,
then (H - I)/H = (20 - 19)/20 = 0.05, and the Cartwright diagram gives for the ebb-tide V/V_O = 0.35, or 35% of the value of the ebb-tide current.

Sea-bed currents according to the Cartwright diagram (figure 5).

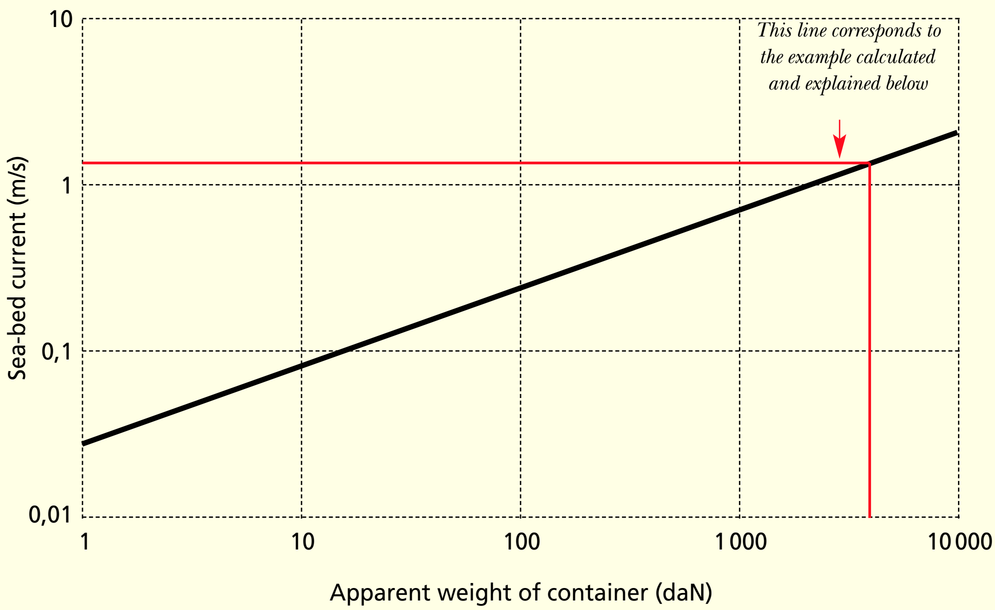


Maximum speed at flood-tide and ebb-tide at mean spring-tide (Manche-Iroise)

H = depth of water
I = depth of the layer
Vo = speed at the surface
V = speed at the layer

A package lying on a horizontal sea-bed will move above a certain value of the sea-bed current given by figure 6.

Movement of a package on the sea-bed (figure 6).



Example
A tank container with a mass in air of 25 000 kg occupying a volume of 21 m^3 *will have an apparent weight* P_a *(weight in water) given by:*
P_a *= weight - upthrust =* $V\varphi g - V\varphi_0 g$
$= V\varphi g(1 - \varphi_0/\varphi)$*, where*
φ *= mass of a litre of the body, i.e. = 25 000/21 000 = 1.19 kg/l;*
φ_0 *= mass of a litre of seawater, i.e = 1.025 kg/l;*
$g = 10$ *m/s*^{2}*;*
V = 21 000 litres.
Hence $P_a = 1.19 \times 10 \times 21\,000\,(1 - 1.19/1.025) = -40\,234$ *N*
i.e. $P_a = -4023$ *daN.*

The apparent weight is negative: the container will sink.
In order to find at what speed of sea-bed current the container will move, refer to figure 6 and locate the figure 4023 on the horizontal axis. The intersection with the straight line occurs at a value on the vertical axis of 1.2 m/s. This is the speed of the sea-bed current beyond which the container will be set in motion.

Substances transported

Two possibilities

The dangerous goods classification is known

- Determine the properties and categories of the substances D1

The dangerous goods classification is unknown

- Describe the labelling of the packages D2
- Notify the ship-owner B

D

Pallet of oxidising substances (photo Cedre).

IMO (International Maritime Organization) classifications of goods

The prevention of pollution by ships was the subject of the MARPOL 73/78 Convention, an international convention whose various regulatory provisions have been defined by the IMO Marine Environment Protection Committee (MEPC) and classified in 5 Annexes.

Chemicals dispatched by sea may be transported in packages or in bulk. The regulatory provisions for dangerous substances transported in packages (Annex III of MARPOL) are those of the IMDG (International Maritime Dangerous Goods) Code which divides chemicals into 9 classes of risk.

The port at Le Havre: container terminal (photo Cedre).

MARPOL classification

Guidelines for the identification of harmful substances in packaged form (extracts from the revised draft of Annex III of MARPOL 73/78).

For the purposes of this Annex, substances identified by any one of the following criteria are harmful substances:

• bioaccumulated to a significant extent and known to produce a hazard to aquatic life or to human health (Hazard Rating "+" in column A*); or

• bioaccumulated with attendant risk to aquatic organisms or to human health with a short retention of the order of one week or less (Hazard Rating "Z" in column A*); or

• liable to produce tainting of seafood (Hazard Rating "T" in column A*); or

• highly toxic to aquatic life, defined by a LC_{50}/96h** hour less than 1 ppm (Hazard Rating "4" in column B*).

**Refer to the Composite List of Hazard Profiles prepared by the IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP) Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), which is circulated annually by the Organization by means of BCH circulars to all IMO Member States.*

***The concentration of a substance which will, within the specified time (generally over a given period of time (generally 96 hours), kill 50% of the exposed group of test organisms. The LC_{50} value is often specified in milligrams per litre (mg/l) or parts per million (ppm).*

D1b

IMDG (International Maritime Dangerous Goods) classification

Packaged products transported in containers with widely varying capacities are classified according to the recommendations of SOLAS 74 Convention (Safety Of Life At Sea), i.e. according to the nature of the risk (Figure 8).

Class 1 - Explosive substances and articles
Division 1.1.: Substances and articles presenting a risk of explosion en masse
Division 1.2.: Substances and articles presenting a risk of being projected but without the risk of explosion en masse
Division 1.3.: Substances and articles presenting a risk of catching fire with a slight risk of a blast or a discharge or both, but without the risk of explosion en masse
Division 1.4.: Substances and articles presenting no appreciable risk
Division 1.5.: Very insensitive substances presenting a risk of explosion en masse
Division 1.6.: Extremely insensitive substances presenting no risk of explosion en masse

Class 2 - Gases
Class 2.1.: Flammable gases
Class 2.2.: Non-flammable, non-poisonous gases
Class 2.3.: Toxic gases

Class 3 - Flammable liquids
Class 3.1.: Low flashpoint
Class 3.2.: Medium flashpoint
Class 3.3.: High flashpoint

Class 4 - Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases
Class 4.1.: Flammable solids
Class 4.2.: Substances liable to spontaneous combustion
Class 4.3.: Substances which, in contact with water, emit flammable gases

Class 5 - Oxidising substances (agents) and organic peroxides
Class 5.1.: Oxidising substances
Class 5.2.: Organic peroxides

Class 6 - Poisonous substances and infectious substances
Class 6.1.: Poisonous substances
Class 6.2.: Infectious substances

Class 7 - Radioactive materials

Class 8 - Corrosive materials

Class 9 - Miscellaneous dangerous substances and articles

Products identified as "marine pollutants" present a particularly high risk to aquatic life.

Labelling of packages

The IMDG (International Maritime Dangerous Goods) Code contains provisions that in principle make it possible to identify dangerous goods contained in packages, in goods containers or in portable tanks recovered at sea.

The provisions of the IMDG code relate to

■ The classification of dangerous goods: these are arranged in rows depending on the nature of the danger in the various classes (figure 8).
The class indicates the nature of the main danger.
The degree of danger is defined by the packaging group:

- Packaging Group I: for substances presenting great danger,
- Packaging Group II: for substances presenting medium danger,
- Packaging Group III: for substances presenting minor danger.

The identity of the goods is indicated by the proper shipping name (correct technical name). This consists of the chemical name under which it is listed in the IMDG Code, supplemented by a chemical name of the substance or substances that are dangerous and by the UN number.

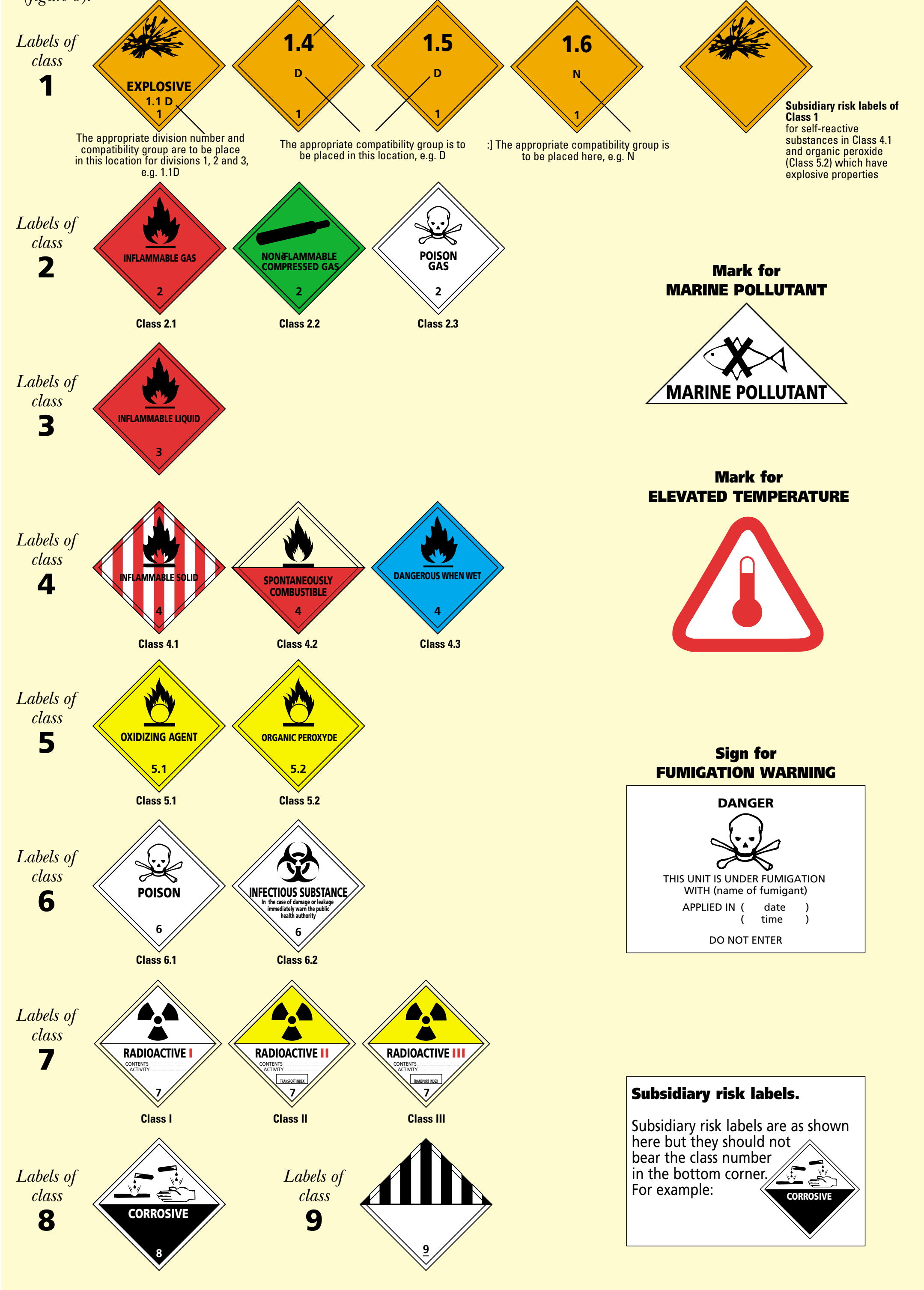
■ The use of approved packaging for the transport of dangerous goods, and the requirement to carry marking certifying the approval.

■ The marking of packages: in addition to the above labelling, each package must carry an inscription of the proper shipping name and the UN number.
Figure 7 shows an example of a drum containing dangerous substances, labelled and marked in conformity with the regulations. For the exact meaning of the markings, reference should be made to the IMDG Code.
The method of applying the labelling and marking must be such that they are still readable on the packages after remaining for at least three months in seawater.

Labelling of a drum.
(figure 7).

■ Labelling of packages: each package must carry the label for the class of danger relating to the substance contained in it and, if necessary, labels denoting any subsidiary risk. These labels are reproduced in figure 8.

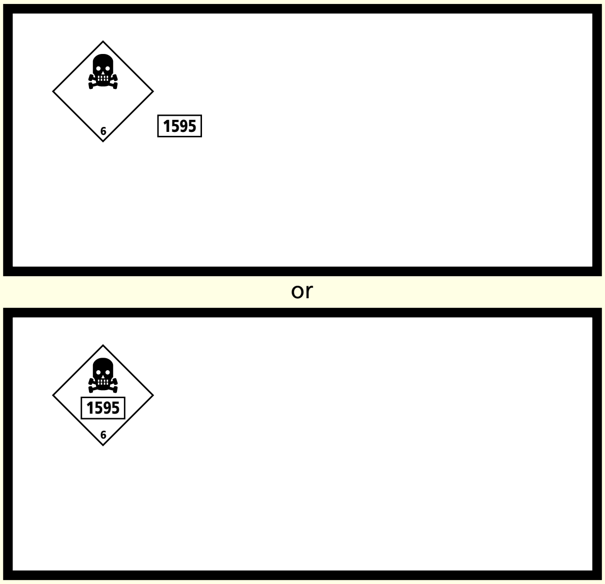
Labels, marks and signs. (figure 8).



D2

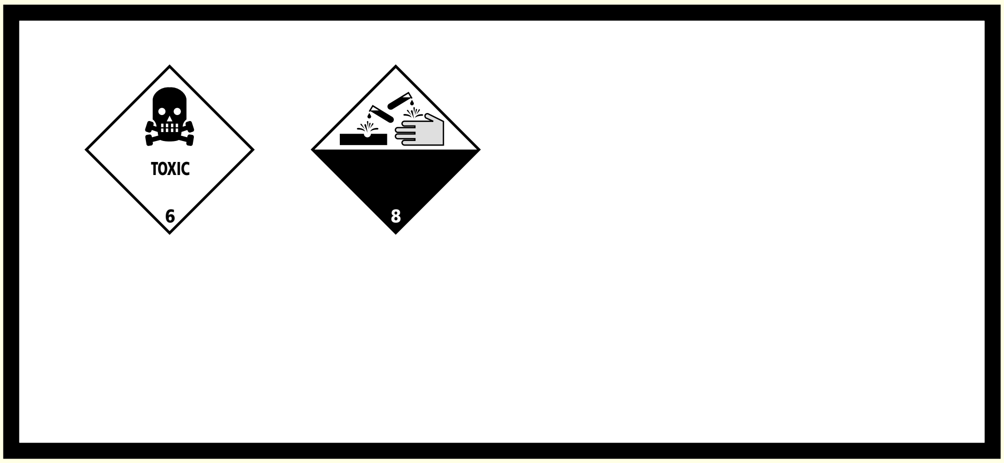
■ Displaying placards on the means of transportation: enlarged labels (placards) must be affixed to the means of transportation. For containers, they have a 250 mm x 250 mm format, while for packages (drums, boxes, etc.) they should be 100 mm x 100 mm.
Figure 9 shows an example of a goods container (general-purpose container) containing packages of a single dangerous substance. Both sides and both ends of the container must carry a placard or placards corresponding to the appropriate labels.
Figure 10 shows an example of a container containing packages of dangerous substances belonging to different classes. Only placards have to be affixed.
Figure 11 shows an example of a portable tank (tank container). As well as the placards and the UN number, the proper shipping name must be marked on at least the two sides.
■ Drawing up a transport document: this document, which is obviously never recovered with the package, may, when it is obtained from the carrier, nevertheless give additional information about the goods, such as the packaging group or the flashpoint, when it involves a substance not listed by name.

*Labelling of general-purpose containers containing a single dangerous substance.
Here, the substance is poisonous and belongs to Class 6.1: it is in fact dimethyl sulphate (labels on each side and on each end).
(figure 9).*



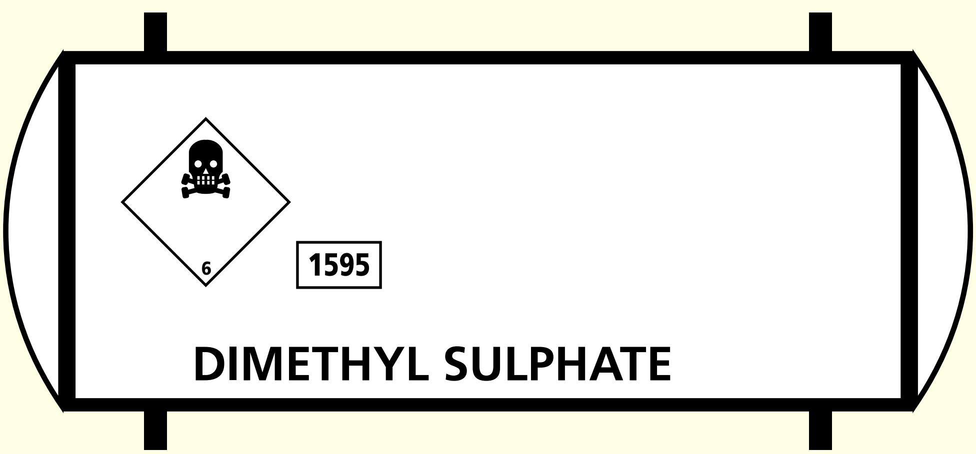
If the package has no apparent marking relating to the enclosed substance or substances, it must be assumed to be potentially dangerous.

Labelling of containers containing several dangerous substances of Class 6.1 and Class 8 (labels on each side and on each end) (figure 10).



D2

Labelling of tank containers (placard or placards on each side and on each end; proper shipping name at least on both sides) (figure 11).



Risk profiles

Condition: the nature of the substances in question is known

Harmless substances

Sunken containers

- Risks to trawlers (getting hooked)

Sunken drums

- No risk, but later identification needed in case of recovery

Floating containers

- Danger to navigation

Floating drums

- Danger to navigation
- Warn the coastal communities concerned

Discovery of a floating container in St George's Channel (photo Cedre).

Dangerous substances

Regulations concerning harmful liquids transported in bulk (Annex II of MARPOL) give invaluable information about the dangers presented by such substances when being transported. Harmful liquids are grouped into four categories (A, B, C and D) using a hierarchy ranging from the most dangerous products (MARPOL A) to the least dangerous (MARPOL D).
The MARPOL classification system is based on the assessment of risk profiles for chemicals transported in bulk by sea. Its methodology has been defined by a GESAMP working group (Group of Experts on the Scientific Aspects of Marine Pollution).

Tank container washed up on the coast of Brittany (photo Brest Fire Department).

MARPOL substances A and B: explosive, reactive, toxic substances

Marpol A and B regulations relate to substances in bulk, but they give invaluable information for packages: that is why the subject is mentioned here.

Sunken packages

The risks to human health and for flora and fauna are very high in this case. When accidentally recovered by a fishing vessel, there is a high risk of poisoning. In a shallow region less than 40 metres deep, the drift on the seabed may be considerable under the action of the swell.

Floating packages

Considerable danger to navigation, particularly to yachts, is posed by floating packages. As they drift, they will reach the coast after various periods of time. Walkers on the beach, as well as the local flora and fauna, are in danger of being seriously harmed.

Impacts on beauty spots, particularly tourist attractions, will have serious consequences for the local economy.

MARPOL substances C and D

Sunken packages

There is little environmental risk here. If the water is shallow, however, the package may drift.

There are dangers to fishermen in the case of accidental recovery.

Floating packages

Although not very toxic, these packages may create problems for navigation, and for walkers when they reach the coast. The danger to sites is minimal.

Drifting television sets (photo French Navy).

Assessment of risk profiles by GESAMP (Group of Experts on the Scientific Aspects of Marine Pollution)

More than 2200 products have been assessed by the GESAMP working group. Risk profiles are considered in 6 columns, each taking into account a certain number of criteria.
The table below gives the procedure for assessing risk profiles from GESAMP.

It is quite possible that new parameters defining the risk profiles for liquids transported in bulk might change the classification of substances.

Column	Former procedure	Current procedure (1999)
A	**Bioaccumulation and change of taste** Bioaccumulation Change of taste	**Bioaccumulation and Biodegradation** Bioaccumulation • Octanol/water partition coefficient (Kow) • Bioconcentration factor (BCF) • Biodegradation
B	**Aquatic toxicity** Acute toxicity Indirect toxic effects (BOD)	**Aquatic toxicity** • Acute toxicity • Chronic toxicity
C	**Human health** Ingestion	**Human health** • Ingestion (by mouth) • Cutaneous penetration • Inhalation
D	**Human health** Contact with skin and eyes Inhalation	**Human health** • Skin: irritation, corrosion • Eye: irritation, corrosion
E	**Reduction in usage**	**Interference with other uses of the sea** • Change in taste of seafood • Interference with recreational activities • Effects on wild fauna and benthic habitats
Comments	Other considerations Carcinogenic properties	Particular physico-chemical properties (e.g. gases) Reactivity with sea water Appraisal of knowledge to be made Specific aspects vis-à-vis human health or the environment .

Unknown substances: no markings

The most common cases are the following

- Unknown package located by chance A2
- Unknown package recovered accidentally A3

In this situation, the salvage team must allocate the substance to the same category as that of a dangerous product.

Consequently:

- Observe the package from the windward side
- Note any abnormal behaviour (smoke, colouring of the water, etc.)
- Mark the package H1

Samples of the substance must be taken by a specialist team provided with protective gear and "ad hoc" equipment. Such samples preferably consist of the substance, in the pure state or supposedly so, found inside the package or, failing that, as near as possible to the package. A decision can only be made after a chemical analysis.

Decision-making

MARPOL categories have been established

MARPOL substances A: neutralisation required F1

MARPOL substances B, C and D

- Neutralisation advised F2

Other substances

- Explosives F3
- Reagents F4
- Toxics F5

The substances are unknown B

Harmless substances

- Neutralisation unnecessary F6

MARPOL substances A

■ An emergency unit must be assembled to discuss the various options in the presence of appropriate experts and specialists (scientists, members of the fire service, emergency services, etc.).

■ Towing to a sheltered and uninhabited region may be recommended.

■ Destruction may only be considered in a few very specific cases. For example, for heavily damaged packages that cannot be recovered.

■ Do not tow into a port before the packaging has been made safe (put into salvage drums for example).

■ In the case of unsuccessful searches or spillages, carry out analyses (of sediments, fish, plankton, etc.) to monitor the area.

Recommendations

Action to deal with this type of product is essential in areas over the continental shelf.

i2b

i5

J

MARPOL substances B, C and D

■ These substances, although less toxic than those in the previous category, may present considerable risks depending on how dangerous they are (flammability, reactivity, toxicity, explosivity).

■ Products in classes 1.1, 1.2, 2.1, 2.3, 3.1, 3.2, 4.1, 4.2, 5.1, 5.2, 6.1, 6.2 and 6.7, together with certain corrosive and miscellaneous substances (classes 1 and 9) require the same precautions to be taken as for MARPOL substances A.

■ The opinion of experts should be sought before making a decision.

■ Destruction in the open sea is possible when there are multiple internal packagings in a container. Care should be taken to prevent their being scattered over the surface. i5

■ Do not tow into a port before the packaging has been made safe.

■ Taking on board is possible if the personnel involved are protected (from burns by discharged material) and the risks to the ship (from combustion, explosive gases) are minimised. i2a

■ Put loose drums into salvage drums. i1 i3

If the search is unsuccessful, these goods may be abandoned after an assessment of the dangers of drifting (on the surface or on the sea-bed).

Explosives

The attitude of those taking action to deal with packages containing explosives is dictated by the nature of the explosives

Container
with explosive substances
(IMO 1)

UNKNOWN, damaged or **nitrated oils** (including nitroglycerine) having lost their solvent

High risk of explosion

Recovery dangerous

Towing i2b

Blow it up in the open sea i5

Note: nitroglycerine explodes even when wet

All containers, even damaged ones, **not containing nitrated oils.**

Low risk of explosion (TNT, dynamite, etc.)

Recovery possible without too much danger i1 i2

Unless

Fire or very violent impact

In all cases, contact a specialist in explosive substances.

F3

Other substances capable of exploding or reacting (IMO 2.1, 3, 4, 5, 8)

- **Either the substance (gas, liquid, solid) is flammable**
- **Or the reaction (with air, water or other substance) creates flammable and explosive gases**

↓

Firmly establish the nature of the risk, particularly the reactivity

↓

Container intact

↓

No fumes or leakage

Recovery possible with measuring equipment and adequate protection

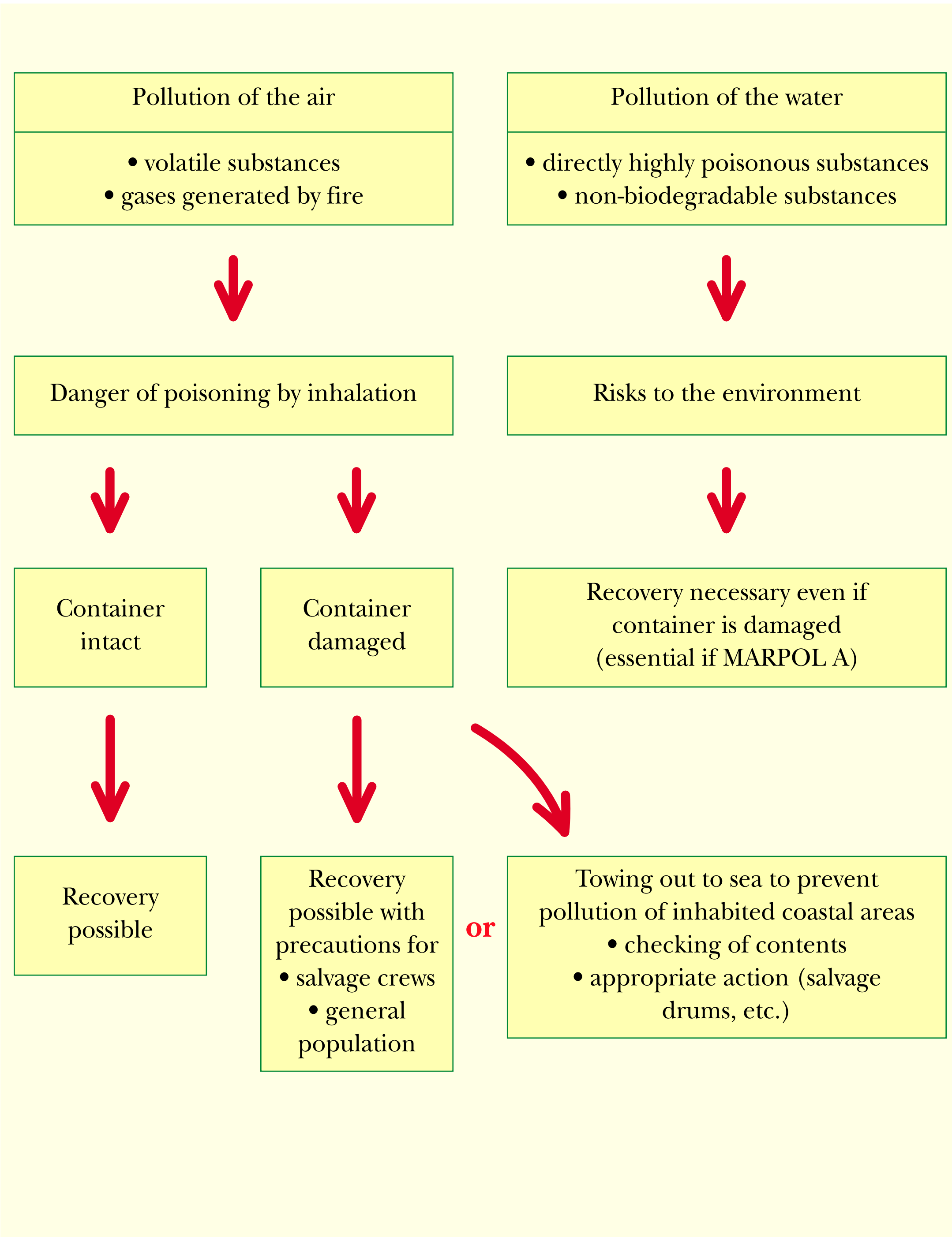
Container damaged

↓

Fumes or leakages

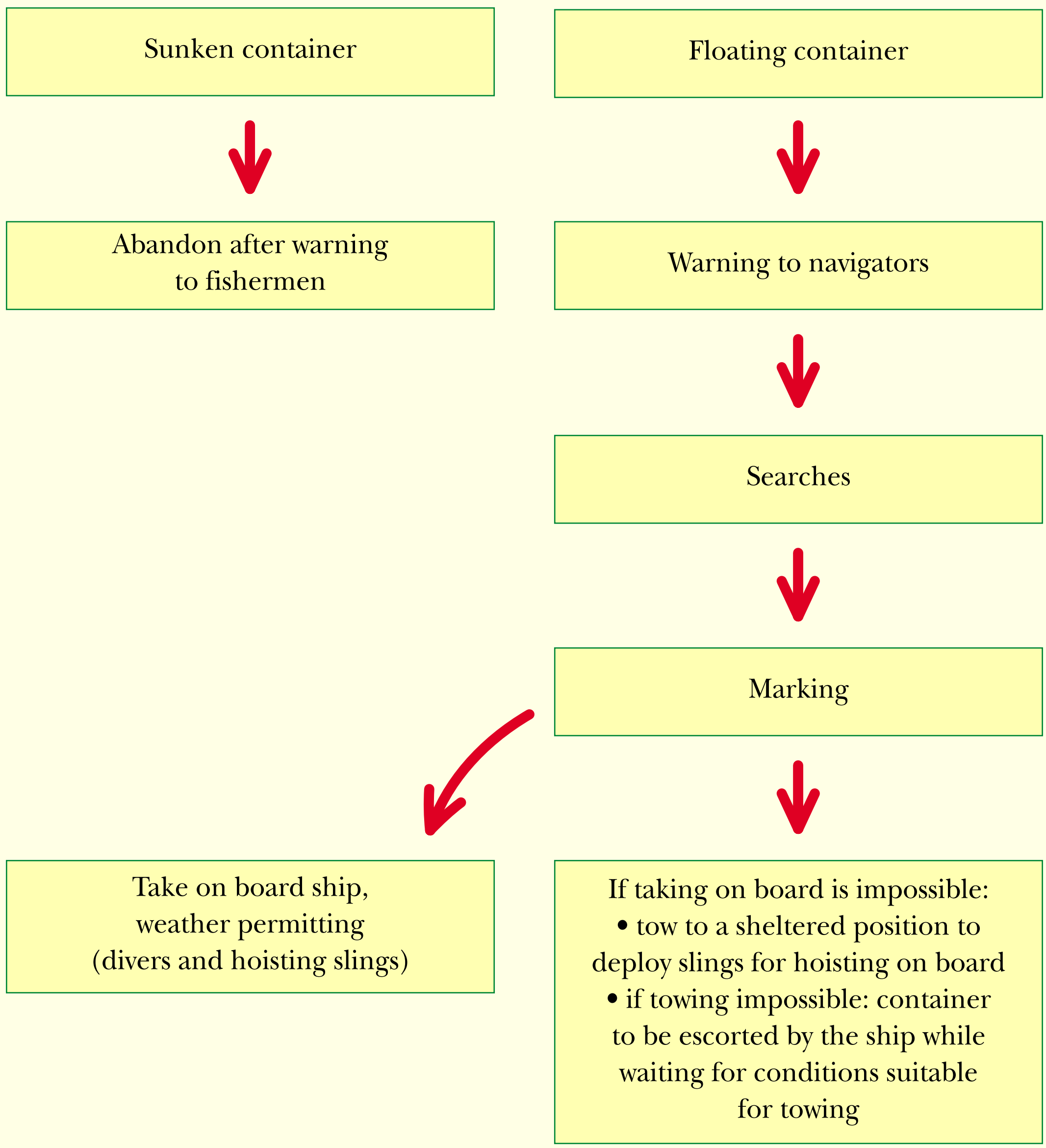
Action to minimise the leakage (plugging)	Depending on the substance: • use of foam • immersion in water • checking of concentrations • destruction at sea

Poisonous substances (IMO 6 and 2.3)



F5

Harmless substances



If the searches are unsuccessful, the above may be abandoned after a few days (the container being considered sunk).

F6

Searching

The action to be taken has now been decided

The package has not been located: look for it

- On the surface G1
- On the sea-bed G2

The package has been located: mark it and lay a beacon

- On the surface H1
- On the sea-bed H2

The package has been located and marked

- Neutralise it .... i1 à i6

The package still cannot be found

- High risk profile:
  - continue to search .... G1 / G2

- Low risk profile:
  - abandon the search

Surface searches

Visual searches for a floating object should be used at first while waiting for aircraft or ships fitted with specific sensing apparatus to arrive at the area (particularly the infra-red detectors in aircraft on maritime patrol).
The search may be undertaken by any type of ship or aircraft in the area, provided look-outs are on duty.

A surface search should not be carried out randomly. The essential prerequisite to any successful search is an estimation of the drift.
The search methods themselves are well known to airborne crews of the Navy or French Customs, who use them when searching for wrecks.
They are quoted here for the record:

- search by sectors;
- search by crossing squares;
- zigzag search;
- search in parallel passes.

The French Customs crew of the POLMAR II aircraft in action: KIDOUR exercise.

Visual detection

Visual detection is one component of a search whose effectiveness depends on:
- the resources (number of observers, altitude);
- the visual field scanned;
- the visibility (cloud cover);
- sea conditions;
- the size of the article;
- the tiredness of the observer.

It should be realised, however, that visual detection is very limited in its effectiveness, particularly in rough seas.

The altitude at which the search is made depends on the size of the article:
- a drum (comparable to a person in the water) should be sought at a height of between 200 and 500 feet;
- a container (comparable to a small boat) should be sought at a height of between 1000 and 3000 feet.

Side-looking airborne radar (SLAR)

Principle of the method

Electromagnetic pulses (microwave frequencies) are transmitted by an aerial located on the side of the aircraft.

The signals are back-scattered by any objects they encounter and are detected by the same aerial. This makes it possible to pick out echoes whose position on the screen depends on the distance from the object to the aerial.

Limitations

These are the same as for any circular radar system.

However, the resolution of SLAR is of the order of 15 to 20 metres depending on the altitude, which limits its use to the largest floating packages (40-45 foot containers).

Recommendations

This type of radar is fitted in specialised aircraft engaged in the fight against marine pollution. When conditions are favourable for its use, the width of the scanning is a considerable advantage.

The signals are processed in real time. Side-looking radar can be used day and night, whatever the weather. Detection depends on the resolution of the radar and its range (breadth of field).

Underwater search and detection

An underwater search for articles lying on the sea-bed is a long and costly operation. One of the decisive factors leading to its success is the accuracy with which the probable location of the article can be determined.
Underwater detection is a field in which naval personnel excel but in which the search methods are often highly secret. However, physical oceanography has made it possible to develop civilian versions of their equipment.

Various techniques are at present in use for detection under water and on the sea-bed:

Detectors

Detector	Advantages	Restrictions Drawbacks	Notes
Sonar • hull-mounted • multibeam • hull-mounted panoramic • towed • panoramic on Remotly Operated Vehicle (ROV)	• Only means of underwater detection (with magnetometer • System tried and tested during other uses • Good resolution • Availability: many manufacturers except for deep-sea ROVs	• Effect of motion of supporting system • Area covered depends on the frequency (range) • Identification of echoes in turbulent areas	• Technology constantly developing
Magnetometer	• May supplement detection by towed sonar • Availability	• Metallic content of containers is low: hence range is reduced and area covered is small • Interpretation of "echoes"	• Weak response
Underwater Cameras	• Only means of visualising a container under water (apart from divers)	• Short range • Limited in turbulent area	• Carried by an ROV associated with a surface vessel • Available commercially

Echo sounding

Principle of the method

A sonar system emits a sound wave which is reflected by an obstacle and detected on its return. A measurement of the time taken for the echo to return gives the distance of the obstacle, given that the speed of propagation of sound is of the order of 1500 m/s. The frequencies used range from 200 Hz to 5 kHz.

Several types of sonar are available. In the equipment currently available for all types of ship (fishing vessels, yachts, etc.), the transmitter is mounted on the hull and covers an area on the sea-bed vertically under the ship.

Limitations

Except when the sea is calm and shallow, a small object on the sea-bed is very difficult to detect using this type of system.

Recommendations

A hull-mounted sonar is available for the majority of ships. It can be recommended for use at depths of less than 30 - 40 metres, provided the wind strength is no greater than force 2.

An acoustic boom mounted on a Tripartite minehunter (Photo French Navy).

Multibeam sonars

Principle of the method

The transmitted beam is narrower than that of a traditional sonar (or echo-sounder) and scans a vertical sector under the ship. This type of sounder is used in fishing vessels.

With multibeam sonars, it is possible to scan a pre-determined slice of water over a variable angle.

Limitations

The performance of multibeam sonars, although better than that of conventional hull-mounted sonars, is affected by sea conditions.

Some sonars can only be operated over shallow water. An example is the LENNERMOR system produced by THOMSON, used by the French Naval Hydrographic and Oceanographic Service, whose measurements are made from a depth of 8 m under the hull and up to an oblique distance of 500 m. The precision achievable is of the order of 30 cm.

Recommendations

Oceanographic ships are fitted with multibeam sounders for bathymetry. Thus, the echo-sounding equipment on the Atalante (the oceanographic ship of Ifremer), EM12 produced by SIMRAD, has 151 beams capable of mapping the greatest depths. The width of the corridor scanned is 7 times the depth of the water (between 100 and 10 000 metres).

Sonars used in minehunting

Principle of the method

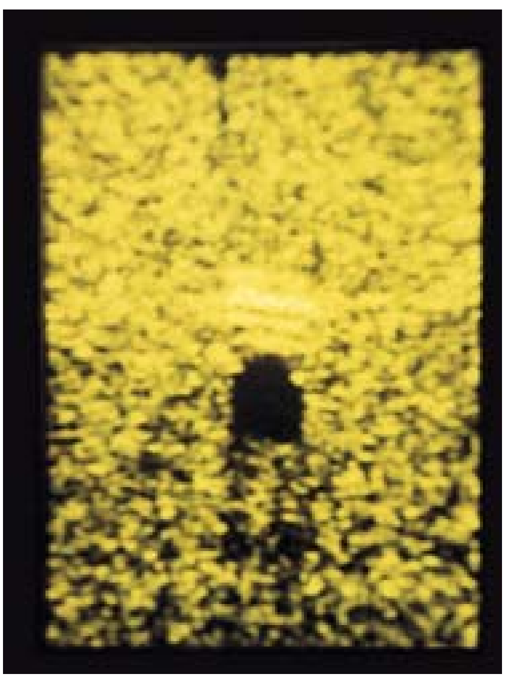
The sonars fitted in Tripartite minehunters transmit a signal in front of the ship (35° on each side of the midship centre line). The detector operates as a frequency of 100 kHz, while the "classifier" transmits at 420 kHz for a scanning angle of 30°.

Limitations

The state of the sea does not always allow the sonar housing to be opened.
The observed images need "classification" and video location by a self-propelled "fish" (Poisson Auto Propulsé or PAP in French). The latter is difficult to use when currents exceed 1.5 to 2 knots.

Recommendations

A 20-foot container lying on the sea-bed at 100 metres has been identified at a distance of 900 metres ("classification" at 150 metres).
The type of detector gives good results over known depths. In turbulent areas, however, articles of the size of a drum would be difficult to detect.



Container located by a minehunter (photo French Navy).

Towed sonars

Principle of the method

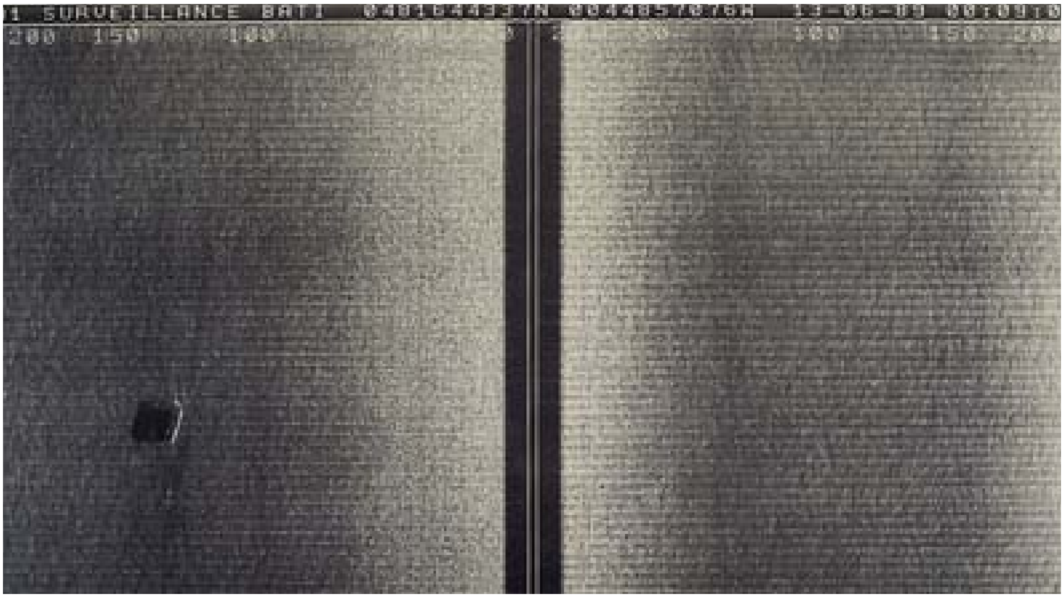
Two transducers (devices that, on transmission or reception, convert a physical phenomenon with a view to its transmission) are placed on each side of a "fish" towed at a controlled depth.
The echoes received are analysed at the surface and a map of the sea-bed is printed on a video screen or recorder.
The exact position of the "fish" relative to the ship is obtained by analysing an acoustic signal emitted by the "fish".

Limitations

For large sonar systems the worst sea condition in which it is effective is limited to force 4 (troughs from 1.5 to 2.5 m) due to the demands made by handling the "fish" (lowering it into the water and taking it back on board). There are, however, sonars that are easier to manoeuvre. A sea-bed that is too uneven may cause a collision with the "fish".

Applications

The towed side-scan sonar is the best system for underwater searches, with the areas covered being large for high quality images.
An example is the Lagadmor system from Thomson Sintra, which is towed at a speed of 10 knots for a scanned width of 400 metres.
The images obtained are sharp and require no subsequent identification. Its main disadvantage is its high price.



Container lying at a depth of 100 m (Dourvac'h 4 exercise). Detection by DUBM42 sonar.

G2d

Magnetometry

Principle of the method

Magnetometry involves the measurement of the Earth's magnetic field and its variations. The variations may be produced by metallic masses and are measured in gamma.

Limitations

The signal between the detector and the object causing the variation follows a 1/r3 law, where r is the distance between detector and object. Thus, if the distance is doubled, the signal is reduced 8-fold.
A good magnetometer should detect a 20-foot container at a distance of 30 to 50 metres. However, there is a commercially available nuclear resonance magnetometer (manufactured by Thomson Marconi Sonar) that increases the response 100-fold.
Magnetometers are mounted on towed "fish". Their use is limited by the maritime weather conditions.
The towing speed is from 2 to 3 knots.

Applications

Magnetometry may be used to supplement detection by sonar. An image not identified by sonar may be identified using magnetometry.
It is a method particularly recommended for the English Channel, where magnetic perturbations are almost non-existent.

Underwater cameras

Principle of the method

Underwater cameras, mounted on Remotely-Operated Vehicles (ROVs), are generally used for visual inspection of the condition of wreckage that has already been located. The images are transmitted from the ROV to the data-processing facility by optical or coaxial cable.

Limitations

There is no limit to the depth because supplementary illumination can be used to overcome the lack of natural light.

Applications

The resolution of digital images in present-day cameras is comparable with that in photography. Data can be transmitted to other locations in real time using a modem.

The best digital cameras have sensitivities similar to that of a film, i.e. lying between ISO speeds of 60 and 750.

Marking, beaconing

There are two possibilities

Marking converts a passive object into a cooperative one, easy to trace and to recover in the following situations:

• an accident occurring during the recovery process: breakage of the towline, breakage of the hoisting sling, etc.;

• deliberate disengagement from the point where a container has been found in order to carry out a mission with greater priority (saving of human lives or because of a deterioration in weather conditions);

• aerial detection, leading to subsequent guidance of the nautical resources.

Surface marking

Two factors are to be considered:

- The float H1a
- The system for identifying the buoy H1b
  - VHF
  - Optical
  - Radar
  - Satellite

	Containers/drums	**Means of detection and associated support facilities**	**Advantages Drawbacks**
RADIO BEACON constant transmission pulsed or triggered by search teams	• Container on the surface • Conteneur under water if connected to the beacon	• Radio receiver • Radio-goniometer receiver • Aerial and naval facilities	• Range of detection and accuracy limited by the frequencies used • Goniometry receiver required. Homing* on trans-mitter
SATELLITE BEACON (e.g. Argos beacon) Transmission compa-tible with satellite service	• Marking of dange-rous container (MARPOL A or B)	• Satellites • Data transmission by VHF or INMARSAT	

**Homing: being directed towards the point of transmis-sion using a radio or acoustic signal.*

Choice of float

■ If the buoy is released from an aircraft, the float should comply with the following requirements:

◗ compatible in size with the aircraft's launching chamber or tubes,

◗ resistant to impact during contact with the water,

◗ drift comparable to that of the article to be marked.

■ If the float is released from a helicopter, the above requirements are more flexible. In some cases, the buoy may be attached to the article to be marked: e.g. by a magnet, a quick method of attachment.

■ If the float is released from a ship, the only requirement to be considered is the system for attaching it to the container: a hook or magnet in case of bad weather.
The buoy is preferably attached to the container by means of a 50 or so metre cable and a hook of the ABK or CROSBY type coupled to a corner casting. This manoeuvre requires an inflatable boat to be lowered into the water, something not always possible in rough seas.

Recommendations

Being concerned to achieve uniformity in equipment, we recommend the use of floats of the type employed in marking oil slicks at sea.

It is essential to keep in mind that the difference between the drift of the article and that of the buoy will increase with time and will depend on the size of the emergent part of the article.

Identification

VHF transmission

Radiogoniometry requires the search facility to use a receiver tuned to the transmission frequency. For marking buoys, this frequency lies in the 150 MHz range.

The range of these systems depends very much on the sea conditions and the height of the aerial. Detection by aircraft is possible up to 15 or 20 nautical miles from the transmitter, whereas ships can only receive the signal at a distance varying between 1 and 7 miles.

Optical signal

A blinker beacon mounted on a buoy makes it visible at night at distances of a few miles if sea conditions are favourable.

Radar detection

A radar reflector may be mounted on the buoy. Its effectiveness depends on its height above the water. The main advantage of this system is that ships and aircraft both carry radar.

Detection by satellite

Transmissions from Argos are currently used for location at sea.

The uncertainty in the position of the object is about 300 metres. Access to the data is by modem via the Argos centre in Toulouse, France.

The main disadvantage is that several hours may separate two signals, the data being obtained after a time lag (1 to 3 hours). However, in view of the drift speeds, the Argos system seems to be well suited to marking on the surface.

It should be noted that goniometry is possible with an Argos transmitter provided that a dedicated receiver is available. Such a receiver is expensive however.

Marking on the sea-bed

Here, we must consider:
- acoustic detection by "pingers" (acoustic transmitters);
- facilities for detection.

Marking on the sea-bed: acoustic detection by "pingers"

Principle of the method

An acoustic transmitter sends ultrasonic pulses at precise rates over a given frequency range enabling the sound to be transmitted through the water. A receiving system enables the source to be located by homing.

Limitations

These acoustic transmitters, although very reliable, should not be fixed directly to the article, with masking effects limiting the range of transmission. Moreover, in the case of a floating article marked by a "pinger", there may well be some deterioration in the transmitter during contact with the sea-bed.
The choice of frequency is of vital importance: a low frequency (10 kHz) will carry further than a high frequency (40 kHz) but will be more difficulty to locate exactly.

Recommendations

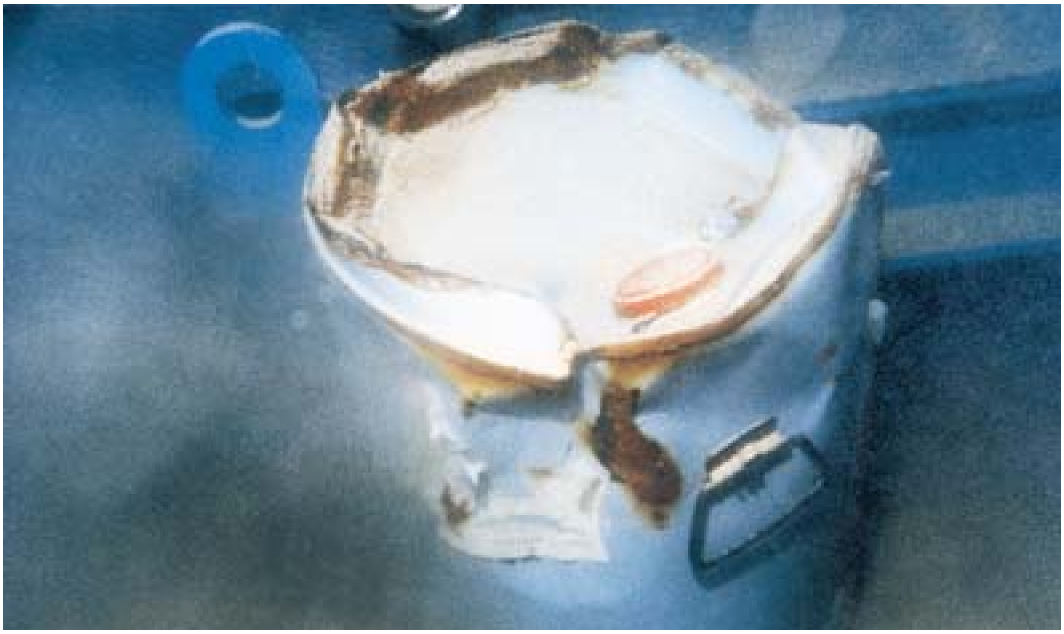
Any article located and identified as a package being sought should be marked using an acoustic transmitter.
It is imperative that the pinger is attached firmly to the article by means of a floating rope some twenty metres in length. We recommend increasing the buoyancy of the pinger to avoid masking effects and the risk of deterioration resulting from impacts or jamming on the sea-bed.
The cable should be attached by a diver, a ROV or a manned submersible.
The frequency chosen will depend mainly on the possibilities of detection.
For particularly dangerous floating containers, the surface marker buoy could be equipped with a pinger to avoid problems if the container should subsequently sink.

Increasing the buoyancy

In some cases, it may be beneficial to raise the container to the surface by giving it greater buoyancy using suitable items of equipment known as "salvage sheets".

■ Salvage crews will then be able to neutralise the floating container i2

Drum containing chemicals lying in the wreck of the Perintis (photo Marine Pollution Control Unit, Great Britain).



Recovery, destruction

The marking has been carried out effectively

Recovery is possible

- **If the article is floating**
  - drum i1
  - container
    - taking on board possible i2a
    - taking on board impossible: towing i2b
- **If the article has sunk**
  - drum i3
  - container .... i4a / i4b

Recovery is impossible

- Await favourable conditions

or

- Destroy i5

i

Recovery of floating drums

Principle of the method

The recovery of dangerous floating drums does not pose any major technical problems as long as the drums are intact.

Recovery can be carried out using a net or a sling.

If, however, there is a possibility of leakage, introduction into a salvage drum may be necessary on board.

Limitations

Introducing a dangerous loose drum into a salvage drum may prove to be a tricky operation in rough seas, even for an experienced crew.

In any case, deck crews must don protective gear adapted to the substances involved and providing protection for the skin and eyes.

Where the nature of the contents and the condition of the drum are uncertain and where there is no salvage drum or protective gear, it is dangerous to attempt recovery. The drum should either be marked or destroyed.

Recommendations

Manoeuvre the ship so that the drum is on the leeward side.

If there is no suitable net available, a loop of cable is passed around the drum. This operation requires an inflatable craft to be lowered into the water with a crew protected against fumes and spray.

Special nets should be held in national stocks of emergency equipment.

Specially designed trawler net for the recovery of drums (photo Cedre).

Recovery of floating containers

Floating containers may be recovered in two different ways:

- the container is accessible and presents no danger to the salvage crew or to the ship i2a
- the container cannot be hoisted on board i2b

A diver fitting a hoisting sling around a container (photo Cedre).

Taking on board

Principle of the method

A floating container may be recovered on board a supply ship by winching it through the stern of the ship using slings made fast round the lower corner castings.

Limitations

Apart from the dangers presented to the ship and the divers by the nature of the container, there are other requirements essential for recovery on board:

- a suitable ship, similar to an oil rig supply vessel, must be available;
- the weather must be mild enough to allow divers to make fast the slings (danger of impacts during any pounding of the container).

If the container is unknown and there is some doubt about its cargo, no manoeuvre should be undertaken to recover it. Marking is advisable however.

Sling for the recovery of a container on board (photo Cedre).

Recommendations

Slings that are specially designed for the purpose should be kept on board. These slings (bridles) are fitted with two hooks (ABK or CROSBY) having a carrying capacity of at least 20 tonnes (length of each leg: 5 metres, breaking load: 50 tonnes).

The procedure to be adopted may be as follows:

- clear the deck of the ship and prepare it using protective gear if necessary;
- run out from the ship 100 metres of steel cable with buoys attached to enable it to float;
- divers embark the bridle into an inflatable craft;
- attach a buoy to the loop of the bridle so that it floats;
- with the bridle in the water, divers fix the hooks to the lower corner castings, while embarking the shackle of the bridle and the lifting cable on board the inflatable craft;
- the ship is then turned about the cable, setting the stern to the sea in order to relieve the strain on the container during the winching;
- if possible, make the doors of the container face the front;
- hoist the container on board by controlling the tension in the cable (a 20-foot container fl filled with water has a mass of nearly 30 tonnes);
- as soon as the container is riding a wave, activate the winch;
- when the container is balanced on the flat of the stern, it can be made fast and any later movement can be prevented. Once the container is in this position, it can then be taken back on board immediately;
- it is possible to get it back on board with a simple sling hooked on to a single corner casting.

i2a

Towing

Principle of the method

The container is gripped by one or more of its corner castings and towed to a place where it can be safely manoeuvred.

Limitations

Such a manoeuvre poses no technical problems. **However, a potentially dangerous container in the open sea may prove in fact to be highly dangerous if the contents have spilled out while being towed near a sensitive coast.**
The landing zone for the container must be chosen carefully and in any case aerial and underwater marking must be carried out beforehand.
The route taken by the ship should be accurately plotted.

Recommendations

Experience has shown that a container may be lost while being towed and that subsequent searches may prove fruitless. It is therefore prudent to carry out prior marking: H1 and/or to increase buoyancy: H3.
An asymmetrical towline with four polypropylene cables is recommended so that the container presents an edge acting like the stem of a ship. Such a towline is difficult to set in place even in a slight swell and as a result two hooks may have to be enough (one submerged, the other emergent) at each end of a vertical edge.
If the sea is rough enough to prevent a diver submerging, it is possible to make fast one hook on one of the emergent corner castings. In such a situation, the towline will sweep through an angle of about 30° on each side of the midship centre line.
If the towline is made of polypropylene and the loads remains small it is possible to tow a few tonnes at 4 knots.

20-foot container fitted with instruments hoisted on board a supply ship (photo Cedre).

i2b

Recovery of drums lying on the sea-bed

Principle of the method

Dangerous drums lying on the sea-bed may be recovered by divers, either with adequate protective gear or using an ROV (Remotely-Operated Vehicle) for large depths. In both cases, the drums are stored on the sea-bed in salvage drums previously lined up in a rack of about ten salvage drums.

Once the rack is full, the salvage drums are closed. With highly dangerous products, the salvage drums may be sealed using quick-taking cement.

The rack is then raised to the surface with a crane.

Limitations

The maritime weather conditions must be very favourable.

Recommendations

The method using ROVs has now been perfected and any work on the sea-bed can be carried out with them.

Where a large number of drums are to be recovered from the sea-bed and where the currents there lead to fears that they may start to move quite quickly, a sea-bed net can be used to prevent them from scattering.

This technique may prove particularly useful around a wreck.

Recovery of a container lying on the sea-bed

Recovery of a drum in shallow waters (photo Brest Fire Department).

Action by divers

Principle of the method

Once located, mark the wreckage of a container with an acoustic transmitter: H2

The operations involved in the recovery are carried out by divers, who capture the container using a sling connected to the recovery vessel.

If the container (or the wreck) has been ripped open, the divers store the drums in temporary containers that are raised to the surface when full.

Limitations

■ Depth

Divers are subject to decompression sickness (caisson disease or the bends). Because of this, depending on the depth, the stages required for decompression and the logistic arrangements on the surface may be limiting factors.

■ Chemicals

The drums in containers may leak and have damaging effects on the health of divers. It is essential for them to be protected (combination of watertight diving suit and face mask).

An area for the decontamination of the waterproof suits must be provided on the surface, together with specific medical support.

■ Current

This must be less than 0.5 knots.

Recommendations

A careful examination of the wreck must precede any decision and samples (of sediment, water) must be taken around the wreck to assess any leaks.

The use of divers to recover a dangerous container should be very limited.

Any action should be simple, rapid and without danger for the diver: i.e. involving a substance that is not toxic or only slightly so, shallow water (accessible to divers), a sheltered area and a container that has not released its cargo.

Use of manned submersibles or Remotely-Operated Vehicles (ROVs)

Principle of the method

The container is located accurately by sonar (hull-mounted or towed G2). A submersible is lowered into the sea and, with its articulated arms, hooks a sling over one or more of the corner castings. The recovery ship then proceeds to raise it.
The submersible can also "work" on the sea-bed, i.e. manipulate drums and store them in an intermediate container.

Limitations

These machines cannot operate in fast currents and become difficult to manipulate in currents of more than 1.5 knots.

Recommendations

After marking the container with a beacon, the recovery ship moves, by dynamic positioning, to a point vertically above the container using its acoustic transponders. The ship lowers a cable whose position is constantly monitored by underwater acoustics.

Those involved in the action may be advised to increase the buoyancy of the container before hoisting it on board. It is essential to appraise the situation in the light of the resources available on the surface.

Manned submersibles require particular logistical resources (special gear, specific ship) for lowering them into the sea and for the recovery operation.
Some ROVs are highly efficient in fast currents and these will undoubtedly be used to carry out future sea-bed operations. They take up less room on board, are easy to handle and are capable of remarkable technical feats.
Finally, they do not put human lives at risk.

Destruction

Methods for destroying a drum or a container vary considerably and are assessed by the authorities in terms of the resources available in the area and the size of the article involved.

■ There are two main methods of destruction:

◗ destruction using a firearm (floating drums);

◗ destruction by explosives (containers, tank containers, articles lying on the sea-bed).

■ The latter method calls for a few comments:

◗ only specialists should deploy explosives;

◗ destroying a general-purpose container holding small packages may lead to a scattering of the packages that would be to neutralise as a whole;

◗ destruction may take place only after a full assessment of the risks.

Monitoring of developments

In order to be able to reassess the situation at any time, a procedure for monitoring the future behaviour of packages is necessary.

Depending on the situation (involuntary or deliberate loss of control), the following techniques will be used

- Searching .... G
- Marking .... H

Opening a container recovered at sea (photo Cedre).

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