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RISK MANAGEMENT IN THE BLACK SEA BASIN

Monography

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Foreword

Black Sea Region is a strategic bridge linking Europe with Caspian, Central Asia and the Middle East, and Southeast Asia and China, characterized by close ties and great potential, but also diversity and rivalries. This region comprises the EU member states Bulgaria, Greece and Romania, candidate country Turkey and Armenia, Azerbaijan, Georgia, Moldova and Ukraine and the Russian Federation as a strategic partner.

The authors emphasize the importance of studying the risk situations for the exploitation of the Black Sea basin. any deviation from the rules that protect marine ecosystems leads to ecological imbalances. Moreover, it is climate change that is making its mark on these ecosystems, implicitly on the imbalances within them.

The book is structured in 9 chapters in which it is presented: *MAJOR RISKS, METHODS OF RISK ANALYSES ASSESSMENT AND PREVENTION, MANAGEMENT OF RISK. MARINE RISKS, MAIN TEHNOLOGICAL RISKS, TECHNOLOGICAL RISKS ASSOCIATED WITH THE BEHAVIOR OF LIQUIDS AND COMPRESSED GASES IN LOSS OF STRUCTURAL INTEGRITY, RISK OF FAILURE OF A PRESSURIZED VESSEL CARRYING CAPACITY PRESSURE, ACCORDING THE COMMITTEE OF ADVISERS ON THE MAIN HAZARDS (CAMH), MAJOR TECHNOLOGICAL RISK. FIRES. EXPLOSION, ENVIRONMENTAL RISK. RISK MANAGEMENT, MANAGEMENT OF OIL SPILL ON SEA – SIMULATOR.*

Authors

CONTENT

Chapter 1

MAJOR RISKS

1.1. Introduction about Black Sea dimension

Black Sea Region is a strategic bridge linking Europe with Caspian, Central Asia and the Middle East, and Southeast Asia and China, characterized by close ties and great potential, but also diversity and rivalries. This region comprises the EU member states Bulgaria, Greece and Romania, candidate country Turkey and Armenia, Azerbaijan, Georgia, Moldova and Ukraine and the Russian Federation as a strategic partner.

1.2. The role of the European Union in the Black Sea Region

Black Sea Region is strategically important for the EU as the Black Sea is a part of the EU and hencing common challenges and opportunities for the EU and the countries in this region sharing a common need to ensure peace, democracy, security, stability, regional cooperation and sustainable prosperity in the Black Sea. For that it is needed a more coherent, sustainable and strategic approach.

1.3. The Black Sea – Ecological Status

The Black Sea is a unique water body and there are many books needed to describe the full characteristics of the ecological status of it. In this section you will find a summarized overview on the following topics:

- General physical geographical description;

- Black Sea, a unique body of water;
- The health of the Black Sea;
- Major problem areas;
- Marine and coastal ecosystems;
- Problems with coastal zone management;
- Protection and rehabilitation.

1.3.1. General physical geographical description

Area: 422 000 square kilometers or about 0.12 % of the world oceans:

- Greatest length along the parallel 42° 12’ N: 1,148 km;
- Greatest width along the meridian 31° 12‘ E: 615 km;

Catchment basin area: over 2 million square km;

Maximum depth: 2,212 m:

- Average depth: 1,300 m;
- Seasonal level variations: up to 20 cm;

Volume: about 540,000 square km:

- Volume of the hydrogen sulphide zone: 87 %;
- Volume of the oxygen zone: 13 %.

Wave height: up to 6 – 7 m:

Wave length: up to 90 – 100 m;

Tidal variations: 3 – 10 cm;

Salinity of seawater at the surface: 18 ‰;

Salinity of seawater at the bottom: 22 ‰;

Mean average winter temperatures of seawater: 4 °C;

Mean average summer temperatures of seawater: 22 – 24 °C;

The largest bays: Karkinitski, Bourgas, Kalamitski, Dneprovski, Dnestrovski, Synop, Samsun etc. The largest capes: Kimburn, Kherson, Sarich, Ingeburnu, Kerempeburnu, Emine, Kaliakra etc. The largest islands: Jarilchach, Zmeini etc.

The largest rivers flowing into the Black Sea: the Danube, the Dniester, the Dnieper, the Don, the Kuban, the Souther Bug, the Rioni, the Kazilirmak, the Kamchia etc.

1.3.2. Black Sea, a unique body of water

The surface salinity varies with the season. Vertically salinity starts increasing at a depth of 50 m; at 200 m it is considerable, but below 200 m it increases at a much slower rate. The composition of salts in the Black Sea water is identical to that in the oceans. The Black Sea waters contain considerable amounts of nutrients, particularly the nitrogen and phosphorus compounds that enter the sea via the rivers.

1.3.2.1. The distribution of salinity

The vertical distribution of salinity and temperatures determine the density of seawater. Because of the specific characteristics described above, the Black Sea has two distinct water layers: the lighter upper layer from 0 to approximately 200 m deep and the heavier lower layer from 200 m down to the seabed. This stratification of waters causes weak vertical circulation within them. The waters from the two layers do not mix very easily and that fact has an enormous influence on life in the sea.

1.3.2.2.The influence of marine environment on the biodiversity

In the entire Black Sea at a depth greater than 150 – 200 m there is a permanent hydrogen sulphide zone devoid of life. Oxygen is completely absent at this level. Oxygen rich surface waters supporting life in the sea constitute only about 13 % of the Black Sea volume. These features influence the condition of the marine environment and the diversity of organisms depending on it. They are the key to the character and the problems of the Black Sea’s environmental health.

1.3.3. The health of the Black Sea

This depends on the human activities-as the most significant cause of the Black Sea's environmental decline, especially in the coastal areas. Agriculture is another important source of nutrient pollution. The mechanism of ships pollution is worth considering in greater detail.

<u>1.3.3.1. The ecological problems</u>

The essential nutrients, though non-toxic, create problems because their components are easily utilized by the tiny floating plants, found in the surface waters, for their life functions. The effect is very much like the enrichment with fertilizers: it stimulates the growth of the miniature plants living in the sea that are known as plankton algae or phytoplankton that perform photosynthesis. Their proliferation, known as algae blooms in the Black Sea, poses threats to the ecosystem in two ways.

The second threat comes when the algae eventually come to the end of their lifecycle and die. Their bodies are decomposed by bacteria, which use up a lot of oxygen in the process, oxygen that is vital for marine organisms like seaweed, jellyfish, mussels, fish, crabs etc.

Due to the specific structure of waters in the Black Sea and their stratification into two layers – upper layer containing oxygen and lower anoxic layer, which mix very poorly, eutrophication has far reaching and undesirable effects.

The minute blooming algae on the surface form a thick layer, resembling a cloud, which blocks sunlight. In this way they prevent the sunlight entirely or partially from reaching the larger plants on the seabed below – sea grass and algal seabed, which in turn begin to die. This seabed vegetation provides food, shelter and a place to breed for other marine creatures like worms, crustaceans, demersal fishes etc. With the destruction of their living environment they leave or die decreasing their numbers, which means less food for other marine species including mammals and birds. Yet the threat does not end there.

Falling to the seabed dead organisms begin to decay. Vertical water circulation is poor, so in the process of decomposition any oxygen in the lower layer is used up. Some bacteria decomposing organic matter use the oxygen in sulphate, a natural component of seawater.

This process generates hydrogen sulphide, which is present in the entire lower layer of the Black Sea. It constitutes 87 % of its volume and is devoid of marine life. As a result biodiversity decreases and with it the possibilities of the system for self-regulation.

1.3.4. Major problem areas

The major problems areas are:

- pollution;
- loss of biodiversity;
- coastal degradation.

The eutrophication phenomenon or the over-fertilization of the sea by compounds of nitrogen and phosphorus (also called nutrients), largely as a result of pollution from agricultural, domestic and industrial sources is a major transboundary pollution issue.

1.3.4.1. Chemical pollution

Chemical pollution has been identified as the most serious transboundary problem.

Oil pollution threatens the Black Sea coastal ecosystems and the levels of pollution are unacceptable in many coastal areas and river mouths. Oil enters the marine environment as a result of operational or accidental discharges from vessels, as well as through insufficiently treated wastewaters from land based sources. Other toxic substances such as pesticides and heavy metals appear mostly as ‘hot spots’ near well identified sources.

Heavy metals such as cadmium, copper, chromium and lead are usually associated with waste from the heavy industry and ash remaining from burning coal for generating electricity. Pesticides enter the sea mostly through rivers and streams due to agriculture.

1.3.4.2. The discharge of insufficiently treated sewage waters

This results in microbiological contamination and poses a threat to public health. Radioactive substances have been introduced to the Black Sea in small quantities from nuclear power plants and in more significant amounts after the nuclear power plant disaster in Chernobyl in 1986.

An unusual form of pollution from ships is the introduction of exotic species, mostly through exchange of ballast waters or other wastewaters. Introduced by accident into the Black Sea they proliferate in the new environment for lack of natural predators that can limit their numbers.

1.3.4.3. Solid waste

The final major type of problematic pollutants is solid waste, dumped into the sea from ships and some coastal towns. Any floating or semi-submerged waste inevitably ends on the seashore.

Therefore the Black Sea beaches tend to accumulate a lot of garbage, which is unsightly and presents a risk to the health of humans and marine species.

1.3.5. Marine and coastal ecosystems

The sea is home to a great variety of marine communities and species. These plants and animals in the Black Sea form a complex food chain. Marine plants, dominated by phytoplankton or micro algae, provide the primary source of food to the oceans and are known as primary producers, the first level of the food chain. They provide food to the minute herbivorous animals predominating in the zooplankton, the primary consumers. They are food for the larger carnivorous zooplankton or fishes.

Fishes are the food source for consumers further up the food chain – larger fishes, birds, marine mammals and humans.

Phytoplankton consists of miniature free-floating algae that drift in the upper surface layers of the sea where there is enough sunlight to use in the process of photosynthesis supporting their basic life functions. Increased nutrients loads in the coastal zone over the recent decades have resulted in a shift in the ratio of species with a relative increase in the numbers of dinoflagellates and the appearance of several new phytoplankton species.

Zooplankton or the free-living marine animals include marine larvae but not adult fishes and some other adult marine species. The zooplankton community is particularly sensitive to changes in the structure of its populations like the introduction to the Black Sea of an exotic species, the jellyfish Mnemiopsis Leidyi.

The seabed or benthic communities are comparatively well studied, the most abundant being arthropods and worms. Another foreign ‘invader’ to the Black Sea, the snail Rapana Thomasiana, is often harvested by the illegal method of bottom trawling. This is harmful to the seabed because the trawls plough through it and destroy the benthic communities.

The marine mammals in the Black Sea are represented by the dolphin family. The most common species are the common dolphin, the bottle-nosed dolphin and the harbor porpoise.

There are many important bird areas all along the Black Sea coast. They are breeding and wintering sites for geese, ducks, swans, shelducks, warblers, wheathers, storks, gulls and raptors.

A considerable number of wetlands – swamps, marshes and lakes, are of special significance for the wintering of resident and migrant birds and are therefore defined as Ramsar Sites.

1.3.6. Problems with coastal zone management

The coastal zone is particularly vulnerable to pollution and damage, both direct and indirect, from human activity.

The destruction or pollution of habitats there can destroy or drive away dependent species thus influencing the entire food chain all the way up to humans.

Insufficiently treated wastewaters may contain pathogens, as for example the microbiological contaminants causing hepatitis-A or meningitis. The poor quality of coastal waters has a negative influence not only on life in the sea but also on tourism and the whole coastal economy.

To protect the coast however we need to make long term integrated planning. The process is well known as Integrated Coastal Zone Management.

The instruments for implementation of the Integrated Coastal Zone Management is the effective enforcement of regulations and environmental impact assessment.

1.3.7. Protection and rehabilitation

The governments of the six Black Sea countries have reached common agreement on the necessity to take preventive measures when there are reasonable grounds for concern that an activity may increase the risk of presenting hazards to human health, harm living resources and marine ecosystems, damage amenities, or interfere with other legitimate uses of the Black Sea.

The Convention on the Protection of the Black Sea against Pollution, signed in Bucharest in 1992 and ratified by the six national assemblies, includes a general framework of agreement and four specific protocols: on the control of land-based sources of pollution, on the dumping of waste and on joint action in the case of accidents, such as oil spills; and on the protection of biodiversity and landscape. The implementation of the Convention is overseen by a Commission with a permanent Secretariat, which started functioning in the autumn of 2000, and is based in Istanbul, hence the Istanbul Commission.

The UN Conference on the Environment in Rio De Janeiro in 1992 marked the beginning of activities on the introduction of the sustainable development principle called Agenda 21. All countries of the Black Sea basin were actively involved in the process.

In 1993 at the request of the governments of the six Black Sea countries the Global Environment Facility (GEF) and the European Union established a fund of 9,3 million dollars which made possible the development of the Black Sea Environmental Programme. The Programme prepared and published a system scientific analysis on the causes of the environmental problems of the Black Sea called Transboundary Diagnostic Analysis, the basis of the regional strategic action plan.

In 1996 the governments of the six Black Sea countries adopted the Strategic Action Plan for the Rehabilitation and Protection of the Black Sea. The signature day of the document, October 31, was proclaimed International Black Sea Day and is marked regularly every year.

In the period 2002 - 2008 a long term project entitled ‘Control on Eutrophication, Harmful Substances and Related Measures for the Restoration of the Black Sea Ecosystem’ (Black Sea Ecosystem Recovery Project) was implemented by the Black Sea countries with support from the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP) within the framework of the new GEF initiative: Strategic Partnership for the Countries of the Danube and Black Sea Basin.

Meeting of the Contracting Parties to the Convention on the Protection of the Black Sea against Pollution (Bucharest Convention) will take place in Kyiv, Ukraine in the spring of 2009. The meeting will adopt and approve a number of important regulatory instruments among them the Trans-boundary diagnostic Analysis 2007 and the updated Black Sea Strategic Action Plan.

1.4. What is the risk?

According to all the major authors and authorities dealing with the notion of global risk,

$$\mathbf{R = P \times C} \tag{1.1}$$

Where: R - risk; P - probability; C - consequence.

Risk is therefore a function of both the probability (probability) and the consequence of a certain danger to be realized, so when we think about risk, we have to think about the two factors involved:

- Likelihood of an adverse event (such as accidental oil spills at sea);
- Consequences of the adverse event (such as environmental damage, businesses or, consequently, state relations).

Another definition of risk [2] would be:

$$\mathbf{R = (H + V) / Cap} \tag{1.2}$$

Where: R - risk; H - hazard; V - vulnerability; Cap - Head-capacity, in which case:

- Hazard is a natural process or phenomenon, or a substance or human activity that can lead to loss of life, injury and other health effects, property damage, loss of livelihood and services, social and economic disruption, or degradation environment;
- Vulnerability is the relative lack of capacity of a community or the ability of an asset to withstand damage and loss due to chance.

- Capacity is the combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve the set objectives.

Risk has different connotations in different disciplines. In general, risk is defined as "a combination of the probability of an event and its negative consequences" (UNISDR 2009). Long-term risk is therefore multidisciplinary and is used in a variety of contexts [1].

1.5. Applications of major risks & management of risk. Major future risks to the marine environment

1.5.1. The problem of climate change

Many coastal areas in the Black Sea are at risk of rising sea levels due to climate change. Rising sea levels could have a very significant impact on river deltas and low-lying coastal areas, which are often more densely populated, with highly developed infrastructure. These problems are exacerbated by increasing coastal erosion and the risk of flooding caused by storms and heavy rains.

Scientists estimate that by the middle of the 21st century about 70 % of the population in coastal regions will be concentrated along the Turkish coast, which in combination with rising temperatures and sea levels will put additional pressure on the environment in the southern Black Sea basin.

The main risks for the future of the marine environment are related to the impact of climate change, mainly rising temperatures, acidification of the oceans and changes in sea level. The interaction between them, with the effects of past practices and existing fishing pressures, the capture of pollutants and the development of urban and industrial coastal areas and ports, poses a major threat to the values of marine ecosystems as we know them today.

The changes are likely to affect the natural diversity and ecology of coastal waters, bays, estuaries and tidal areas, as well as the fishing, recreation and tourism industry, with unpredictable results.

For example, as ocean temperatures rise, the survival of cold-water species to be fished may be gradually reduced, but these species may be temporarily replaced by warm-water species. Each region has a specific set of pressures, which will certainly increase in value in the next 20 – 50 years, given the current management measures. For example, several effects will occur with the escalation of the oil and gas industry. The lack of a regional integrated framework for the management of the marine environment is currently a major risk, and this will increase as pressures and complexity increase, with unpredictable consequences for marine ecosystems [2].

1.5.2. Predictions of the main risks for marine environment in the next 20 – 50 years

The main risks for the marine environment are summarized below and their potential impact in 20 years and 50 years is classified as time intervals, presented in the form of a simplified risk assessment matrix (Fig. 1.1).

These risks have been assessed as remaining risks, taking into account the current management arrangements that apply in the relevant jurisdictions [2].

Impact / Probability	Catastrophic	Major	Moderate	Minor
Almost sure	I.1	I.2	I.3	I.4
Probable	II.1	II.2	II.3	II.4
Possible	III.1	III.2	III.3	III.4

Fig. 1.1 Simplified risk assessment matrix - major future risks for the marine environment [2]

I. The risks with the almost certain probability have been identified as the following:

I.1. Almost certain risks in probability and catastrophic in impact:

- Ocean/sea temperature rises, impacting fish and plankton;
- Ocean/sea acidification increases, impacting plankton, shellfish production and calcification processes.

I.2. Almost certain risks in probability and major in impact:

- The development of the port or the urban development of the coast, leads to the destruction or disturbance of the environment;
- Fishing (recreational and illegal), leads to species change or loss or to impacts on ecosystems;
- Marine debris, which can poison or confuse species;
- Sea levels rise and have an impact on coastal erosion and flooding;
- Extreme or severe phenomena (storm, tide, precipitation, floods), which can increase the level of run-off and sediments/toxins;
- The increase comes from the capture of nutrients, sediments and toxins;
- Algae blooms in estuaries, which can be toxic or lead to hypoxic water;
- Changes in ocean / sea currents, leading to changes in production.

I.3. Almost certain risks in probability and moderate in impact:

- (Commercial) fishing, which leads to the modification or loss of species or to impacts on ecosystems;
- Navigation, which leads to a wider introduction of parasites;
- Changes in the beach and shore, which leads to a change or loss of habitat;
- Oil and gas extraction, which leads to increased development of maritime transport and consequently has an impact on ecosystems.

I.4. Almost certain risks in probability and minor in impact:

- (Traditional) fishing, which leads to the change or loss of species;

- Ship blows on cetaceans;

- Ghost fishing — lost nets that can catch species.

II. The likely risks in the next ten years for the marine environment would be the following:

II.1. Risks with probability and major chances in impact:

- Oil and gas accidents, or oil spills, impacting species populations, ecosystems and habitat;

- Transport accidents, with an impact on populations of species and habitats;

- Sand equipment, on shores and islands, leading to the destruction or disturbance of populations of species and habitats;

- Introduction of pest and outbreak species, leading to increased competition or other effects on native species;

- Lack of integrated management, which affects the conservation of ecosystems.

II.2. Risks with probability and moderate chances in impact

Desalination discharges, with an impact on water quality and habitats.

II.3. Risks with probability and minor chances in impact:

- Oil and gas exploration and risks related to seabed disturbance;

- Coastal and island tourist facilities, leading to disturbances and destruction of the environment.

III. Possible risks in the future:

III.1. Possible risks with catastrophic impact

Major volcanic/tectonic phenomena leading to changes related to the hydrogen sulfide layer on the seabed.

III.2. Possible risks with moderate impact

Introduction of species outbreaks [2].

1.5.3. Efforts at regional and international level to save the Black Sea

In 1991, UNEP took the first steps in its global strategy to address pollution, convening experts from 52 countries to a meeting in Nairobi. The meeting developed 6 objectives for the global strategy to reduce environmental degradation from land-based sources of pollution and coastal activities [3].

The UNEP Nairobi meeting led to the design of the Global Program of Action for the Protection of the Marine Environment from Land-based Activities (GPA) in 1995 at an intergovernmental conference in Washington DC [5]. The purpose of the GPA is to identify sources of land-based pollution or harmful activities and to prepare priority action programs with measures to reduce them. It focuses not only on shoreline issues - such as landfills in metropolises, other urban areas, ports or industrial enterprises in the coastal area - but also aims to pollute all catchment areas, including sources such as agriculture, forestry, aquaculture and tourism.

1.5.3.1. Marine protected areas

According to the UNEP-World Conservation and Monitoring Center (World's Protected Areas Database, 2008), 125 protected areas have been designated riparian Black Sea. They range in size from small scientific reserves of 1 ha, to the newly designated Zernov area in the northwestern plateau of Ukraine (402,500 ha).

However, in many cases, it is not clear from the designation data whether or not any of the coastal areas are part of the protected areas, so the list provided here should be treated with caution. Currently, it seems that about 1.1 million hectares of protected coastal/marine areas have been designated by the Black Sea countries, but about half of them are represented by the Danube Delta Biosphere Reserve, in Romania alone. The most important places that definitely include a suitable marine area are:

• The Danube Delta Biosphere Reserve (Romania), which has a marine buffer zone, extends to a depth of 20 m and covers 103,000 ha;

• May 2: Vama Veche (Romania) is entirely marine, covering 5,000 ha;

• Kholketi National Park (Georgia) has an adjacent marine reserve that includes a 6-8 km coastline and covers 15,742 ha

• Zernov's Phyllophora Biosphere Reserve (Zakaznik), declared in November 2008, which is entirely marine and covers 402,500 ha;

• The Chernomorskiy Biosphere Reserve (Ukraine) includes Tendrivsky and Yagorlitsky Bays and covers 74,971 ha (84 %) of the area; and

• Bolshoi Utrish (Russia) has 2,530 ha of marine area up to 40 m deep extension 2 km offshore [6].

Chapter 2

METHODS OF RISK ANALYSES ASSESSMENT AND PREVENTION

2.1. Implementation of risk management

The implementation of the framework will ensure:

- Proper synchronization;
- Alignment with organizational strategy and processes;
- Compliance with regulations;
- Application to organizational processes;
- Staff training and education;
- Communication and consulting;
- Implementation of the risk management process;
- Defining the process for the organization;
- Implementation at all levels (appropriate processes);
- Establish a monitoring process.

2.2. The risk management process

The risk management process must be an integral part of management, be linked to culture and practices and adapted to the business processes of the organization. As can be seen in figure 2.1, the risk management process includes five activities:

- Communication and consultancy;
- Establishing the context – figure 2.1;
- Risk evaluation – figure 2.1;
- Risk management – figure 2.1;

- Monitoring and review – figure 2.1.

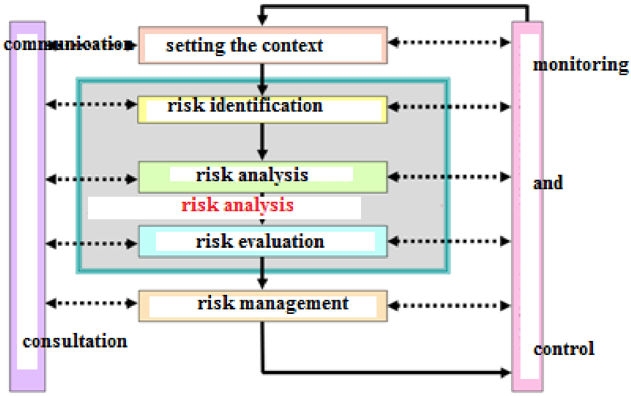


Fig. 2.1 Risk management process activities

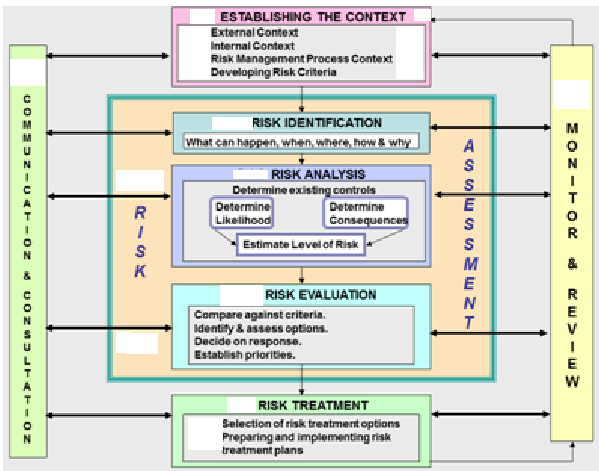


Fig. 2.2 Additional explanations regarding the activities of the risk management process [6]

Figure 2.2 shows additional explanations regarding the activities of the risk management process, while Figure 2.3 shows another way of describing the management process.

Fig. 2.3 Another way to describe
the process risk management [6]

2.3. Methods of risk analyses assessment and prevention

Once the plan is ready, the first key step in risk management itself is to be identified. This is the process of identifying potential risks, their root cause and their consequences.

Risk identification is a systematic process. It requires a group effort, in which different experts in the field participate. The most common tool used in the risk identification process is brain storming. Within it, experts in the field from different groups meet and note their potential risks. During brainstorming activity, no identified risk is assessed or criticized. The intention is to note as many risks as possible in a limited time.

Other working tools such as Ishikawa diagram, flow chart and SWOT analysis can be used. In this case, the term SWOT represents strengths, weaknesses, opportunities and threats. The result of the risk identification is a list of risks or a register of risks. What is done with the risk list depends on the nature of the risk. Some low-priority risks can be kept simple only in the form of a list with red flag terms and will be monitored periodically. Some high priority risks can go through a process of rigorous assessment, analysis, mitigation and planning. The following risk management process analyzes the risks and helps in making a decision.

2.3.1. Risk assessment techniques

In accordance with ISO / IEC 31010: 2009 Risk management - Risk assessment techniques, a risk assessment seeks to answer the following fundamental questions:

- What can happen and why (by identifying the risk)?
- What is their probability of happening in the future? What are the consequences?
- Are there factors that reduce the likelihood of risk or reduce the consequence of the risk?

Organizations do not have sufficient resources to deal with all risks. After obtaining the list of all potential risks, the next logical step is to analyze and prioritize them. Some risks may require a detailed action plan and others require only regular monitoring. The organization can accept some of the risks without any action. In this risk analysis stage we will examine how risks are analyzed and prioritized. This is the process of quantifying risky events, documented in the previous stage, so that the organization can focus on critical risks. For a risk analysis, a quantitative and qualitative analysis is performed. Qualitative risk analysis is subjective and is easy and fast. Some of the tools that help with qualitative analysis are probability and impact matrix.

On the other hand, quantitative risk analysis is detailed risk analysis. It is not necessary to perform a quantitative analysis for all risks but it can be done within the time available.

Tools for conducting quantitative analysis include monitored and expected value analysis:

- Monte Carlo analysis;
- the decision fault tree analysis;
- Bow Tie charts;
- also quantitative risk tools.

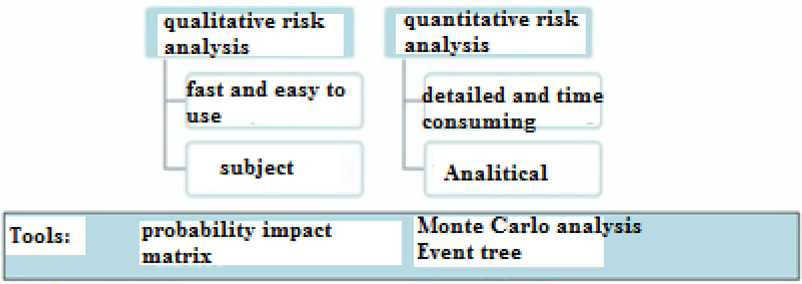


Fig. 2.4 Methods of risk analysis – qualitative and quantitative

As mentioned above, probability and impact matrix are tools for qualitative risk analysis. This matrix has two aspects, the probability that the risk will occur and the potential impact if the risk occurs. These two are classified from less likely to very likely.

In the probability and impact matrix, the probability of risk and the impact of risk are given a score from 1 to 9, where 1 is the lowest grade and 9 is the highest (Table 2.1). A risk score is then calculated by multiplying these two numbers. Instead of giving a score of 1a 9, one can use one from 1 to 3 or from 1 to 5. These rules are stipulated in the risk management plan.

Table 2.1. Probability score and description

Probability	Probability score	Description
Very high	9	The risk event is expected to occur
High	7	The event is likely to appear, than not appear
Probable	5	It may or may not happen
Low	3	The event is more likely not to happen than to happen
Very low	1	The risk event is not expected to occur

In this course we will use the score from 1 to 9. In this example, the group assigns a score of 1 for the probability of risk and a score of 9 for the value of the impact. This means that the risk in question has a low chance of happening but if it does the impact will be very high. Because the score from 1 to 9, attributed to probability and impact, is subjective, the organization that manages the risk creates some guidelines to ensure that they are consistent.

Once we have assigned a number for the probability of the risk and one for the impact of the risk, they are plotted on the probability and impact matrix. Such a simple example is illustrated in the figure. Let's look at the four squares shown in figure 2.5.

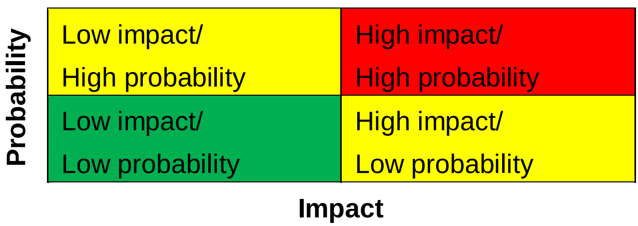


Fig. 2.5 Simple initial example of probability and the impact matrix [1], [7], [8]

The risks in the upper right have an important critique since they have high degrees of impact and probability. These are the risks with the highest priority that you need to pay the most attention to. The risks at the bottom left have a low degree of impact and probability. You can often ignore them. The risks in the upper left are of moderate importance, given that they are risks with a low degree of impact and a very high probability.

If these things happen you will be able to collaborate with them and move on.

However, you should try to reduce the likelihood that they will happen. The risks at the bottom right have a very high impact and a low probability of risks and they have little chance of happening. For these, you should do what you can to reduce the impact and you should have ready plans for unforeseen events, in case they happen. This and figure 2.6, figure 2.7 show examples of probability and impact matrix. In this example, a score from 1 to 9 is assigned to probability and impact [7].

Probability	1	3	5	7	9
9	9	27	45	63	81
7	7	21	35	49	63
5	5	15	25	35	45
3	3	9	15	21	27
1	1	3	5	7	9

Impact

Fig. 2.6 Probability and impact matrix, with assigned scores [7]

Probability	Very low	Low	Medium	High	Very high
Very high	Medium	Medium	High	High	High
High	Low	Medium	Medium	High	High
Medium	Low	Medium	Medium	Medium	High
Low	Low	Low	Medium	Medium	Medium
Very low	Low	Low	Low	Low	Medium

Impact

Fig. 2.7 Probability and impact matrix, with assigned risk values [7]

The image above describes an example in which probability and impact matrix, where probability and impact matrix have assigned values from very low to very high.

2.3.2. Risk management

According to the standard, risk management is the "risk modification process" [9], [10], [11], [12].

The following notes better explain this notion:

NOTE 1 Risk management may involve:

- risk avoidance;
- increasing the risk for pursuing the opportunity;
- removal of the source of risk;
- change in probability;
- changing the consequences;
- risk sharing with another person or group [including risk financing];
- mitigating the risk through informed decisions;

NOTE 2 Risk management may create new risks or modify existing ones.

Risk management, figure 2.8, is often a cycle of: Control options, Residual risk assessment, Accept?, Treat risk?, Control options, Assessment “Communication and consulting” [9], [13], [14].

“Continuous and complete processes that the organization undertakes to provide, share or obtain information and engage in dialogue with stakeholders (stakeholders) on risk management

NOTE 1 Information may relate to issues related to the existence, nature, form, probability, significance, evaluation, acceptability, treatment.

NOTE 2 Consulting is a two-way process of communicating information between an organization and stakeholders on an issue before making a decision or determining direction on this issue. Consultation is a process that impacts a decision through influence, rather than power; and a contribution to the decision-making process, not joint decision-making.

Once we have analyzed the risks, the next step in risk management is to plan the risk response for each identified risk. When planning a risk response we tend to reduce the impact and chance of negative risks and increase the impact and chance of positive risks [10].

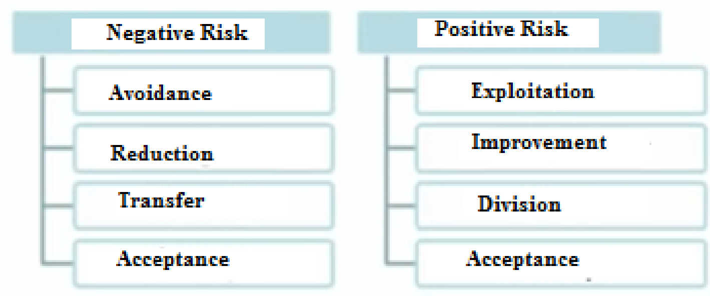


Fig. 2.8 Risk control/treatment methods [9]

Figure 2.8 illustrates four risk responses for both negative and positive risks. We will continue to look at each of these answers.

In avoiding risk, we completely eliminate the possibility of risk. An example might be to use an old and proven process, instead of a new and risky process. The risk can also be avoided through better communication, the provision of information or the co-optation of an expert. If you can't avoid a complete risk, try to mitigate it.

The purpose of risk mitigation is to reduce the size of the risk exposure. This is done either by reducing the likelihood of risk, or by reducing the impact [9].

The risk transfer strategy aims to transfer ownership of a particular risk to a third party. It is also important to remember that the transfer of risk almost always involves the payment of a risk premium. A cost-benefit analysis could be done to ensure that the costs of the risk transfer are justified.

Accepting a risk means that the probability, and / or severity of the risk is quite low, that we will do nothing about the risk unless it occurs. There are two types of acceptance, active and passive. Acceptance is passive when nothing is done to deal with the risk. Acceptance is active, when we decide to make an emergency plan, for what should be done, when the risk arises.

The following sentences will address risk responses for positive risks, or opportunities. The first response to dealing with the positive risk is that of exploitation. This answer tries to eliminate any uncertainty, so the opportunity is sure to happen.

The improvement response focuses on the root cause of the opportunity and continues to influence these factors, which will increase the likelihood that the opportunity will occur.

Sometimes exploiting a positive risk is not possible without collaboration. Collaboration with another group, department or company may be required to exploit a positive risk. As with negative risk management, a positive risk could be actively or passively accepted. Accepting a risk means that the probability, and or severity of the risk is quite small, so we will do nothing about the risk unless it occurs. After identifying risks, analyzing and then making a plan to deal with them, the next step is to monitor and control the risks.

A risk management program will never end. Risk monitoring and control should be ongoing and ongoing. New risks will arise and existing risks will disappear. You need to be able to deal with them. Unexpected risks occur during risk monitoring and control. These unexpected risks are risks that you did not identify in the risk identification process. An alternative solution is created to deal with such risks [9], [10], [13].

2.4. Sea level damage risk

2.4.1. Environmental degradation - Information on Black Sea pollution

Oil pollution on the Danube, amounting to 53,000 tons/year, represents approximately half of the estimated total annual amount of oil that pollutes the Black Sea. There is little or no data on the operational unloading of ships and, unless properly regulated, the increase in shipping through the Black Sea could lead to a significant increase in oil pollution [14], [15].

There is a rapid growth in the use of the Black Sea as a shipping route, especially for the transport of oil from the Caspian Sea oil fields. [9]

The Black Sea plays an important role in the transit of hydrocarbons in the region. Nearly a third of Russia's oil exports, about half of Kazakhstan's exports, and all of Azerbaijan's exports cross the Black Sea and the Bosphorus Strait, which it crowds [15]. 55,000 ships pass through the Bosphorus annually. 30 % of them (around 10,000 ships) are oil tankers carrying around 155 million tonnes of oil. This leads to a high risk of oil pollution [16]. There are standards that keep things under control, such as MARPOL, but history (not necessarily in the Black Sea) has shown that, even in well-controlled situations, oil pollution can occur.

There are some political and economic obstacles in the region, but the Black Sea continues to attract the interest of international oil companies, including wealthy people, in offshore drilling. Until recently, deep waters remained largely unexplored by seismic studies [15].
The economic evolution of the countries on the Black Sea coast, as well as the need for energy, has led most of the countries in the region to improve their plans in terms of prospecting and start oil and gas extraction [17]. The evolution of deep-sea offshore drilling and the opening of new oil fields will lead to an increase in maritime traffic and, subsequently, to an increase in the risk of oil pollution.

2.4.2. Environmental degradation - Climate change

The third evaluation report IPCC (2001) (Intergovernmental Panel on Climate Change) estimates a warming of the average annual temperature until 2100 (compared to 1990) between 1.4 ºC (2.5 ºF) and 5.8 °C (10.5 Cº), average of 3 ºC (5.4 ºF). Global warming is part of climate change and if it persists it will affect water availability, flood risks, agricultural productivity and natural areas. Natural and human systems are exposed to these changes and undermine sustainability [20].

2.4.3. Environmental degradation - Human health

Human health is closely linked to the environment. It is usually difficult to identify the cause and effect relationship between, say, noise, pollution, and heart disease. The IPCC's special report on the regional impact of climate change acknowledges that the climate has an impact on heart disease. Most African countries are affected by environmental diseases such as malaria, cholera, meningitis, rift valley fever.

2.4.4. Case analysis - the case of oil pollution in the Black Sea

Vulnerability is a relatively new concept and addresses not only the vulnerability of human communities on the coast, but also the vulnerability of the environment, states and all other stakeholders [1].

Capacity means the ability to prevent more than the ability to cope / intervene after hydrocarbon pollution. Capacity is closely linked to vulnerability; When we talk about the capacity, we are talking about the authority (or lack of authority) to impose the legislation, about the very existence of this legislation. Capacity is not just about standards and legislation. It could also refer to the financial source of using different technologies and methods that create a strong and resilient environment, but also to the financial power to stop an oil spill from spreading (here the technologies vary from simulation tools of computer oil spills, to the use of specially designed powders and floating devices to neutralize and collect oil). The idea of stakeholders should also be presented here. By definition, a stakeholder is an entity that may be affected by the results in which it is said that they are stakeholders, that is, those in which they have a stake. Oil pollution in the sea / ocean affects the environment, communities, businesses, in different quantities. So, the parties involved in this case may be different institutions of different states, environmental control and conservation organizations, affected environment, the polluting entity in the rails [9].These concepts explaining risk (probability, vulnerability, capacity) and stakeholders need to be analyzed together and interconnected (see Figure 2.9).

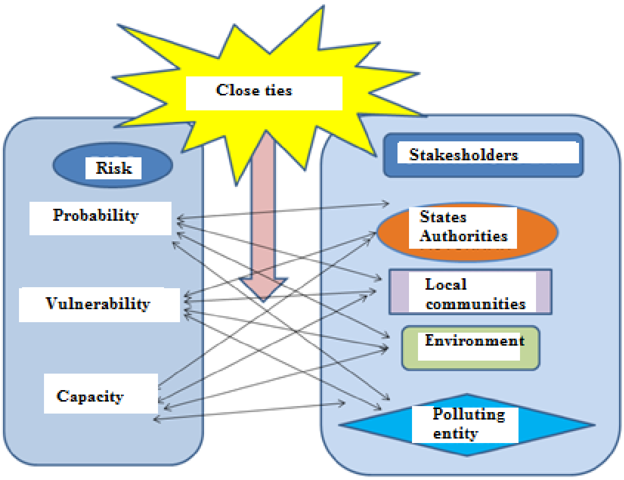


Fig. 2.9 Interconnection between risk elements and stakeholders [9]

For example, probability depends and can be affected by stakeholders. For example, the environment that an interested party may be a factor affecting probability (high wave weather can lead to marine accidents); it can also influence the idea of vulnerability (a strong, resilient clean environment is stronger and can recover faster than a weak environment); Capacity is also influenced by the marine environment in many ways. Another important issue to discuss here is the time because when it comes to oil pollution, in order to have a real and lasting prevention of the risk of oil pollution, most of the actions must be targeted not after the time of oil pollution, but before. Here we start talking about the disaster management cycle [10]. The idea of a disaster management cycle applies to any oil pollution in the Black Sea, because any oil pollution, no matter how small, is a (small) disaster. And a one-square-foot oil slick is a disaster for a tiny part of the environment.

The figure 2.10, oil pollution = Oil pollution, Recovery = Prevention, Prevention = prevention, Preparedness = preparation, Response = response.

As can be seen in figure 2.10, the risk management cycle has four stages: response, recovery, prevention and preparedness.

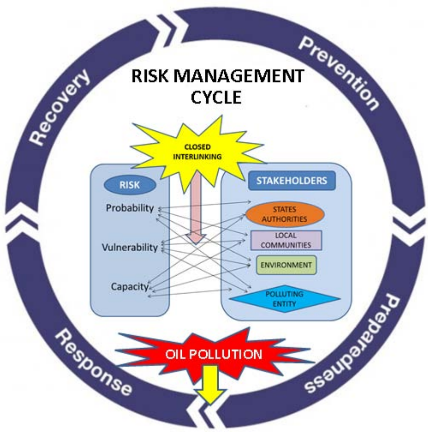


Fig. 2.10 Risk and stakeholders
are included in the risk management cycle [9]

The circle in figure 2.10 is better seen as a spiral. After oil pollution of the sea occurs, stakeholders take action (response, recovery, prevention and preparedness), not only to recover and return to the pre-event situation, but to be better prepared for a possible future event. Of course, the idea is to get an ALARP risk level (as low as possible - as low as reasonably possible). If the action is clearly organized and focuses on prevention (before), rather than intervention (after), we can talk about sustainable development.

In this way, all parties must be interested in taking part in the effort and also reaping the benefits of this sustainable development.

Sustainable development is effective when, after a disaster, stakeholders cope, recover quickly and move (evolve) in the spiral of the risk management cycle.

2.5. Risk assessment on the sea. Application to a cross-sea route

On November 12, 2007, severe winds of 100 km/h, with waves of almost 5 meters in the Black Sea and the Kerch Canal - destroyed in the Russian oil tanker "VOLGONEFT 139" and caused the discharge of almost half of the cargo into the sea. ship's oil - 4,800 tons of oil (Fig. 2.11) [9].

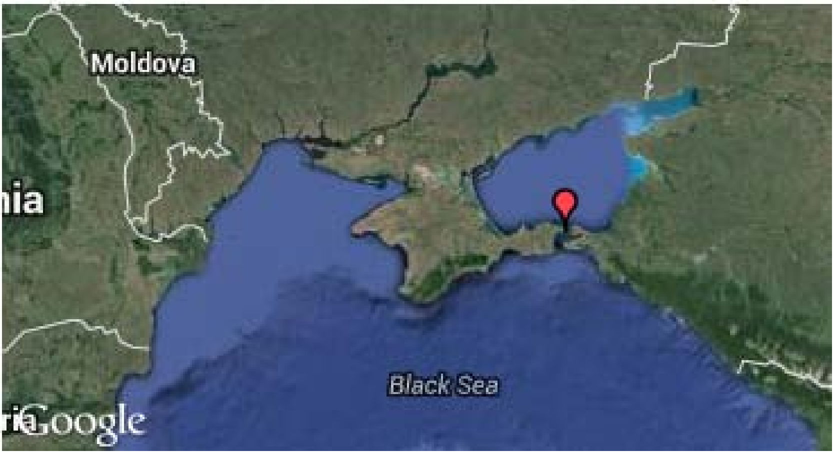


Fig. 2.11 Map with the position of the location where the oil pollution took place.
The Kerch Canal between the Sea of Azov and the Black Sea [9], [16]

Other ships were affected, a significant amount of sulfur also reached the sea. Five people died, another 19 disappeared, 30,000 birds died (Fig. 2.12), due to the oil that poisoned them and got caught in their feathers.

Fig. 2.12 A poisoned and oil-covered bird, stands dry in front of local volunteers [15]

The whole ecosystem has received a major blow. According to some sources, 898 million dollars is the approximate value of financial losses. Apparently, the oil slick moved to the Sea of Azov in the following days.

Russian environmentalist Vladimir Sivyak told the BBC that the sinking of VOLGONEFT-139 was a "very important disaster for the environment." He added that it would take years to remove the heavy oil that has already sunk to the bottom of the sea [9], [14]. The image below (Fig. 2.13) shows the oil spills detected by satellites during the years 2000 - 2004 in the Black Sea [16], [17].

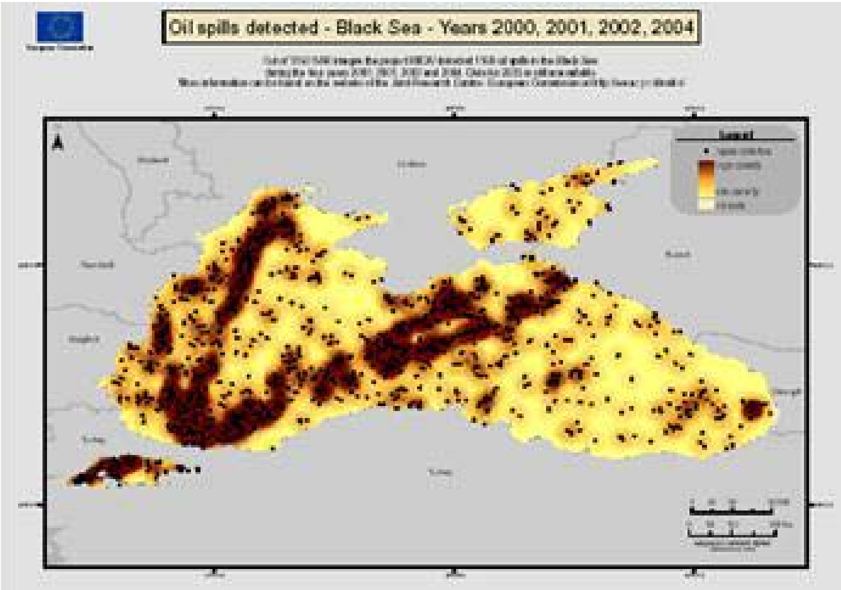


Figure 2.13 Map of oil spills in the Black Sea
in 2000, 2001, 2004 [18]

As can be seen from the case above and from the image in figure 2.13, the problem exists and it is very important to treat it in a very serious way. This treatment of the problem can be started by approaching the risk management cycle presented in figure 2.10. There is a lot of regional effort in this direction, which is a good thing, but it lacks clear organization, for political, financial reasons, and all kinds of interests between the states bordering the Black Sea [18].

If we ask the right questions and take into account the interconnection between the elements of risk and the status and possibilities of stakeholders, given the "before" and "after" paradigms brought by the risk management cycle, a lot of important answers can appear. Apparently, the ship (Volganeft 139) was not designed to sail the sea. The weather forecast is not new nowadays, so the event could have been better predicted and prevented (bringing the ship to port, to safety, emptying its cargo). Old ships should be thoroughly inspected before receiving approval for marine operations.

There is a lot of information that we can learn from any situation oil pollution, in the Black Sea area or around the world. The most important thing is to take steps for a sustainable development of the region, to solve the problem of oil pollution in a sustainable way.

The risk of oil pollution in the Black Sea is a serious issue, given the current situation: oil is already brought into the sea by rivers, the Black Sea environment is already weakened, due to the international crisis, there are financial problems, there are also important differences and different cultures between coastal states. However, stakeholders need to act in an organized way.

Chapter 3

MANAGEMENT OF RISK.
MARINE RISKS.

3.1. Introduction

Throughout our lives or activities, all individuals or organizations manage risk consciously or unconsciously, but rarely systematically. This systematic way of managing risks is given only by one standard. Therefore, in the following, we will use the main risk management standards, used and highly appreciated internationally, to present how we should manage risk:

ISO 31000: 2009, Risk Management – Principles and Guidelines.

ISO Guide 73: 2009 Risk Management – Vocabulary.

When you manage risk, you prove that you think ahead and most importantly, that you think ahead in a responsible and balanced way. Working systematically will also maximize opportunities and minimize threats. The risk management process provides a framework to facilitate more efficient decision-making [20].

In its simplest definition, risk management answers one simple question:

- What could go wrong and what are we going to do about it?

There are a few secondary questions that follow the main question:

- What could go wrong in achieving our goals?
- What could go wrong with our activities?
- "How likely are they to go wrong?"
- How bad would it be (ie what impact would it have) if they went wrong?

- What can we do to prevent them from going wrong?
- Do we do enough about what could go wrong?
- Who is responsible for us answering these questions correctly? [21]

Here is what Kevin W. Knight (AM Chair of the ISO 31000 Working Group & Chair of the ISO 31004 ISO Focus Project Committee, in June 2009) said about this standard: “ISO 31000 is obviously different from the existing guidelines because the emphasis it is moved from what is happening - the event - to the effect on the objectives.

3.2. Elements of history regarding ISO 31000 standard

There are three countries that initiated the design of ISO 31000- Australia, New Zealand and Japan, based on an older standard AS/NZ 4360.

Over the course of several years and meetings, more than 30 countries have participated in discussions to create this standard in the form in which it exists today. It was finally adopted in November 2009, and is now officially considered the first International Standard for Risk Management. Vocabulary guide 73 & ISO 31010 quickly followed the standard.

In 2011 a group called PC 262 was formed to design ISO 31004, an ISO 31000 implementation guide. Two annual meetings were held until completion. The guide was published in 2015, followed by updates to ISO 31000 [22].

3.3. ISO Guide 73: 2009
Definitions related to risk management.
The interaction betwen problem of climate change and major risk.

3.3.1. Definitions related to risk management

According to the new standards, risk is the effect of uncertainty on objectives.

However, there are some notes in the standard that help to better understand the notion of risk:

- NOTE 1 An effect is a deviation from what is expected - positive and/or negative.
- NOTE 2 Objectives may have different aspects (such as finance, health and safety and environmental goals) and may apply at different levels (such as strategic, organizational, project, product and process).
- NOTE 3 Risk is often characterized by reference to possible events and consequences, or a combination thereof.
- NOTE 4 Risk is often expressed in terms of a combination of consequences of an event (including changing circumstances) and the associated probability of occurrence.
- NOTE 5 Uncertainty is the state, even partially, of a deficit of information related to the understanding or knowledge of an event, its consequences, or its probability of occurrence (Fig. 3.1) [23].

According to the Risk Management standard is the identification, assessment and prioritization of risks (defined in ISO31000 as the effect of uncertainty on objectives) followed by the coordinated and economical application of resources to minimize, monitor and control the probability and / or impact of annoying events or maximize opportunities [21].

	Knowledge of results	
	Well defined results	Poorly defined results
some information available for probabilistic analysis	ambiguity	
Probability Knowledges	**„Uncertainty”**	
no information available for probabilistic analysis	uncertainty	ignorance

Fig 3.1 Risk and other complementary issues, at the intersection of probability and result [23]

With the tools offered by risk management (Fig. 3.2), the potential risks are identified, then it is evaluated to know which of the identified risks are more or less critical.

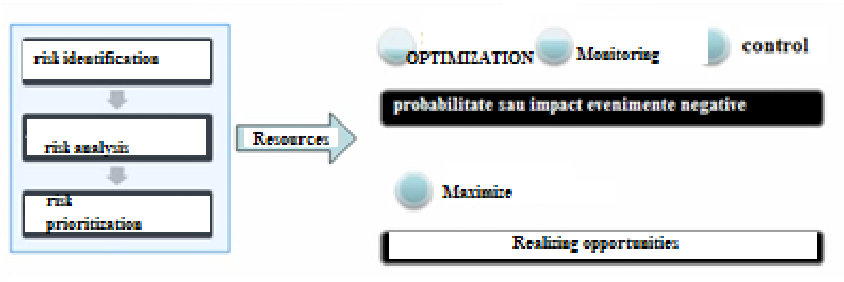


Fig. 3.2 Definition presentation diagram risk management [21]

Other definitions related to risk management:

- risk owner - the person or entity with the responsibility and authority to manage a risk

- control - the measure that modifies the risk.

NOTE 1 Controls include any process, policy, device, practice or other action that modifies the risk.

NOTE 2 Controls may not always have the intended or intended modifying effect.

- risk management framework - set of components that provide the basis and organizational rules for the design, implementation, monitoring, review and continuous improvement of risk management within the organization.

NOTE 1 Basis includes policy, objectives, mandate and commitment to risk management.

NOTE 2 Ways of organizing include plans, relationships, responsibilities, resources, processes, and activities.

NOTE 3 The risk management framework is embedded in the policies, practices and practices of the global, strategic and operational organization.

3.3.2. Areas of application for standards risk management

The ISO 31000: 2009 standard is intended to be used by a wide range of stakeholders (stakeholders) including: those responsible for implementing risk management within their organization:

- those who need to ensure risk management in an organization;
- those who need to manage the risk to the organization as a whole or within a specific area or activity;
- those who have to evaluate the risk management activities of an organization;
- developers of standards, guidelines, procedures and codes of practice, which largely or in part determine how risk will be managed in the specific context of these documents.

3.3.3. General description of the standard risk management

There are three critical components of the risk management standard: principles, action framework, and management process (Fig. 3.3, Fig. 3.4), all of which are well explained and well connected [9].

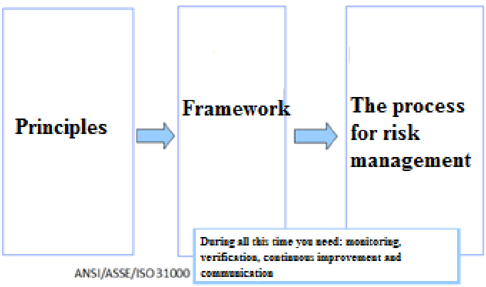


Fig. 3.3 The relationship between the critical components of ISO 31000 [9]

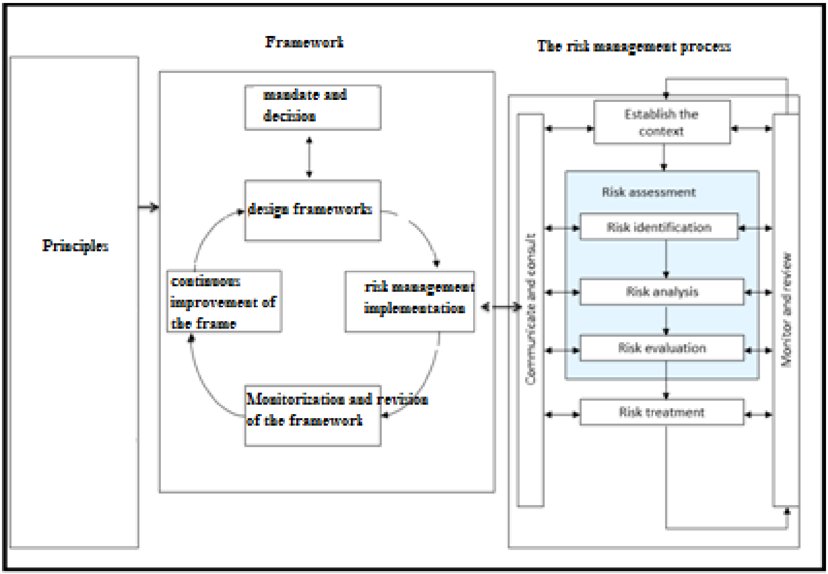


Fig. 3.4 Details of the three critical components of ISO 31000: 2009 - directly from the standard [9]

As can be seen above, the three critical components that need to be taken into account are in fact steps that need to be taken for effective risk management activity. First of all, the principles give us the basic rules. For example, if you don't get the value from a risk assessment, why do you do it again? Also, some guidelines to follow are highlighted by these principles, which are presented below and then taken one by one and explained.

3.4. Principles of risk management

According to the standard, risk management must [10], [11], [24]:

- To create values;
- To be an integral part of organizational processes;

- Be part of decision making;
- To deal directly with uncertainty;
- To be systematic, structured and time-bound;
- Be based on the best information available;
- To be customized;
- Take human factors into account;
- Be transparent and complete;
- To be dynamic, iterative and receptive to change;
- To be able to continuous improvement and development.

3.4.1. Risk management creates and protects values

One of the biggest challenges for risk managers is to demonstrate that risk management adds value. This principle recognizes that risk management helps the organization achieve its goals. Risk management (RM) helps the organization achieve its goals and helps improve performance in many areas, including, for example, human health and safety, security, legal and regulatory compliance, public acceptance, environmental protection, product quality, project management , efficient in operations, governance and reputation.

Once an organization has set goals, policies, and processes, applying risk management thinking can help improve performance by supporting new opportunities and minimizing the risk of deterioration.

RM helps to create value - taking risks for reward.

RM helps protect value. Risk management applications for the business process, in accordance with laws and regulations, financial management, human resources management, OSH & E-management, business continuity management.

The benefits of risk management include increasing the likelihood of achieving objectives, improving stakeholder confidence, minimizing losses, improving operational efficiency and effectiveness, and establishing a reliable basis for decision-making and planning.

The value should be clearly documented in the risk management policy.

The management of risk activities ensures continuous communication / consolidation to risk owners and stakeholders.

In conclusion:

- Risk management contributes to the achievement of objectives;

- Protects value - minimizes the risk of damage, protects people, systems and processes.

3.4.2. Risk management-integral part from organizational processes

Risk management activities should not be separated from the main activities and processes of the organization.

Risk management activities must be incorporated into and included in business, business processes and management controls at all levels and should be a part of management responsibilities - including strategic planning and all project processes and change management.

The Republic of Moldova is not "Supplementary". The word "additional" implies that it may not be necessary, good to have, not obligatory, not important.

Who likes extra work?

How to integrate:

At the strategic level:

- The SWOT analysis;
- Workshop on strategic risk plans;
- Risk analysis together with the plan;
- Involving the right people.

At the operational level:

- Issue internal controls, policies and procedures and ensure that they are complied with;

- Many organizational processes involve decision-making.

In conclusion:

- The Republic of Moldova is not an independent activity within the management system of the organization;
- The Republic of Moldova is part of the process - by no means an "additional" task to be respected.

3.4.3. Risk management - part of decision making

Every time a manager makes a decision (at a strategic or operational level), there is a certain risk exposure.

This principle acknowledges that good risk management helps managers make better decisions to minimize risk and optimize every opportunity.

The integral part of corporate governance (“the way a corporation/or company is run, managed or controlled”) and all these activities require decisions. Resources are limited - Take a close look at the risk when allocating resources (eg money, people, time).

The higher the risk project, the higher the risk processes and decisions.

Many decisions involve a level of uncertainty (the following principle).

In conclusion:

- Risk management helps decision-makers to do so by being well-informed, prioritizing their actions and distinguishing between alternative courses of action;
- Helps to allocate limited resources.

3.4.4. Risk management directly addresses uncertainty

Risk management directly deals with uncertainty, the nature of that uncertainty and how it can be treated.

Uncertainty is inherent in any business and by identifying and analyzing a range of risks, risk owners are much better able to implement controls and treatments to mitigate risk and/or consequence uncertainty and establish a more resilient organization.

Minimizing uncertainty (or certain types of events) is important for some stakeholders.

Shareholders - financial performance for the return of a dividend Creditors - loan repayment.

Risk management systems prove that they have more confidence.

Uncertainty levels:

None (uncertainty): Results can be accurately predicted (walking in the rain - getting wet).

Level 1 (objective uncertainty): The results are identified and the known probabilities (tossing a coin - head or straw).

Level 2 (subjective uncertainty): Results are identified and unknown probabilities (% market share of a new product - probability?).

Level 3 (uncertainty): Results are not fully known and probabilities are unknown (impact of climate change).

In dealing with uncertainty we will usually apply a systematic approach.

In conclusion:

- Risk management explicitly takes into account uncertainty, the nature of the uncertainty and how it is treated;
- The Republic of Moldova treats uncertainty regardless of its degree.

3.4.5. Risk management must be systematic, structured and time-bound

A systematic, timely and structured approach to risk management contributes to efficiency and consistent, comparable and reliable results. Like other management systems, risk management should be planned and controlled to ensure efficiency.

The standard itself promotes a structured and systematic risk management process and a risk management framework in which each step is drawn to the next to build.

Setting context-helps align the risk management structure with the organization's goals and the needs of stakeholders and becomes the initial commitment.

Initial and continuous communication - sets the stage for people (why, when, who and why?).

Training - helps people understand (risk management, company policy).

Risk assessment & control assessments - put theory into practice (workshops).

Treatment plans - treat the inherent risk.

Periodic risk reviews (quantity, annually?).

Regular monitoring of risk (reporting by the Board, the Audit Committee, senior management of results and progress.

A good technology of risk management assessment after / or part of the development of the risk management structure will help. Why? Computers are systematic logical thinkers.

A risk structure must be defined first (for example, that a chart of accounts).

Systems can call people into action. Other-Gen Y work, audit, multiple reports. The purpose of this systematic and structured thinking is to improve our understanding of risks and controls, ie obtaining good information.

In conclusion:

- A systematic, timely and structured approach to risk management contributes to efficiency and consistent, comparable and reliable results;

- The more aligned they are - the more effective and efficient they are.

3.4.6. Risk management must have at based on the best information available

Inputs to the risk management process are based on sources of information such as historical data, experience, stakeholder feedback, observation, forecasts and expert opinion. However, decision-makers should be informed, and should take into account, data or modeling boundaries used or the possibility of divergence between experts.

This principle looks a bit like a warning. It is acknowledged that information is often limited, expensive and imperfect. However, good risk management will take into account information from several sources, including observation, experience, forecasts and experts.

For start-up use "resident" information with risk owners, which is easily accessible. If more information is needed - spend more time, do more research, hire specialists.

The amount of information you gather must be proportionate to the level of risk or uncertainty.

More risk/uncertainty, more information needed.

Exchange of considerations-Cost vs. benefit of more information

The impact of imperfect information on decisions. In conclusion:

- Inputs to the risk management process are based on sources of information such as historical data, experience, stakeholder feedback, observation, forecasts and expert opinion;
- Information costs money. Perfect information is not always possible;
- Start with the resources / expertise you have or earn easily;
- Increase the level of information as the level of risk increases.

3.4.7. Risk management must be adaptable

Risk management is aligned with the context and the internal and external risk profile of the organization. While industry organizations have similar risks and opportunities, this principle recognizes that each organization is unique, risk management is not prohibited, it must be appropriate to the organization, and risk management should take into account the stakeholders, context and risk profile of the organization. organization.

There are organizations that fail to implement the structure of risk management, when they think it is as simple to set up a commission, a development strategy and risk management ... they ask why the manager could not to attend a risk workshop? The risk management framework should be specific and appropriate to that organization. At least adapt:

- "What" we will do - risk assessment, risk reporting, risk workshops, training etc.;

- “How” will we do them - risk criteria, risk areas, that and group?, documentation requirements;

- "When" - frequency, trigger points;

- "Who" - the owner of the risk, the risk manager, the internal audit, the General Manager, the Board;

- When adapting - setting the context and commitment of the stakeholder (stakeholder) is critical.

Context:

- The hardest area;

- The depth and scope of the risk management program;

- He will complete all the others later.

More about stakeholders when we talk about "Risk management is transparent and complete".

In conclusion:

- Risk management is aligned with the context and the internal and external risk profile of the organization;

- Different risk appetites & different measurements;
- Context remains one of the most difficult areas.

3.4.8. Risk management must take into account the human factor

Risk management takes into account human and cultural factors.

This principle is linked to the principle that risk management is adaptable.

Risk management must recognize the capabilities, perceptions and intentions of people from outside and inside that can facilitate or hinder the achievement of the organization's objectives.

This principle is effective on the "what do I gain?" Approach. question for stakeholders and risk owners and ensuring risk management activities are appropriate.

Consider the myths about risk management, barriers and resistance issues.

How you deal with these barriers will have an influence on cultural factors:

Common myths (I have insurance, we are not experts in the Republic of Moldova).

Common reasons for resistance (not a priority, shows "painful".

Overcoming the difficulty - divides the tasks into smaller ones, education (earlier, sooner rather than later), involvement, execution (politics), coercion (if not, vacancies).

In conclusion, risk management recognizes the capabilities, perceptions and intentions of people that make each organization different.

3.4.9. Risk management must be transparent and complete

Proper and timely involvement of stakeholders, and in particular decision-makers at all levels of the organization, ensures that risk management remains relevant and up-to-date. Involvement also allows stakeholders to be adequately represented and their views taken into account when setting risk criteria.

Internal and external stakeholders can have a major impact on the organization.

This principle recognizes the need to include stakeholders during the risk management process, including when setting the context and determining risk criteria.

The interesting parts.

Get to know your stakeholders.

Internal (Risk owners, board) vs external (regulators, suppliers, financiers).

The role - passive or active.

Risk appetite?

Main or secondary priority - Power vs. Interest.

More power, more interest = Close management; low power and interest – monitoring.

Type of influence - financial, environmental, social (related to risk categories).

Type of engagement approach - communication (briefings, reports, presentations), consultation (survey, questionnaires), dialogue (advisory panel, forums), partnership (JV, alliances).

In conclusion:

- Proper and timely involvement of stakeholders, and in particular decision-makers at all levels of the organization, ensures that risk management remains relevant and up-to-date;

- Risk management must be clearly set out in job profiles/employment contracts and in annual assessments.

3.4.10. Risk management must be dynamic, iterative and receptive to change

Risk management is dynamic, iterative and responsive to change. In an ever-changing world, an organization will need to respond to internal and external changes in the environment.

Because these internal and external events occur or are expected to occur, as information and knowledge change - new risks arise, some change and others disappear. People come and go from an organization, processes will change, events will take place.

Organizations respond by changing business strategy, management plans, financial plans, policies and procedures of organizational structures.

Similarly, an organization's risk management framework and processes must respond to these changes. Regular risk control and assessment should take place through regular monitoring of the entire risk management, including context and processes.

Therefore, risk management continuously detects and responds to change.

In conclusion:

- External and internal events take place, the context and knowledge change, monitoring and review take place, new risks arise, some change and others disappear;
- You need to keep the Republic of Moldova relevant and correct, so that it supports decisions and strategies;
- Periodic review of the register and the risk structure;
- The internal audit program must be informed of the risk register.

3.4.11. Risk management must be capable of continuous improvement and development

This principle is based on the last principle (dynamic and iterative).

Organizations are encouraged to be flexible and to continuously improve the risk management maturity framework, along with other elements of their organization, to build adaptability and the capacity to maximize opportunities. The maturity stages of an entity are as follows: basic, development, competence, progress.

The Insurance and Risk Society (RIMS) - has seven behavioral attributes:

1. Adopt an ERM-based approach;
2. The ERM management process;
3. Risk appetite management;
4. Root of discipline;
5. Risk discovery;
6. Performance management;
7. Resilience and business sustainability.

There are four elements of maturity: culture, processes, experience, application. There are also five enhanced risk management attributes listed in ISO 31000.

Continuous improvement: Organizations should set performance targets, performance measurements and regular reviews. As part of this performance assessment, a review of the structure of risk management should be undertaken as well as documented improvements.

Full responsibility for risks: Designated risk owners should have the appropriate authority and delegations to manage risk and be properly and competently trained in the risk management process. Their responsibilities should be clearly defined and communicated through the job description.

Applying risk management in all decision-making: business processes and activities (eg meetings) must clearly document the common and unusual thinking of risk management.

Ongoing Communications: Organizations should have formal risk management reporting processes. This includes reporting "significant risks" and risk treatments.

Full integration into the governance framework of the organization: Organizations must consider the risks both politically and practically. This is done by explicitly considering the risks and how uncertainty affects the achievement of organizational objectives.

In conclusion:

- Organizations need to develop and implement strategies to improve the maturity of risk management, along with all other aspects of their management system;

- Maturity of the Republic of Moldova The maturity and improvement strategies should be included in the Plan of the Republic of Moldova.

3.5. Risk management development framework

Once we clearly understand the principles, the next step in implementing risk management is to establish a framework. As seen below, in figure 3.5, the framework can be easily understood by comparing four actions, which are located in a circle that evolves towards development (plan-solve-verify-act) [9].

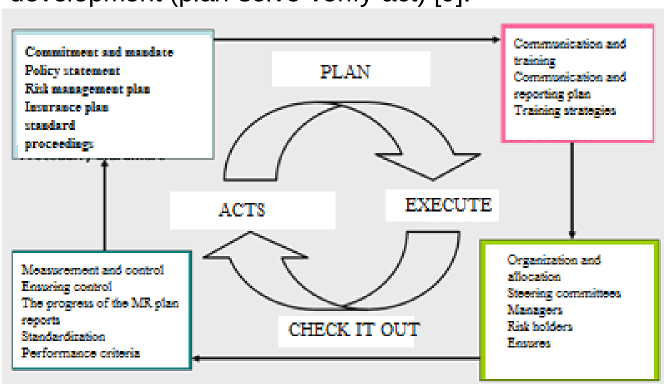


Fig. 3.5 Management development framework

according to AS/NZS ISO 31000: 2009 [12]

The same idea can also be found in other related standards, such as ISO 14001 [12]. This simple explanation for the framework is developed in more detail in figure 3.6 [9], [13], [14].

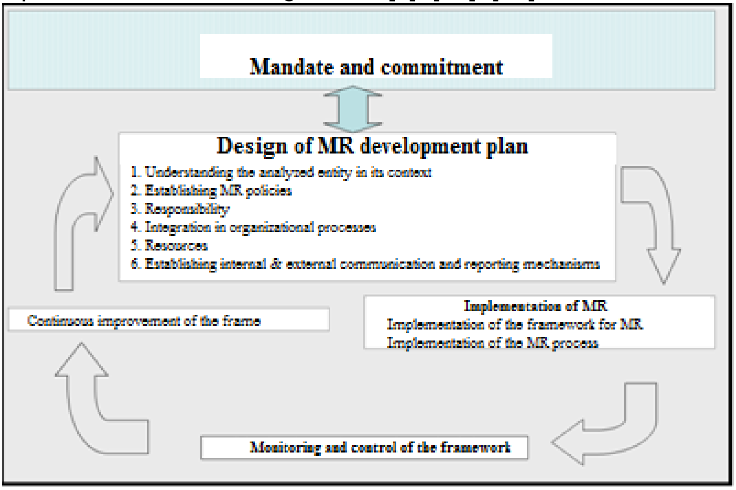


Fig. 3.6 The relationship between the components of the risk management framework [9]

3.5.1. Understanding the analyzed entity in the context

To understand the EXTERNAL CONTEXT of the organization we must consider:

- Trends;
- Key factors;
- Perceptions/values of key stakeholders.

A good tool for further analysis in the context of environmental risk is PESTLE (meaning Political, Economic, Social, Technological, Legal and Environmental factors).

PESTLE analysis

Political factors are how and to what extent a government intervenes in the economy. Specifically, political factors include areas such as fiscal policy, labor law, environmental law, trade restrictions, tariffs, and political stability. Political factors may also include goods and services that the government wants to provide or be provided (goods of merit), or those that the government does not want to be provided (penalty goods or bad goods). Moreover, governments have a great influence on the health, education, infrastructure of a nation.

Economic factors include growth, interest rates, exchange rates and inflation. These factors have a major impact on the way companies operate and make decisions. For example, interest rates affect the cost of a capital firm and therefore the extent to which a business grows and expands. Exchange rates affect the costs of export goods and the supply and price of goods imported into an economy.

Social factors include cultural aspects and include health awareness, population growth rate, age distribution, career attitudes and emphasis on safety. Trends in social factors influence the demand for a company's products and the way the company operates. For example, an aging population may involve a smaller and less willing workforce (thus increasing the cost of labor). Moreover, companies can change different management strategies to adapt to these social trends (such as recruiting older workers).

Technological factors include environmental and environmental issues, such as R&D, automation, technology incentives and the rate of technological change. They can cause barriers to market entry, minimum level of production efficiency and influence outsourcing decisions. Moreover, technological changes can affect costs, quality, and lead to innovation.

Legal factors include discrimination law, consumer protection law, antitrust law, labor law, health law and security law. These factors can affect the way a company operates, its costs and the demand for its products. Environmental factors include weather, climate, and climate change, which could particularly affect industries such as tourism, agriculture, and insurance. Moreover, raising awareness of climate change affects the way companies and the products they offer work - creating new markets but also diminishing or destroying existing ones.

When we think of the INTERNAL CONTEXT, we must consider:

- Governance structures;
- Objectives, strategies and policies;
- Knowledge, qualifications and resources;
- Organizational culture;
- Contractual relations.

3.5.2. Establishing the risk management policy

The risk management policy must be simple, achievable, easy to understand and auditable with the mandate and commitment of clear top management, it must be aligned with the culture of the organization, risk decision makers, risk factors and risk owners.

The components of this document - Risk Management Policy are the following:

- Arguments and political connections;
- Responsibility and responsibility;
- Management of conflicts of interest;
- Measuring risk management performance;
- Reporting processes.

3.5.3. Responsibility

All responsible risk owners are clearly identified and have the authority and resources to manage risk. The responsibility of the board to implement the framework The responsibility of risk owners at all levels of the organization is clearly identified Performance measurement processes must be in place Reporting and escalation processes must be clearly established.

3.5.4. Integration into processes

Organizational

Risk management should be part of routine Organizational processes.

Policy development

Business/strategic planning

Management of change

Decision making processes

The Risk Management Plan must take into account and be applied in and by the entire organization and must be linked or integrated with other plans: strategic, implementation, operational etc.

3.5.5. Resources

Good risk management will make the organization more efficient, but requires dedicated resources, which may include:

- People: skills, experience and competence;
- Time and funds: to execute the process;
- Defined processes, methods and tools;
- Information systems;
- Awareness, education and training programs.

3.5.6. Establishing internal-external communication and reporting mechanisms

Internal communication and reporting mechanisms can be listed for:

- Ongoing awareness, education and training;
- Performance reporting framework and conclusions;
- Information management;
- Stakeholder engagement;

External communication and reporting mechanisms can be listed for:

- Stakeholder engagement;
- Regulatory reporting requirements;
- Using reporting to build trust;

- Business continuity communication (associated risk interruption management).

3.6. Implementation of risk management

The implementation of the framework will ensure:

- Proper synchronization;
- Alignment with organizational strategy and processes;
- Compliance with regulations;
- Application to organizational processes;
- Staff training and education;
- Communication and consulting;
- Implementation of the risk management process;
- Defining the process for the organization;
- Implementation at all levels (appropriate processes);
- Establish a monitoring process.

3.6.1. The risk management process

The risk management process must be an integral part of management, be linked to culture and practices and adapted to the business processes of the organization. As can be seen in figure 3.7, the risk management process includes five activities:

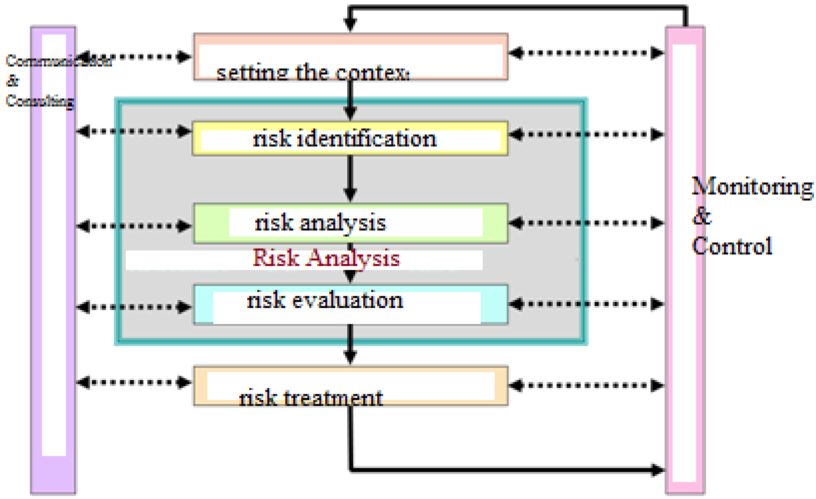


Fig. 3.7 Risk management process activities [9]

Risk assessment techniques

In accordance with ISO/IEC 31010: 2009 Risk management - Risk assessment techniques, a risk assessment seeks to answer the following fundamental questions:

- What can happen and why (by identifying the risk)?

- What is their probability of happening in the future? What are the consequences?

- Are there factors that reduce the likelihood of risk or reduce the consequence of the risk?

Organizations do not have sufficient resources to deal with all risks. After obtaining the list of all potential risks, the next logical step is to analyze and prioritize them. Some risks may require a detailed action plan and others require only regular monitoring. The organization can accept some of the risks without any action. In this risk analysis stage we will examine how risks are analyzed and prioritized. This is the process of quantifying risky events, documented in the previous stage, so that the organization can focus on critical risks. For a risk analysis, a quantitative and qualitative analysis is performed. Qualitative risk analysis is subjective and is easy and fast. Some of the tools that help with qualitative analysis are probability and impact matrix.

On the other hand, quantitative risk analysis is detailed risk analysis. It is not necessary to perform a quantitative analysis for all risks but it can be done within the time available.

Tools for conducting quantitative analysis include monitored and expected value analysis, Monte Carlo analysis and the decision tree (Fault Tree analysis). Bow Tie charts are also quantitative risk tools.

- Communication and consultancy;
- Establishing the context;
- Risk evaluation;
- Risk management;
- Monitoring and review.

According to the standard, risk management is the "risk modification process". The following notes better explain this notion:

NOTE 1 Risk management may involve:

- risk avoidance;
- increasing the risk for pursuing the opportunity;
- removal of the source of risk;
- change in probability;
- changing the consequences;
- risk sharing with another person or group (including risk financing);
- mitigating the risk through informed decisions.

NOTE 2 Risk management may create new risks or change existing ones.

Risk management is often a cycle of: Control options, Residual risk assessment, Accept?, Treat risk?, Control options, Assessment

“Communication and consulting”

“Continuous and complete processes that the organization undertakes to provide, share or obtain information and engage in dialogue with stakeholders (stakeholders) on risk management (figure 3.8) [9].

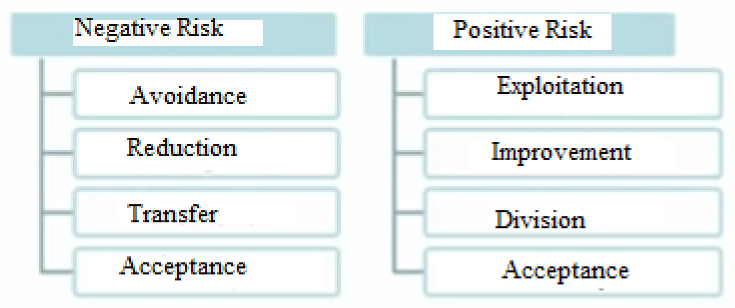


Fig. 3.8 Risk control/treatment methods

NOTE 1 Information may relate to issues related to the existence, nature, form, probability, significance, evaluation, acceptability, treatment.

NOTE 2 Consulting is a two-way process of communicating information between an organization and stakeholders on an issue before making a decision or determining direction on this issue. Consultation is a process that impacts a decision through influence, rather than power; and a contribution to the decision-making process, not joint decision-making.

Once we have analyzed the risks, the next step in risk management is to plan the risk response for each identified risk. When planning a risk response we tend to reduce the impact and chance of negative risks and increase the impact and chance of positive risks [14], figure 3.8 illustrates four risk responses for both negative and positive risks. We will continue to look at each of these answers.

In avoiding risk, we completely eliminate the possibility of risk. An example might be to use an old and proven process, instead of a new and risky process. The risk can also be avoided through better communication, the provision of information or the co-optation of an expert. If you can't avoid a complete risk, try to mitigate it.

The purpose of risk mitigation is to reduce the size of the risk exposure. This is done either by reducing the likelihood of risk, or by reducing the impact, [29].

The risk transfer strategy aims to transfer ownership of a particular risk to a third party. It is also important to remember that the transfer of risk almost always involves the payment of a risk premium. A cost-benefit analysis could be done to ensure that the costs of the risk transfer are justified.

Accepting a risk means that the probability, and/or severity of the risk is quite low, that we will do nothing about the risk unless it occurs. There are two types of acceptance, active and passive. Acceptance is passive when nothing is done to deal with the risk. Acceptance is active, when we decide to make an emergency plan, what should be done, when the risk arises.

The following sentences will address risk responses for positive risks, or opportunities. The first response to the positive risk is exploitation. This answer tries to eliminate any uncertainty, so the opportunity is sure to happen.

The improvement response focuses on the root cause of the opportunity and continues to influence these factors, which will increase the likelihood that the opportunity will occur.

Sometimes exploiting a positive risk is not possible without collaboration. Collaboration with another group, department or company may be required to exploit a positive risk. As with negative risk management, a positive risk could be actively or passively accepted. Accepting a risk means that the probability, and or severity of the risk is quite small, so we will do nothing about the risk unless it occurs. After identifying risks, analyzing and then making a plan to deal with them, the next step is to monitor and control the risks.

A risk management program will never end. Risk monitoring and control should be ongoing and ongoing. New risks will arise and existing risks will disappear. You need to be able to deal with them. Unexpected risks occur during risk monitoring and control. These unexpected risks are risks that you did not identify in the risk identification process. An alternative solution is created to deal with such risks [13], [14].

3.7. Predictions on the main risks for the marine environment in the next 20-50 years

“The decisions we make in the next several decades will more profoundly shape the future of the ocean than any other period in human history. In a recent report, my colleagues and I showed that the oceans are in vastly better shape than terrestrial ecosystems. This makes sense: humans are a terrestrial species and historically it has been harder for us hunt, farm and build in the ocean. But things are changing.

We must address three major challenges in the next 30 years if we wish to preserve the health and wildness of our global oceans.

3.7.1. Marine Industrialization

A marine industrial revolution (alternatively called an emerging blue economy) is welling up in our oceans and represents a dramatic shift in the way we do marine business. Historically went to sea to fish. By 2050, we are poised to see massive expansions in marine industries like seabed mining, underwater power plant construction (e.g., offshore wind, tidal energy) and oil/gas extraction. On land when we shifted from hunting animals to building our industries in their habitats, we saw a major spike in wildlife extinction. If we don’t carefully plan out marine industrialization, we may face a similar fate for ocean wildlife.

3.7.2. Fishing vs. farming in the oceans

The Food and Agriculture Organization predicts that in less than 20 years fish farming will put more fish on our tables than wild-capture fisheries. We have to carefully ensure this explosive growth in ocean farming happens in a clean, healthy and sustainable way. In parallel to this growth in aquaculture, we must redouble our efforts to be sure that wild fisheries can continue to provide healthy free-range fish by setting aside ocean protected areas and coming up with novel solutions for managing the lawlessness associated with fishing in many settings (e.g., the high seas).

3.7.3. Ocean climate change

None of these actions will have purchase if we don't slow the rates by which we are warming and acidifying the oceans. Many marine species have demonstrated a very encouraging capacity for adaptation to climate stressors. Anything we can do to slow carbon emissions will buy them time to adapt.

By squarely facing the urgency of the situation in the oceans and prudently managing these new forces of change, we can chart a brighter future for life in the oceans and can avoid making many of the environmental mistakes we made on land" [25].

"The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change" [26].

"The IPCC prepares comprehensive Assessment Reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. It also produces Special Reports on topics agreed to by its member governments, as well as Methodology Reports that provide guidelines for the preparation of greenhouse gas inventories [26].

“Marine systems and associated livelihoods in SIDS face higher risks at 2 °C compared to 1.5 °C (medium to high confidence). Mass coral bleaching and mortality are projected to increase because of interactions between rising ocean temperatures, ocean acidification, and destructive waves from intensifying storms (Section 3.4.4 and 5.2.3, Box 3.4). At 1.5 °C, approximately 70–90 % of global coral reefs are projected to be at risk of long-term degradation due to coral bleaching, with these values increasing to 99 % at 2 °C (Frieler et al., 2013; Schleussner et al., 2016b). Higher temperatures are also related to an increase in coral disease development, leading to coral degradation (Maynard et al., 2015). For marine fisheries, limiting warming to 1.5 °C decreases the risk of species extinction and declines in maximum catch potential, particularly for small islands in tropical oceans (Cheung et al., 2016a). Long-term risks of coastal flooding and impacts on populations, infrastructure and assets are projected to increase with higher levels of warming (high confidence). Tropical regions including small islands are expected to experience the largest increases in coastal flooding frequency, with the frequency of extreme water-level events in small islands projected to double by 2050 (Vitousek et al., 2017). Wave-driven coastal flooding risks for reef-lined islands may increase as a result of coral reef degradation and SLR (Quataert et al., 2015). Exposure to coastal hazards is particularly high for SIDS, with a significant share of population, infrastructure and assets at risk (Sections 3.4.5.3 and 3.4.9; Scott et al., 2012; Kumar and Taylor, 2015; Rhiney, 2015; Byers et al., 2018). Limiting warming to 1.5 °C instead of 2 °C would spare the inundation of lands currently home to 60,000 individuals in SIDS by 2150 (Rasmussen et al., 2018). However, such estimates do not consider shoreline response (Section 3.4.5) or adaptation.” [27] (Fig. 3.9) [28].

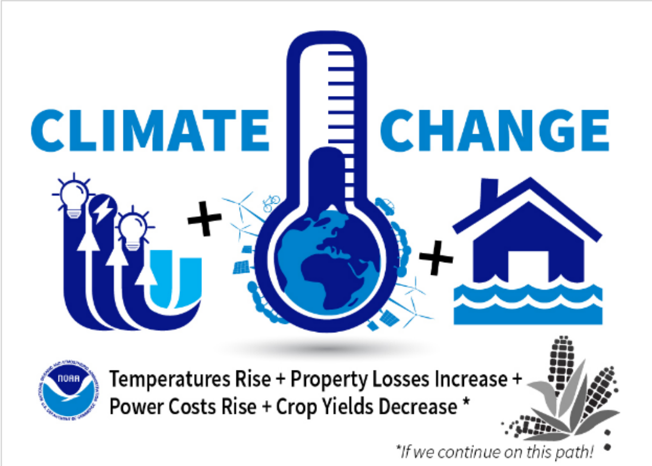


Fig. 3.9 Climate change [28]

Marine debris

"Marine debris is a global problem. The mission of the NOAA Marine Debris Program is to investigate and prevent adverse impacts from marine debris"[29].

"Types and Sources

Marine debris takes many forms, including derelict fishing gear and vessels, abandoned recreational equipment, and discarded consumer plastics, metals, rubber, paper, and textiles. Countless consumer items make their way into the ocean every day, while thousands of abandoned and derelict vessels litter ports, waterways, and estuaries.

Garbage Patches

All across the world, large areas of concentrated marine debris are formed by rotating ocean currents. These areas are known as garbage patches and are mostly made up of microplastics that swirl throughout the ocean's water column.

Extreme Impacts

The ramifications of marine debris are many: economic losses, habitat damage (including to fragile coral reefs), hazards to navigation resulting in costly vessel damage and loss, potential invasive species transport resulting in expensive and devastating effects on ecosystems, and wildlife injury, illness, and death.

Less Trash, More Cash

A team of researchers found that by removing derelict crab pots in certain active fishing areas, harvest of blue crabs could increase by 23.8 percent (38 million pounds), which translated to $33.5 million over the study period.

Fishing for Energy

The NOAA Marine Debris Program supports the Fishing for Energy partnership, which provides collection bins for old fishing gear at participating ports. Gear collected is first sorted for metals recycling, and the remaining non-recyclable material is converted into energy. More than four million pounds of fishing gear have been collected in 52 communities across the United States. The Fishing for Energy partnership also provides grant funding for derelict fishing gear removal and innovation in gear technology to reduce the loss of gear at sea.

Vulnerable Sea Life

Marine debris can impact a large variety of marine life, from small microorganisms to humpback whales. Animals may inadvertently eat debris or become entangled in it. For instance, plastic bags are a common threat to sea turtles, which often mistake them for a common food item—jellyfish. Marine debris affects other species as well, such as the endangered Hawaiian monk seal, where one death caused by marine debris is a huge loss." [29].

Chapter 4

MAIN TEHNOLOGICAL RISKS

4.1. Basic concepts, terminology

For the first time in 1985 the society of the Chemical and Technological Engineers/USA/is trying to establish an order in the terms risk and danger, which are often regarded as synonymous. Various branches of industry put different content in these terms.

The term "risk" in insurance terminology is used to refer to the subject of insurance as equipment production etc.

Economists and statisticians understand 'risk' as a measure of possible consequences that occur at some point in the future. Risk is the possibility for something unpleasant to happen and can be formulated as a probability of occurrence of an event in after the occurrence of another event. To risk means consciously to accept that possibility. The term "risk" includes both the possibility and the consequences. In colloquial speech, often the term "risk" is used to denote more consequences than probability. For example: If you see a rider to jump over high obstacles, we can say "it's risky" and associate this not with the high probability the horse to stumble, but with the severe consequences if this happens.

The term individual risk (incidence of critical effects on a particular individual), arising in the implementation of a hazard in a particular point in space (where the individual is situated).

The term social risk (incidence of striking impact on a group of people living in a certain territory) arising in the implementation of a hazard in a given area of space. The second term characterizes the scale of the catastrophic dangers.

The term Risk assessment – describes the procedure for estimating the social and individual risk for a concrete industrial plant or a village.

4.2. What must be taken in the risk assessment's process?

1 The possibility for an event to be realized (low, high).

2. The event itself for which this probability is taken.

3. The seriousness of the consequences. All of these components are understood when considering a risk, but must be distinguished clearly when assessing societal risk.

There must be known three things to risk:

- there is no such thing as "zero risk".

- no matter how small the risk is, it can always occur. Lowest possible risk does not mean that there is no risk at all.

Chances to diminish the risk more or less depends on where you live, mobility, age etc.

4.3. Risk tolerance

The term "tolerance" does not mean "acceptance" but the willingness of people to live with a certain risk, in order to secure certain benefits and to be confident that the assumed risk is properly controlled.

To tolerate a risk means that you do not treat it as something insignificant, or as something that can be ignored, but rather as something that must constantly keep under surveillance and be reduced in every possible way.

A risk is "acceptable" when we are ready to accept it as it is - for the convenience of life or our work.

4.4. Controlling of the industrial risk

The tests, applied in controlling of the industrial risk are very similar to those, applied in everyday life. They include the determination of the answer of the questions (Fig. 4.1):

1. Whether a risk is so large and its consequences are so unacceptable that it must be completely rejected as inadmissible.

2. Whether the risk is so small or is reduced to such an extent that it is not necessary to take further measures to protect.

3. Whether the risk falls between the above limits, it must be reduced to the lowest practically achievable level, taking into account the benefits arising from its taking and considering its costs for a further decrease. The basic principle underlying in the safety says that any risk should be reduced as far as it is reasonably practicable, or to a level that is "as low as is reasonably practicable" or short/ALARP/.

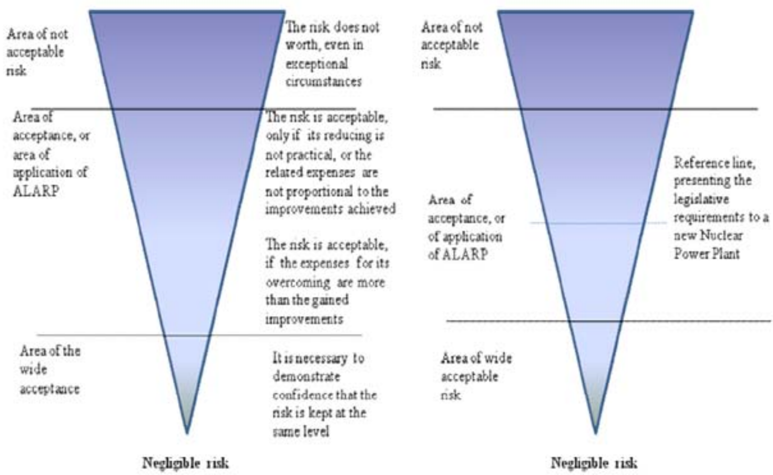


Fig. 4.1 Risk levels-principle ALARP [30]

4.5. Taxonomy of hazards

A phenomenon (natural, technospheric), in which is possible the occurrence of events orprocesses leading to the destruction of people, inflicting of material damage with a destructive effect on the environment and humans. Hazards can have different origins - mechanical, biological, radiological, chemical and others. At this point we would focus on the chemical hazards.

Chemical Hazards - a hazard, associated with chemicals or processes. They have basic forms of manifestation - fires, explosions, toxic releases, corrosion. These concerns are at the heart –of the major risks, the implementation of which causes major industrial accidents.
The term "taxonomy" has a Greek origin (taxis - properly positioned + nomos - law).

Taxonomy can also be translated as classification and systematization of complex areas of a reality constructed in hierarchy.

Taxonomy of dangers, at the beginning the difficulties that arises the term "risk" for describing of a number of completely different concepts were pointed out. Dangers can also exist in different forms and show their (destructive) potential in various ways causing damage.

Classification by type of the effects on man.

Impacts, associated with increasing or decreasing of the temperature of the human body (both internally and externally) can lead to injury or death. To these effects can be led thermal radiation, convection and the direct heat transfer to the skin, the inhalation of cold or hot air, respectively taking cold or hot liquids.

a) Effects of hot liquids

It is obvious that, the destruction of steam shirts apparatus, boilers, and steam pipes can lead to injury and death, as the number of affected is close. In the case of disposal of flammable liquid the victims are significantly more as a result of the fire. A typical example is the accident of 11/04/1975 at Scantory, England. As a result of the explosion of the basket holding the melted metal the situated around people (23 people) have been inundated with discarded metal (as a result of physical blast). 4 people died on the spot 7 in the hospital and 8 were treated for burns

b) Effects of low temperatures

Cryogenic liquids – causing the so-called "cold burns". Unlike the strong hot burns the strong "cold burns" does not kill the nerve endings thus the affected suffer in acute pain Spillage of cryogenic liquids (gas) can cause fatal end as a result of asphyxiation or due to subsequent fire or explosion.

c) Effect of different liquefied gases

The liquefied gases have the ability to propagate in the surrounding space, as a result their impact is significantly greater compared to the cryogenic liquids. It is very likely that in case of loss of structural integrity of tanks, in the apparatus with liquefied gases to occur injuries, including death, not only as a result of fires, explosions and toxic releases, but also as a result of the entry of cold droplets or vapors in man.

d) Lowering of the concentration of the oxygen in the air:

Asphyxia – caused by the termination of the air supply to the lungs.

Asphyxia under the action of fluids - such as a sudden burst of tank (as is the case in Maritsa East which caused 5 deaths). Many technological liquids have a lower density than water and therefore a person caught in such a liquid, although harmless cannot be held above it, and drowns. A typical example is the accident in Boston - USA in 1919, when as a result of the destruction of a tank containing 9,000 tons of molasses - 21 people was killed and 40 received injuries. Drowned are many animals and a bridge is destroyed. The cause of destruction is the bad design of the tank. The flood in the Burgas region which took three victims, as well as those in Varna Asparuhovo, Berkovitza, Misia, Kovach were caused by not cleaned riverbeds, illegal constructions, destroyed because of slaughter forests, destroyed embankments of dams, not well maintained hydro devices.

Asphyxia under the influence of bulk materials

Backfilling with finely ground materials as in case of landslips, groundfalling processes. A similar incident occurred in 21.10.1966 in Aberfan (England) where a landslide of a mountain of waste from a coal mine, 250 meters high, buried 147 people 116 of which children. The cause of death - asphyxiation. On the road of this landslide happen to be placed two schools and many homes.

Asphyxia in oxygen deficiency. In case of fire in close areas, premises, indoor spaces.

The loss of atmospheric oxygen is observed in a process of oxidation, or when it is shifted from the other gases. Mass deaths occur in 1976 in England in abandoned coal mines. As a result of the slow oxidation of the coal the oxygen pressure had fallen sharply. The air with no oxygen in it had been sucked to the entrance tunnel, where people were killed. A similar situation can occur when pressure drops in drainage systems and in sewage.

The following table 4.1 provides the symptoms when inhaling air with reduced content of oxygen.

Table 4.1. Signs and symptoms of lack of oxygen in the inhalwed air

Amount O_2, % vol.	**Signs and symptoms of lack of oxygen in the inhaled air**
12 - 14	Deep breathing, faster heart rate, poor coordination of movemets
10 - 12	Severe diffculty breathing (dizzinees, bluish lips)
8 - 10	Fainting, vomiting, loss of consciousness
6 - 8	Upon exposure eight minutes – death (100 %); 6 min. – 50 %
4	Over the course of 40 seconds develops coma, termination of breathing

Effects of increased oxygen content

Estimated in terms of produced amount the liquefied oxygen production takes 4th place after the sulfuric acid, chlorine and ammonia.

The toxic effects - in short exposures at a pressure of 0.3 MPa or in long exposures under reduced pressure.

Increased tendency to burn

1) Decreases the level of the initial energy of ignition (spark from static electricity).

2) Increases the velocity of burning directly proportional to the oxygen concentration. Greatly increases the rate of burning of clothes, hair of the body. Burning is further accelerated at a pressure higher than atmospheric pressure.

3) Fire retardant materials in excess of oxygen burns severely.

4) Increase the temperature of the flame.

5) Fire fighting is troubled when dispensing of liquid nitrogen (boiling temperature – 196 ºC) a liquid oxygenate (boiling temperature - 183 ºC), may be formed. In addition, many organic materials saturated with oxygen become stronger explosives.

Sudden change in the pressure of the environment: blast wave, mechanical trauma;radiation;pathogens; electromagnetic fields; electricity; sound loads

Classification by the number of affected.

Classification by the specificity of danger.

Classification by the way of taking – voluntary, force caused.

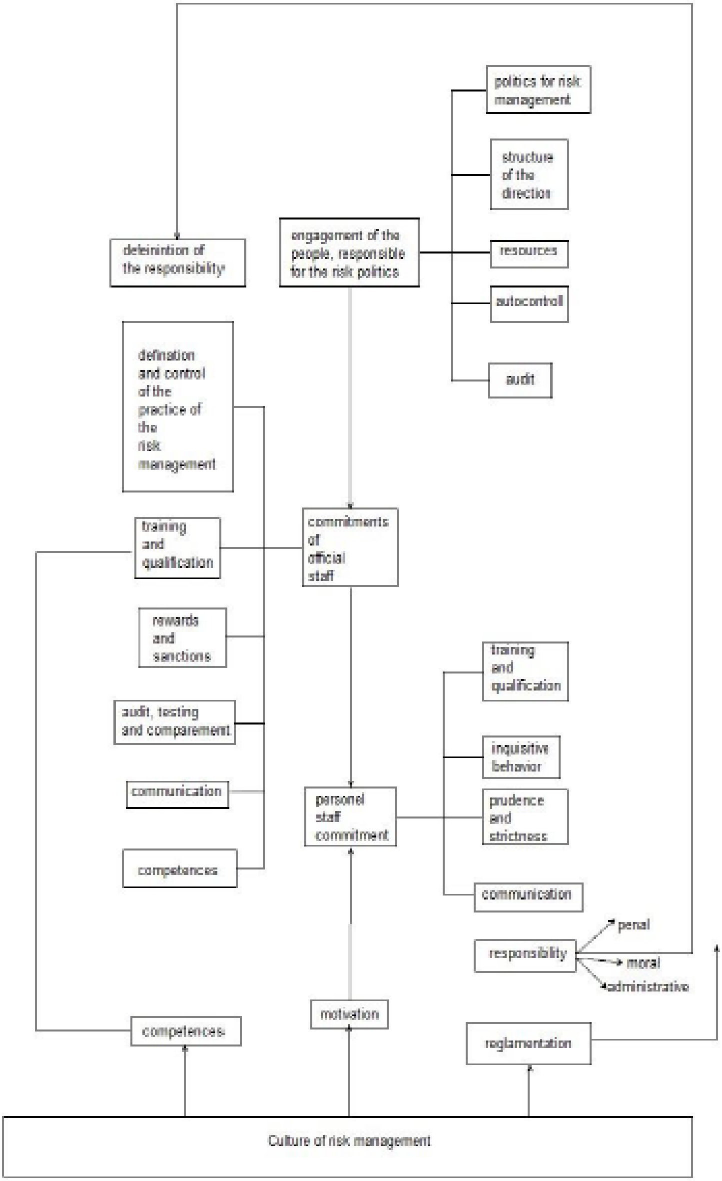
Classification by time scale.

A) Risk of REC/large-scale industrial accident: fires, explosions sudden toxic releases, etc.. chem. hazards, hazards with non-chemical nature.

B) Fatalities: injuries, suffocation, burns, falls, hand tools, el.injuries.

C) Risks associated with health impairment: slow poisoning, cancer, asbestosis, silicosis, stress, deafness.

D) Allergies.


politics for risk management
structure of the direction
deleinintion of the responsibility
engagement of the people, responsible for the risk politics
resources
autocontroll
audit
defination and control of the prectice of the risk management
training and qualification
commitments of official staff
rewards and sanctions
training and qualification
audit, testing and comparement
inquisitive behavior
communication
personel staff commitment
prudence and strictness
competances
communication
penal
responsibility
moral
administrative
competences
motivation
reglamentation
Culture of risk management

Chapter 5

TECHNOLOGICAL RISKS ASSOCIATED WITH THE BEHAVIOR OF LIQUIDS AND COMPRESSED GASES IN LOSS OF STRUCTURAL INTEGRITY

Relation between the physical properties and the behavior of liquids and compressed cases in case of a spill. Physical properties determine the behavior in case of spills in the atmosphere and their effectiveness, the possibility of degassing and identification.

5.1. Vapour pressure

This is one of the most important physical characteristics. Along with the external factors, the vapor pressure (P) determines their volatility, respectively sustainability of the area. Regardless of the physical content, substances with low vapor pressure can successfully pollute the atmosphere only in the form of aerosols. Substances, which at low temperatures have high enough vapor pressure, evaporate easily and the vapor will be enough to create a striking concentrations.

In a closed system, the liquid and the vapor phases are in a dynamic equilibrium, i.e. the number of the molecules, which leave the liquid phase, is equal to the number of the molecules, which condense. The vapor above the liquid phase is saturated. The pressure does not depend on the amount of liquid and vapor, but depends on the nature of the substance and temperature.

$$P = \text{const. } T\ ^{o}C = \text{const.} \qquad (5.1)$$

The increase or the decrease of the temperature alters the average speed of the molecules (law of Boltzmann for the distribution of the molecules according to their energy), which leads to the change in the number of molecule agglomerates above the liquid phase and thus to the change in the pressure of the vapor.

$$P = f(T) \tag{5.2}$$

As a result of the increasing of the temperature, the molecules with extra energy abandon the condensed phase, which result in an increased pressure.

5.2. Temperature of boiling and melting

The boiling temperature (T_b) and the melting temperature (T_m) are important properties of every substance on the basis of which can be made predictions regarding the duration of the infection, the method of storage and identification.

As is known T_b - this is the temperature at which the vapor pressure of the liquid is equal to the ambient pressure. It is directly related to the vapor pressure, and may be related to the volatility of the substance. At an usual temperature the lowest the T_b is, the greater the vapor pressure and its volatility is. Consequently to this fact, in the preservation of a low-boiling liquids (eg highly toxic cyano -hydrogen T_b 26.5 °C) occur some features related to charging and recharging. The increased pressure of the vessels for storage, at ambient temperature is taken into consideration in the design and the choice of the material, while constructing these vessels. T_b may also characterize the sustainability. At its value can be estimated the duration of the infection for example. Of course, in this case we have to take in mind many other factors. Short term infection effect possess substances whose T_b is low and vice versa those with higher T_b will evaporate slowly and will last longer. Many of the substances with T_b higher than 130 °C can permanently infect the area and cause damage not only after an inhalation of the vapor but in case of contact with the skin.

5.3. Maximum concentration of the vapor

The maximum concentration (C_{max}) – is the amount, contained in an unit of volume filled with saturated vapor at a certain temperature.

The maximum concentration depends on the nature of the substance, the external pressure, the temperature, and thus of the pressure of the vapor it is a function of P and T.

$$C_{max.} = f\,(P,T);\ C_{max} = 16\ MP/T\ \ [mg/l] \qquad (5.3)$$

The term maximum concentration refers to a closed system where the liquid and the vapor phases are in equilibrium. In practice, such a system does not exist. The external influences such as wind, air currents, atmospheric diffusion and hydrolysis continuously discharged the vapor.

As a result, the liquid phase is left by more and more noni-molecules in which the pressure is restored, and the substance is evaporated. Like P and T_b, the importance of C_{max} for the different substances is quite different. Substances with very low maximum concentration which even at very high temperature of the air have very low volatility and can contaminate the air only as aerosols. And vice versa in a situation of high volatility of the spilled (discarded) substances even in very large quantities, a significant concentration can be maintained only for a few minutes. Very slowly evaporating substances, cause prolonged infection of the air, making the activities of localization and the liquidation of the consequences of the major industrial accidents (MIA) very difficult. In case of fast evaporating volatiles, degassing is not necessary, while for the less volatile, degassing for the personnel and the materials is required.

5.4. Resistance

It is in close connection with its volatility. The volatility is not dependent on the time, but the pressure and the volume of gas affects on the rate of vaporization. The resistance of the area does not only depends on the weather conditions (wind speed, temperature, resistance of the air layers, humidity etc.), but also on the nature of the area (ground soil texture, topography etc.) The resistance can be determined according to the formula of Leytner:

$$S = V_{d1}/V_{d2} = P_1/P_{2*}\sqrt{M_1T_1/ M_2\,T_2} \qquad (5.4)$$

V_{d1}, V_{d2} – velocity of the evaporation of water in T_1 (15 ºC) and evaporation of the substance in air temperature T_2 ;

P_1/P_2 pressure of the water vapors in 15 ºC/air temperature;

M_1/M_2 -molecule mass of the water and of the substance.

Thus, the volatility is a value, inverse of the rate of evaporation of the substance V_{d2} at air temperature and in Vd1 of water at 15 °C accepted as unit one.

Resistance indicates the time for which the substance evaporates comparing to water, but it gives no information on the duration of action, as it is determined not only by the volatility and stability, but also by its toxicity.

5.5. Relative vapor density

The effectiveness of the vapors is determined by their vapor density.

The density is equal to the density of the substance divided by the density of the air. Substances with a specific density less than 1, rapidly diffuse into the atmosphere and their striking effect quickly disappears and vice versa at a density greater than 1, the vapor creeps on the earth, filling every hole. The relative vapor density can be calculated by the molecular weight of the substance. For air, the average molecular weight is 28.9, which gives a density of M substance/28.9.

5.6. Ability of substances to make aerosols

Large part of the compounds related to the industrial hazardous substances (PHS) are solid or liquid. Their physical properties, particularly the volatility in certain conditions under a situation of MIA allow for a relatively short time to develop striking concentration of aerosols covering a large territory with the following of this situation damage of the workers and the population.

Methods for the preparation of aerosols:

a) as a result of the condense of the vapor in the air;

b) as a result of the evaporation of the solvent 10^{-4}, 10^{-8}.

The aerosol represents kvasi stable system of particles with sizes of 10^{-4} to 10^{-8} cm.

Aerosols are characterized by high resistance in the air, high penetrating power and long range of activity. Smaller they are, easier and deeply penetrate into the body.

The reason for their kvasi stability is determined by the weather – factors, high mobility – the Brownian motion and the gravity. The velocity of sedimentation is determined by the size and the electricity charge. The opposite in sign electric charge contributes to coagulation. Decreasing the aggregation and the coagulation level more and more crudely dispersed systems emerge, the stability of which falls with the increasing of the particle’s size.

5.7. Solubility and solutions

The solubility or the miscibility is important for their storage, use, identification and determination, and also for their - effective degassing.

We distinguish the following types of mixtures:

- Limited miscible;
- Practically immiscible;
- Unlimitedly Miscible.

The ability of the compounds to penetrate the body depends on their solubility in the lymph and the temperature.

Information on solubility is important for their degassing.

5.8. State diagram

When studying the processes of (moving) transportation and storage of substances it is appropriate to take advantage of the state diagram. For simplicity, we will assume that the system is a single component system, and the changes in its condition there is no chemical decomposition observed (Figure 5.1) [30].

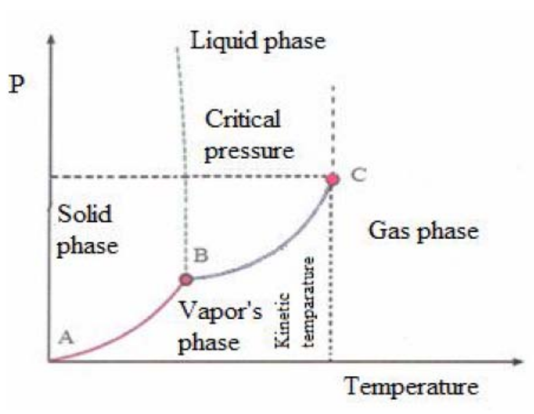


Fig. 5.1 State diagram [30]

The curve of the phase equilibrium the A-B curve shows the relation between the vapor pressure and the temperature for the solid phase and the phase equilibrium curve B-C the ratio of the vapor pressure and temperature of the liquid phase. Point C corresponds to the "critical temperature". At temperatures greater than the critical ones, the substances may not be present in a liquid state. The pressure that corresponds to the point C we name "critical" because at this pressure there still exists the possibility of compression of the gaseous phase. The physical properties of the liquid and gaseous phase at this point are identical for example the density, the relative entalpiya, etc., has the same meanings, and the internal heat of gas generation (condensation) is zero.

The gaseous phase of some substances has a sub-phase, which is called "vapor" which in the range of temperatures is below the critical one and to switch to the liquid phase is only necessary to be compressed. For the zone of a gaseous phase, lying above the critical temperature there is no special name entitled, however, in the XIX century was assumed that gases such as O_2 and N_2, unlike CO_2 cannot be liquefied only by increasing the pressure and they were given the term "permanent" gases. It is now clear that this was caused by a significant excess of operating temperature above the critical. Today, all such gases successfully liquefy in processes where there is a pre-cooling of the gas to a temperature below its critical. In the table 5.1 are given the critical parameters**.**

Table 5.1. Critical parameters

Substance	**T boiling in atm. P [°C]**	**T critical. [°C]**	**Critical pressure [bar]**
H_2	-252	-240	12.8
N_2	-196	-147	34
O_2	-183	-118	50.5
CH_4	-164	-82	46.5
C_2H_4	-103	9.5	50.2

Substance	T boiling in atm. P [°C]	T critical. [°C]	Critical pressure [bar]
C_2H_2	-88.6	32.2	48.3
Cl_2	-34.5	144	77
NH_3	-33	132	113
H_2O	100	374	218

In the modern literature the terminology "vapor and gas" are not used in the strictly established meanings. For example the so called liquefied petroleum gas - in practice these are liquefied petroleum vapors, however, the term "liquefied natural gas" is fully faithful (accurate) on the other hand if we talk about an explosion of a vapor's cloud there could be understood, an explosion of a combustible gases such as H_2, CH_4.

5.9. Density of volatile substances and methods for storing

Density (or its reciprocal value is called a relative volume) - is one of the main factors affecting the economical use of a volatile substances. The gas or the vapors have so low density that to storage them in a gaseous state is highly expensive. That is why there are two main ways of storing gases:

a) at constant P and variable volume;

b) at variable P and constant volume.

The gas storage tank in conditions of an atm. temperature has a relatively simple design, but very large size, as their volume reaches 250-300,000 m^3. Most often the containers are with (dimensions) volume of about 1,000 m^3 and a pressure of 30 bars.

In the way of storage and transportation (transportation) the substances can be divided into four main categories:

- First category of substances for which the critical temperature is lower than the ambient temperature. Substances that are "permanent" gases but are present in a liquid state are often called "cryogenic substances." Of these cryogenic substances most important in terms of basic chemical hazards appears the compressed natural gas composed mainly of CH_4, but also containing small amounts of hydrocarbons with two or more carbon atoms. The atmospheric gases such as N_2 and O_2 also fall into the category of substances for which the critical temperature is significantly below the ambient temperature. For substances of this category the transportation technology and storage are based on the usage of high-quality thermal insulation with a vacuum shell. It should be noted that to store CH_4, O_2, N_2, in liquid form, through cooling is very difficult, as this can only be done at the expense of coolants with lower temperature. The formed upon the evaporation vapors can be immediately used again, can be compressed for longer storage or simply can be released into the atmosphere. The behavior of the cryogenic substances in case of a spill is determined by the intensity of the heat flow from the environment.

- Second category of substances for which the critical temperature is higher and the boiling point is lower than the temperature of the environment. For the liquefaction of these substances is enough only to be compressed. These are propane butane, NH_3, Cl_2. They are distinguished by their ability to "instantly evaporate" i.e in case of decompression, part of the liquid evaporates instantly, and the rest is cooled to the boiling point at Patm. This can happen along with the development of a vapor cloud, which is a significant problem at the area of basic chemical hazards. These substances can be stored under pressure at ambient temperature (ambient) or refrigerated.

- Third category of substances in which the critical pressure is higher than atmospheric pressure and T boiling is greater than the ambient temperature.

$$P_{critical} > P_{atm} \text{ and } T_{boil} > T_{ambient} \quad (5.5)$$

This class includes substances which are liquid in P_{atm}. Those which have relatively low T_{boil}, depending on the ambient temperature can be also placed in the upper category.

For example, in cold weather and R_{atm}. The butane is liquid ($T_{boil.}$ About 0 °C) and the ethylene oxide in a hot weather is compressed gas (T_{boil} = 13.5 °C).

All substances which at ambient temperature are in solid form also fall into this category.

However, the solids are considerable interesting to us insofar as they are explosives or substances present in the air in a dispersed state.

- Forth category of substances present (or stored to) at higher temperature. In operating conditions the liquids of Category III are similar to the compressed gas especially when they are held under the conditions of heat supply and pressure at a temperature higher than the boiling point in P_{atm}. A typical example of this is the water vapor in the boilers, and the cyclohexane (T_{boil}= 80 °C with a critical temperature of 280 °C). In the factories of the company Fliksboro in England the cyclohexane was stored under pressure of 9 bar and temperatures of 70-80 °C exceeding T_{boil} in P_{atm}. The depressurization of the equipment in which it was stored, led to the accident on 1 July 1974.

5.10. Spills IV category

There is a certain similarity between the category IV fluids which at a temperature higher than the boiling point at atmospheric pressure represented liquefied vapor and fluids category II. It The similarity comes out from the behavior in case of spilling causing an instant evaporation.

The Accident form June 1st, 1974 in Fliksboro (England) is the most significant example of MIA (Major Industrial Accident) involving fluid from category IV. (Shown in the following scheme,F figure 5.2).

In the official reports for this MIA is not mentioned the amount of the vapors of the cyclohexane, it is described only as a „big vapor cloud." The report says that just 2 minutes before the explosion there was nothing suspicious, so there must had been an instant evaporation.

After the discharge of the bypass connecting the reactor № 1, 2, 3 and 4, the evaporation of the vapor happened through a hole with a diameter of Ø = 0.7 m, and also through an opening in reactor № 6 relates to a treating tank. The report suggests that at the initial moment the volume of the flow coming out by the hole with diameter 0.7 m either from № 4 or 6 can be calculated by using the speed of the sound of the vapors of cyclohexane going out of the vessels. The meanings of the flow rate are presented in the following table 5.2.

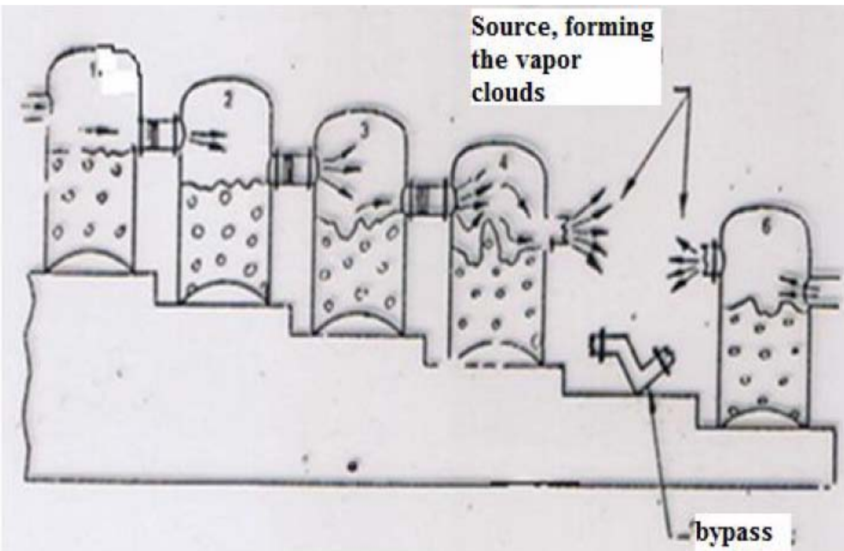


Fig. 5.2 Major Industrial accident involving fluid from category I [30]

Table 5.2. The meanings of the flow rate

Period of flow, sec	**Massloss T, c**	**Amount of vapor released, t**
to 5	0.56	2.8
at 10	0.43	5.30
at 20	0.25	8.70
at 22 end of the sound s regime	0.22	
at 30	0.15	10.20
at 48		12.55

The reactors were with size of Ø 3.55 m – 9.89 m^2. Assuming there was a pressure of 8 Bar/ mol and a mass of the cyclohexane – 84 we receive a flow rate of 2.73 m/s and this is the approximate speed of the instant evaporation. With the exception of the initial phase lasting about 1 sec. When the liquid was released from the reactor the involved afterwards fluid was about 1 %. It is obvious from the report that the instant evaporation in the accident in Fliksboro was significantly lower compared to the total destruction. The flow of the vapors was greatly reduced because of the diameter of the hole – Ø 0.7 m (S= 0.38 m^2) the total surface of reactor № 1-4 is 40 m^2, and reactor № 6 is 20 m^2. Attitude of the surface of the area and the separation area is equal respectively for reactors 1 to 4 to 0.38: 40 and 0.01: 1 for reactor № 6 is 0.38/20 and 0.02: 1.

5.11. Reason for violation of the tightness of the liquefied gasses' vessels

This item's aim is to get a brief overview of some general cases for technological problems, concerning non-pressure systems, including tanks with liquids under pressure. Such an approach is justified by the fact that liquefied gas is the main component of hazards in chemical industries. Pressure systems are all kinds of pressurized vessels such as piping, valves, pumps, compressors, equipment etc. On figure 5.3 can be seen the range of pressures delivered by the chemical and petroleum industries.

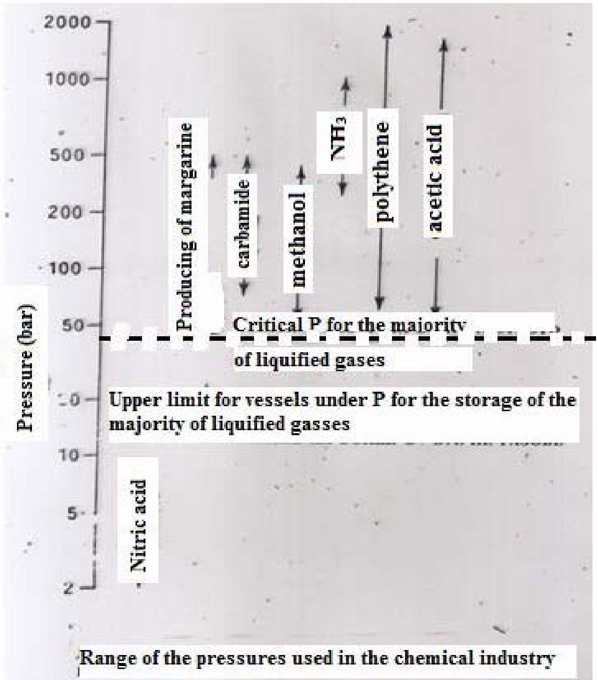


Figure 5.3 Range of the pressure used in the chemical industry

It is clearly seen that there are no higher pressures included in the figure, though at a first glance they form greatest danger. That is because the systems that operate at high pressure contain significantly lower amounts of easily flammable or toxic substances than systems containing liquefied gases – to some extent this is explained by the inability of the equipment (tanks) with a diameter of several meters to withstand the necessary pressure. The destruction of tanks under pressure can cause a number of serious consequences, which can be quickly liquidated and localized. The critical pressure for many hydrocarbons is on the range of 4 Mpa and for a number of reasons, these substances are stored as liquefied gases at P = Mpa, which refers also to Cl_2, and NH_3.

Destruction of the system's shell, designed for work under pressure in the range of 1-2 Mpa was a reason for a number of serious emergency situations in the past, including the incidents in Ludwigshafen, Fliksboro, San Carlos. In this context, particular attention will be paid to the reasons for the accidents of pressure tanks and systems operating under a pressure of 1-2 Mpa.

5.12. Characteristics of high-pressure tanks

Pressure carrying vessels are vessels that are designed for storing of liquids under pressure greater than the atmospheric pressure, which are designed and implemented according to the requirements to the high pressure tanks.

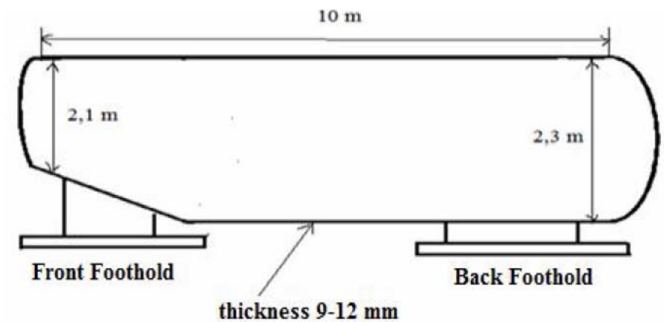


Figure 5.4 Scheme of a vessel (ASME) [30]

The main source of information, regarding pressurized vessels is the book of the American Society of Mechanical Engineers (ASME) – „The journal of High Pressure Technology „(JHPT).

On figure 5.4 can be seen a scheme of a vessel in accordance with the popular definition. This is a transport vessel with typical for this type of vessel sizes.

5.13. Synopsis of the mechanism of destruction

Violating of the integrity of the pressurized vessel happens through the formation and development of cracks. However, the mechanism of destruction of some materials is the so called brittle destruction. A typical example of this is the glass and the cast iron. Other materials deform plastically. If the material is from the group of brittle materials as a result of the destruction are formed a plurality of fragments of different sizes. In the plastic destruction the large-scale fragments are relatively little as a number. In some materials, when they are under pressure exceeding the certain pressure, the crack, once reached a critical length continues to grow. The development of the crack is favored or complicated by the ductility of the material.

According to the theory of the destruction in case of the application of any force to the object the pressure in it is distributed unevenly around the defined points, known as „stress concentrators", and it may be from 2 to 100 times greater than the average value. Stress concentrators could be sharp edges, scratches and cracks.

The design of the vessels under pressure includes not only the construction of resistible thin walls able to withstand a certain pressure, but also the ability to avoid internal stress, „stress concentrators", or if this is not possible, the ability to provide sufficient reserve of strength. The design also includes a selection of suitable structural material, which in the operating conditions (for small deviations of the parameters) to resist the impact of the pressure besides as well as fatigue and corrosion, weakening the strength of the vessel's walls etc.

5.14. Constructive criteria

The pressurized vessels are divided into two main classes – with thin walls and with thick walls.

For the thin walls:

$$K = d_{out} / d_{in} < 1.2 \tag{5.6}$$

For the thick walls:

$$K = d_{out} / d_{in} > 1.2 \quad . \tag{5.7}$$

Chapter 6

RISK OF FAILURE OF A PRESSURIZED VESSEL CARRYING CAPACITY PRESSURE, ACCORDING THE COMMITTEE OF ADVISERS ON THE MAIN HAZARDS (CAMH)

According to (CAMH 1979) pressure tanks can be considered as non destroyable if they resist to a certain degree of load, are properly designed and are regularly checked under the conditions they are designed to work.

This situation is valid for pipes which have a large diameter and limited length.

Failure in the leading pipelines can happen in small diameter pipe or in several pipes the cumulative diameter of which is not less than the largest one.

It should be noted that a general statistics of failures in systems under pressure does not exsist, regardless of the statistical analysis of available accident, which facilitate the study of the accidents, regarding vessels under pressure.

This analysis is done by Warren and Smith (Smith 1981) as a request of the management board in nuclear energy sector, with initial idea to clarify the possible failures of pressurized vessels in the nuclear industry.

The analysis was conducted with the safety and reliability director (SRD) and the integrated management of the insurance committee of the industry in England.

6.1. Method for organization systemetization and analyses of risks

The Method for Organization, systematiZation and Analysis of Risks/MOZAR/was created in the 70's at the Center for Nuclear Energy in France by a group of experts under the leadership of prof. Jan Marie Penalva. The original task of the method was in providing of safe operation of nuclear power plants. Subsequently Prof.Penalva turned into the detection and consequences of major industrial accidents and examination of their impact to the environment. For that purpose he created special workshop for modeling of various types of industrial installations.

6.1.1. Principle of the method MOZAR

Method MOZAR's main objective is to contribute to the development of the main features of the risks, existing in an industrial system and to study their effects on man and his environment.

To ensure objectivity and to improve the efficiency and effectiveness of risk analysis, it needs to be done in an organized manner, following a certain sequence. Shown on the figure 6.1, below:

1. Definition of the field, which would be checked;
2. Basic processes and equipment in the checked system;
3. Systems of sources of hazardous streams (figure 6.1);
4. Adverse events;
5. Network of the Risk - quantitative assessment of the elements;
6. Selection of scenarios;
7. Event Trees;
8. Consequences of the implementation of the selected scenarios;
9. Installing of technological and functional barriers;

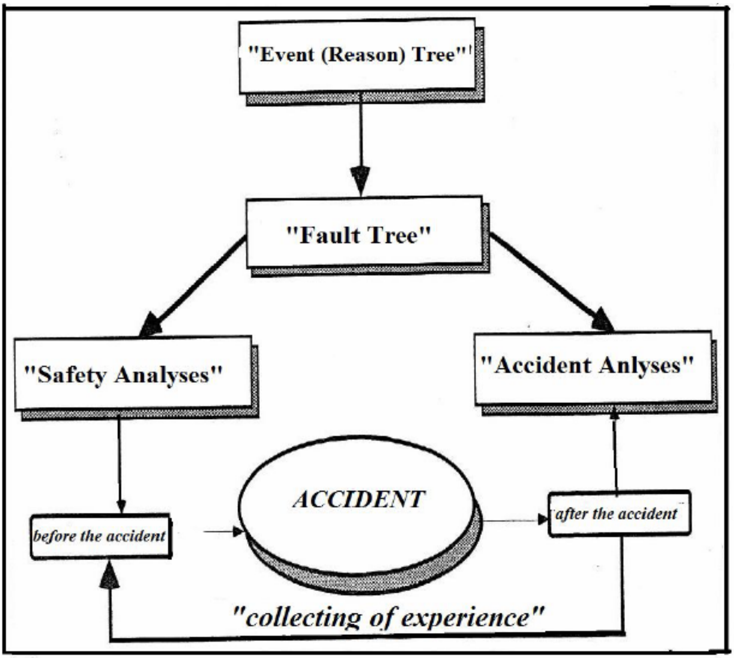


Fig. 6.1 MOZAR Scheme [30]

6.1.2. Area activity of MOZAR

This method deals with the modeling of the reality. The development of the whole issue of risk is based on the theory of models. What is a model?

Representation of reality, a way to communicate through mental images. What is reality? From our perspective this is a sequence of activities and actions in time. If within these sequence appears a "failure" in the normal development of the process, then we talk about dis-functioning of a part of the system or the entire system or for incidents (with human involvement) and anomalies (technical and natural phenomena).

Event analysis is based on the so-called. Tree causes and Fault Tree Analysis (tree of causation). In the analysis of security should be considered throughout the system in unity, and that means to apply a systematic approach to the analysis and management of risks.

6.1.3. System - definition and criteria

The system is a community of objects organized by the function of achieving of a specific purpose, placed in an environment characterized by five criterias, defining its status:

- integrity;
- autonomy;
- synchronicity;
- acttivity;
- static.

The system in its classical form is presented as a sheme in figure 6.2.

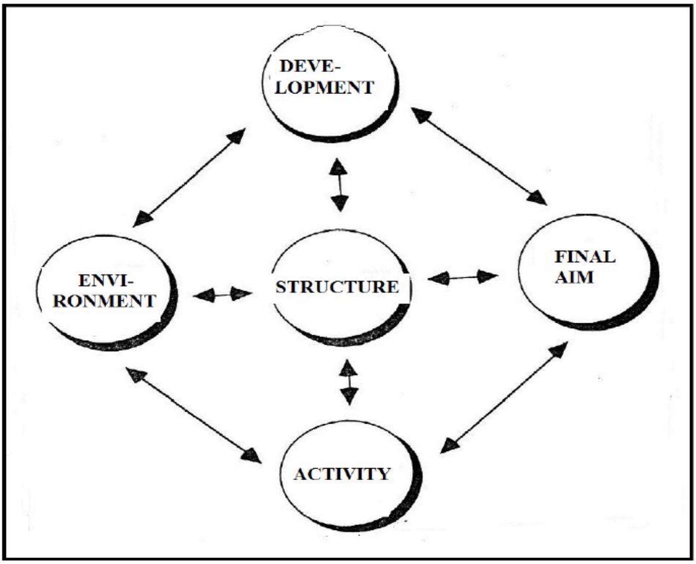


Fig. 6.2 Classical form of system' presentation [30]

6.1.4. Types of systems

According to their origin: Natural systems - created and evolve without human intervention and Artificial systems- created as a result of human intervention.

According to the activity of the environment towards the system - active and passive to the environment.

The effectiveness of the functioning of sistemata- normal and degraded state.

6.1.5. The life phases of each system

The life phases of each system are:

- Phase of the development of the concept of the system;
- Phase of the implementation of the system;
- Phase of putting the system into action;
- Phase of support of the system;
- Phase of improvement of the system;
- Phase of termination of the system.

6.1.6. Risk

The dysfunctioning of the system is associated with the occurrence of undesired elements.

The risk that characterizes these undesirable elements, depends on three elements: level of hazard, the probability and severity of the event:

$$R= D*P*G \qquad (6.1)$$

Where:

R - risk raised by an unwanted event;

P - probability of an event to happen (Table 6.1);

D- risk of occurrence of an adverse event - shows the frequency with which a hazard can occur in a given situation (Table 6.2) [30]

Table 6.1. The probability of the event (P) [30]

Probability (P)	
0.1	Barely noticeable
0.2	Practically impossible
0.5	Least possible
1.0	Least possible, but possible in a limited case
3.0	Low probability
6.0	Entirely possible
10.0	Relatively high probability

Table 6.2. Severity of the event (G) [30]

Severity of the event/damage/(D)		
1.0	small	Small injury without lost lives
3.0	significant	Injuries with loss
7.0	serious	Disabled, permanently paralyzed
15.0	dangerous	1 case of death
40.0	catastrophic	Many cases of death

Table 6.3. Risk of occurrence of an adverse event (D) [30]

Frequence of occurence (F)	
0.5	Too low (less than one time per month)
1.0	Very low (up to one time per week)
2.0	Low (up to one time per day)
3.0	Average (up to 1/3 of working time)
6.0	High enough (half of the working time)
10.0	Continous (all time)

After the calculation of the risk, using the above listed parameters and the given formula is developed a risk classification, as shown in table 6.4.

Table 6.4. The intensity of risk (R) [30]

Risk (R)		
1.	To 20	Very limited, acceptable risk
2.	From 20 to 70	Small risk, caution measures are necessary
3.	From 70 to 200	Needed actions for risk reduction
4.	From 200 to 400	An immediate improvement of working conditions
5.	> 400	Cessation of the activity for eliminating the risk

6.1.7. Binary system

In the process of identification, analysis and management of risks according to the methodology of the group of analysis of the dis-functioning of the systems are considered as mutual connectivity of binary systems, given on figure 6.3.

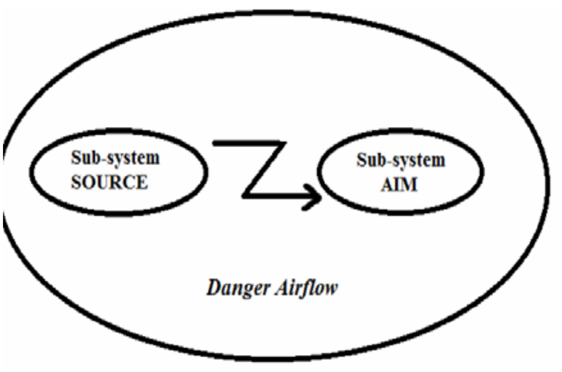


Fig. 6.3. Binary system [30]

An example is given in table 6.5.

Risk of failure of a pressurizes vessel carryng capacity pressure, according the committee of advisers on the main hazards (CAMH)

Table 6.5. Example of Binary system

Sub-system "source"	Sub-system "aim"	From the position of:
Installation	Installation	Security of the material resources
Installation	Operator	Ergonomics, safety engineering
Operator	Installation	Safety engineering
Installation	Population/People	Hygiene, health, ind. safety
Population/People	Installation	Negligenge, development of aggresion
Installation	Ecosystem	Hygiene and environmental protection etc.
Ecosystem	Installation	External fators, causing accidents-floods, earthquakes etc.

6.1.8. The method for risk analysis MOZAR, step by step

The method for risk analysis MOZAR, step by step:

- a model that will allow to identify the risks associated with the operation of a system and afterwards would be managed;

- MOZAR is appied to an industrial plant;

- MOZAR investigates any links concerning the functioning of the system: Continuous processes in parallel and linear sequence, or discontinuous processes (the linear sequence of one or more lines - in a parallel sequence);

- any links related to the geographical distribution of the plant are takenn into consideration. An industrial system is a system that must be precisely defined by its borders, constituting elements called sub-systems;

- determination of the context of the installation - mainly concerns operating subsystems of the system in a wider sense;

- identification of the risks in an installation in advance - finding a state of dis-functioning of the system, which may cause the occurrence of adverse events. Dysfunction can be expressed by the occurrence of failures in the components of operating system failures, or in the interrelations.

6.1.9. Structure of the method

Module A: identification, evaluation and management of the key risks. Using the model of the plant as a system consisting of subsystems for which we can determine which are the closest interactions of the individual elements of the installation, which can generate accident scenarios. Once these elements are identified by MOZAR the analysis of the system is developed and through it could be achieved management of the major risks in the system.

At Level A1 are defined the methods and facilities to identify risks.

At Level A2 methods and tools to calculate the risk and determine the consequences of their implementation are applied.

At Level A3 are negotiating objectives and is build probability - weighting network and acceptable and unacceptable risks are defined.

At Level A4 are developed barriers to neutralize the dangerous processes. The final part of the risk analysis is the inclusion of barriers for preventing necessary to neutralize the process of danger.

These barriers are divided into two kinds: technology; and functional.

The technological barrier is an element which opposes automatically on the occurrence of an event bearing damage with regard to security of the plant (it is a process in which there is no human intervention). Technological barriers can be:

- Static/equipment, providing security of the vessel;

- Dynamic/detection system for pressure in case of opening the valves etc.

Functional barriers are actions carried out in the presence of human intervention, based on an accurate prescription and order and activated by a member of the team or by simple observation of the developing processes in an industrial plant.

6.1.10. Modeling of Hazard in MOZAR

The Modeling of the risks is presented in the following figures: figure 6.4, 6.5 and 6.6.

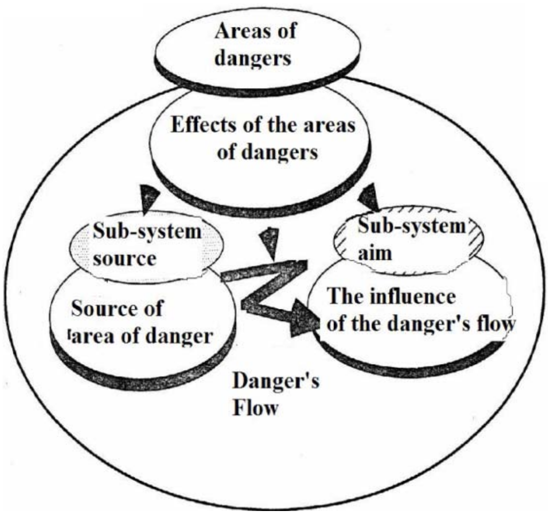


Fig. 6.4. The process of dangers [30]

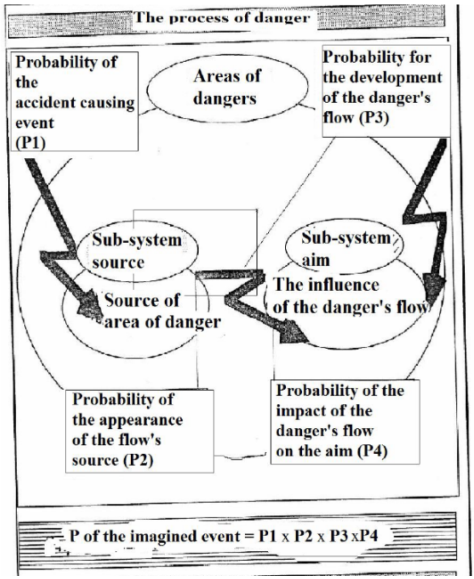


Fig. 6.5. Introduction to safety-sample model 1 [30]

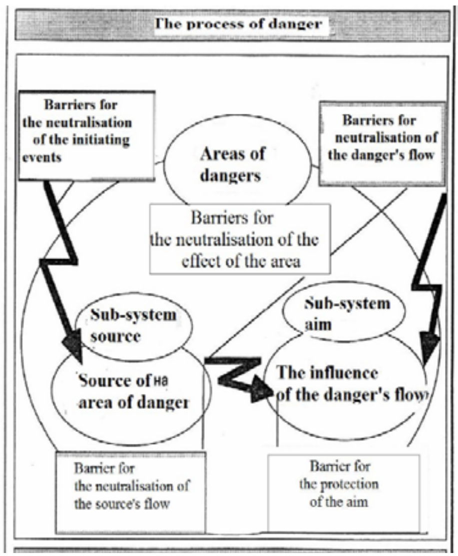


Fig. 6.6. Introduction to safety-sample model 2 [30]

6.1.11. Systems for danger flow's sources

In MOZAR, the main groups of hazards are presented as eight systems related to the letters A to H. These systems refer to sources of hazardous flows in production, storage and transport of materials as follows:

1. A. Hazards arising from technological equipment:

A1 - Pressure Equipment:

- gas;
- mixed vapors;
- liquids.

A2 - Elements under mechanical treatment;

A3 - Moving elements:

- solid substances;
- liquid substances;
- gas substances.

A4 - Items requiring manipulation:

- manual;
- mechanical.

A5 - System of sources of explosions with no physical origin except these listed in A;

A6 - System of sources for falls from heights;

A7 - System of sources for falls from equal surfaces;

A8 - Other systems of sources and injuries;

A9 - System of sources of noise and vibration;

2. B. Hazards arising from working with chemicals, gases, vapors, dust - harmful substances in the air of the working environment, flammable or explosive materials, corrosive and reactive substances, allergens, carcinogens:

B1 - System of sources associated with chemical reactions;

B2 - System of sources of explosions between raw materials used or in contact with other materials, or gas phase;

B3 - System of sources of toxicity and aggressiveness;

B4 - System of sources of air pollution;

B5 - System sources of oxygen deficiency;

3. C. Hazards arising from from electricity - working with electric, electric regulating, electrically driven equipment:

C1 - Electricity as direct or alternating current;

C2 - Static electricity;

C3 - Capacitors;

C4 - High Frequency (HF).

4. D. Sources of fire hazard:

D1 - Source of fire;

D2 - Materials used:

- In structures;
- In production.

5. E.Sources of danger from ionizing radiation, electromagnetic radio frequency and microwave:

E1 - Ionizers;

E2 - Alpha, beta, gamma rays;

E3 - Neutrons:

- Contamination (radiation);
- Critical exposure.

E4 - ultraviolet radiation, infrared radiation in the visible region;

E5 - Lasers;

E6 - microwave radiation;

E7 - Magnetic field.

6. F. Sources of biohazards: microorganisms, bacteria, viruses, toxins, etc.:

F1 - Viruses, bacteria;

F2 – Toxic.

7. G. The human system as a source of danger: level of access- tight spaces, poor ergonomics, monotonous duties, imposed pace of work, posture, heavy physical work:

G1 - Normal situation;
G2 - Envy, malice;
G3 - Source of danger at work;
G4 - Source of danger during severe accidents;
G5 - other sources of injury (puncture, cut etc.).

8. H. Systems of sources of hazards associated with the environment. Pests, noise, vibration, ultrasound, infrasound, fluids under pressure/compressed air, vapor, liquid/microclimate, exposure to high and low temperatures:

H1 - Noise, vibration;
H2 - poisoning the atmosphere, bad smell;
H3 - Very light;
H4 - Medium to high temperature;
H5 - Flood;
H6 - Lightning;
H7 - Earthquake;
H8 - Other sources of natural hazards (black ice, slippery terrain etc.).

6.2. Analysis of failures in systems

6.2.1. Classes of failures

The are two classes of failures:

a) Potential, or discovered as a result of verification surveying;

b) Real, or causing accidents.

There are 20,000 vessels investigated with a total life cycle of operation 300.000 years.

Based on the analysis are set 216 potential and 13 real refusal, that would occur in 300.000 years of operation of these vessels. If the frequency of events is taken as: $6.9 \cdot 10^{-4}$ potential failures in a year and $4.2 \cdot 10^{-5}$ real failures (accidents) in the year out of 216 potential can be seen that 9.4 % are caused by cracks. The reasons for cracking are shown in Table 6.6.

Table 6.6. Reasons and number of cases

Reasons	Number of cases	%
Defects, detected during inspections	63	29
Not detected defects	61	28
Fatigue	52	24
Corrosion	30	14
Other reasons	10	5
Total	**216**	**100**

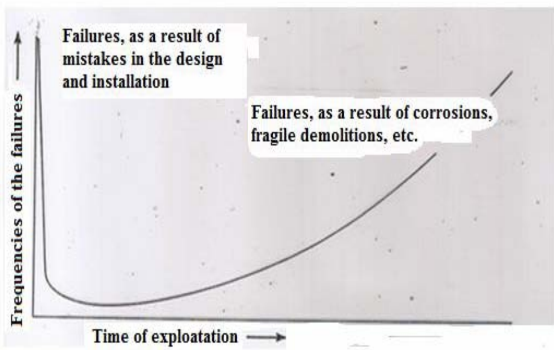


Fig. 6.7 Graph of iontensity of failures [30]

It should be noted that many accidents are seen mainly during the first years of operation of the vessel, as this period is often strictly checked for a likelihood of accidents. On figure 6.7 can be seen a diagram of the dependence focusing on the probability for emerging of a demolition period after the end of a life time period of a vessel. Such a curve is called a graph of intensity of failures.

The design and development of the pressurized vessels in the chemical and oil refining industry is associated with different types of production activity: mechanics, machinery, chemical technologies. Partly this includes metallurgy, and some other areas of action (Table 6.7).

Table 6.7 Types of failure

Operation	Area of activity		
	Mechanics	Chemical technology	Metallurgy
Scheduling		X	
Choice of material	X	X	X
Design	X		
Development	X		
Inspection	X		
Operation	X	X	
Exploitation		X	X
Periodic control	X		
Technical maintenance	X		
Reconsruction	X	X	X

Errors made by people in any of the operations listed in the table (by operations we mean the phase of the life cycle in one or another area of activity each of which is important and can lead to failure). Failure of the vessel may be potential or the revision can give information on the way the failure can happen in case of not taking appropriate actions. The failure of the vessel can be catastrophic – unexpected- accident without warning.

There are of course intermediate stages of leakage through a small slot, which can lead to major accident. We will not discuss in detail all the possible causes for failures but on the most interesting for the chemical technology ones, and a special focus would be given to the role of the human in their development.

6.2.2. Theory of the logic trees

<u>6.2.2.1. Main principles</u>

The logic trees can be drawn in two directions - failures and reasons.

To build a logical tree, you should very well know the system. This means that the team which developed the tree should include as many different specialists, familiar with the work of the particular system as possible. The work begins with a precise definition of the adverse events to the system, they are placed on top, or at the beginning of the tree and are called “top events”. In return, they are divided into intermediate and basic events connected in a network or acting alone. The logic tree investigates the reasons of these events to happen and this deductive procedure continues until the reaching of those events which do not need any further decomposition - these events are called primary or elementary. The decomposition of an intermediate event of his composing events is done through logical operators called ports.

<u>6.2.2.2. Typology and graphic display of events</u>

Top event- his choice is at the bottom of conducting the whole analysis of the risks in the system.

It is displayed with a rectangle:

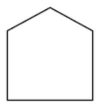
Intermediary event are those, whose occurrence or initiation is caused by joint or isolated action of other events in the system. They are also represented by a rectangle.

Primary elementary events - are situated on the bottom level your deductive risk analysis can be carried out. This is the level at which it was decided to end this analysis. This is the lowest level at which the decomposition is carried out of the system. The question is how far can this decomposition go? The answer to this question is in the practice and not in terms of the systematic approach. Choosing where to stop the decomposition of a system is only in the hands of researchers who have to make that decision, complying with certain conditions, and the types of results that will be obtained out of the analysis. These are primarily qualitative results corresponding to the probability of top event. In this case, the data will be the likelihood of failures that are available and will determine the level and depth of analysis.

6.2.2.3. Primary events-types

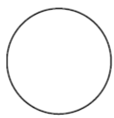
Normal events - events that can be carried out with a high degree of probability as it is unthinkable to occur during normal operation of the system.

Schematically presented as house:

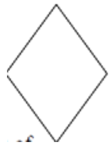


Basic events - events whose occurrence cannot be predicted with certainty - they are most often associated with failures composed of specific elements called primary failures. These are internal events that may arise during the operation of the system (eg. fuse).

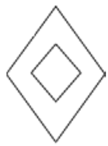
They are displayed with a circle:



Basic pseudo-events, their name suggests, that these events can also be decomposed. They are almost never associated with an error in the data or the accuracy of the statements which concern them

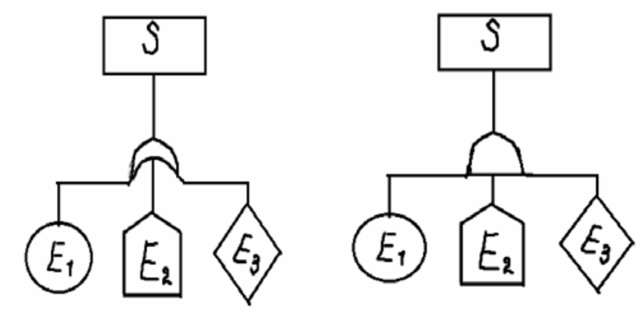


After these events exist, they show that their contribution to the development of the top event in many cases cannot be ignored and may not be taken into account when processing the Fault Tree analyses, or they are not included there. These events may report another type of failures that affect the main event, presented with a diamond if they can further be decomposed or double diamond, if it cannot be decomposed further.



6.2.2.4. Typology and graphical representation of the ports

There are two fundamental types of ports "AND" and "OR".



Port ”OR” is marked with a crescent. To realize the top event S is necessary to realize at least one of the events E1, E2 or E3.

Port "AND" is marked with a semicircle. To realize a top event S is necessary to realize simultaneously the events E1, E2 or E3.

There are combo port, between both "AND" and "OR" ports.

6.2.2.5. Procedures for the construction of fault tree (FT)

The construction is preceded by two phases:

a. Definition of the system - define the exact boundaries of the system, its purpose and objectives. Examine the environment of the system and its possible impact on the system.

b. Definition of the adverse top event, this is the event which generally "will impede the implementation of the system objectives" It must be defined precisely because its choice is the basis for the entire analysis of the FT and determines the efficiency of the system.

6.2.2.6. Rules for constructing of FT

"What – “When" Analysis should be oriented mainly to determine the top event and secondly to intermediate events, having in mind what is the top event and how it is manifested.

Classification of events on the basis of "error of the elements of the system" and "system error". After the specifically defined intermediate event, before the decomposition of the system will be proper to answer the following question "Does this event concerns the system or concerns, a system’s component?". If the answer is "concern element of the system", this event is under the port "or". In case of failure due to incorrect command, the system’s elements does not perform very concrete functions, for example one of the possible ways for a failure to happen as a result of not performing the accurate function is when there is a wrong command from the operator or because of internal failure of another part of the system. If the answer of the above question is "an element, which concerns the system" then it is classified under “error concerning the system”. The easiest way in which the two categories of events can be distinguished is to determine where "originally" comes out the energy that generates the error. If the reason is external to the element of the system, in this case we speak for an error that affects the system.

Application of the term "momentary reason" You have to clarify all reasons with momentary effects on the events affecting the system.

Between two ports may not have a direct connection, must describe all inputs of ports in the form of certain events. Not following this rule leads to incomplete understanding of how the system works and inaccurate analysis.

6.3. Case study with failures of an example of vessel Scheduling

The specification of pressurized vessels consists of drawings, description of the sequence of operations in the design of the vessel. Taken separately the drawing does not give an adequate picture of the vessel. In the chemical and petrochemical industry, the specifications of the vessels are taken from the technological scheme. Therefore, the specification is done by the designer, who in most of the cases is chemical technologist. The design of the vessel is usually performed by a mechanical engineer.

The specification includes the following parameters:

1. Total internal volume;
2. Volume and weight characteristics of the content;
3. Description of the contents including possible impurities in the different phase states (liquid, gas);
4. Working pressure;
5. Approximate dimensions and geometry;

6. Orientation (vertical, horizontal);

7. The range of temperatures in normal operation and in case of accident;

8. Location (room and outside the room);

9. Availability of thermal insulation;

10. Size and location of the pipelines associated with the vessel;

11. Equipment - including an emergency waiver of the pressure, control instrumentation, drencher systems and others.

In many cases pressurized vessels are not used as reservoirs but as apparatus for instance, this can be a rectification column, a steam boiler, heat exchanger or a reactor.

6.3.1. Choice of construction material

For the majority of the pressure vessels, working in conditions of high temperatures is used different brands of carbon steel, and in case of working in low temperatures - steel with copper, brass, aluminum. When using carbon steel for vessels, working with liquefied gas is essential to regard the temperatures in which there is a phase transitions in the steel.

6.3.2. Phase transition temperature in steel

When developing pressurized vessels there should be done everything necessary for prevention of the possible destruction, since such destruction as opposed to plastic flow appears suddenly and sharply.

It is known that the steel, which is plastic under normal conditions at low temperatures sometimes, is fragile. According Tilsh, the majority of cases in which there is a rupture of the steel because of it being fragile happens in ships and bridges.

Some of the pressurized vessels are destroyed following the scheme of the fragile mechanism; there are cases when this mechanism led to the destruction of pipelines. Destruction which Tilsh called "shocking fragility" is distinctive for the fragile materials that have cracks, hitch or other problems. Such destruction could happen and because of defects in the seams when applying loads below the limit of turnover. Tilsh brought as an example 10 specific cases of fragile fracture of vessels in the chemical and petrochemical industry. The temperature of the phase transition he defines by following form. The temperature of the phase transition of the steel -this is the temperature above which the steel behaves advantageously as a plastic material, and below which as advantageously fragile material.

The behavior of the construction’s materials such as metallic and non-metallic materials are discussed in details in the book / Wigley, 1978 / in the description of the test of Sharpy about the formation of cracks. Sharpy’s test gives us information also on the work, done on strengthening of materials.

As an illustration of the behavior of steel at low temperatures may bring the following example. The lowest air temperature in England is about - 18 °C, however, the leakage of liquid propane from a vessel made from mild steel even at ambient temperature may cool the wall to – 40 °C, which is below the temperature of the phase transition of the soft steel.

The Table 6.7 illustrates the dependence of the strength from the temperature for structural steel. From the above written information is obvious that the soft steel is totally unsuitable for storage of cryogenic fluids.

Table 6.7. Low temperature limit for the transmission from plastic to a fragile demolition of the different constructive materials

Low temperature limit, °C	The material its code within ASTM	Comment
-18	Soft steel A53, A120	Not suggested for special

Risk of failure of a pressurizes vessel carryng capacity pressure, according the committee of advisers on the main hazards (CAMH)

Low temperature limit, °C	The material its code within ASTM	Comment
		use
-23	Soft steel A53, A106, A135	Sharpie´s test > 20 J
-45	Carbon steel	same
-100	Steel with 3,5 %	-,,-
-195	Steel with 9 % (A353)	-,,-
-250	Stainless steel	Irregular dependende
No limits	Copper, aluminum, brass	same

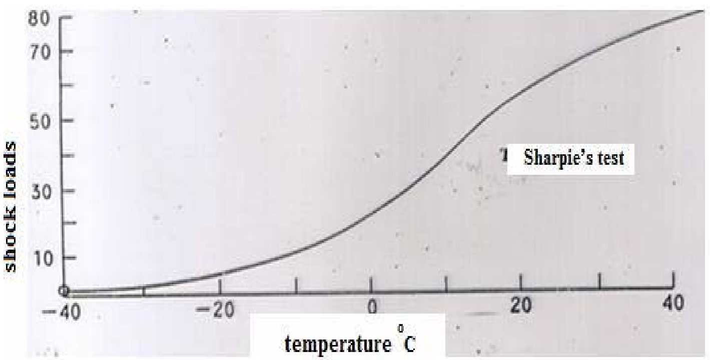


Fig. 6.8. Dependence on the stroke of structural steel in a pressurized vessel by the temperature

6.3.2.1. <u>Other materials</u>

In some cases there is a need for the development of multilayer walls. The reactor for the synthesis of caprolactam of the company Nypro Works in Fliksboro which worked at a temperature greater than ambient – 130 °C. The vessel's wall is multilayered and is made of 12 mm mild steel sheets between which are placed stainless steel sheets with a thickness of 3 mm. The purpose of this combination was the matching of the expensive corrosion-resistant stainless steel with a relatively inexpensive mild steel.

6.3.2.2. Specific problems associated with certain substances

Chlorine, if used in steel structures must be dry. If there is a case in which the water mixes with it (eg. From the remains of water after hydraulic controls) it leads to corrosion. For example N_4HCl in contact with certain steels can make them fragile.

6.3.2.3. Design, inspection and development

Design - pressure tanks are designed in accordance with the specification and any deviations of them lead to design errors, which can lead in certain circumstances to a failure. Ignoring the standards can lead to an accident. In the design process changes are done only in the direction of improvement and increase of reliability, a special emphasis is put on the internal check (inspection), because it can be a reason for amending the specification.

Preparation - the preparation must be done according to the prescribed technology in accordance with the standards.

Inspection - the standard provides methods that need to perform verification of the vessel. They includes non-destructive control methods (radiography and ultrasound). The Radiography method is extremely effective in determining the volume defects such as caverns formed by welding. The ultrasonic method is less effective for the control of cracks.

Defects in the surface can be determined by magnetic powder coating or paint. Some tests for pressure verification are obligatory. The standard introduced in Bulgaria/BS, 1982/recommended the hydraulic tests as an alternative of pneumatic although the latter are allowed in those cases where, under certain conditions, hydraulic tests are impossible.

Table 6.8 Relation between the work of destruction and various pressures

Pressure, bar	Wa/Ww·10^3	Pressure, bar	Wa/Ww·10^3
2.4	0.6	26	2.25
5.8	6.4	67	1
13.6	4.	135	0.56
1.9	2.8	400	0.2

W_a – the role of the air in the demolition's process
W_w – the role of the air in the demolition's process

It should be borne in mind that the water is very dangerous at elevated pressures. At any time during the test there is a possibility for a destruction and the development of a dangerous leakage. To avoid the destruction in a fragile manner, it is recommended to carry out studies at a temperature greater than 7 °C.

According to the standard/BS, 1982/the test pressure is:

$$Pt = 1{,}25 \,.\, P \,.\, \frac{f_a}{f_b} \,.\, \frac{t}{t-c} \tag{6.1}$$

where:

P_t – test pressure;
P – project pressure;
f_a – nominal design load in testing temperature;
f_b – nominal design load in project temperature;
t – nominal width of the wall;
c – corrosion allowance.

The pressure test should be conducted for 30 min. For the hydraulic testing is preferably to use water due to its small compressibility. Of course the water creates difficulties in those cases where traces of water may serve as a cause of corrosion. In these cases there should be used other liquids even if their contraction is greater.

The standard warns of the dangers in testing of special steel tanks if the water contains chlorides. The use of sea water in the Persian Gulf recently led to a failure in a vessel made of stainless steel due to a microbiological corrosion. The vessel which was a subjected to hydraulic test should stay opened for several fills to ensure the absence of an airbag.

Chapter 7

MAJOR TECHNOLOGICAL RISK. FIRES. EXPLOSIONS.

7.1. Fires

7.1.1. The process of combustion in case of fire

Burning is every physicochemical process, which is characterized by three features:

- Chemical conversion of substances;
- Heat emitting;
- Emission of light.

The main requirements, which have to happen for the sake of the realization of the combustion process, are three: combustible substance, an oxidant and a source of ignition. These three conditions are necessary but not sufficient for combustion, as they should have quantitative and qualitative correlation.

Combustible substance and the oxidant (chlorine, bromine, sulfur, oxygen, oxygencontaining substances) are reactants in the combustion process. The combustion of substances may take place not only in the oxidizing environment in the presence of oxygen, but in the presence of other oxidizing agents. For example, the sulfur is burning in the presence of chlorine.

However, to occur, combustion process it needs on the first place a source of ignition.

This may be the flame, spark, the hot surface, etc., or the heat development of any other kind of form of energy - chemical (exothermic reaction), mechanical (stroke, compression, friction) and others.

7.1.1.1. __Flame__

For continuous combustion, the flame plays an important role, because this is the volume at which the chemical interaction between the reactants happens. The flame represents the gas volume, which became a burning vapor and gases, in which is released: heat, products of combustion and light. With a flame burn only these substances which upon heating are able to be decomposed or evaporated to produce vapors and gases. The ability of the combustion substances to form combustion products or to heat up has important practical significance to extinguish fires. This allows almost unerringly to determine the nature of the burning material and accordingly to apply one or another way of fighting. Depending on the fact whether the flame is seen or not the fire can be open and hidden. Open fires are those in which the flame is visible from outside or after entry into a building or room and hidden fires are those which can be detected after ripping off structures, plaster, paneling and more. The combustion may be with a flame or flameless.

7.1.1.2. __Flame combustion__

The burning substance in the form of dust or gases form with the oxygen a flammable system and the flame is the volume in which these oxidation processes are performed. The flame is characterized by height (torch), temperature and color.

The flame height (size) depends on the intensity of introducing of the substances, and the amount of flammable vapors and gases involved in combustion. Flames can reach up to 120 m of torch.

The closest distance at which you can stand in this case is 150-180 m from the site. The temperature ranges from 1,000-1,100 to 3,000 ^{o}C, depending on the type of the burning material.

When burning metal powders (termite powders) temperature is 3,000 ^{o}C. When pyrogenic substances burn the temperature is about

2,500 ^{o}C. When you burn oil products temperature moves at the range 1,200 - 1,350 ^{o}C.

Combustion happens at a certain speed. The velocity of combustion of various materials in a fire is different. It depends on the type of the burning material on the physical condition and the presence of oxygen. By reducing the amount of oxygen in the room in case of fire, the burning rate can be reduced. In case of a fire burn solid, liquid and gaseous substances. During the fire, the physical conditions of the substances may vary - solids pass into liquids (resin, rubber, wax etc.), liquids in gases (petroleum, easy combustible and combustible liquids etc.).

The rate of combustion of the solid combustible substances depends on the specific surface and the degree of humidity. By increasing the humidity of the combustible material is reducing the rate of quenching, since a part of the heat necessary for combustion is consumed for evaporating of the water.

The burning rate of the fluid depends on their ability to evaporate. Light oil burn relatively stable and peaceful as a torch or flame of the free (mirror) surface of the liquid. When there is burning of dark oil their burning rate may be amended at the expense of explosive boiling over or the disposal of flammable liquids, which complicates the whole situation in the combusting processes. The burning of the gas substances occurs as a torch or explosion. It is observed in case of departure of the combustible gas under pressure. The combustion in the form of an explosion takes place in conditions of pre-forming concentration of a mixture of gas and air.

In case of combustion is released heat. The main heat source is the flame or more specifically its illuminating part. The amount of heat released during combustion depends on the amount of combustion products, the rate of combustion of these substances, and their heat transfer capability. Simultaneously with the release of the heat in the combustion process is carried out its dissipation.

*7.1.1.3. **Heat transfer***

Heat transfer in a fire is carried out in three ways:

- by thermal conduction;
- by convection;
- by radiation.

Thermal conductivity as a way of heat transfer is characteristic for solid and liquid materials. In a fire the heat is transferred from one room to another through the building structures, metal rods, tubes and more.

Convection as a way of heat transfer is based on the movement of the heated gaseous and liquid masses. In case of a fire, the combustion products and air absorb and relate to the surrounding atmosphere a significant part of the heat. Part of this heat is transferred to the combustion products, which are in the path of the convection flows and prepare for fire or ignite.

For fires in confined spaces - basements, bunkers steamers, dryers and more, the emitted heat from combustion is not transmitted outside, but accumulated from building structures, materials, air, combustion products and other present in the room. Such fires are characterized by high temperature in the burning room, which has a detrimental effect on the actions of the fire fighting activities and personnel.

Heat transfer by radiation (radiant heat) is based on the distribution of thermal energy in the form of electromagnetic waves. The amount of heat transmitted through radiation depends on the temperature of the flame and its dimensions. Radiant heat is distributed in all directions, making the extinguishing of the fire quite difficult and at the same time creating conditions for its spreading. The largest quantity of the radiation is transmitted perpendicular to the front of the flame. Depending on the amount of deviation from the perpendicular direction, the radiant heat is reduced proportionately. Absorption of heat by the combustible materials cause their heating, preparing them for ignition or self-ignition, which depends on the properties and the surface, the time and intensity of the radiation.

Through the magnitude of the radiation, which causes pain in the unprotected parts of the human body, is determined the minimum distance from the flame to a human. This safe distance is the coefficient 1.6 multiplied to flame height (R = 1.6N). Or if the flame height is 12 m one can operate safely from a distance 19.2 m.

The intensity of the absorption of radiant heat is dependent on the color of the materials and their surfaces. Bodies that have white color, reflect much of the radiant heat back, on the contrary the black ones absorb almost all radiation. Smooth and polished surface also reflects some of the radiant heat but the rough one swallows it almost completely.

7.1.1.4. <u>Combustion products in fire</u>

Combustion products are the gaseous, liquid and solid substances which are formed as a result of the coupling of the burning substance with oxygen. Their composition depends on the physico-chemical properties of the burning materials and on the conditions under which combustion occurs. As a result of the combustion products, remain materials, which may be in three physical states. In the solids the combustion depends on the humidity, the dispersibility, on the weather conditions.

The different oil products burn in different ways – the light petrol, the diesel burn like a candle, the dark - burn fuel oils, burn by overheating (due to the fact that as a result of the combustion process is released heat.)

7.1.1.5. <u>Reasons for fire starting</u>

The reasons may have different nature, some of which, not able to be classified.

1. Technological reasons - may arise from a breach of the technology industry and this is the most common reason. In most of the equipments there is an automatically controlling, dosing, etc., but no matter how secure the system is, it gives deviations and if not monitored often leads to fatal consequences.

2. As a result of wearing of some parts of the equipment

3. As a result of the aging of the parts of the equipment:

- As a result of aging of the technology and precisely the technological equipment.
- Scheduled repairs. One repair is often associated with the suspension, and that is why sometimes these repairs are neglected and as a result there is a failure and combustion occurs.

4. Other reason for fire starting is the electric installations. Fires arise from:

- short circuits;
- electrical overload in the plant or equipment - all installations are calculated by the amount of the current we can draw from the installation, the wires are sized according the work load on a certain surface and if the load is bigger than expected cause overheating of conductors;
- arcing in the contact device - heating appliances (iron), fans, refrigerators;
- large transient resistances;
- heating devices;
- stray currents - means that we do not have good grounding. These currents are obtained as a result of improperly laid rails of the railway and tram lines in the failure of power cables and wires for lighting. They are the reason for corrosion in the plant or the equipment no matter of its position-above or below the ground;
- static electricity - in any process where there is a dynamic interaction, such as mixing, atomization, crushing, moving through pipelines, machining of dielectric materials could be formed

electric. charges. In hazardous industries the use of equipment or installations, the work of which is accompanied by the formation of static electricity without protective devices, is not allowed. The main method of protection is the grounding;

- the Atmospheric electricity (lightning) - is an air break between two clouds or between a cloud and the ground.

5. Negligence as a cause of fire – cigarette, intentional burning of cars and more.

7.2. The process of combustion in case of fire. Characteristics of fires. Taxonomy of explosions

7.2.1. Characteristics of fires

The dissemination of fire is actually its movement in time and in this situation the most important question is how fast.

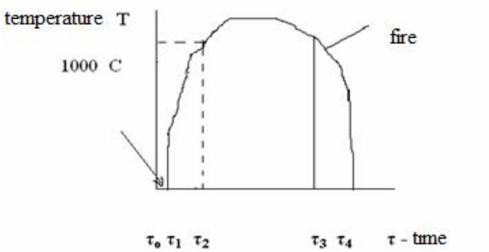


Fig. 7.1. Disseminational and non-disseminational fires [30]

The speed of propagation of fire most often corresponds to the speed of the chemical reaction.

To be effective, we have to take actions at this point from 1 to 20 min, after that the temperature is rising suddenly to 1,000 ^{o}C it is called a temperature shock.

7.2.2. Pathways of fire dissemination

When we have fires in buildings on the greatest influence on their spread has the building design. At the beginning fire occurs in one room and then spreads or the spreading of the fire increases the area of the fire. The main reason for the development of fire is the emitted heat. Effect on the speed and the direction of fire in buildings have also the fire resistance of the building structures, the number of rooms. When the building has a single storey the fire spread mainly horizontally, while cover the entire room. If the building is multi-storey the fire spreads in both horizontal and vertical direction. Main ways for the spread of fire in buildings with non-combustible walls are the various openings in the walls and trimmer, windows, doors, staircases, lift shafts, ventilation and others.

The spread of fires also depends on the quantity and the physical state of the combustible materials, on the emitting and transfer of heat and the conditions of gas exchange. An influence on the fire spread has the weather - rain, wind, air temperature.

7.2.3. Ways and means to terminate burning

Example - fire station Ezerovo near Varna (two tanks with propane butane exploded on a railroad. Torn hose caused a spark, which led to an explosion. Later exploded the second tank of the composition.)

Table 7.1. Basic methods for termination of fire

Ways to terminate the combustion	Methods for termination of combustion
Cooling the combustion zone or burning substances	1. Cooling through laying out on the surface of fire extinguishing substances (FES)
	2. Cooling of the burning substances through mixing
	Fragmentation of burning materials and cooling them with FES
Isolation of the	1. Creation of an insulating layer by coating the

Ways to terminate the combustion	Methods for termination of combustion
reactans in the combustion zone	surface of the flammable substances with FES or non-combustible materials
	2. Creation of an insulating layer on combustible materials (CM) by explosives
	Creation of a line to stop the spread of combustion
	Creation of a hermetic closure by closing doors, windows and other openings
Dilution of the reactants from the combustion zone with non-combustion materials	1. Dilution of air entering the combustion zone by introduction in non-combustible vapors and gases
	2. Dilution of CM by layering their surface with easy burnig or decaying FES
Chemical slowdown of the combustion reaction	1. Submission of inhibitors on the surface of the CM
	2. Inserting inhibitors in the air entering the combustion zone

7.2.4. Fire extinguishing means

As fire extinguishing means are described: Fire Extinguishing substances (FES), materials, fire vehicles and their equipment.

The extinguishing materials are divided into two groups:

- means for termination of combustion;
- means of their delivery to the site of the fire, feeding into the combustion zone, and for implementation of other work in firefighting.

Means used for the termination of combustion are normally referred to as FES. They must meet certain conditions, such as:

- To have high effect of extinguishing - at lower cost per unit area or volume of the fire to cease burning;
- to be cheap;
- to be safe for people in their storage and use;
- not to have significant damage to objects and substances subjected to impact.

FES can be in the three physical states, but are used most often in liquid, solid and gas state or as mixtures. The most common FES are: water, chemical foam, air-mechanical foam, CO_2, CCl_4, brom-methyl compounds, dry chemical etc. Water is the most common FES. The main and extinguishing effect is coming from the large thermal absorption capability.

Furthermore, water can be dilute the reactants, isolate the burning material from the zone of combustion and thus contribute to the termination of combustion.

7.2.4.1. Water

Water has one significant disadvantage and it is - at 1,200 – 1,400 ^{o}C water, decomposes to H_2 and O_2.

Water has a lower wetting ability, has a small coefficient of shrinkage.

In practice for extinguishing of fires is used water in which are added different salts, which makes a good conductor of electricity out of it. That is why, when fighting a fire with water, especially in the presence of voltage installations is required compliances with safety technique. Water interacts with some substances as explosion.

7.2.4.2. Foam

Foam is not used for firefighting of electrical installations because it contains water.

The foam is specific dispersed mixture consisting of gas and liquid in the form of bubbles. The extinguishing effect of the foam is mainly explained by the isolation and partial cooling of the surface of the burning liquid. Due to its relatively small weight (0.004 – 0.25 g / cm^3) and stickiness, the foam floats on the surface of the burning structures and materials. Its insulating ability are characterized in two ways, namely:

First: Avoids the release of flammable vapors and gases and their entrance in the zone of combustion;

Second: Reduces the heat transfer from the flame to the surface of CM.

The properties of the foam, on which depends the extinguishing effect are: multiplicity, stability, viscosity and dispersion.

Multiplicity of the foam is the ratio between the volume of the resulting foam to the volume of the starting products. Multiplicity shows how much gas is contained in the foam prepared from a given volume of solution.

Stability of the foam is the time during which 20 % of the resulting foam destroys. The Normative time for this is assumed to be 30 to 50 min. Stability of the foam depends on its type (chemical or mechanical air).

Viscosity (stickiness). The viscosity characterizes the ability of the foam to dispense on the surface.

Dispersity gives an idea of the degree of fragmentation of the bubbles and determining their size. The foam is poly-dispersed, consists of bubbles of different sizes. The effectiveness of the foam to extinguish is determined by the sum of all its properties.

With the foam should not be extinguished Na, K containing substances because they react with water and the emitted oxygen, enhances combustion. Depending on the receipt and content of foam bubbles is: chemical and mechanical air.

7.2.4.3. <u>CO_2</u>

The extinguishing properties of CO_2 comes from the fact that it is noncombustible and can be mixed with reactants. The extinguishing concentration of CO_2 is 22 vol. %, and in some cases may reach 30-35 %. At a temperature equal to 0 °C and a pressure of 36 atm. it liquefies. The liquid CO_2 instantly turns into gas, increasing its volume 400-500 times. In its rapid evaporation, during its turning into gas becomes sharp expansion. As a result, it is cooled and slightly changes to "snow" with temperature -78,5 °C. It is used mainly for fighting through cooling and dilution. Is a poor conductor of electricity. With carbon dioxide can extinguish gas, solid CM, machinery, chemicals, valuables and securities, electric, etc. Best effect, however, is in extinguishing of fire indoors - shafts, tunnels, ship bunkers, workshops, warehouses and others. Weak effect occurs when fighting substances as cotton, paper, wood etc.

The disadvantage of CO_2 is its harmful effects on the human body. In concentrations of 20 % and more can occur paralysis and death. When using CO_2 its concentration is substantially greater need to take measures in the safety measures. Such premises should not be entered without insulating mask or other respiratory protection and protective clothing.

7.2.4.4. CCl_4

Is a colorless highly volatile liquid with a relative density of 1.6 g/cm^3.

Vapors have specific gravity, which is 5.5 times heavier than air. With CCl_4 are extinguished fires mainly from internal combustion engines, electric etc, facilities and installations under pressure, highly flammable liquids in small quantities and others. The extinguishing concentration is 10.5 % by volume. The greatest disadvantage of CCl_4 as fire fighting substance is that at a temperature above 250 °C and in the presence of water vapors it decomposes to phosgene and hydrochloric acid. People, using it should use insulating mask, and after the fire is eliminated the room should be ventilated. CCl_4 should not be used for firefighting of: potassium, which in an environment with CCl_4 and at a temperature of 65 -70 °C explodes and artificial wool, because it can give $COCl_2$ and HCN as a result.

7.2.4.5. <u>Chemical substances</u>

Bromoethyl compounds with high extinguishing effect.

Nitrogen is a Gas without color, odorless and tasteless non flammable, does not support combustion. Used for extinguishing fires of organic matter and where the use of CO_2 is not possible. It extinguish gases and liquids.

7.2.4.6. <u>Dry chemical firefighting substances (FFS)</u>

Dust substances - $NaHCO_3$ and $K2CO_3$ (potash), alum and others. salts. The composition of FFS is different. The most widely used are based on powders $NaHCO_3$ (sodium bicarbonate), $K2CO_3$ (potash), alum and other salts. The extinguishing effect of FFS consists mainly in the fact that they isolate the burning substance or the air from the zone of combustion.

FFS is used primarily for fighting of fires in the early stages of development, but they can be used for extinguishing big fires caused by burning surfaces.

Bromoethyl compounds - metilenbromid, etilenbromid, tetrafluordibrometan, water etil brom emulsion and others.

7.2.5. Conclusion

For the successful extinguishing of fires of great significance is not only the right choice of construction and civil engineering, but also the quantities which should be sent to the combustion zone. Each FFS has its own firefighting properties or there is a fixed norm which ensures termination of combustion. The rate of consumption of FFS is called delivery rate of FFS, which means the quantity of FFS supplied per unit time on unit area or volume of the combustion process. Each FFS depending on the intensity of the submission, the burning properties of substances and other conditions has its speed of fire fighting (suspension of burning). The most effective FFS is the one that has the lowest cost which provides the termination of combustion for minimum time.

Fight fighting to a same place with water and foam at the same time is not allowed, because the water will help to destroy the foam. When extinguish liquids the foam should be fed smoothly without shocks.

7.3. Basic methods for termination of fire.

Bow Tie charts, another way to analyze technological and environmental risks.

7.3.1. Bow Tie charts

Bow Tie Analysis is a qualitative risk assessment methodology that provides a way to effectively communicate complex risk scenarios in an easy-to-understand graphical format and shows the relationships between the causes of unwanted events and their potential escalation for losses. and damage. Bow Tie can display commands, which prevent the Top Event from happening in the first place, specific to each Threat and also recovery measures, which are ready to limit the possible effects once the Top event has taken place, specific to each credible result (Fig. 7.2).

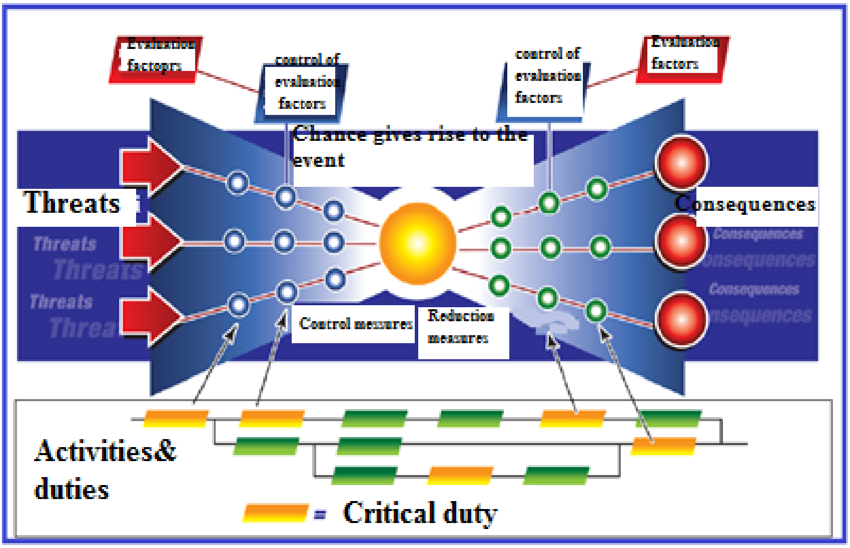


Fig. 7.2. Bow Tie Analysis

The main advantages of the Bow Tie adoption approach (figure 2) in risk analysis are:

- provides a sound technique for comprehensively identifying all risk events and promotes an understanding of their mutual relationships;

- uses a format in the form of an easy-to-understand scheme to communicate cause and effect relationships underlying more complex risk scenarios for a wide range of stakeholders;

- helps to clearly demonstrate the level of control that exists over risks and therefore provides a way to identify weaknesses, gaps and opportunities for continuous risk reduction;

- allows verification and connection to relevant sections of the management system that accept controls (including Critical Security Elements and Critical Safety Activities);

- raise awareness of the workforce about the risks associated with their ease and how they are managed;

- uses the knowledge and expertise of the workforce, which best understands the real state of operation of existing controls and threats.

The diagram example in the Bow Tie analysis below focuses on environmental losses and damage resulting from possible oil spill scenarios for exploration drilling (Fig. 7.3) [9].

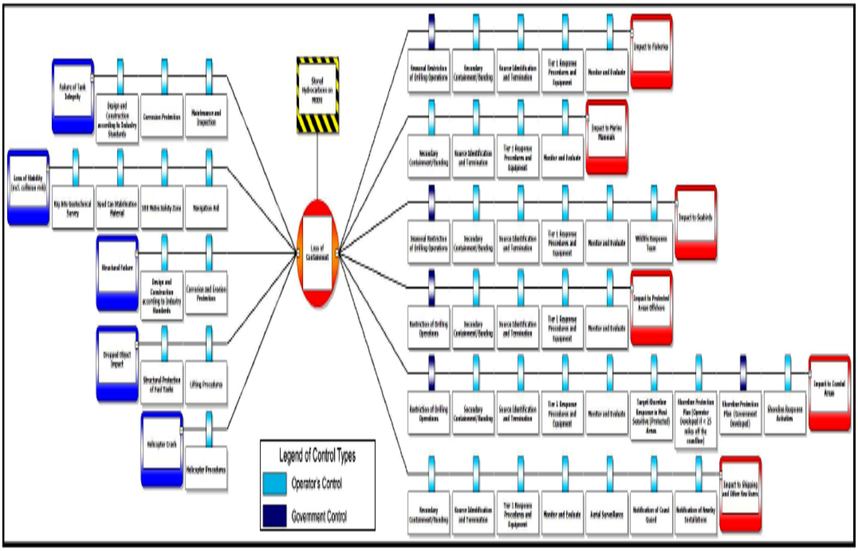


Fig. 7.3. Bow Tie analysis diagram for oil spills at sea

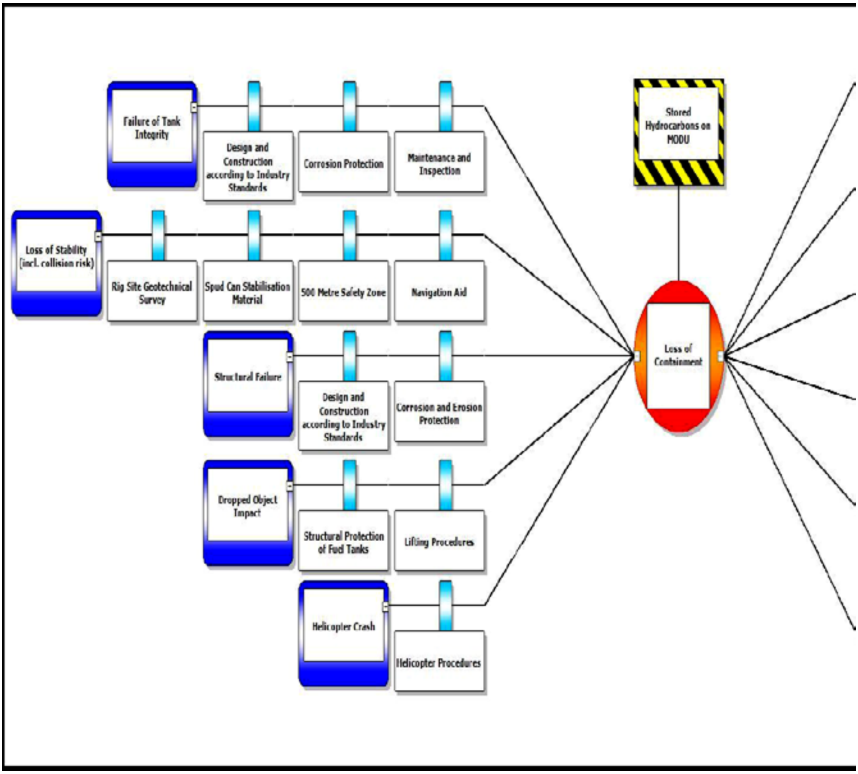


Fig. 7.4. Left Bow Tie chart - threats and control measures for the threat [9]

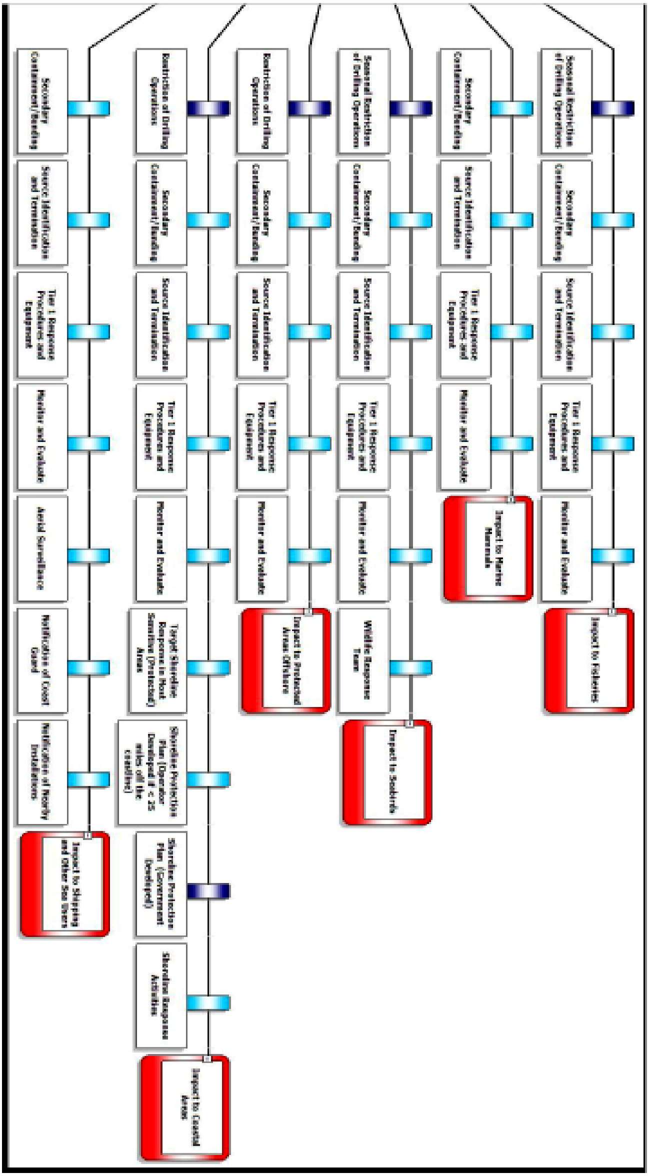


Fig. 7.5. Right Bow Tie chart – recovery measures and consequences [9]

To reach the Bow Tie in figure 7.3, a tool table such as the one shown in figure 7.6 can be used.

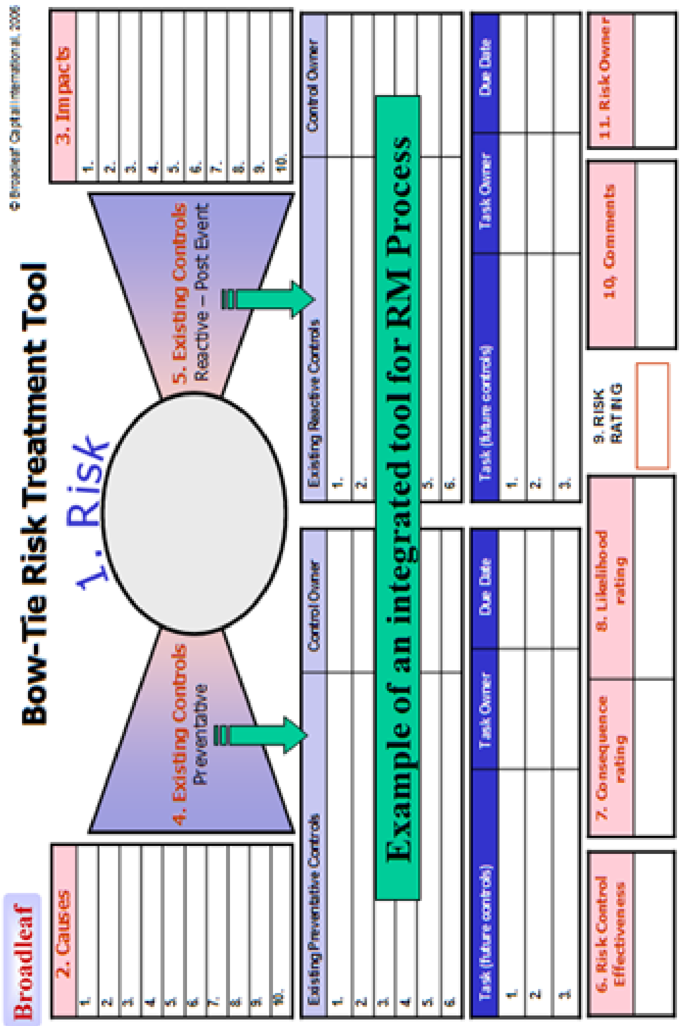


Fig. 7.6. Example of an integrated tool for risk management processes [9], [31], [32]

7.3.2. BLEVE (Boiling Liquids and Expanding of Vapor Evaporation)

Is extremely scary event for storage of liquid flammable products because of the many consequences which BLEVE causes, such as:

- generation of shock waves as a result of the cracking in the vessel due to a sharp acceleration of gases (vapors, inert materials) during their distribution or explosive
evaporation of the liquid, who gave that name BLEVE;

- disposal of small elements or even whole parts of the vessel as a result of the reactive
force caused by the evaporation of the liquid;

- thermal and radiation effects of the fireball and disposal of burning liquid on the ground.

BLEVE mechanism - the mechanism can be represented schematically by the following sequence:

- overflow of a vessel;
- excessively rapid compression;
- explosive boiling.

The concept of tank overflow summarizes two necessary conditions that must be known:

- sealing of the vessel;
- a balanced pressure in the vessel greater than the ambient pressure.

Two major categories of products can cause BLEVE:

- liquefied gases (flammable or not) stored at ambient temperatures;
- fluids exposed to great heat, as in a fire, resulting in increase of pressure in the tank.

Decompression of the vessel - actually the result of depressurization is to allow the fluid to pass from one stable position in unbalanced thermal situation which causes nuclear evaporation i.e almost sudden transition from liquid phase to steam, through the mechanism of the formation of bubbles (nuclei-cores). The rapid lowering of the pressure plays in this particular case, the role of the initiator of the explosion while in other cases its role is more "protective". Only in very rare cases, the sharp pressure drop is almost always, causing by a break in the wall of a vessel.

The possible reasons for the breakthrough could be relevant to the following factors:

- Outside the vessel - an impact of flying objects (explosion in the neighborhood), mechanical shock, thermal or radiation impact (fiery torch, fire);

- Internal for the vessel - corrosion on the wall, fatigue (mechanical or thermal) of metal, impurities in the metal, soldering defects.

It should be noted that the limit of resistance of the metal depends on its temperature, and that during a fire, one of the walls of a vessel is considerably heated. For most steels, a temperature increase of 500 °C causes a reduction of 50 % of the limit of the outbreak, or more precisely the reducing of the pressure drop in the outbreak place.

Fragments and flying parts - as the source of the explosion is initially in a closed environment disposal of fragments and flying parts should be expected. However, contrary to other explosions the typical mechanism BLEVE brings something different regarding the pattern of spreading:

- fragments incurred by the current of the shock wave;

- flying parts (more often in the cylindrical vessels), expelled from the reactive force caused by evaporation of the liquid, as in the launch of an small bomb.

Chapter 8

ENVIRONMENTAL RISK. RISK MANAGEMENT

8.1. Environmental risks

As we already know, risk is not risk without including vulnerability. For example, let's take pollution. Over time, many volcanoes have removed many polluting gases into the Earth's atmosphere. Also, at the beginning of life on earth, the atmosphere was very different from the one we breathe now. And no one at the time was talking about air pollution or the environment or environmental risks. So, the risk appeared with man and will disappear with humanity, while the dangers (natural hazards) will always be there. In conclusion, all risks will affect human beings, directly or indirectly. So all the risks presented in this volume appear in, or are transmitted through air, water, soil or through biological elements, to humans. The causes and characteristics of risk are, however, very diverse. Some are man-made, through the introduction of new technology, products or chemicals, while others, such as natural hazards, result from well-anticipated natural phenomena, such as flooding in a valley or pollution from a industrial factory. Others are completely unsuspected effects at the time of technology or activity development, such as possible effects on the Earth's ozone layer of fluorocarbon sprays or nitrogen fertilizers. Being diverse in rails, environmental risks, as defined here, have a second common feature in addition to being transmitted through the environment. They cause harm to people who have not voluntarily or specifically chosen to suffer the consequences and therefore need regulation from some authorities. These consequences may fall on other groups in the future, such as today, such as the mismanagement of natural resources. The boundaries between environmental and other risks cannot be hard and fast and there are always marginal cases. Given the above, we can see that risk is a complex issue. When we say environmental risks, we are not just talking about a risk, we are talking about a danger that is being addressed, about vulnerability, in one way or another. This vulnerability is often subliminally understood, but we need to know that it is there and that it is the most important part of the risk.

8.2. Characteristics of environmental risks

Environmental risks have a set of characteristics.

These include:

1. Risks involve a complex series in the relationship between causes and effects. They are connected from source to impact in ways that involve environmental, technological and social variables, which need to be modeled and understood concretely.

2. The risks are connected to each other. Usually several risks occur simultaneously in the same country, region or city and require skills to compare them and make compromises or make balanced decisions about how much one risk is accepted in relation to another.

3. Risks are linked to social benefits, so a reduction in risk usually means a decline in social benefits resulting from accepting the risk. The social benefits of different risks are interrelated or may be very similar.

4. The risks are widespread in the world and concern several countries, both developed and developing. They appear in both industrial and agricultural sectors of the economy. There are advantages for nations, therefore, in comparing risk approaches in the context of environmental management.

5. Risks are not always easy to identify and sometimes the identification takes place long after serious negative consequences have been felt. There is no merit in comparing the ways in which different risks arise and are recognized.

6. Risks cannot be measured accurately. Due to their probabilistic nature it is always a matter of estimation. Risk estimation methods have underlying similarities that can be described and improved.

7. Risks are assessed differently in social terms. Thus, a risk considered serious in one place can be considered negligible in another. It is important to understand what similar risk assessment processes can give rise to such different conclusions [34].

8.3. What environmental risks are important?

Many of the environmental risks that have received the public's attention follow urbanization and industrialization; they are risks related to economic development. Not surprisingly, these risks were most often associated with those regions that are already heavily industrialized. Although risks, such as air pollution and toxic metals in food chains, may be more severe in developed countries, they are growing rapidly in the urban-industrial environment of developing countries.

Other risks are more prevalent in the poorest countries - those arising from malnutrition, inadequate housing and sanitation and the like, but they are not lacking in richer countries. Some risks - for example, unsafe water supply - are serious in both developed and developing countries, but for different reasons: contamination with small amounts of carcinogenic industrial residues in one case, and bacteriological contamination in the other. There are insufficient data on the incidence and impact of different risks to quantify the relative importance and severity of the world. Even if such data existed, they would not give a reliable indication of priorities on a global scale, because it is in the nature of the risks and benefits that their relative values are very differently assessed from country to country. A surrogate measure for the magnitude of risk is life expectancy. Since life expectancy is known to be much lower in some countries than in others, it can be inferred that the significant risks in these countries should be given some international priority. An indication of where important risks are thought to lie means that they are acquired from a list of international monitoring activities. The list in table 8.1 below therefore gives an idea of priority risk areas in terms of what is considered important to monitor internationally. This can be compared with the list of "priority pollutants" indicated in table 8.2. Here, again a group of scientists at international level tried to make a list of substances and indicators of environmental stress considered to be of priority interest [33], [34].

Table 8.1. List of international monitoring activities related to environmental risks [33]

General monitoring areas	International monitoring activities
Ecological monitoring	Soil degradation-global Tropical forest area pastures Sediment discharge into the river World Glacier Inventory The concentration of isotopes in precipitation
Biosphere	Sampling and monitoring of wildlife Impact of pesticide residues Living marine resources
Polutants	Air quality monitoring - worldwide Transmission of air pollutants in Europe Water quality - worldwide Eutrophication in inland waters Contaminants in food and feed

General monitoring areas	International monitoring activities
	Pollutants in liquids and tissues The composition of human milk Pollutants in human hair Ionizing radiation
The climate	Climate variability World weather/clock forecast Solar radiation Atmospheric ozone Climate change Mass balance and glacier fluctuation Air pollutants
Oceans/seas	Pollutants from regional seas: - Mediterranean - M.Nordului - M.Baltică - Oc.Atlantic NE and NV - Open ocean waters Marine oil pollution River discharge into the sea Selection of background levels of pollutants
Natural disasters	Tropical cyclones Tsunami information Flood forecasting

Table 8.2 Main pollutants

Substances and indicators of environmental stress that are potentially important with	1. Sulfur dioxide and sulphates in the air 2. Suspended particles 3. Carbon monoxide 4. Carbon dioxide and other traces of gases that affect the radiative properties of the atmosphere

respect to direct and indirect effects on humans and the biosphere [33]:	5. Nitrogen oxides in the air 6. Ozone, photochemical oxidants and reactive hydrocarbons 7. Polycyclic aromatic hydrocarbons 8. toxic metals, especially mercury, lead and cadmium 9. Halogenated organic compounds, in particular DDT and its metabolites, PCBs, PCTs, dieldrin and short-chain aliphatic halogenated compounds 10. Asbestos 11. Petroleum hydrocarbons 12. Toxins of biological origin (from algae, fungi and bacteria) 13. Nitrates, nitrites and nitrosamines 14. Ammonia 15. Selected indicators for water quality: biological oxygen demand (BOD), dissolved oxygen (DO), pH, coliform bacteria 16. Selected radionuclidesAlergeni din aer 17. Eutrophication elements (eg nitrates and phosphates) soluble salts of alkali metals and alkaline earth metals 18. Soluble salts of alkali metals and alkaline earth metals 19. Other substances that have caused significant environmental problems locally in the past, such as arsenic, boron, elemental phosphorus, selenium, and fluoride 20. The noise 21. Waste heating

Another approach to finding out about the environmental problems we face is to ask national governments what they consider to be environmental risk issues that affect them.

A study was conducted by the International Union for Conservation of Nature and Natural Resources (IUCN), in collaboration with the United Nations Environment Program (UNEP). Sixty-three developing countries were asked to assess the risk category of problems in their countries.

The information therefore produced references to the number of national governments recognizing these issues and not to their overall magnitude, either in extent, or socio-economic impact.

The twenty most commonly reported causes of environmental risk are listed below in figure 8.1 [14]. Soil loss through erosion or depletion of fertility is reported by almost all countries, with deforestation in second place.

The most common risks, therefore, from the point of view of national governments, are primarily those of depletion of resources (such as loss of wildlife, depletion of fish stocks, soil erosion, overgrazing, deforestation and the like), habitat (poor waste and sewage, domestic water supply), and pollution risks (air pollution, oil pollution through oil and disposal of industrial and toxic waste).

These are all risks that can be exacerbated by the processes of development of agricultural expansion, industrial development and population expansion in cities and rural areas, on the ground.

Figure 8.1 shows, in particular, the environmental risks (direct example of the IUCRISKMAN project (www.iucriskman.eu) - prevention of ecological and technological risks in the Black Sea (highlighted in red/yellow).

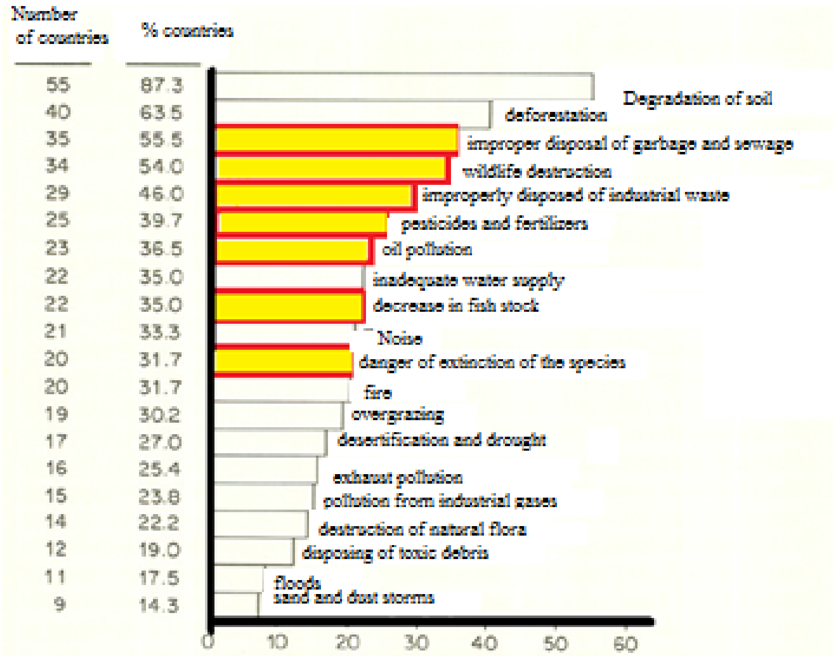


Fig. 8.1. Major environmental risks in 63 countries developing [14]

8.4. Why we need management of environmental risks

The environment is a broad concept that describes our biophysical surroundings. It includes air, water, soil, and living organisms such as plants and wildlife. Another definition would be: it is the sum of all external conditions that affect the life, development and survival of an organism, [38].

The emphasis given by scientific research on environmental issues has highlighted many gaps and deficiencies in the knowledge we have in the field. The pressure of events shows, however, that important decisions on the environment and development are being made now, rather than at an indefinite time in the future. To do this involves making decisions in conditions of risk and uncertainty. The concept of risk has therefore become essential for the environmental management process.

A sufficiently safe, or less risky, course of development would be one that would avoid the dangers of collapse through unsustainable development. In other words, it is about development compatible with the environment - or ecodevelopment/ecodevelopment. It would also reduce or reduce to an acceptable level the unwanted side effects, for those at risk, but also for those who create risks and those responsible for managing them. Choosing a "best path" for development involves not only questions about the total amount of risk, but also the distribution of risks among the population.

Thus, risk management is essential for the ecodevelopment process in two ways. First, it is necessary to ensure that the risks taken will not undermine or nullify development objectives. Second, both the benefits and the risks should be distributed in a socially acceptable way. Companies differ greatly in the range of risks they face and in their priorities.

It is becoming increasingly clear that the assessment of all environmental risks is as serious and important as a responsibility in developing countries and in the most heavily industrialized and largest income nations. Indeed, developing countries are now experiencing rapid industrial evolution or the widespread expansion of commercial agriculture is leading to particularly difficult situations. They demandingly combine some of the traditional risks with natural hazards and resource depletion with the new pollution and technological risks associated with modern industrial development and agriculture. Paradoxically, the more successful the process of economic development, the more likely it is to generate new risks, at the same time, in addition to the "traditional" areas of risk of soil erosion, deforestation, desertification. and natural hazards. Moreover, rapidly developing nations are strongly attracted to the flow of trade and international goods, learn that the standards and regulations set elsewhere for the protection of the environment and human health can have a profound and lasting effect on their development. Sometimes these regulations are appropriate to their needs, but often they are not.

Therefore, environmental risk management raises questions for all nations, both in their own internal or external affairs and in relation to others in the family of nations. This report is therefore not addressed exclusively to one group of nations or another. It seeks to elucidate the issues of environmental risk assessment, especially in its international dimensions, and to show how it relates and fits into the decision-making process in economic development.

There is a great deal of scientific information on certain environmental risks. It comes largely from countries rich in scientific and technical workforce and established research institutes to look closely at environmental risks. In addition, international organizations use this wealth of scientific information to establish or suggest international standards and guidelines. It is not wise, however, for a national government, because a risk has been identified, assessed, and a standard set in one or more countries, to assume that this assessment will automatically apply in their own country.

The consequences of risk vary from place to place, both in a scientifically measured way and as perceived by the local population. However, when the scientific workforce, management skills and institutional capacity are in small quantities, this can be a misallocation of resources if one invests with great effort in research on the toxicity of industrial effluents or the ecological effects of pesticides, in if this was done elsewhere.

Independent risk assessments do not necessarily require the replication of all scientific work needed to assess the risk. Risk management needs resources - money, skilled labor, and time - and is itself associated with the risks of cost, delay, and inaction. Risk management is not, however, a completely new or unknown exercise. Governments are already weighing the risk of depletion or depletion of fish activity while setting up the construction of new fishing vessels, and farmers have widely assessed the risk of drought or parasitic infestation while planting a particular crop.

Environmental risk management is only part of a much larger set of governmental national needs and priorities. Social and economic development often leads to the introduction of new processes and products, as well as to the development of areas at risk, without any consultation with risk assessors or environmental scientists.

The environmental risk manager, at a high ministerial level or as an individual technician, must compete with other requirements of a nation's resources and attention. Often, it will face risks whose origins lie deep in social habits and history, and therefore cannot be improved without more far-reaching changes than can be embraced by environmental management alone.

The factors that are taken into account in any decision must be clearly stated and, where appropriate, the risks involved. The consequences must be explained and understood by both the authorities and those involved in the risk before they are (knowingly) accepted. Only in this sense would we be on the road to more efficient risk management and a safer and more prosperous future [34].

8.5. Risk assessment applied to environmental issues

8.5.1. Case analysis - the case of hydrocarbon pollution in the Black Sea

Vulnerability is a relatively new concept and addresses not only the vulnerability of human communities on the coast, but also the vulnerability of the environment, states and all other stakeholders [14].

Capacity means the ability to prevent more than the ability to cope/intervene after hydrocarbon pollution. Capacity is closely linked to vulnerability; When we talk about the capacity, we are talking about the authority (or lack of authority) to impose the legislation, about the very existence of this legislation. Capacity is not just about standards and legislation. It could also refer to the financial source of using different technologies and methods that create a strong and resilient environment, but also to the financial power to stop an oil spill from spreading (here the technologies vary from simulation tools of computer oil spills, to the use of specially designed powders and floating devices to neutralize and collect oil).

The idea of stakeholders (stakeholders) should also be presented here. By definition, a stakeholder is an entity that may be affected by the results in which it is said that they are stakeholders, that is, those in which they have a stake.

Oil pollution in the sea/ocean affects the environment, communities, businesses, in different quantities. So, the parties involved in this case may be different institutions of different states, environmental control and conservation organizations, affected environment, the polluting entity in the rails [4].

These concepts explaining risk (probability, vulnerability, capacity) and stakeholders need to be analyzed together and interconnected (see figure .2).

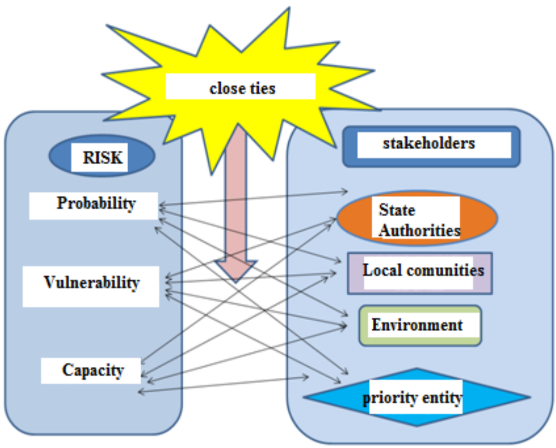


Fig. 8.2. Interconnection between risk elements and stakeholders.

For example, probability depends and can be affected by stakeholders. For example, the environment that an interested party may be a factor affecting probability (high wave weather can lead to marine accidents); it can also influence the idea of vulnerability (a strong, resilient clean environment is stronger and can recover faster than a weak environment); capacity is also influenced by the marine environment in many ways.

Another important issue to discuss here is the time because when it comes to oil pollution, in order to have a real and lasting prevention of the risk of oil pollution, most of the actions must be targeted not after the time of oil pollution, but before. Here we start talking about the disaster management cycle [5].

The idea of a disaster management cycle applies to any oil pollution in the Black Sea, because any oil pollution, no matter how small, is a (small) disaster. And a one-square-foot oil slick is a disaster for a tiny part of the environment.

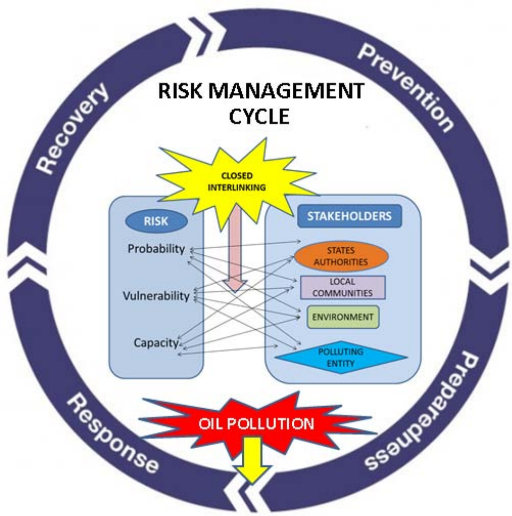


Fig. 8.3. Risk and stakeholders are included in the risk management cycle [1]

Figure 8.3, oil pollution = Oil pollution, Recovery = Prevention, Prevention = prevention, Preparedness = preparation, Response = response [1]

As can be seen in figure 8.3, the risk management cycle has four stages: response, recovery, prevention and preparedness.

The circle in Figure 8.3 is better seen as a spiral. After oil pollution of the sea occurs, stakeholders take action (response, recovery, prevention and preparedness), not only to recover and return to the pre-event situation, but to be better prepared for a possible future event.

Of course, the idea is to get an ALARP risk level (as low as possible - as low as reasonably possible).

If the action is clearly organized and focuses on prevention (before), rather than intervention (after), we can talk about sustainable development.

In this way, all parties must be interested in taking part in the effort and also reaping the benefits of this sustainable development.

Sustainable development is effective when, after a disaster, stakeholders cope, recover quickly and move (evolve) in the spiral of the risk management cycle.

On November 12, 2007, severe winds of 100 km/h, with waves of almost 5 meters in the Black Sea and the Kerch Canal - destroyed in the Russian oil tanker "VOLGONEFT 139" and caused the discharge of almost half of the cargo into the sea. ship's oil -4,800 tons of oil.

Other ships were affected, a significant amount of sulfur also reached the sea.

Five people died, another 19 disappeared, 30,000 birds died (figure 8.5), due to the oil that poisoned them and got caught in their feathers.

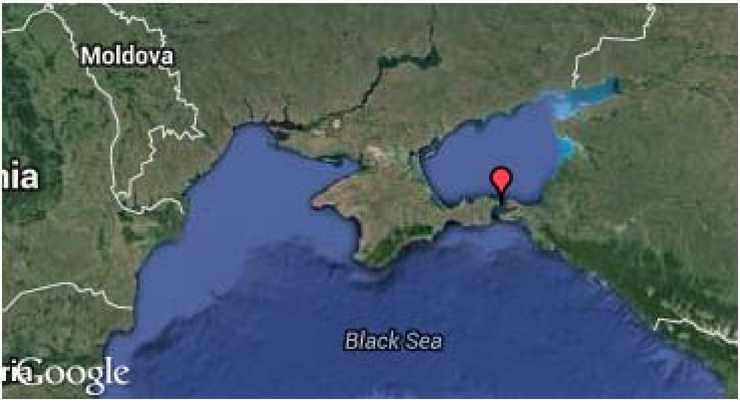


Fig. 8.4. Map with the position of the location where the oil pollution took place [1]

Fig. 8.5. A poisoned and oil-covered bird, stands dry in front of local volunteers [6]

The whole ecosystem has received a major blow. According to some sources, 898 million dollars is the approximate value of financial losses. Apparently, the oil slick moved to the Sea of Azov in the following days.

Russian environmentalist Vladimir Sivyak told the BBC that the sinking of VOLGONEFT-139 was a "very important disaster for the environment." He added that it would take years to remove the heavy oil that has already sunk to the bottom of the sea [6], [37]. The image below (figure 8.6) shows the oil spills detected by satellites during the years 2000-2004 in the Black Sea [18], [19].

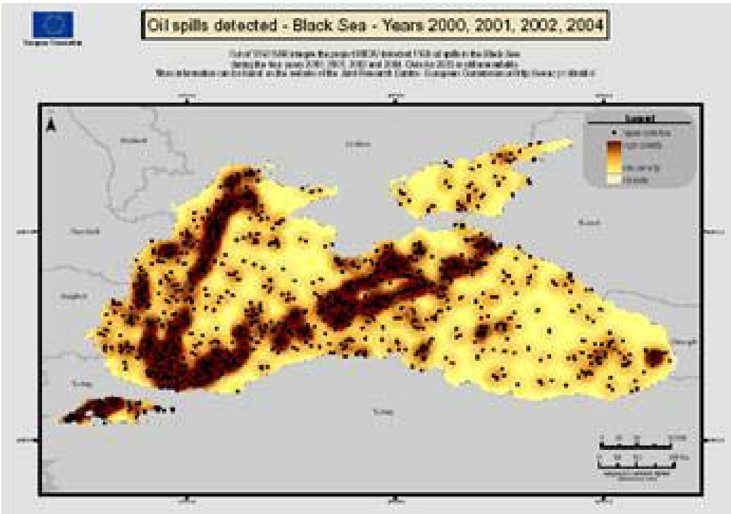


Figure 8.6. Map of oil spills in the Black Sea in 2000, 2001, 2004 [18]

As can be seen from the case above and from the image in Figure 8.6, the problem exists and it is very important to treat it in a very serious way. This treatment of the problem can be started by approaching the risk management cycle (figure 8.3).

There is a lot of regional effort in this direction, which is a good thing, but it lacks clear organization, for political, financial reasons, and all kinds of interests between the states bordering the Black Sea [17].

If we ask the right questions and take into account the interconnection between the elements of risk and the status and possibilities of stakeholders, given the "before" and "after" paradigms brought by the risk management cycle, a lot of important answers can appear. Apparently, the ship (Volganeft 139) was not designed to sail the sea. The weather forecast is not new nowadays, so the event could have been better predicted and prevented (bringing the ship to port, to safety, emptying its cargo). Old ships should be thoroughly inspected before receiving approval for marine operations.

There is a lot of information that we can learn from any situation oil pollution, in the Black Sea area or around the world. The most important thing is to take steps for a sustainable development of the region, to solve the problem of oil pollution in a sustainable way.

The risk of oil pollution in the Black Sea is a serious issue, given the current situation: oil is already brought into the sea by rivers, the Black Sea environment is already weakened, due to the international crisis, there are financial problems, there are also important differences and different cultures between coastal states. However, stakeholders need to act in an organized way.

8.6. Environmental risk assessment

Environmental risk management involves the search for a "best path" between social benefits and environmental risks. It is a balancing or trading process in which different combinations of risks are compared and assessed in relation to certain social or economic gains. Risk assessment has three interconnected components: identification, estimation (analysis) and risk assessment.

8.6.1. Environmental hazards and risk analysis

Risk assessment is a process that determines the nature and degree of risk by analyzing potential hazards and assessing existing conditions of vulnerability that could present a potential threat or danger to people, property, livelihoods and the environment on which they depend. Environmental risk assessment puts together a set of tools to define the probability and magnitude of adverse effects on human health and natural resources generated by environmental agents (Fig. 8.7 [38].

As we all know, disasters have been a major concern since the beginning of human civilization. They continue to strike every generation of human beings, bringing increasing suffering, death and material loss.

Through its activity, humanity continues to change its biosphere, changes in the environment in certain places and at the ecosystem level. Environmental degradation accentuates the real impact of disasters, limits the ability of an area to absorb the impact, and decreases the overall overall resistance to disaster impact and disaster recovery, [38].

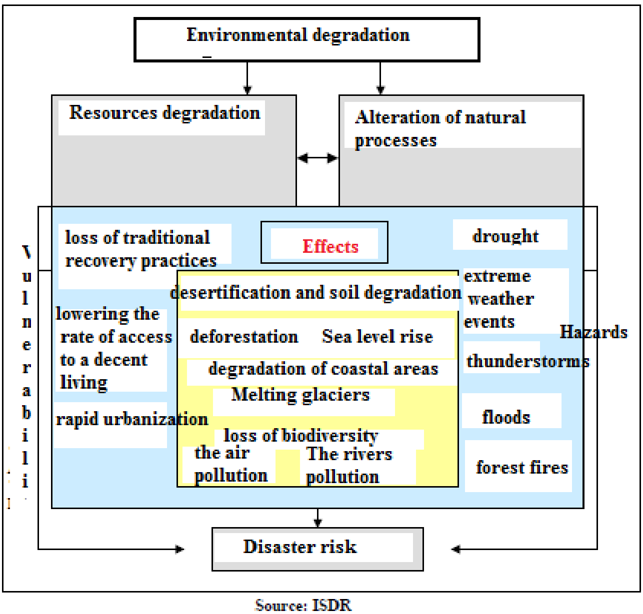


Fig. 8.7. The path from environmental degradation to disaster risk, through vulnerability and dangers

8.6.2. Environmental degradation

Oil pollution on the Danube, amounting to 53,000 tons/year, represents approximately half of the estimated total annual amount of oil that pollutes the Black Sea. There is little or no data on operational landings of ships and, unless properly regulated, the increase in shipping through the Black Sea could lead to a significant increase in oil pollution. [1] 18].

There is a rapid increase in the use of the Black Sea as a shipping route, especially for the transport of oil from the Caspian oil fields [18].

The Black Sea plays an important role in the transit of hydrocarbons in the region. Nearly a third of Russia's oil exports, about half of Kazakhstan's exports, and all of Azerbaijan's exports cross the Black Sea and the Bosphorus Strait, which it crowds [19]. 55,000 ships pass through the Bosphorus annually. 30 % of them (around 10,000 ships) are oil tankers carrying around 155 million tonnes of oil. This leads to a high risk of oil pollution [20]. There are standards that keep things under control, such as MARPOL, but history (not necessarily in the Black Sea) has shown that, even in well-controlled situations, oil pollution can occur.

There are some political and economic obstacles in the region, but the Black Sea continues to attract the interest of international oil companies, including wealthy people, in offshore drilling. Until recently, deep waters remained largely unexplored by seismic studies [19].

The economic evolution of the countries on the Black Sea coast, as well as the need for energy, has led most of the countries in the region to improve their plans in terms of prospecting and start oil and gas extraction [21]. The evolution of deep-sea offshore drilling and the opening of new oil fields will lead to an increase in maritime traffic and, subsequently, to an increase in the risk of oil pollution.

8.6.3. Environmental degradation - Climate change

The third evaluation report IPCC (2001) (Intergovernmental Panel on Climate Change) estimates a warming of the average annual temperature until 2100 (compared to 1990) between 1.4 ºC (2.5 ºF) and 5.8 °C (10.5 Cº), average 3 ºC (5.4 ºF). Global warming is part of climate change and if it persists it will affect water availability, flood risks, agricultural productivity and natural areas. Natural and human systems are exposed to these changes and undermine sustainability [38].

8.6.4. Environmental degradation - Human health

Human health is closely linked to the environment. It is usually difficult to identify the cause and effect relationship between, say, noise, pollution, and heart disease. The IPCC's special report on the regional impact of climate change acknowledges that the climate has an impact on heart disease. Most African countries are affected by environmental diseases such as malaria, cholera, meningitis, rift valley fever.

8.6.5. Disaster Risk Management - General considerations

After the above, and as a conclusion of the previous chapter, it can be seen below illustrated (Fig. 8.8), the link between environmental risk assessment and disaster risk.

Based on the international literature and on the subject in question, we can say that the disaster is:

1. A great or sudden misfortune;
2. A total failure;
3. A person or company that is experiencing a failure;
4. An event that produces subversion or a sudden and violent change in the order of things.

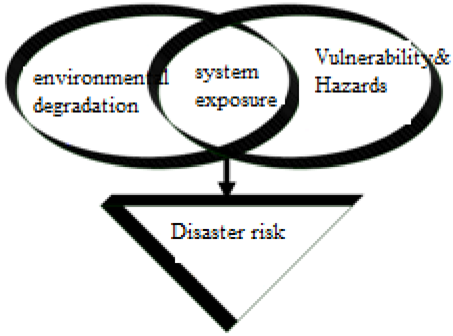


Fig. 8.8. The link between environmental risk assessment and disaster risk management

Also, a natural hazard is the necessary condition for a disaster to occur and natural hazards trigger disasters. The risk of natural disasters can be determined by three main factors:

• risks;

• risk elements;

• vulnerability.

The elements that are threatened by a disaster in a certain area are: population, communities, built environment, natural environment, economic activities and services.

Disaster reduction and environmental management should become the top priorities for any country or manager. Disaster reduction and the environment have a lot in common. Any specialist in disaster reduction should use and have experience as an ecologist.

Disaster risk management approaches reflect planned and structured actions to address natural hazard hazards before an event occurs, [38].

Conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout society, to avoid (prevent) or limit (mitigate and prepare) the adverse effects of hazards, in the broader context of sustainable development [23].

8.6.6. Disaster risk, development and the environment

Disasters are not accidental and do not occur accidentally [24].

They are found at the convergence of dangers and conditions of vulnerability. Disasters not only reveal social, economic, political and environmental problems, but unfortunately contribute to their aggravation. Such events pose serious development challenges because they eliminate gains related to political, social and educational progress, as well as infrastructure and technological development.

The Millennium Declaration recognizes that there is a risk of development resulting from disasters and calls on the global community to "intensify collective efforts to reduce the number and effects of natural hazards and man-made disasters". Several studies have recently pointed out that investment in development is at stake if no precautions are taken to reduce the risk of disasters. However, only a few development organizations take a cautious approach in project design and management, and few still recognize the role of environmental risk management in disaster risk reduction, [24].

The environment, development and disasters are connected which is rarely disputed but the multi-dimensional role of the environment has always caused confusion. Although it is often acknowledged that ecosystems are affected by disasters, it is forgotten that protecting ecosystems can save lives and also protect livelihoods [24].

8.6.6.1. <u>Natural hazards can be directly affected by social processes</u>

Natural hazards are physical processes that can be directly affected by social processes.

Events such as floods, droughts and earthquakes are designated as "dangerous" because they threaten human communities or the elements we value. Dangers are expressions of the physical processes of the earth. However, the myth that we have little influence on the occurrence of tropical cyclones or the deficit of precipitation has been exposed: human activities have an impact on the timing, magnitude and frequency of these physical processes. Human efforts have triggered global warming and have therefore affected the frequency and intensity of extreme weather events. At the local level, deforestation and desertification have demonstrated effects on local precipitation patterns and are complicit in the occurrence of droughts.

8.6.6.2. <u>Healthy ecosystems often occur alone by natural means</u>

The UN recognizes that ecosystems in the event of floods or fires do what is necessary and make a valuable contribution to preserving the environment and human communities. Attention is also drawn to the significant services that ecosystems provide to human communities in regulating hazards. Environmental conditions not only change the frequency and magnitude of hazardous events, but also produce natural barriers that can moderate the effects of a disaster and protect communities. Wetland ecosystems function as natural sponges that slowly collect and release surface water, rain, melted snow, groundwater, and torrential rains. Deforestation is often blamed for worsening flood effects while mangroves, dunes and reefs create physical barriers between communities and coastal hazards.

8.6.6.3. <u>Degraded ecosystems reduce community resilience</u>

Moving the focus from hazards to vulnerabilities has given disaster managers a richer understanding of the factors that erode the adaptive capacities of communities and social systems. The environment plays a role in many of these factors.

There is a strong causal relationship between poverty, a degraded environment and a higher risk of disasters.
People living in marginal or ecologically degraded areas often struggle every day to survive and are unable to cope with additional stressors. Limited living alternatives, limited resource competition, weak governance structures, and lack of access to health care and other services can compromise a community's ability to respond to and recover from a hazard.

Environmental management and community-based resource management can promote more resilient communities by supporting sustainable livelihoods, conflict prevention and strengthening cooperation for good governance.

8.6.6.4. Some effects on the environment require immediate attention

While the environment is generally able to recover from disasters, the impact on the environment can lead to a serious risk to life and livelihoods if the following have not been addressed:

(1) environmental emergencies, defined as the uncontrolled, unplanned or accidental release of a substance into the environment; the risk of these types of emergencies caused by natural disasters will continue to increase as urban and industrial areas are developed without the awareness of the risk of danger;

(2) unplanned recovery processes that fail to take into account the state of ecosystems and ecosystem services: recovery is a period of immediate development, and without proper examination of the environment, pre-existing vulnerabilities can be re-created or exacerbated. Even worse, the new situation may present new risks.

8.6.6.5. Environmental degradation is in itself a danger

Any discussion of the environment and disaster would be incomplete without acknowledging that environmental degradation is in itself a danger - a human-dependent danger. Biodiversity loss or desertification, for example, will continue to severely affect local communities and economic systems. The risk and vulnerability perspective developed by the disaster reduction community also provides a valuable framework for analyzing patterns of vulnerability to environmental change and identifying opportunities to reduce that vulnerability.

Chapter 9

MANAGEMENT OF OIL SPILL ON SEA - SIMULATOR

9.1. Using PISCES II

PISCES: Potential Incident Simulator, Control and Evaluation System.

Software producer: TRANSAS Ltd.

Organization at CMU:

- Installed in 2007, upgrade 2009
- 1 instructor, 6 workplaces, 1 observer

9.2. Exercises and scenarios

9.2.1. PISCES II workplaces

PISCES II workplaces are divided into 3 types:

- primary instructor;
- instructor;
- observer.

9.2.2. Stages of working on exercise

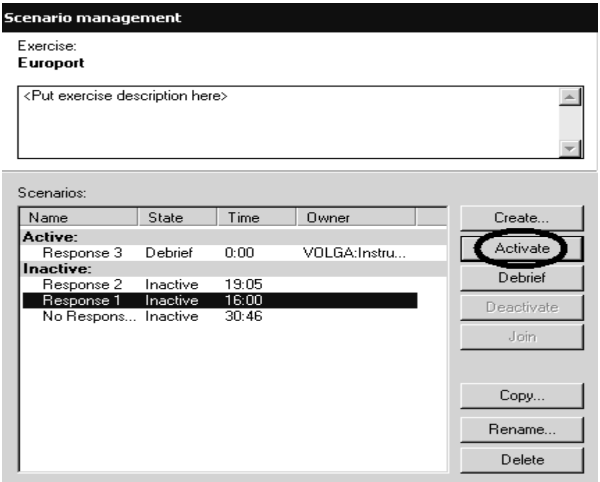
Stages of working on exercise are:

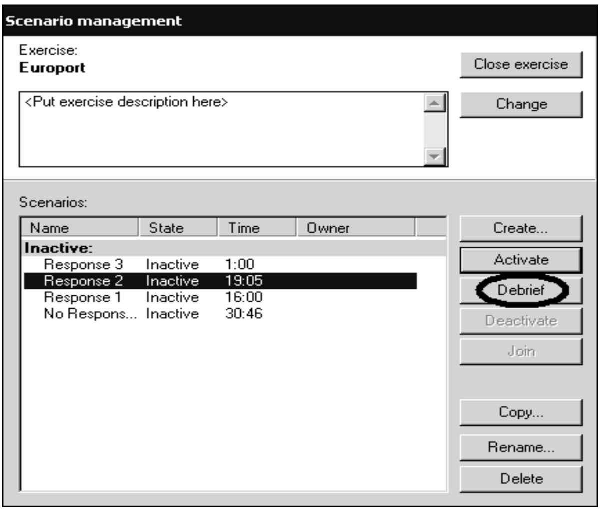
- exercise management;
- scenario management;
- scenario operation.

9.2.3. Scenario operation stages

Scenario operation stages are:

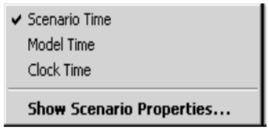
- preparation;
- forecast;
- conduct;
- debriefing;

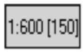




9.2.4. Mode time

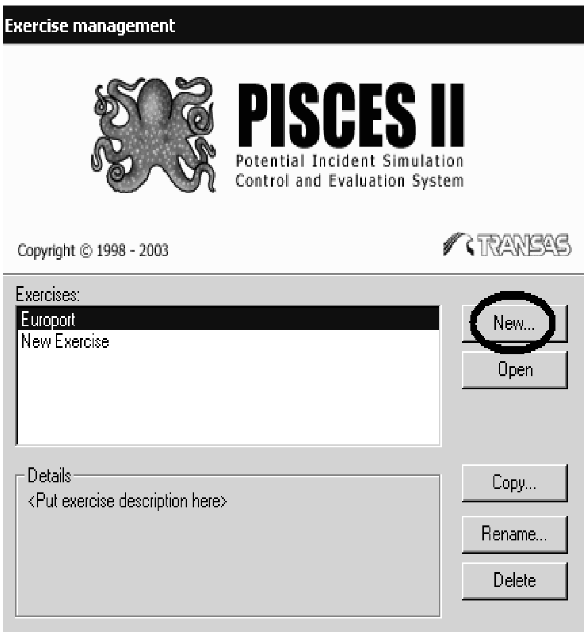
ST = SST + MT

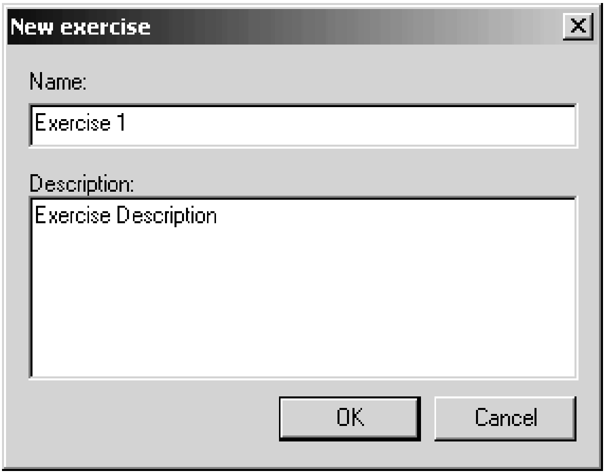




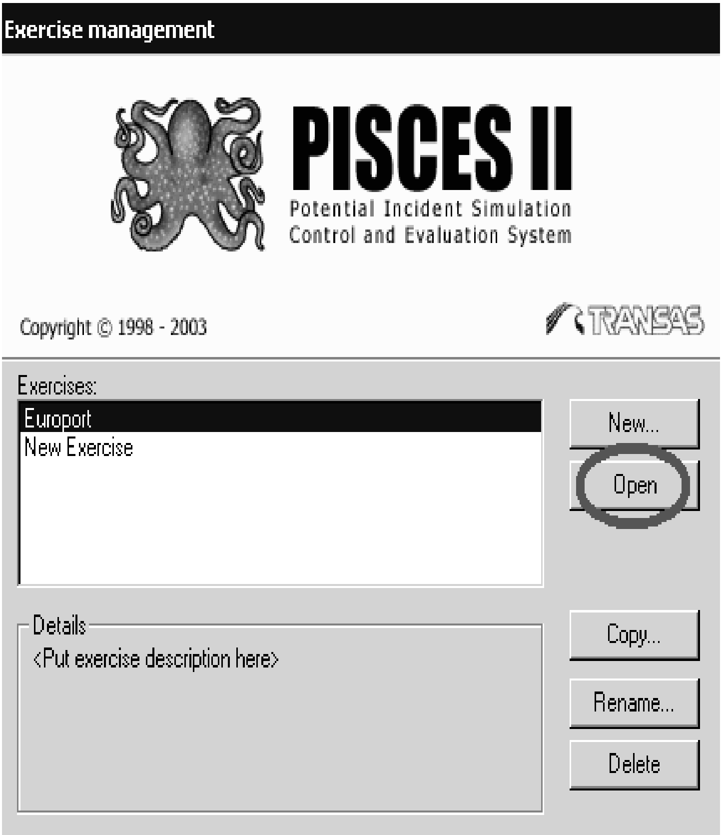
9.3. Exercise management

9.3.1. Create




New exercise
Name:
Exercise 1
Description:
Exercise Description
OK
Cancel

9.3.2. Open


Exercise management
PISCES II
Potential Incident Simulation
Control and Evaluation System
Copyright © 1998 - 2003
TRANSAS
Exercises:
Europort
New Exercise
New...
Open
Details
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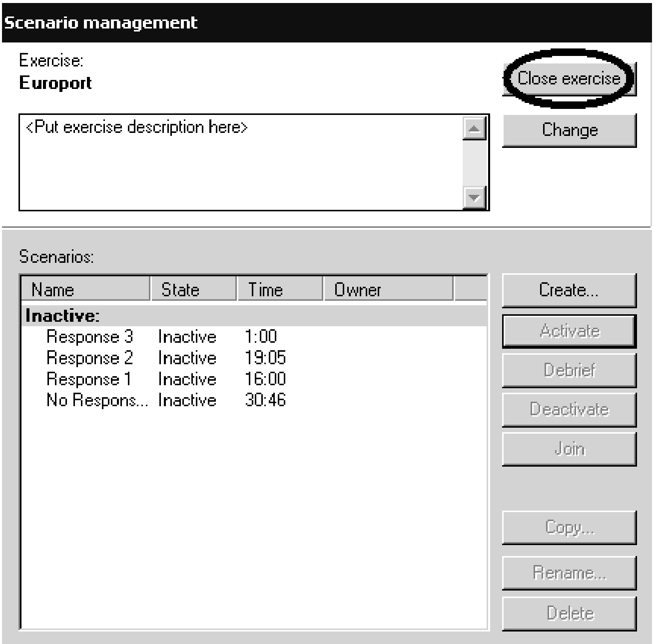
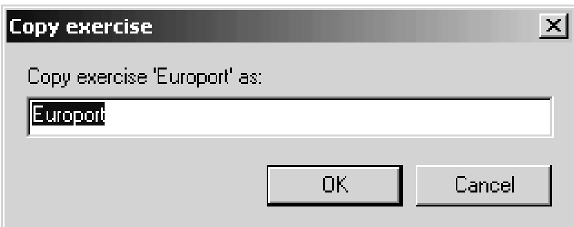
Copy...
Rename...
Delete

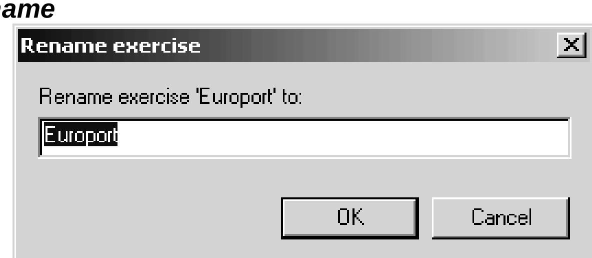
9.3.3. Close



9.3.4. Copy

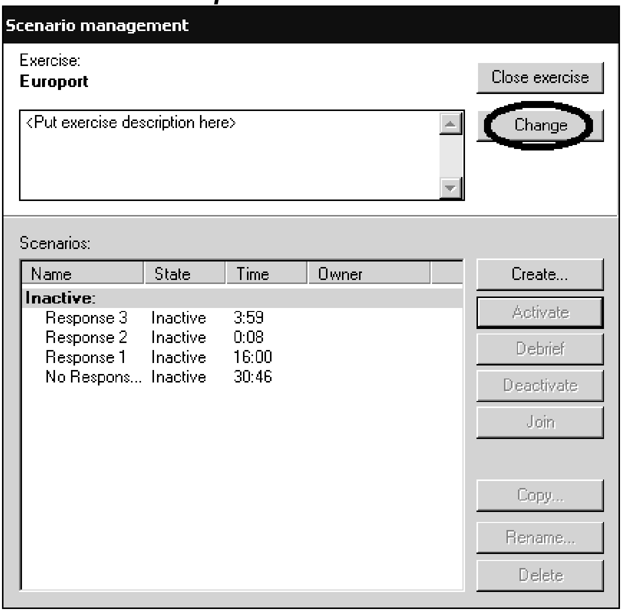


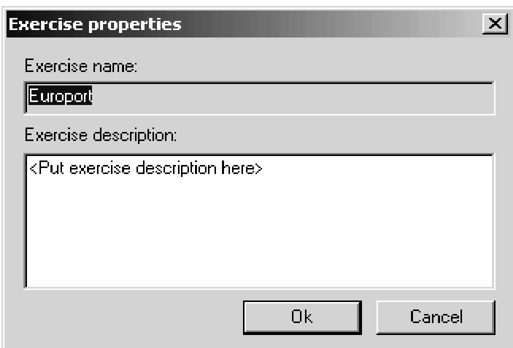
9.3.5. Rename



9.3.6. Delete

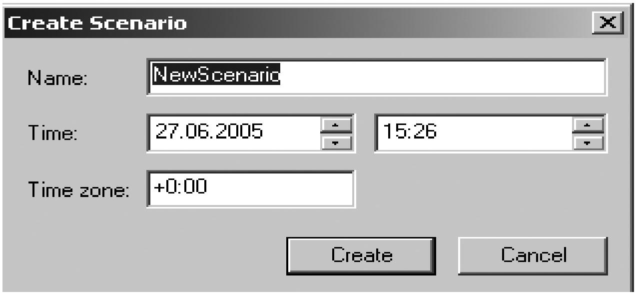
9.3.7. Edit Exercise Description



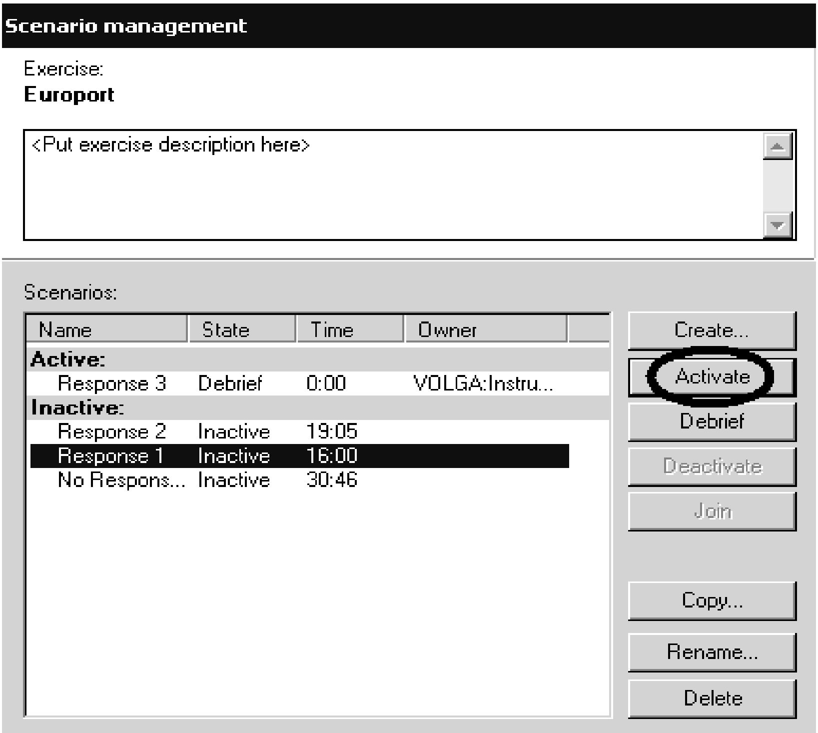


9.4. Scenario management

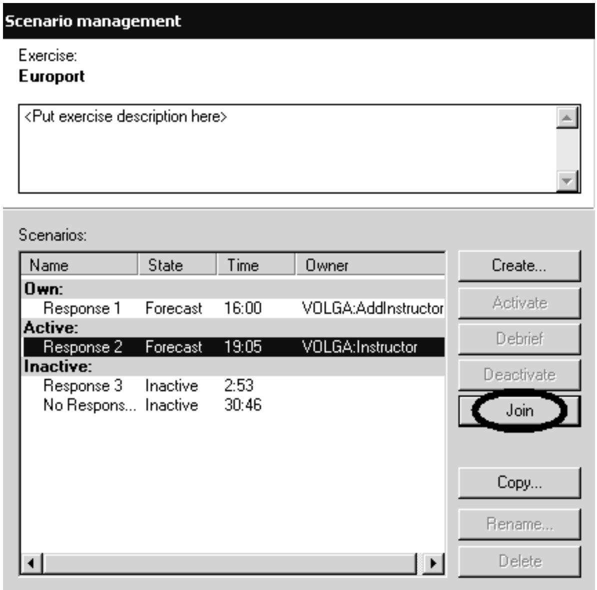
9.4.1 Create



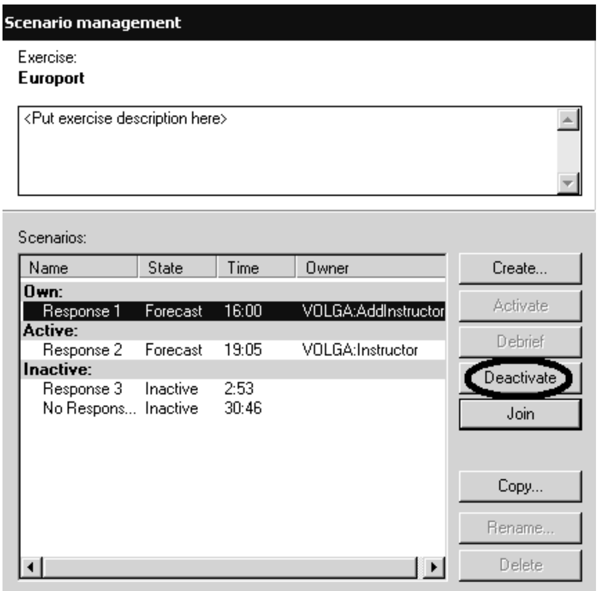
9.4.2. Activate Scenario



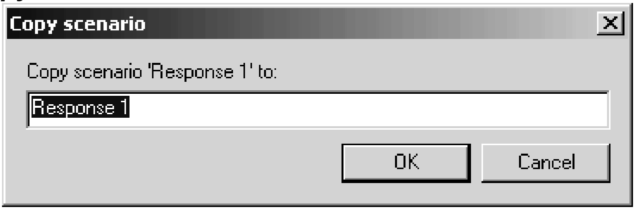
9.4.3. Join Scenario



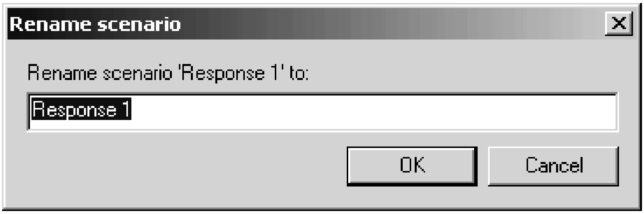
9.4.4. Deactivate Scenario



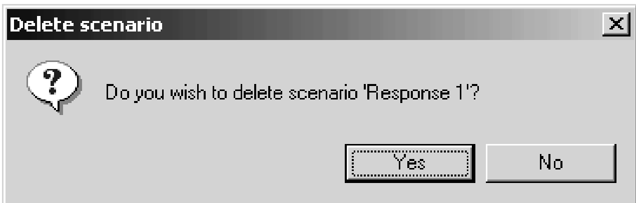
9.4.5. Copy



9.4.6. Rename



9.4.7. Delete

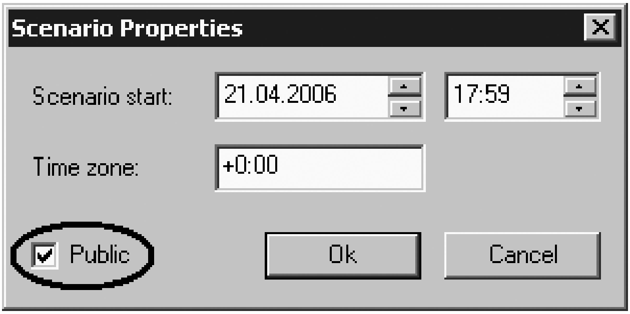


9.4.8. Joint operation of configurations – via internet

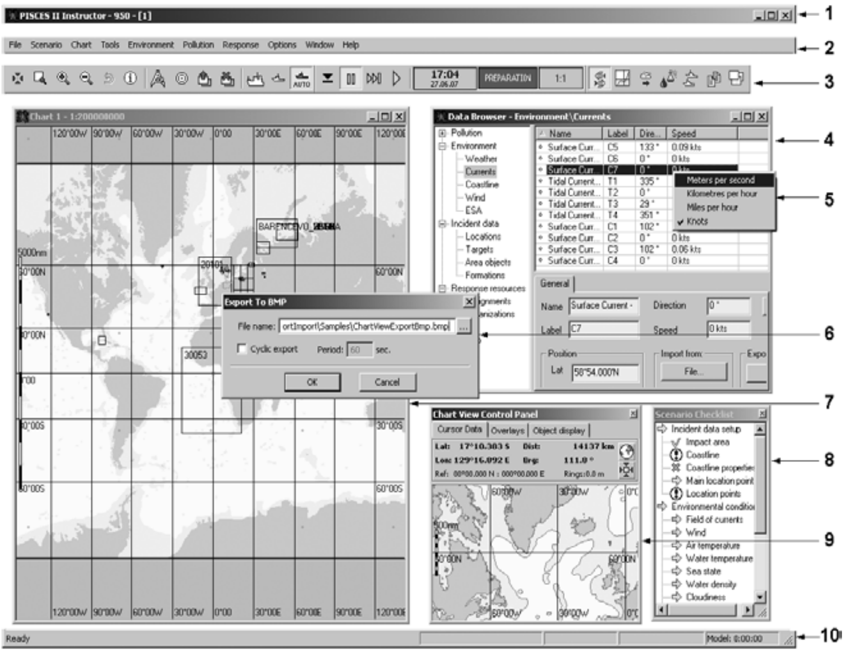
Connection Setup

Work with Common Scenario

Switching Model Object Control Rights



9.4.9. Elements of user interface



9.4.9.1. <u>Standard elements</u>

1. Caption window

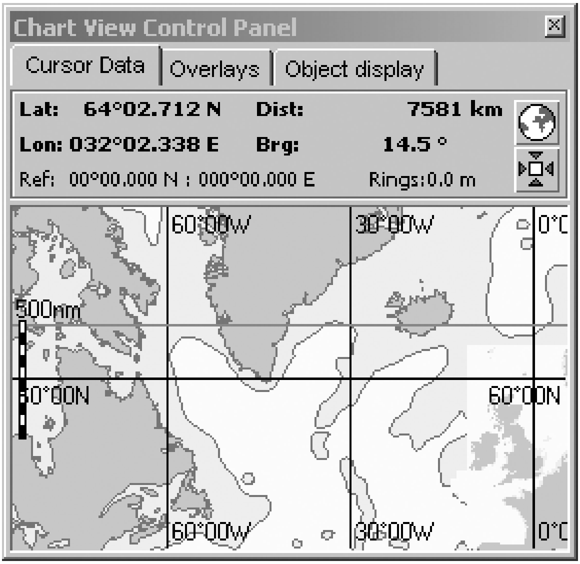
2. Menu is a hierarchy of access to the basic functions of the program

3. Toolbars

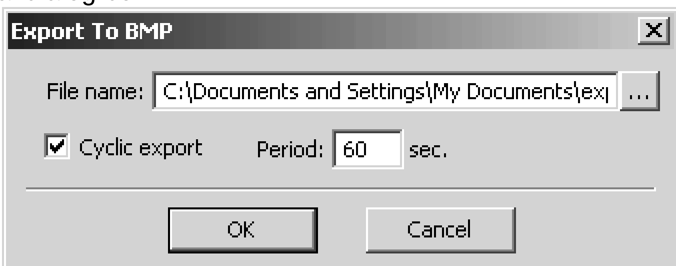
4. Contextual menu

5. Dialog box

6. Non-modal dialog box

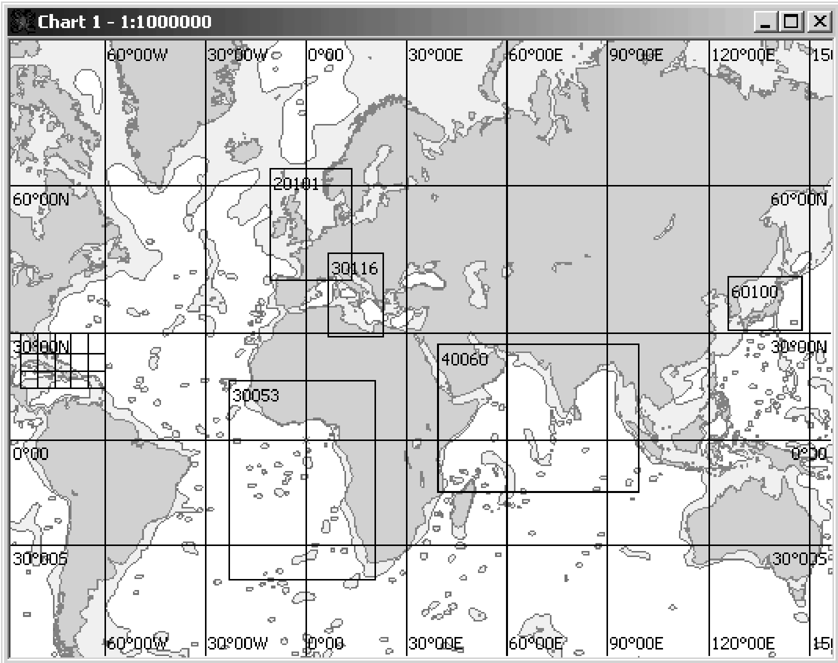


7. Modal dialog box

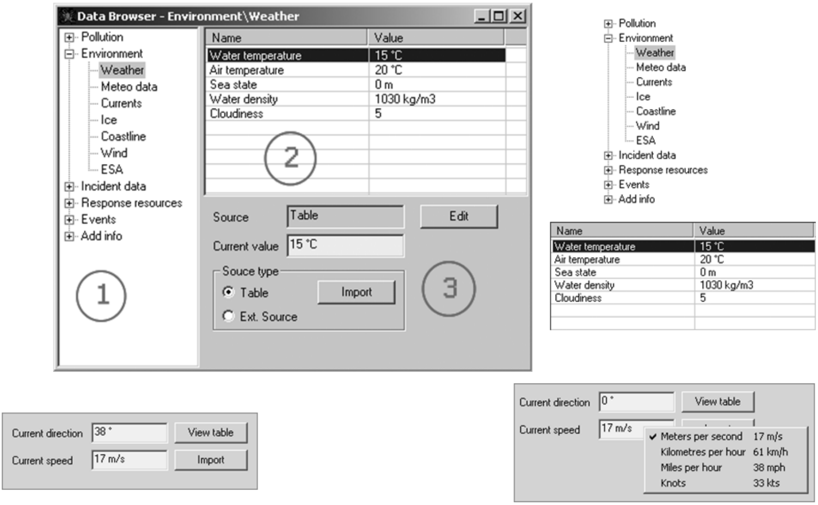


8. Status bar
9. Chart window

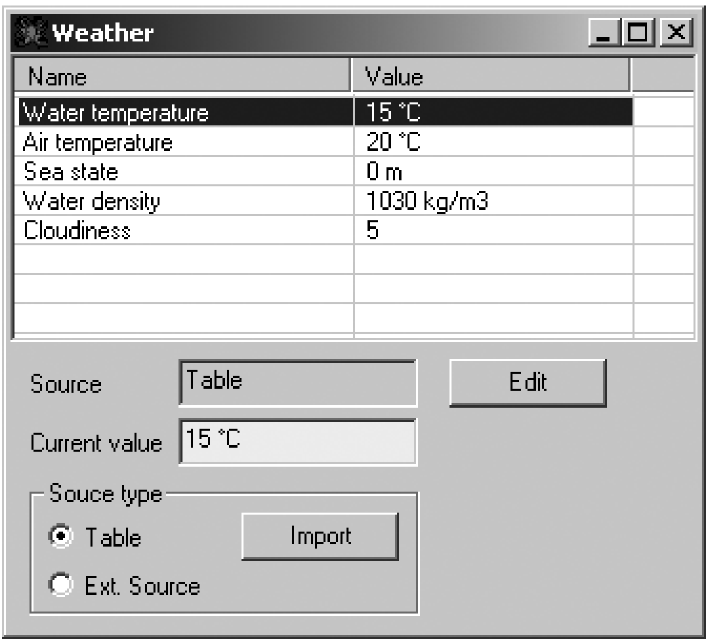
9.4.9.2. <u>Chart window</u>



9.4.9.3. Data window



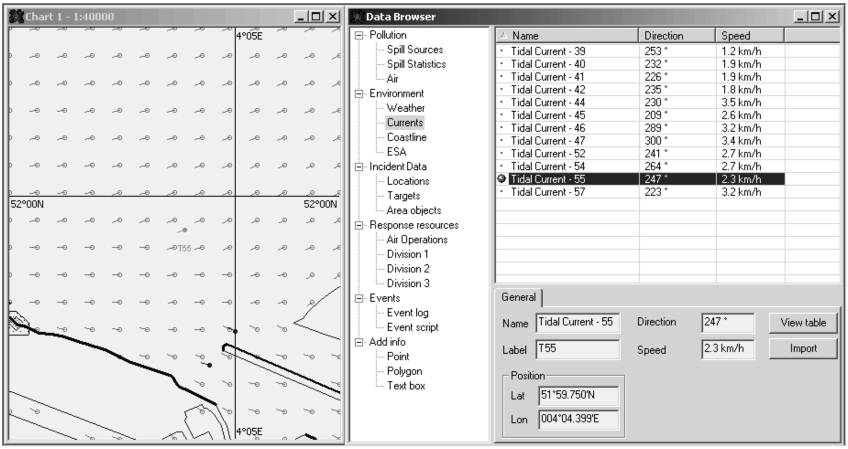
Example, the weather window shows just weather conditions:



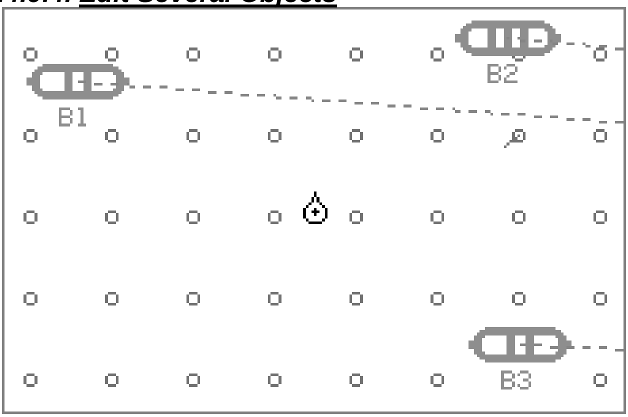
Scenario Control

Sorting in the Data Panel

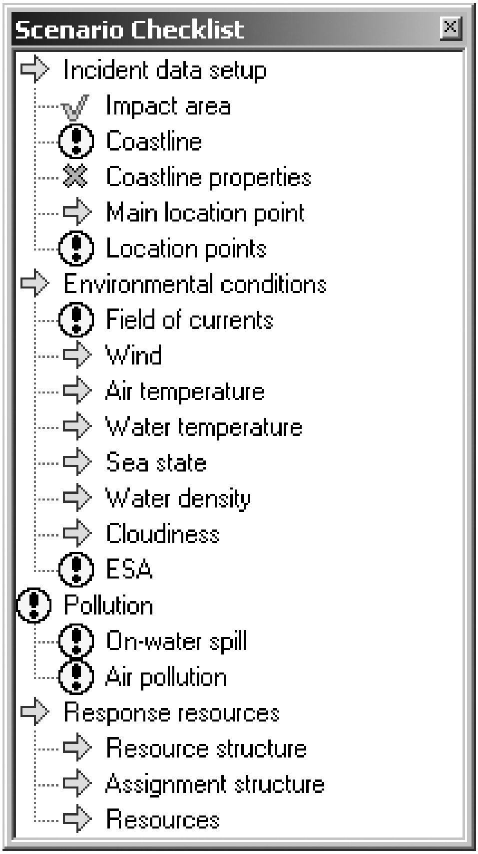
Link between the Chart Window and the Data Window



9.4.9.4. Edit Several Objects



9.4.10. Scenario checklist



The tasks in the list can have four statuses:

- Not started;
- In progress;
- Not available;
- Completed.

9.4.11. Layouts

Icon name	Purpose	Button
General	Basic PISCES II window layout. The screen displays the chart window, the data browser window, the cursor data window and the scenario checklist	
Charts Only	Layout for work with charts. The screen displays the chart window and the cursor data window	
Weather and Currents	Information on weather and currents. The screen displays the chart window, the weather window, the wind window and the current window	
Pollution	Pollution information. The screen displays the chart window, the data browser window, the aerial contamination window, the spill source window, and the parcel window	
Response Resources	Response resource information. The screen displays the chart window, the response resource window and the command panel	
Events	Event information. The screen displays the chart window, the event script and the event scenario	
Custom	Personal user layout. Keep user settings made on the screen	

9.5. Scenario operation

9.5.1. Start

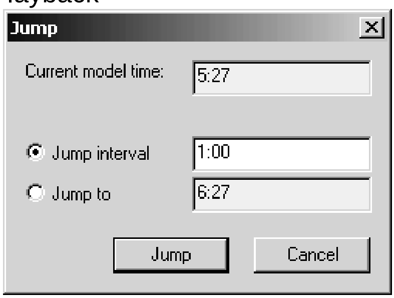
Stop

Make Save Point

Reset To

Jump To

Backward Playback

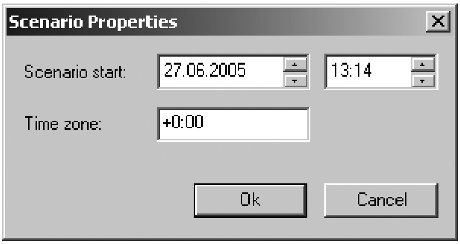


Speed

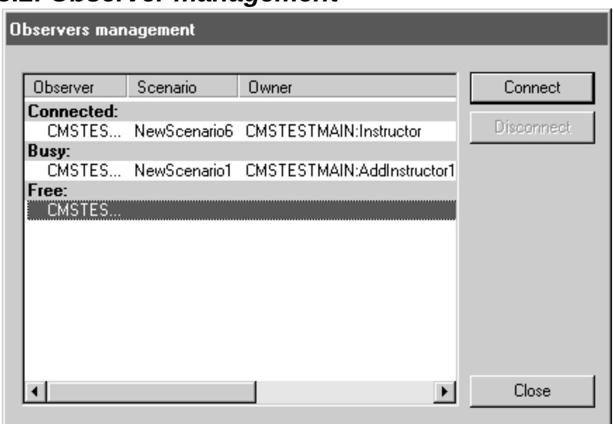
SYNC Real Time Mode

Leave Scenario

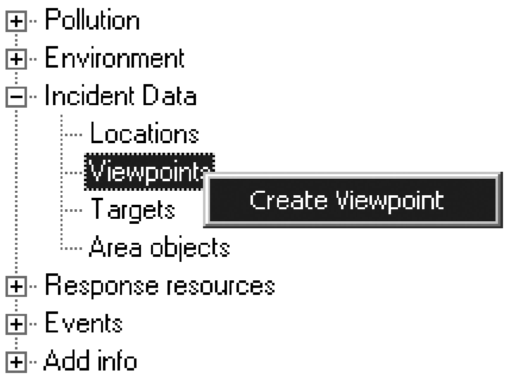
Scenario Properties



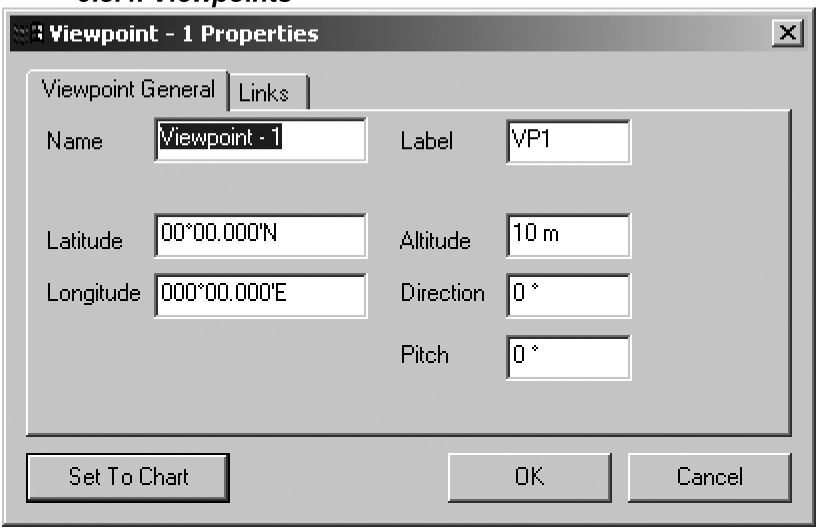
9.5.2. Observer management



9.5.3. 3D Visualization

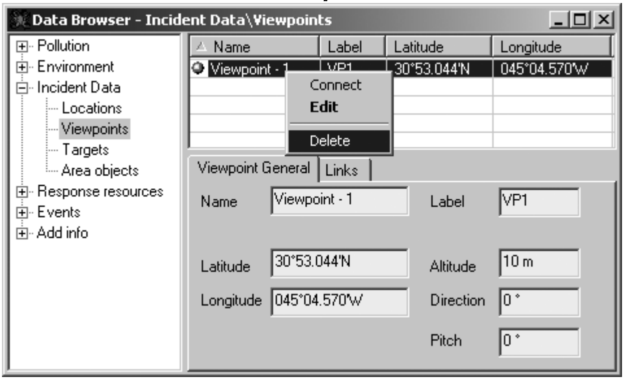


9.5.4. Viewpoints



Edit the created viewpoint using the Properties context menu command.

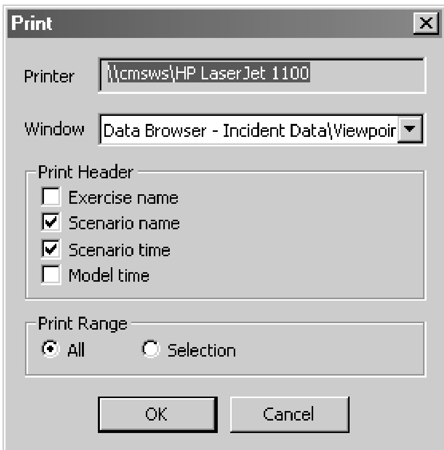
9.5.5. Delete a created viewpoint



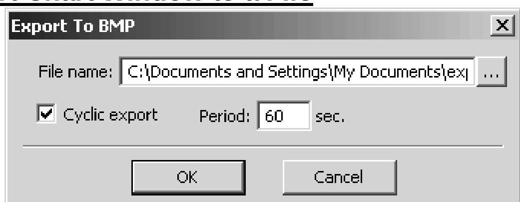
Connection to 3D Visualization Channel

9.5.6. Preparation of reports

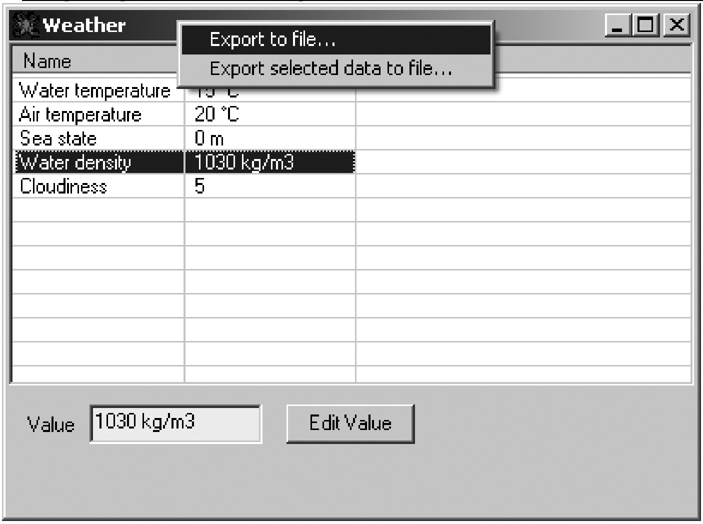
9.5.6.1. Print



9.5.6.2. Export Chart Window to a File



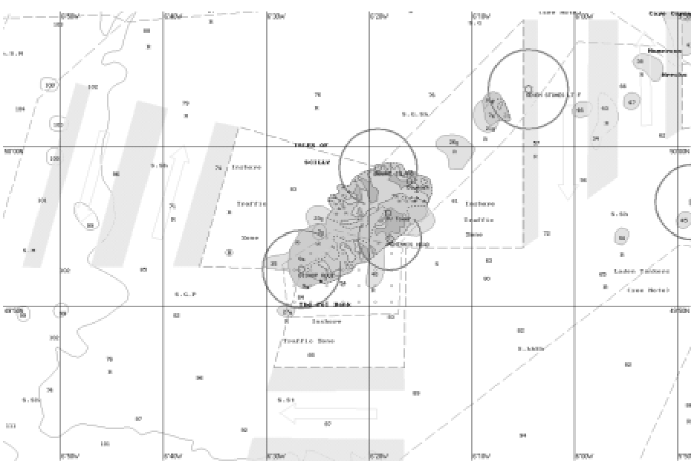
9.5.6.3. Stop Export to File/Export of Data Window in MS Excel



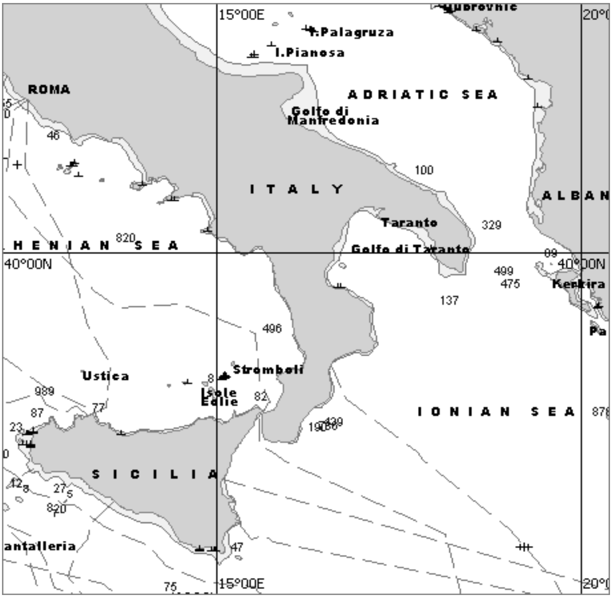
9.5.6.4. Export of Chart Panel to Word

Chart 1

Exercise	No name
Scenario	NewScenario6
Incident Start Time	10.02.2005 18:42
Scenario Time	X+1:49 [10.02.2005 20:31]

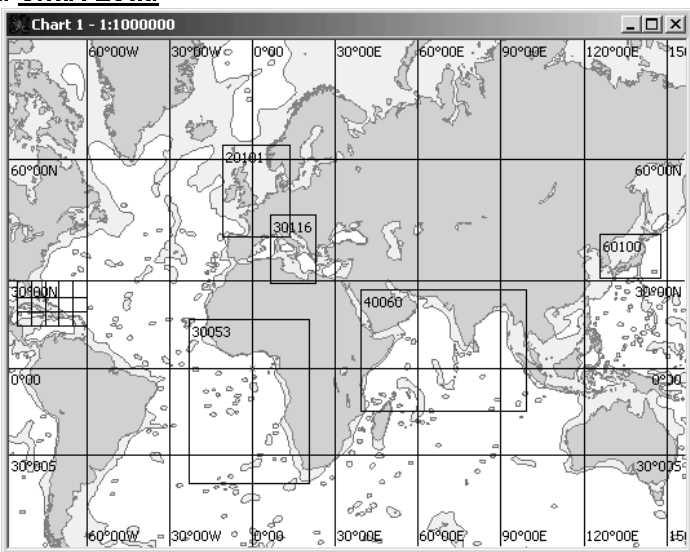


9.5.7. Electronic charts

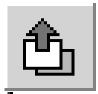


9.5.8. Working with Charts

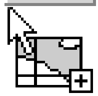
9.5.8.1. <u>Chart Load</u>



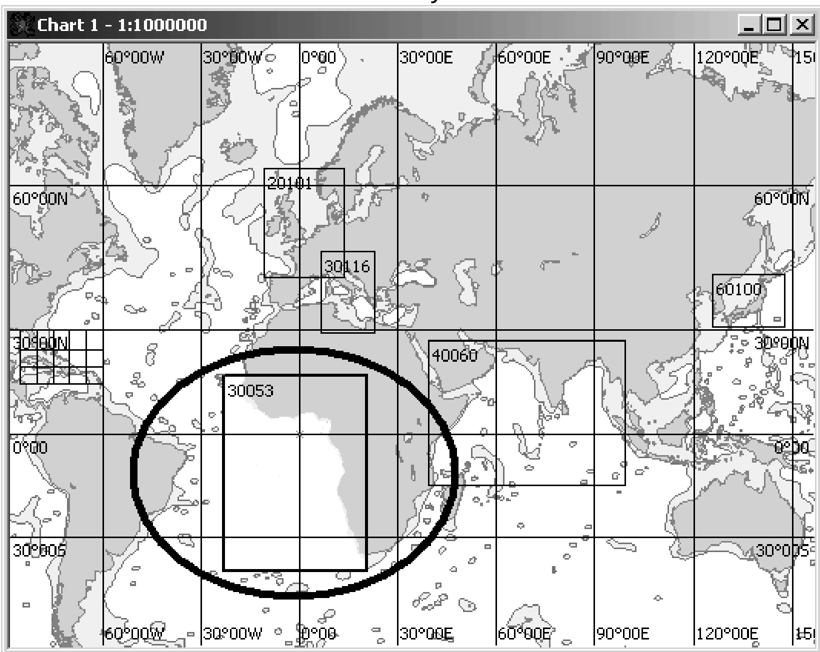
Select the command Tools/Load chart in the program menu or click the “Load Chart” button on the toolbar



The cursor will assume the following form

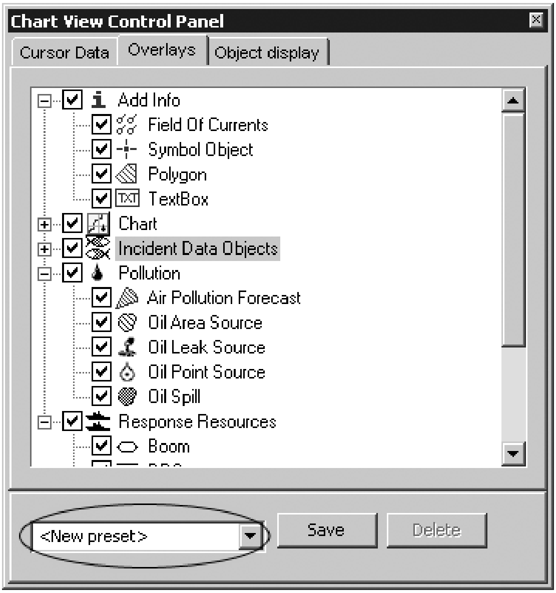


Select a chart for the region concerned featuring a sufficient level of detail and click on its boundary.

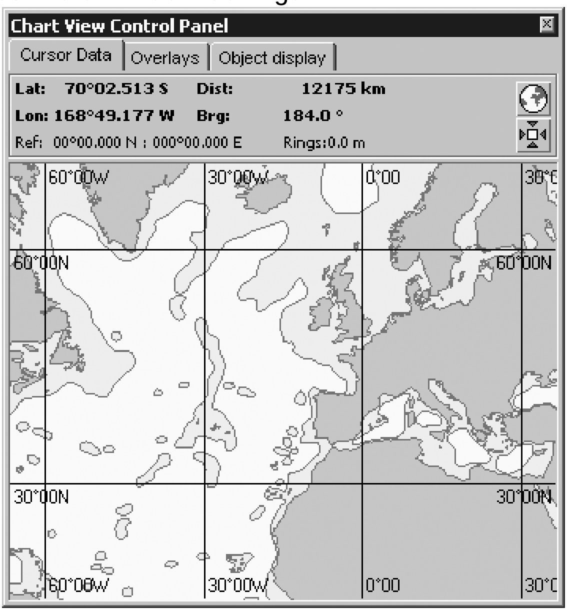


9.5.8.2. ***Chart handling tools***

Chart View Control Panel



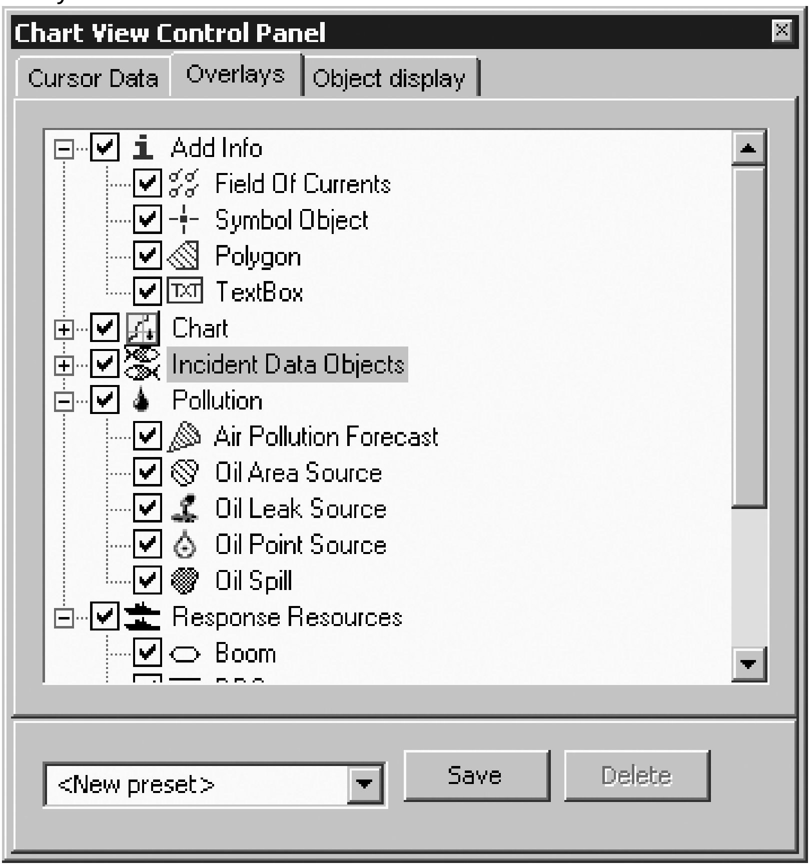
Cursor Data Window Settings



A list of cursor parameters shown in the “Cursor Data”

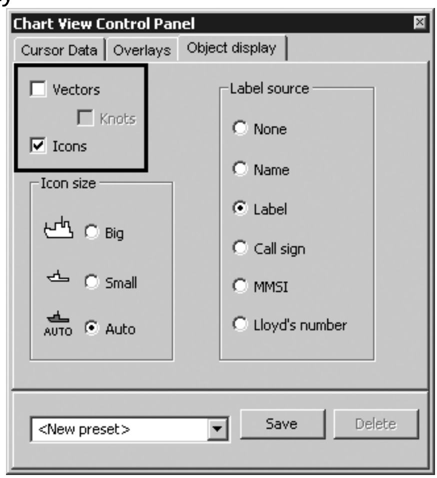
Parameter	Value
Lat	Source latitude
Lon	Source longitude
Ref	Reference point coordinates
Dist	Distance to reference
Brg	Bearing to reference point
Rings	Distance between range rings

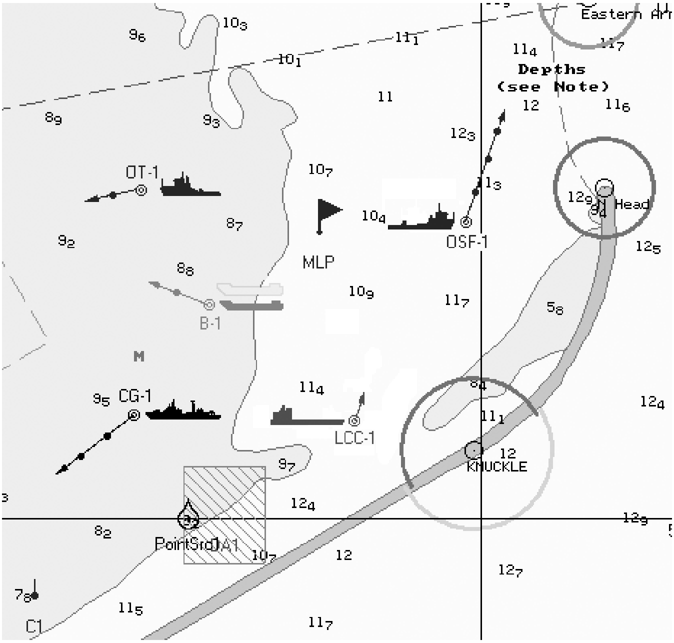
Layer Control



Add Info	**Additional information**	
Field of Currents	Field of Currents	
Field of Winds	Field of Winds	
Point Object	Symbol objects	
Polygon	Polygonal areas	
TextBox	Text boxes	
Chartg	**Chart**	
Borders	Borders of charts available for loading into PISCES II	
DCW Overlays	Special layers of DCW format charts	
Loaded Borders	Boundaries of loaded charts marked with a thick border	
Grid	Coordinate grid	
Raster Images	Raster images, loaded by the user on top of own chart layers	
Rings	Range rings	
TX97 Overlays	Specific layers of TX97 format charts	
Incident Area Objects	**Incident Area Objects**	
Boom towing order	Union of several response resources: a skimmer, boom and several platforms as a single unit	
Coast Line	Coast Line	
Compulsory Burning Area	Burning Area	
Currents	Reference vectors of the currents field	
Dispersant Application Area	Dispersant Application Area	

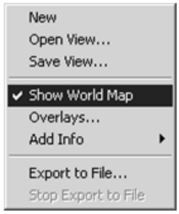
Object Display





Option	Description
Vector	If this option is turned on, the resource motion direction is shown with the speed vector
Speed marks	Turns on the display of speed marks on the speed vectors. The speed marks can be shown in different ways depending on the speed of the resource: • at a speed of up to 5 knots, the speed marks are placed one for each knot and have a form of hatches:  • at a speed of 5 to 20 knots, speed marks have a form of circles placed in 5 knot intervals:  • at a speed of more than 20 knots, the speed mark has a form of an arrow: 
Icon	Turns on/off the display of object icons on the chart. If this button is turned off, all the objects on the chart are shown as points

Show Word Map



Revert 

Centre 

Zooming Area 

Scale up 

Scale down 

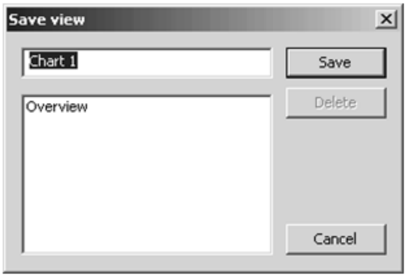
Ruler 

Reference Point 

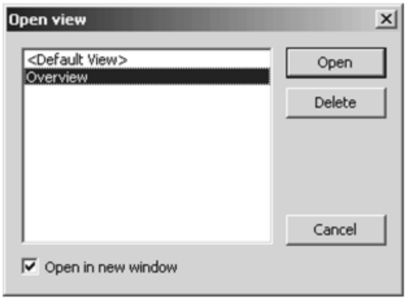
Information on TX97 Chart Objects 

CHART VIEW MANAGEMENT

New View
Save View

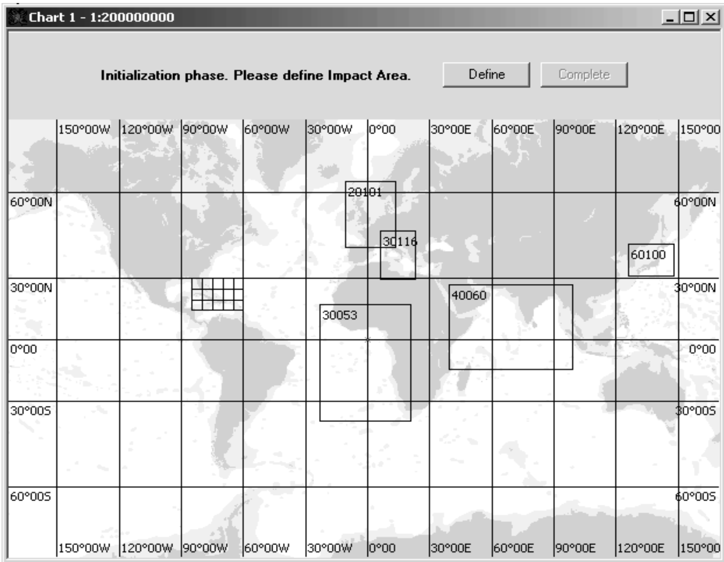


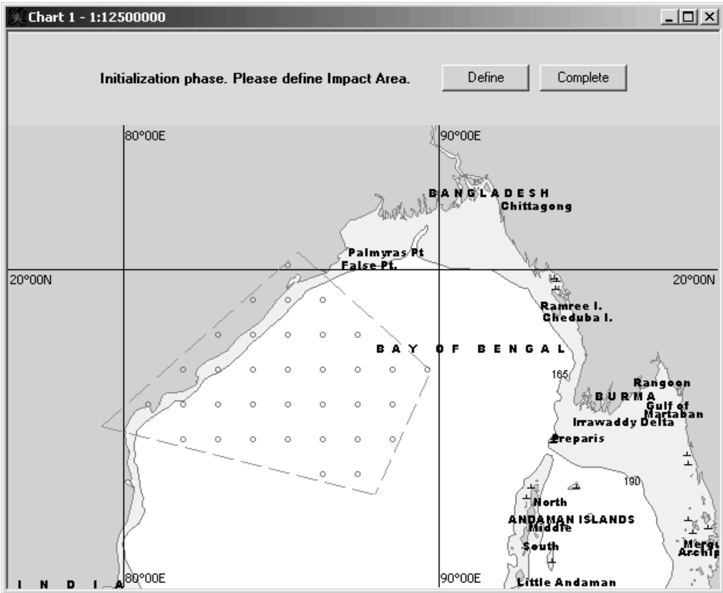
Open View
Delete View



9.5.9. Environment conditions

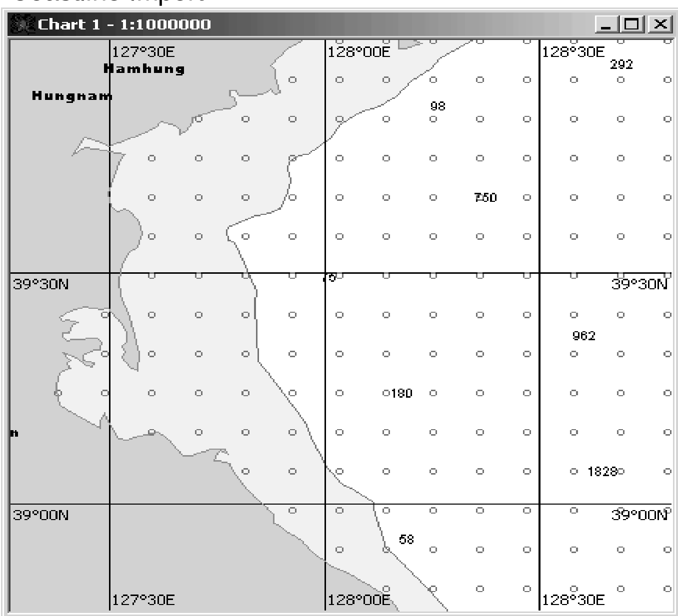
9.5.9.1. Impact area

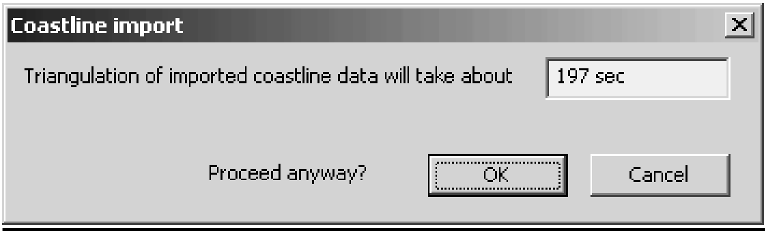




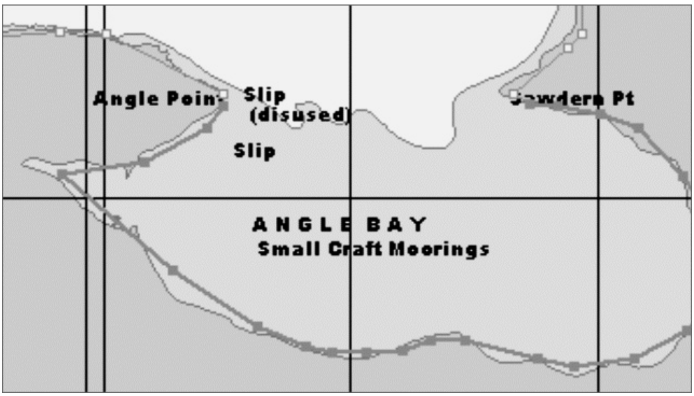
9.5.9.2. <u>Coastline</u>

Coastline Import

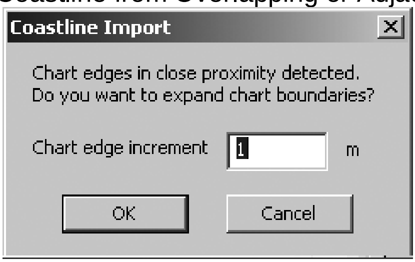




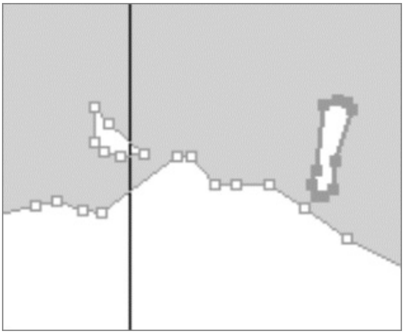
Command	Purpose
Properties	Opening the coastline properties menu
Assign Parcel	Assigning a unique name for the selected coastline segment(s)
New Island	Creation of a new island
Show Islands	Displaying closed coastline parcels, i.e. islands
Show Parcels	Displaying coastline parcels (This is described more fully in the section **4.2.6 Parcels**)
Delete Points	Removal of object point(s)

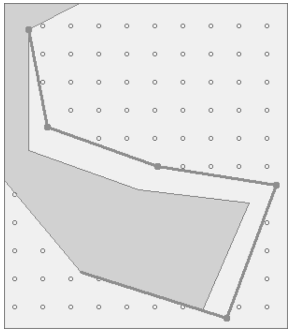


Importing Coastline from Overlapping or Adjacent Charts

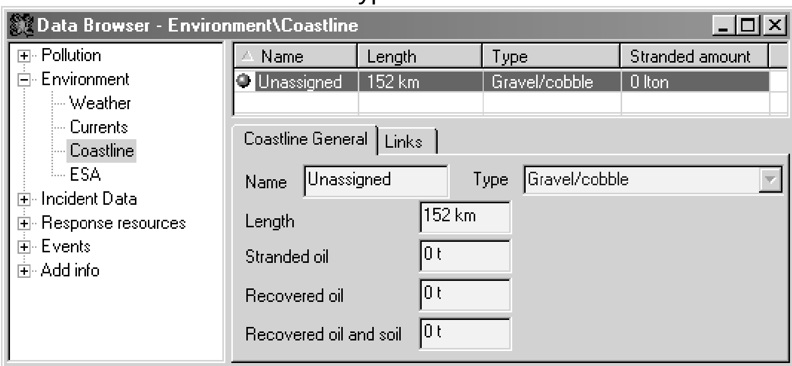


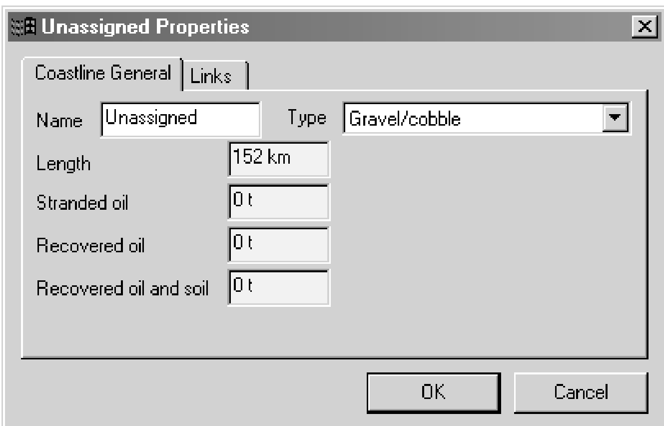
Edit Coastline



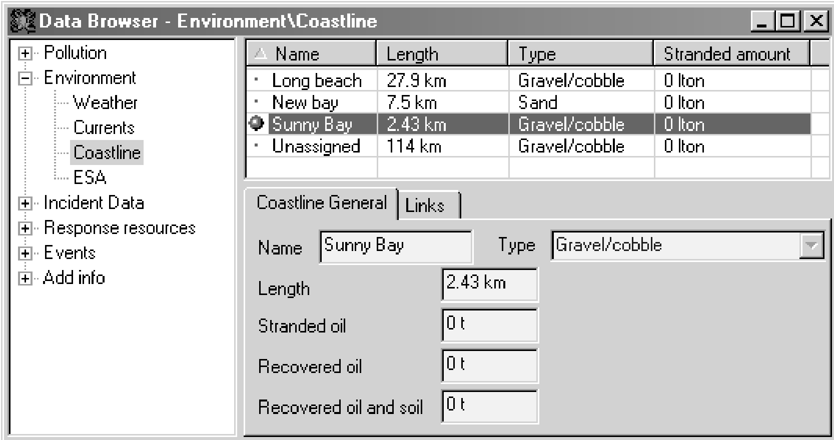


New Island - Coastline Type





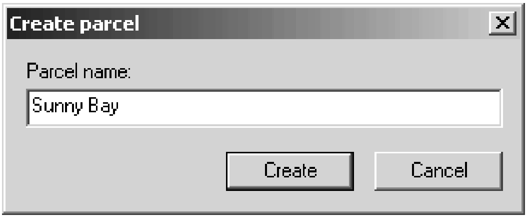
Parcels



Field	Description
Name	Parcel name (editable field)
Length	Coastline length (non-editable field)
Type	Ground type
Stranded oil	Spilled oil statistics (non-editable field)
Recovered oil	Amount recovered oil on shore by shore cleanup equipment (non-editable field)
Recovered oil and soil	Amount recovered mixture soil/oil on shore by shore cleanup equipment (non-editable field)

Assign parcel

New Parcel

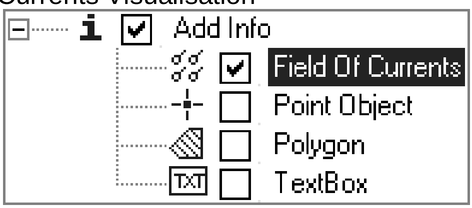


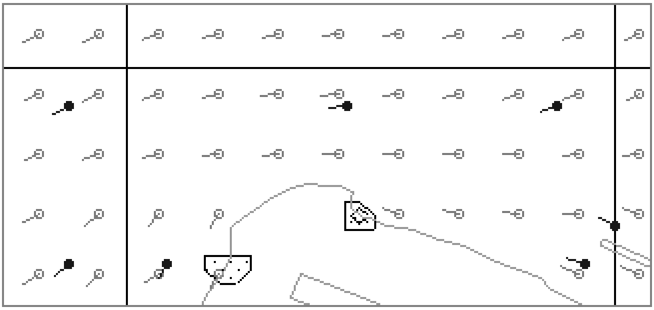
Parcels “Create”

Name	Length	Type	Stranded amount
Sunny Bay	20.3 km	Sand	0 lton
Unassigned	1796 km	Sand	0 lton

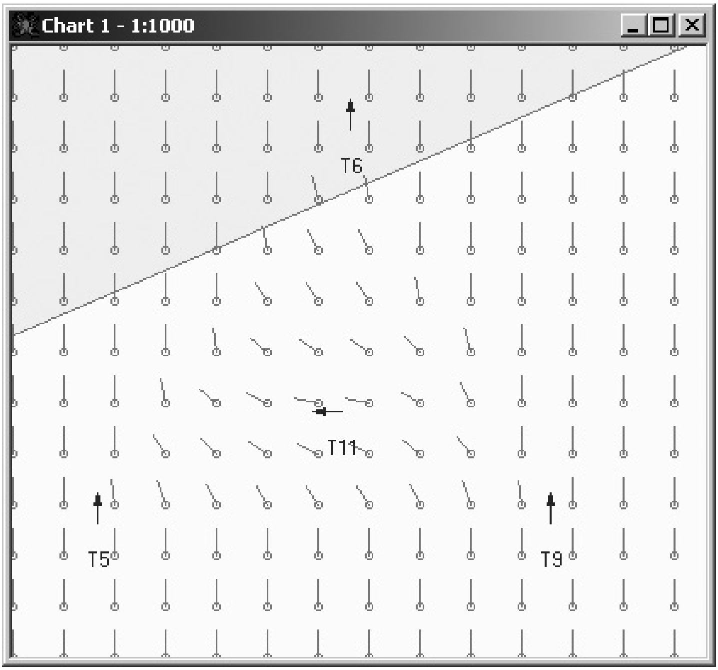
9.5.9.3. <u>Field of currents</u>

Field of Currents Visualisation



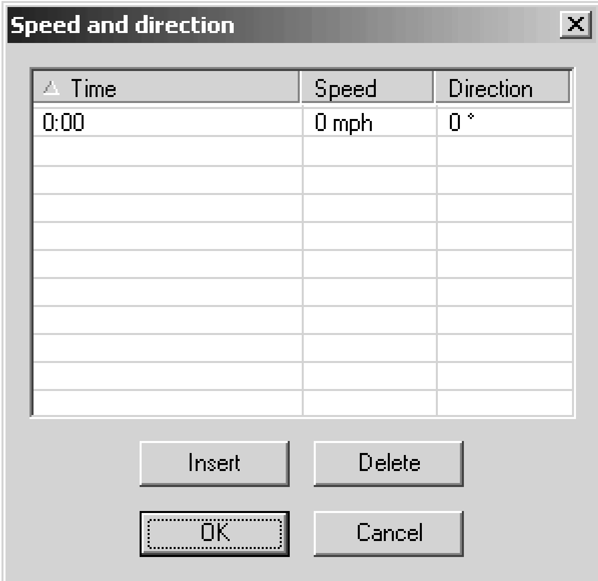


Surface and Tidal Currents

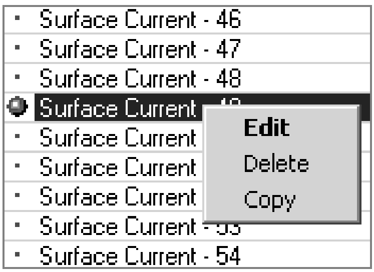


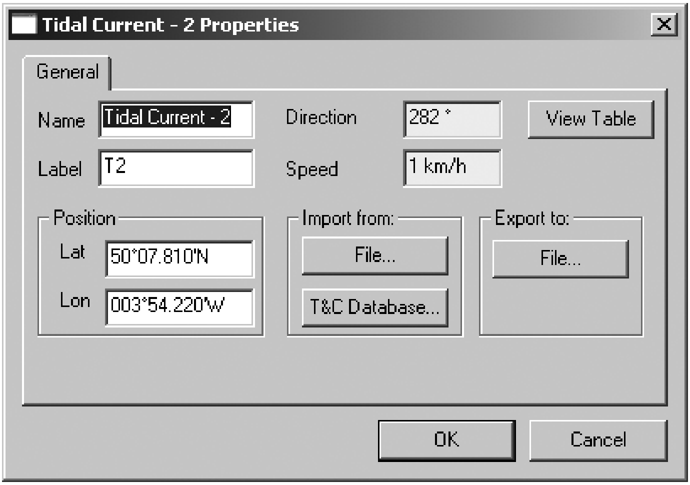
Add Current Vectors

Command is: Environment/create current



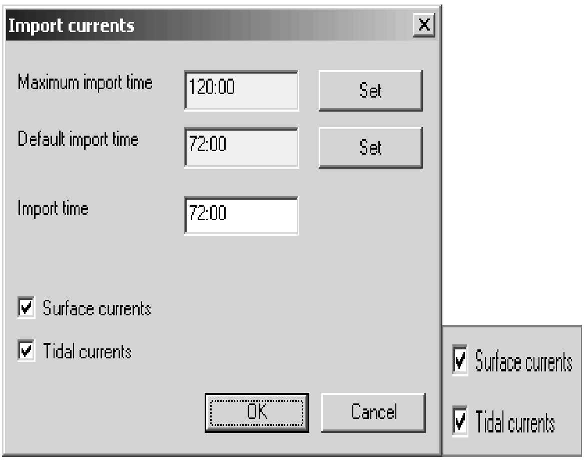
Editing Current Base Vectors

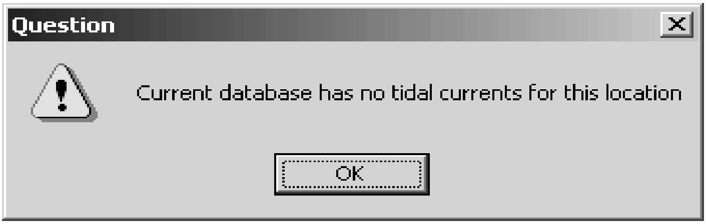


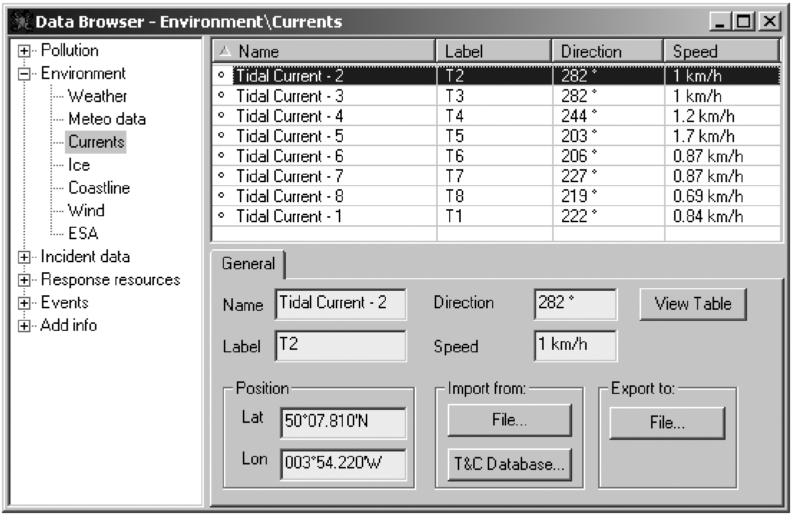


Parameter name	Parameter value
Label	Text label displayed on the chart
Direction	Current direction
Speed	Current velocity
Position	Coordinates
Lat	Vector latitude
Lon	Vector longitude

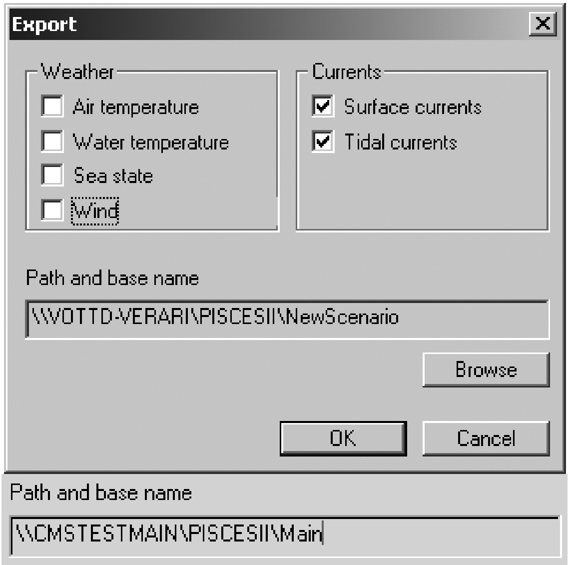
Import of Basic Field of Currents Vectors

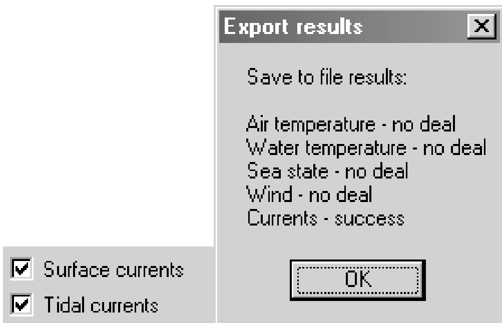






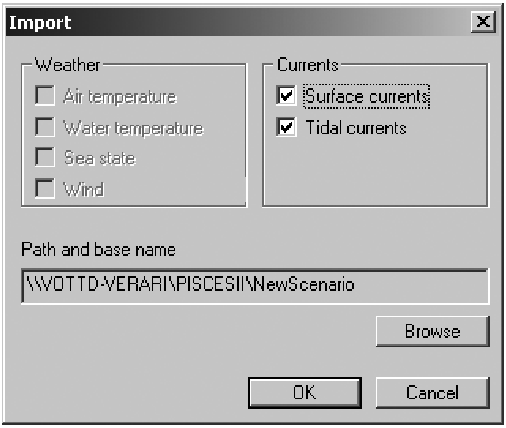
Import and Export of Current Base Vectors to File



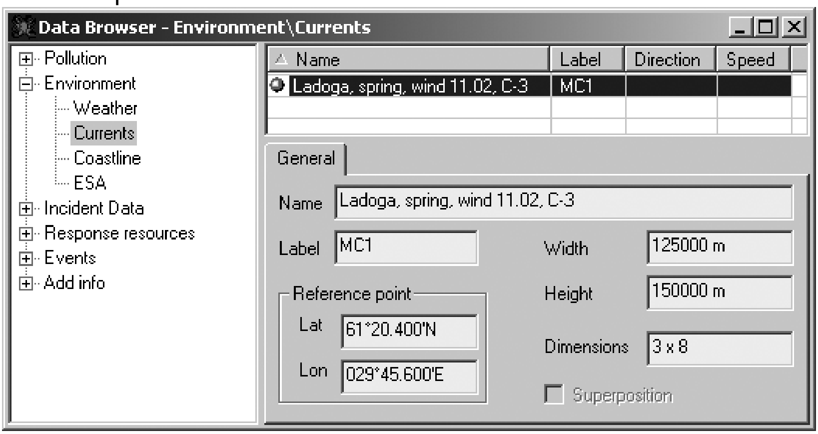


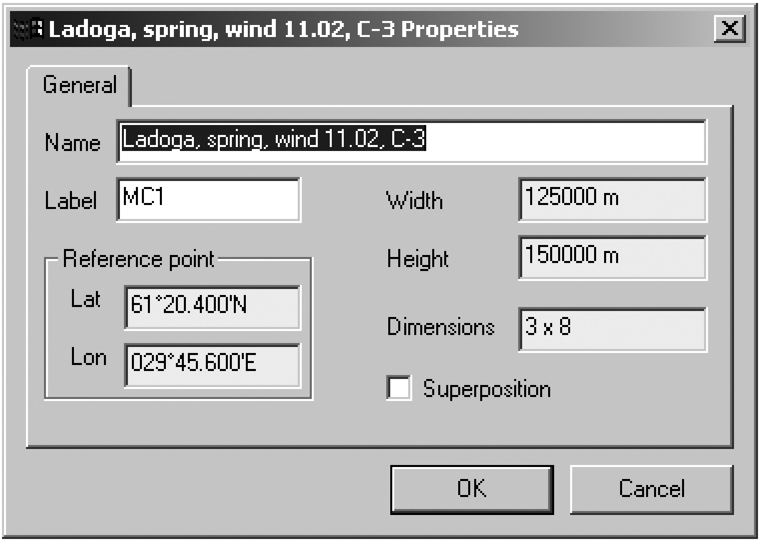
File name	Purpose
`<common name>.foc`	When field of currents are exported, an individual file is created for each current base vector to be exported. The `<common name>.foc` file contains a list of all created files and coordinates of each current
`<common name>` `<current label>.srf`	File, containing the table of relation between the velocity and direction of the surface climatic current and the time. Such file is created for each surface climatic current to be exported
`<common name>` `<current label>.tdl`	File, containing the table of relation between the velocity and direction of the tidal current and the time. Such file is created for each tidal current to be exported

To load data on a field of currents from a file, use the Environment/get from file.

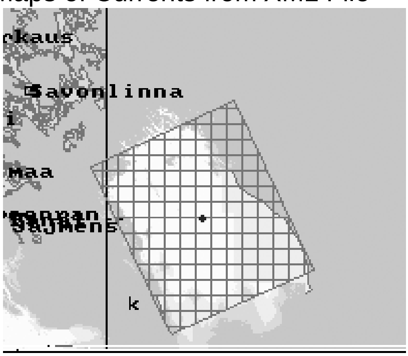


Map of Currents





Importing Maps of Currents from XML File



Displaying Field of Currents in the Chart Window

9.5.9.4. <u>Field of winds</u>

Field of Winds Visualisation

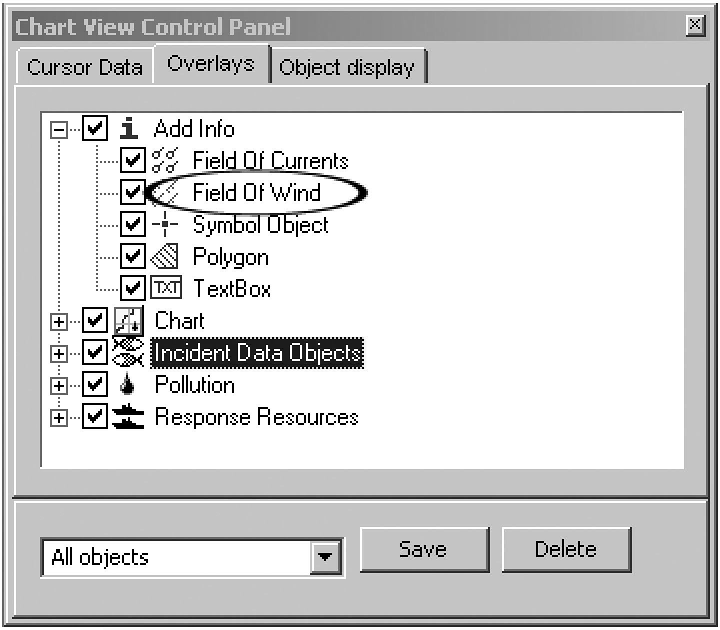
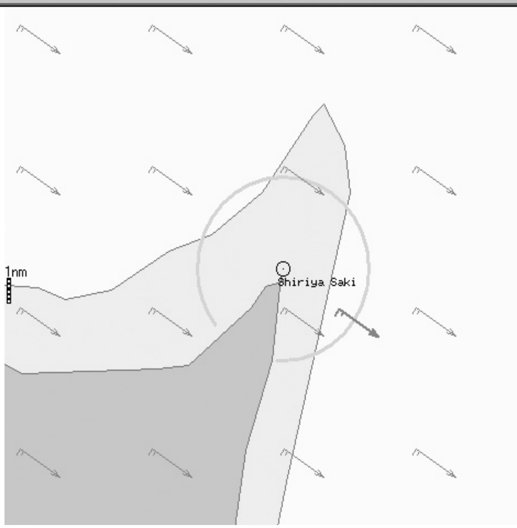
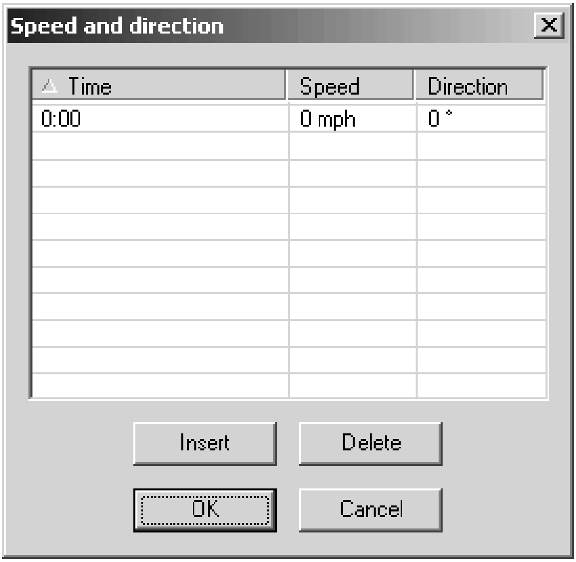


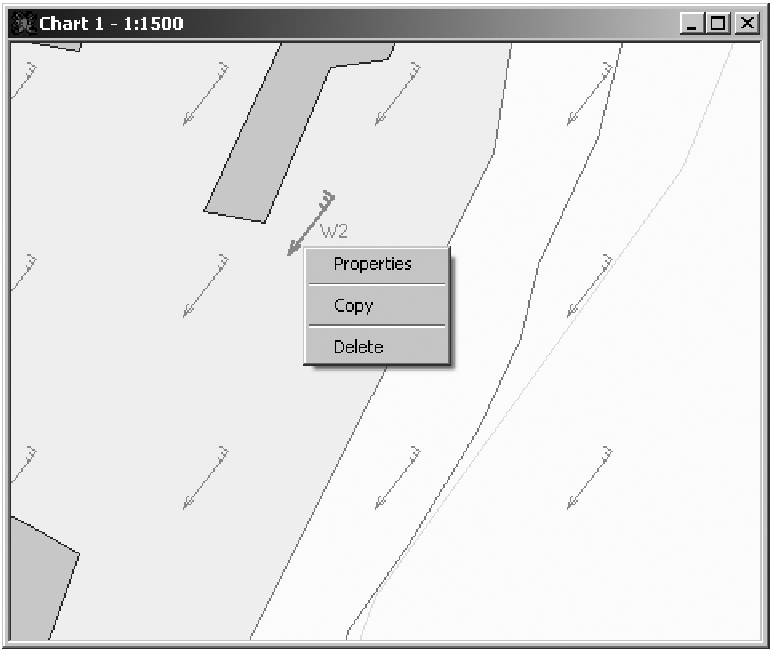
Chart View Control Panel
Cursor Data
Overlays
Object display
Add Info
Field Of Currents
Field Of Wind
Symbol Object
Polygon
TextBox
Chart
Incident Data Objects
Pollution
Response Resources
All objects
Save
Delete


1nm
Shiriya Saki

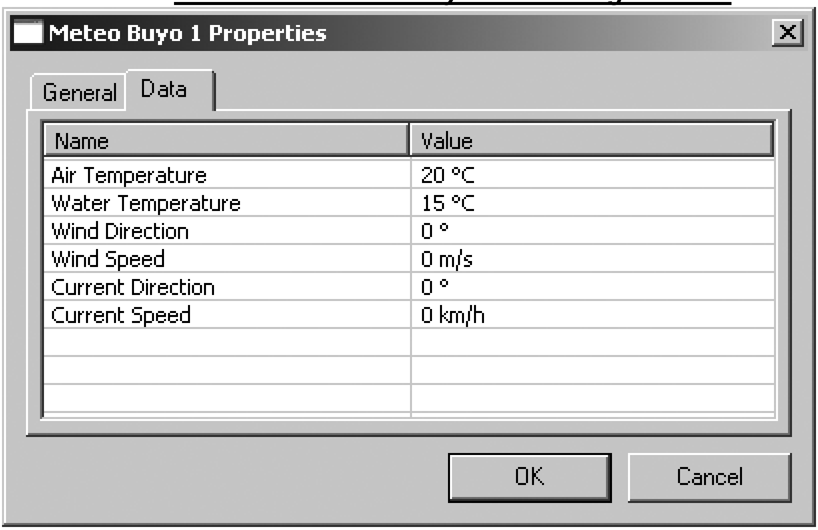
Add Wind Vectors



Editing Wind Vectors



9.5.9.5. <u>External sources of hydrometeorogical data</u>

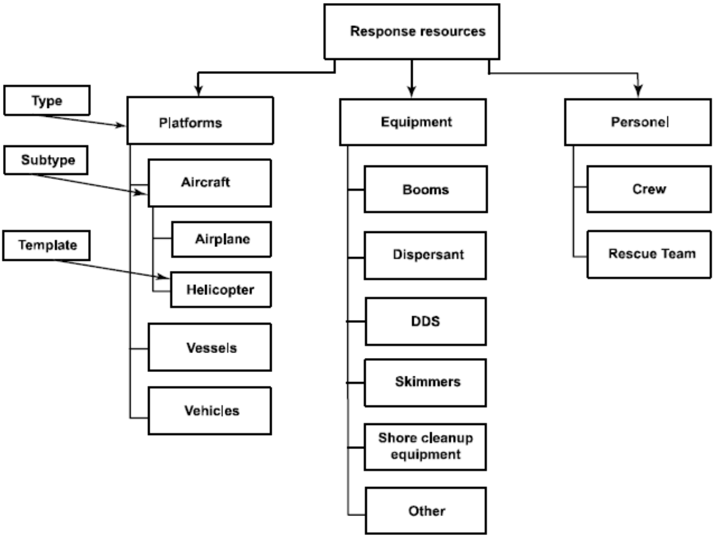


9.5.10. Response resources

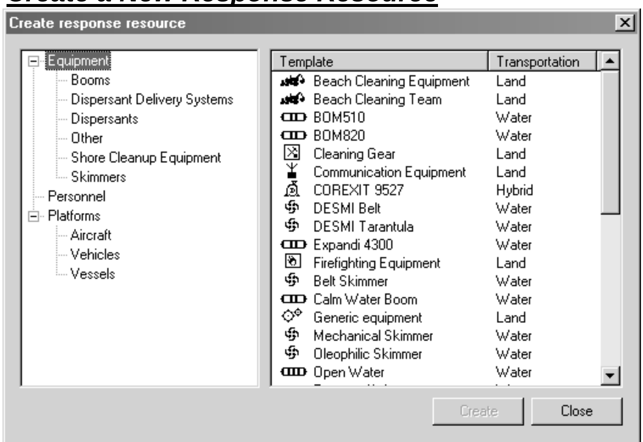
9.5.10.1. <u>Creation of response of response resources</u>

Response resources are:

- platforms;
- equipment;
- personnel.

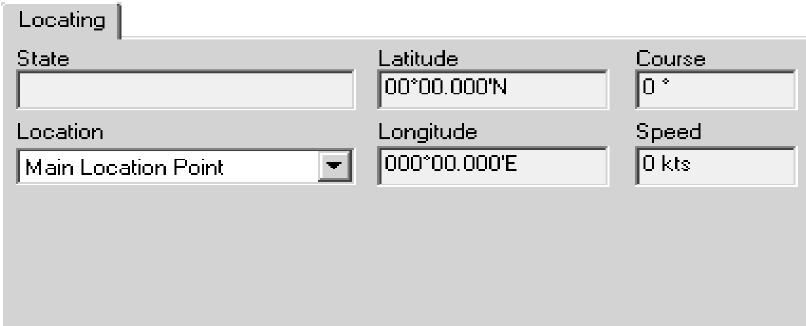


9.5.10.2. <u>Create a New Response Resource</u>



9.5.10.3. General Response Resource Parameters

Location

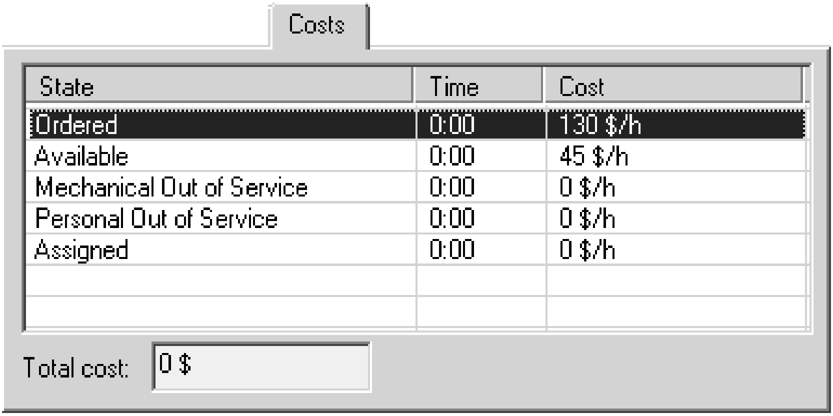


Parameter	Value
State	Non-editable field. Shows location status of the object for the current moment of time
Location	The list can be used to select a location point, to which the current response resource is to be assigned. By default, all newly created objects are assigned to the main location point
Latitude/Longitude	Coordinates of the object on chart
Course	Object course
Speed	Object movement speed

Organisation

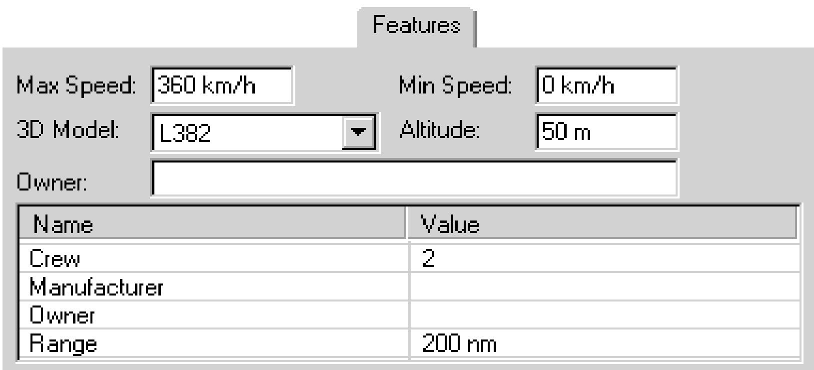
Parameter	Value
Status	Non-editable field. Reflects the object's status as a unit controlled by the Oil Spill Response Command Centre
Assignment	Non-editable field. Shows the current assignment in the oil spill response operation
Organisation	Non-editable field. Shows the object's path to the response resource structure
ETR	Non-editable field. For the resources of the "Out of service" status only. Shows the expected time of return to the "Available" status
Order time	Non-editable field. Time of placing order for the resource

Costs

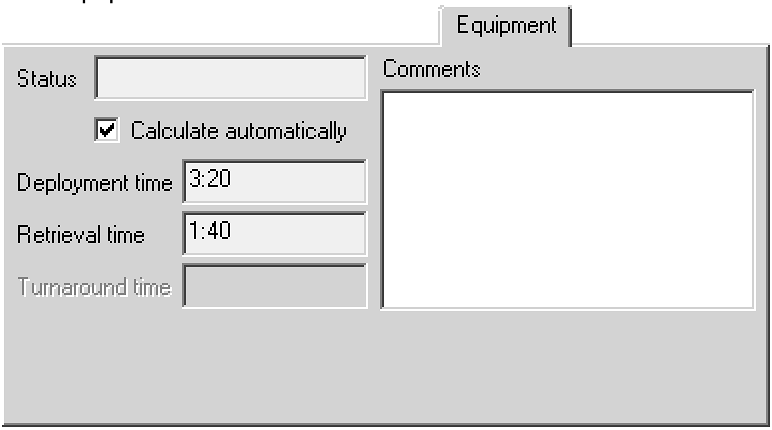


Parameter	Value
Ordered	Resource ordered, but it has not yet arrived for CC disposal
Available	Resource ready for operation
Assigned	Resource assigned a task
Mechanical Out of Service	Resource not ready for operation due to mechanical failures
Personal Out of Service	Resource not ready due to non availability of personnel

Features

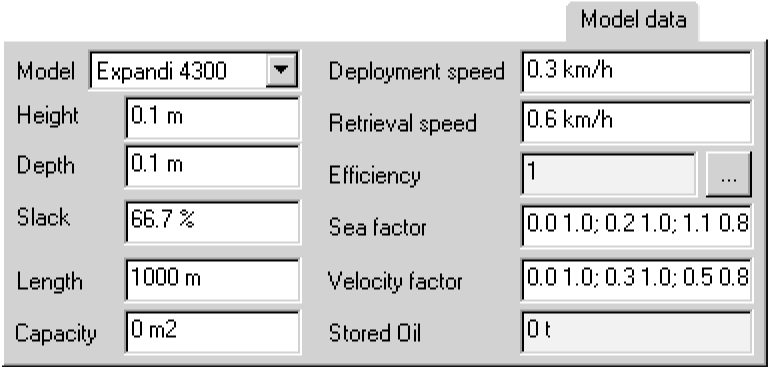


Equipment



Parameter	Value
Status	Non-editable field. Shows the current operational status of the object
Deployment time	Time of resource deployment
Retrieval time	Time of transferring the resource from the operational status to the travelling one
Turnaround time	Time of resource turnaround
Comments	Notes

9.5.10.4. <u>Individual Parameters of the Response Resource Types</u>



Booms	
Model	Boom model, to be chosen from the list
Height	Height has a bearing on the boom form calculation depending on wind and on the amount of oil, passed through the boom. If height of boom is less than thickness of above-water oil film than the boom can pass oil even its efficiency is 100%
Depth	Depth has a bearing on the boom form calculation depending on currents and on the amount of oil, passed through the boom. If depth of boom is less than thickness of underwater oil film than the boom can pass oil even its efficiency is 100%
Slack	Slack shows the ratio of the boom length to the distance between the fixing points
Length	Boom length
Capacity	Capacity per unit of length showing maximum oil volume, which a boom meter can absorb
Deployment speed	Boom deployment speed
Retrieval speed	Rate of transfer to the travelling speed
Efficiency	A value calculated by the model and showing what part of oil interacting with the boom that latter will be able to contain. The value depends on the boom type, current velocity and wave height. The button ... is used to correct efficiency. You can use two methods of efficiency correction in the “Efficiency” dialog box: • Either by directly specifying the required value, or • By specifying a “User factor” coefficient. In the latter case, the resulting value will be computed by multiplying the rated efficiency by the “User factor” coefficient
Sea factor	The line specifying dependence of the boom efficiency on the wave height. This dependence is not subject to editing in the PISCES scenario, it can only be changed by using the resource template editor
Velocity factor	The line specifying dependence of the boom efficiency on the current velocity. This dependence is not subject to editing in the PISCES scenario, it can only be changed by using the resource template editor

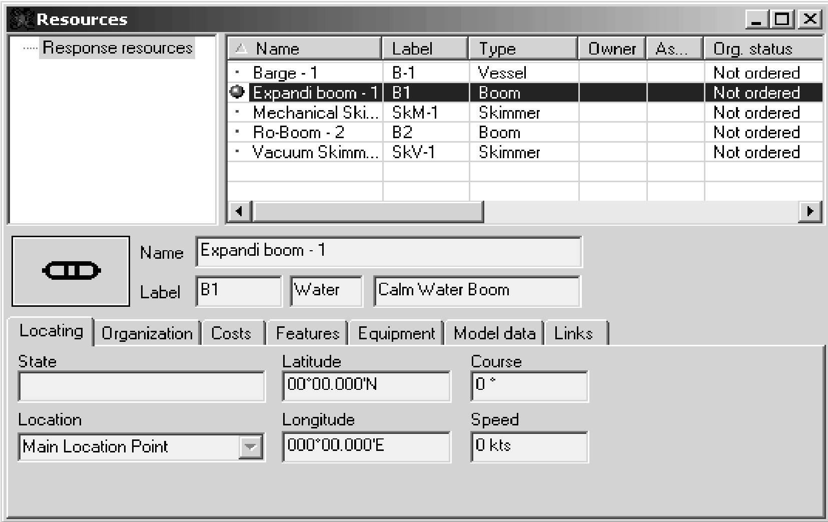
Skimmers	
Storage capacity	Skimmer storage capacity
Recovery rate	Oil collection rate
Recovery radius	Skimmer collects oil in the circle of the given radius
Stored mixture	Non-editable field. Quantity of collected oily mixture
Oil/water ratio	Non-editable field. The oil/water ratio in the skimmed mixture in calculated in the model depending on efficiency values
Additional water	Additional water ratio, which is stored by skimmer with emulsion
Skimmer type	To be selected from the list
Efficiency	A value calculated by the model and showing how much the rated capacity and the oil/water ratio in the skimmed mixture will decrease depending on oil viscosity and wave height. The button is used to correct efficiency. You can use two methods of efficiency correction in the “Efficiency” dialog box: either by directly specifying the required value, or by specifying a “User factor” coefficient. In the latter case, the resulting value will be computed by multiplying the rated efficiency by the “User factor” coefficient
Sea factor	The line specifying the dependence of the skimmer efficiency on the wave height. This dependence is not subject to editing in the PISCES scenario, it can only be changed by using the resource template editor
Viscosity factor	The line specifying the dependence of the skimmer efficiency on the oil viscosity. This dependence is not subject to editing in the PISCES scenario, it can only be changed by using the resource template editor

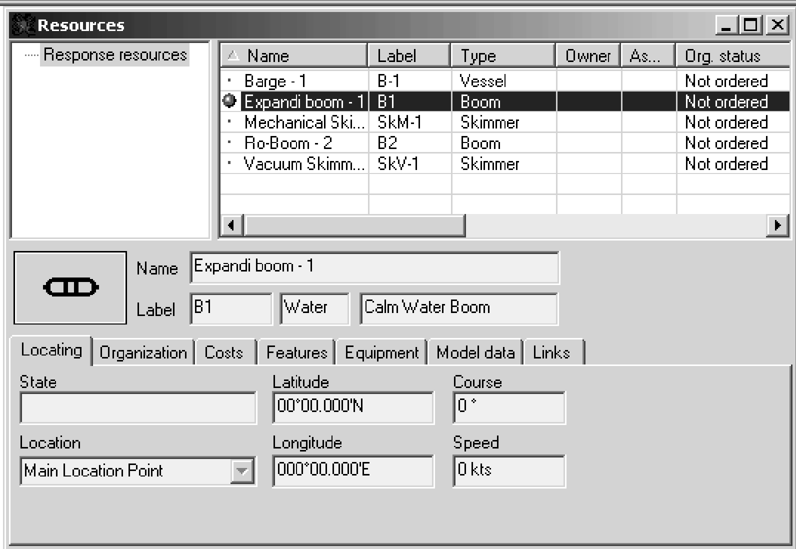
Stored oil	Non-editable field. Amount of oil absorbed by boom
Dispersant ("Model" tab)	
Type	Dispersant grade, to be selected from the list
Rec. O/D ratio	Recommended oil/dispersant ratio
Dispersion coeff	Dispersion coefficient
Density	Dispersion density
Amount	Dispersion quantity
Dispersion spread facilities	
Type	To be selected from the list
Dispersant	To be selected from the list of those available in the scenario
Spread width	Spread width of the equipment
Play rate	Rate of spreading
Amount	Non-editable field. Quantity of spent dispersant
Dispersant Properties	Characteristics of the loaded dispersant. Non-editable fields
Name	Dispersant name
Recom. O/D ratio	Recommended oil/dispersant ratio
Amount available	Quantity of remaining dispersant

Shore cleanup equipment	
Shore cleanup equipment type	To be selected from the list
Basic efficiency	Shows the maximum share of stranded oil that the equipment can collect
Recovery rate	Oil recovery rate
Soil/Oil ratio	Soil/Oil ratio in the collected mixture
Shore cleanup equipment	
Efficiency	Parameter, showing what part of stranded oil can be collected by the cleanup equipment. You can edit efficiency by click . In the "Efficiency" dialog box, you can change efficiency using one of two methods: • Directly specifying the require value; • Specifying "User coefficient". In the latter case, the resulting value will be determine by multiplying the basic efficiency by the user coefficient
Working parcel	Non-editable field. The name of the parcel, on which the cleanup equipment operates
Recovered mixture	Amount of collected oil/soil mixture

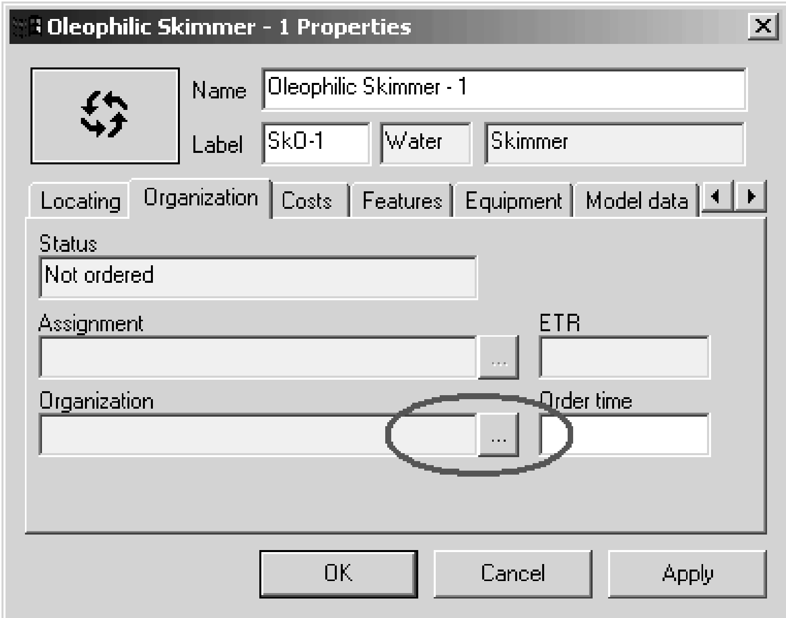
9.5.11. Response resources in the date window

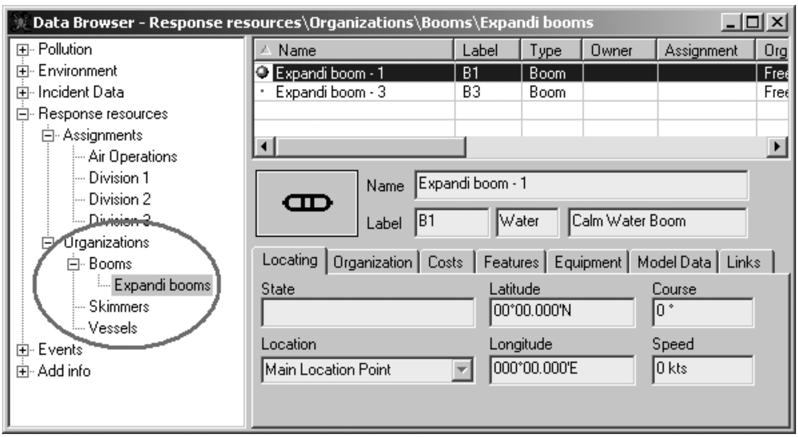
List of response resources





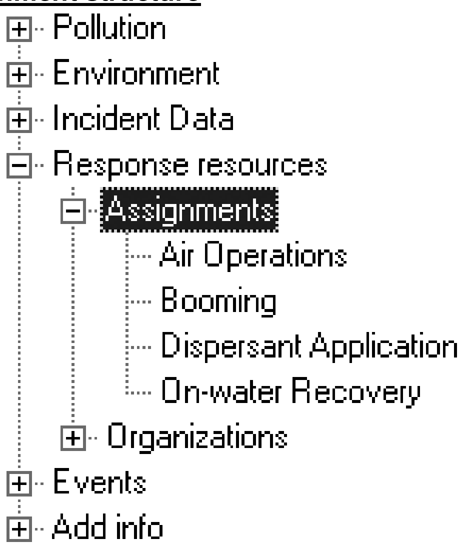
Resource structure





9.5.12. Response simulation

9.5.12.1. <u>Assignment structure</u>



9.5.12.2. <u>Response statuses</u>

The organisational status group includes five elements described in the table below:

Status	Icon colour	Description
Free	Grey	The resource is not involved in the IOSR operations, not reporting to CC. The cost of resource use is not taken into account
Ordered	Semitransparent	The resource is ordered, it is assigned the time of arrival and the location point. It is assumed that all documents required for ordering the resource has been prepared by CC
Assigned	Blue	The resource is assigned a task
Available	Black	The resource is ready for the task
Out Of Service	Red	The resource is not ready for the task; in this case you can specify time, when the resource will automatically return to the “Available” status

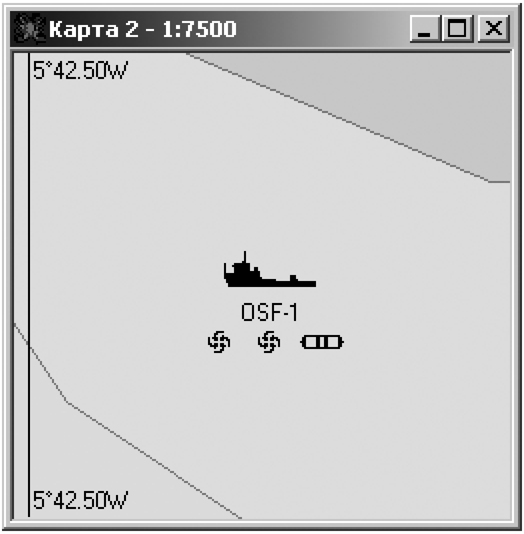
Change the status

The user can change the status of the resource using the following commands available in the object context menu:

Initial status	Command	Resulting status	Description
Free	Employ	Available	To bring instantaneously to the "available" status
	Order	Ordered	To specify the location and time of arrival. The resource will automatically turn over to the "Available" status on arrival
Ordered	Arrive	Available	To instantaneously bring the ordered resource to the "Available" status, not waiting for the specified time to come
	Cancel Order	Free	To cancel the order. The resource transit is cancelled automatically
Available	Assign	Assigned	To assign a task to the resource. Specification of the division the resource is assigned to is mandatory
Assigned	Out of Service	Out of Service	To transfer the resource to the out-of-service status. Specification of the expected time of resource return is mandatory
	Cancel Assignment	Available	To return the resource to the "Available" status by cancelling the task
Out Of Service	Available	Available	To return the resource to the "Available" status by restoration of the "Available" status
Available Assigned Out Of Service	Release	Free	Demobilize the resource and transfer it to the "Free" status

Locating Statuses

Out of Scene	
Blank	Initial status of the resource
In transit	The resource is sent to the impact area. The route is not specified. The only data known is the time of arrival and the location point
Delayed	Transfer of the resource to the impact area is suspended for a specified time period
On Scene	
En-route	Movement along the route
Delayed	Movement of the resource along the route is suspended for a specified time period
At location	The resource is in the impact area not moving
Tracked	The resource position is monitored by GPS systems



Commands available in the object context menu:

Command	Resulting status	Description
Put on Scene	On Scene: At location	Putting the resource on scene immediately. The resource appears at the location point
Depart	Out of Scene: In Transit	Switch the resource over to the In Transit condition, meaning that it will go to the impact area. The route is not specified. Only the time of arrival and the location point are known
Take out from Scene	Out of Scene: Blank	Removing the resource from scene at once
Load on Carrier	On Carrier	The resource is “loaded” on platform, its positional status becomes the same as the positional status of the platform
Unload from Carrier	On Scene: At position Out of Scene: Blank	Unloading the resource from the platform. If the carrier were on scene, the resource would appear on scene having the same coordinates as those of the carrier. It the carrier was outside the scene, the resource will accept the “Out of Scene” status
Set position	At position	Appearing of the resource on scene at the specified position
Set route	En-route	Object moving according to a specified route
Route completed	At position	Interrupting the movement along the route, the resource stopping at a current-coordinates point
Delay route	En-route	Delay of movement along the route for a specified length of time
Attach GPS	Tracked	Connection of the resource to the GPS data source
Detach GPS	At position	Disconnection of the resource from the GPS data source

Operational Statuses

Status	Description
Stowed	Travelling condition
Deploying	Transfer of the resource from the travelling condition to the operational status
Deployed	Operational status
Retrieving	Transfer of the resource from the operational status to the travelling condition
Failure	The resource is out of order due to a mechanical failure

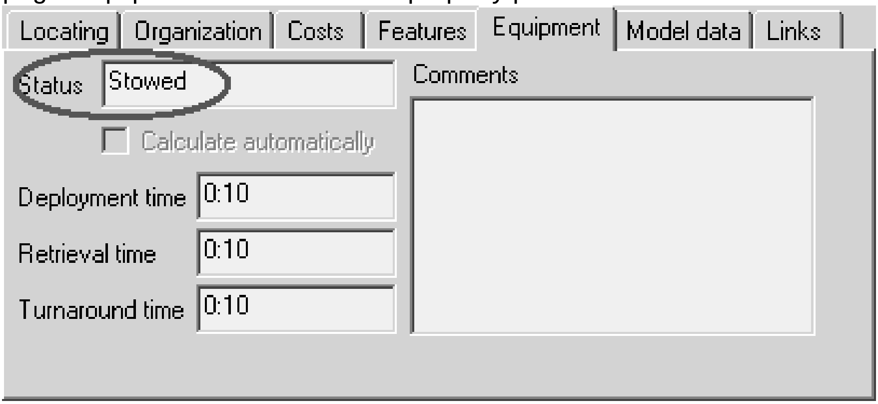
The “Deployed” status for interactive equipment (interacting with oil) is divided into three statuses

Status	Description
Operating	Operational status of the resource
Turnaround	The resource turnaround cycle. On expiration of the specified turnaround period, the resource will automatically accept the operational status. The “Start Turnaround” command of the context menu turns on simulation of the resource turnaround. The “Stop Turnaround” command stops the simulation
Idle	The resource suspends task fulfilment. The transfer to the “Idle” status is performed by the “Stop operation” command of the object context menu. Fulfilment of the task is resumed by the “Operate” command of the context menu

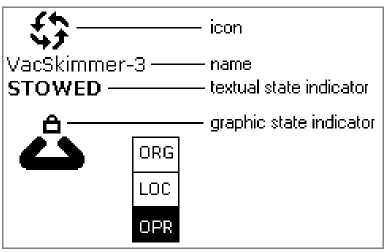
The user can change the operational status of the resource using the following commands, available in the object context menu:

Command	Resulting status	Description
Deploy	Deploying	Transfer of the resource from the travelling condition to the operational status. It takes some preset time
Deploy Now	Deployed	Instantaneous transfer of the resource from the travelling condition to the operational status
Delay	Same as initial	Suspension of the resource transfer from one status to another (from the travelling one to the operational one or vice versa)
Cancel Delay	Deploying	Cancel of suspension for resource transfer to a status
Retrieve	Retrieving	Transfer of the resource from the operational status to the travelling one. It takes some preset time
Retrieve Now	Stowed	Instantaneous transfer of the resource from the operational status to the travelling one
Failure	Failure	Resource transfer to the unavailable condition. Performed instantaneously
Restore	Stowed	Resource transfer for the unavailable condition to the travelling status. Performed instantaneously

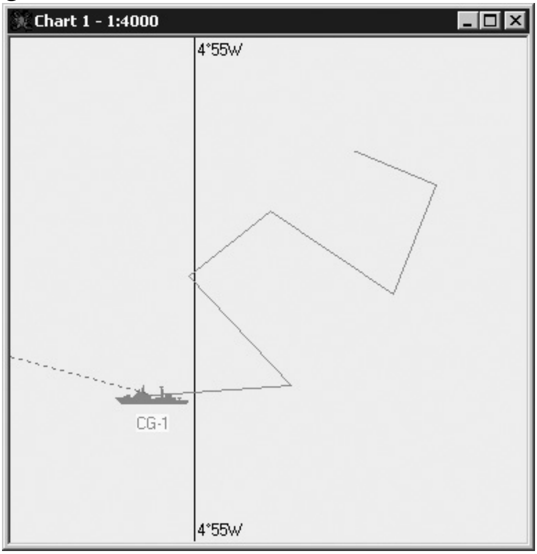
The current operational status is shown in the “Status” field on page “Equipment” of the resource property panel:

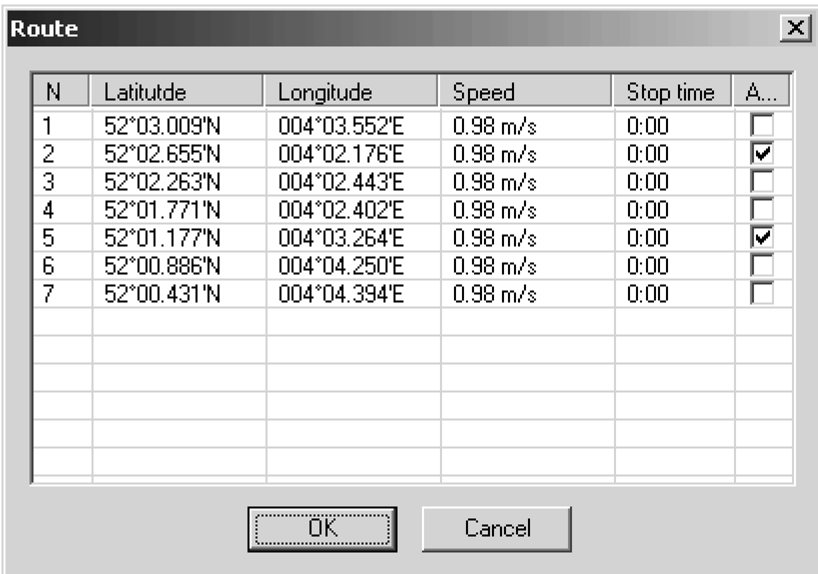


Command Panel



9.5.13. Setting resource route



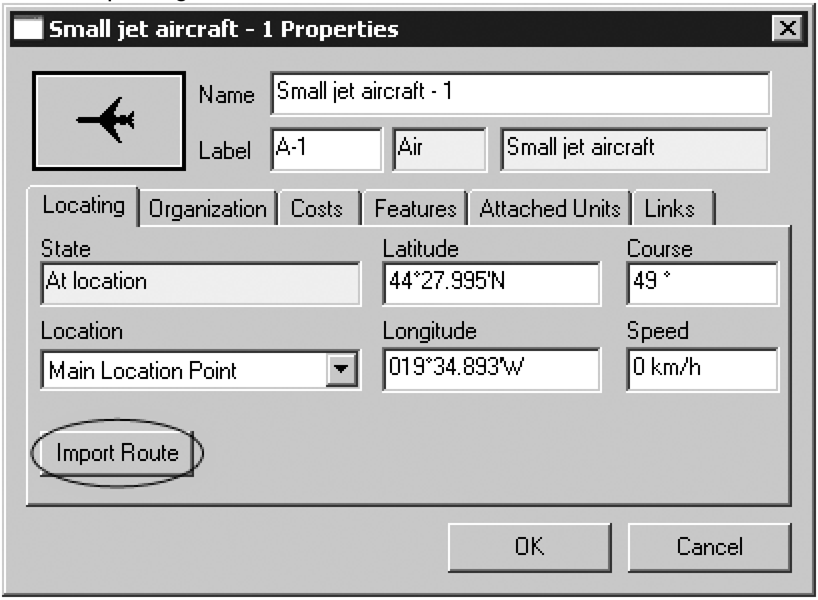


Route

N	Latitutde	Longitude	Speed	Stop time	A...
1	52°03.009'N	004°03.552'E	0.98 m/s	0:00	☐
2	52°02.655'N	004°02.176'E	0.98 m/s	0:00	☑
3	52°02.263'N	004°02.443'E	0.98 m/s	0:00	☐
4	52°01.771'N	004°02.402'E	0.98 m/s	0:00	☐
5	52°01.177'N	004°03.264'E	0.98 m/s	0:00	☑
6	52°00.886'N	004°04.250'E	0.98 m/s	0:00	☐
7	52°00.431'N	004°04.394'E	0.98 m/s	0:00	☐

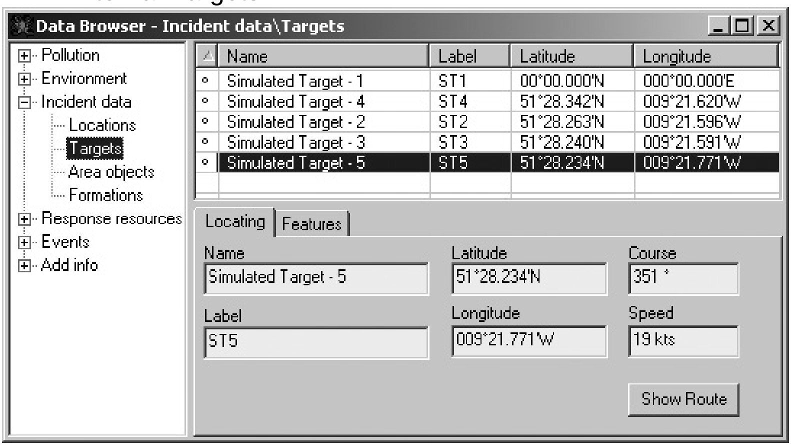
OK Cancel

Importing Resource Routes from Text Files



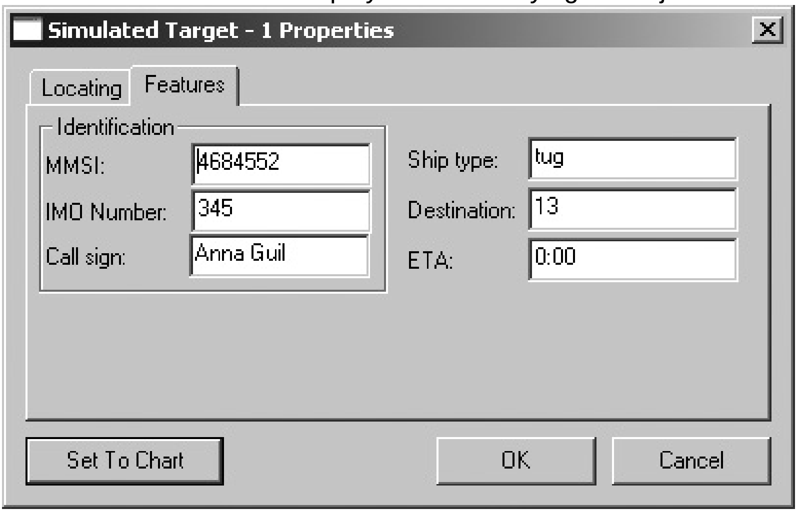
9.5.14. Targets

External Targets



Parameter	Value
Latitude/Longitude	Objects' chart coordinates: latitude/longitude
Course	Object motion direction
Speed	Object motion speed
Name	Object name
Label	Text label in the chart window

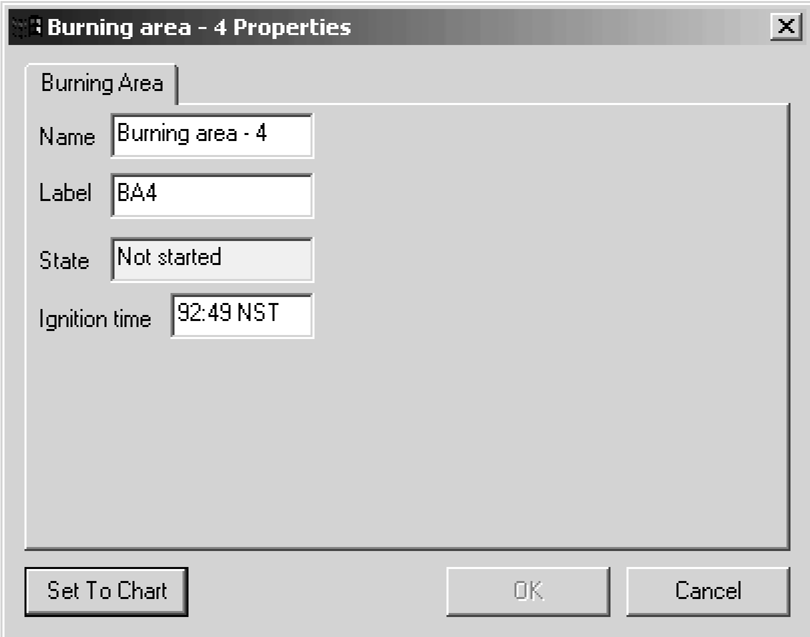
The "Features" tab displays data identifying the object:



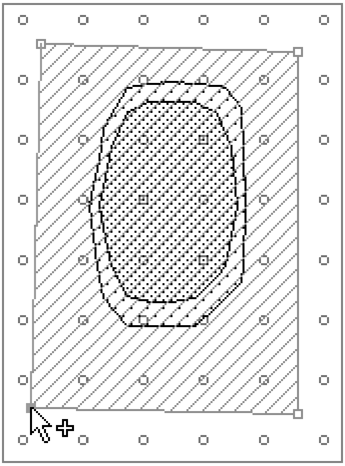
Parameter	Value
MMSI	MMSI number
IMO Number	IMO identification number
Call sign	Callsign
Ship type	Ship type
Destination	Ship's route end point
ETA	Estimated time of the ship's arrival in the point of destination

9.5.15. Areas

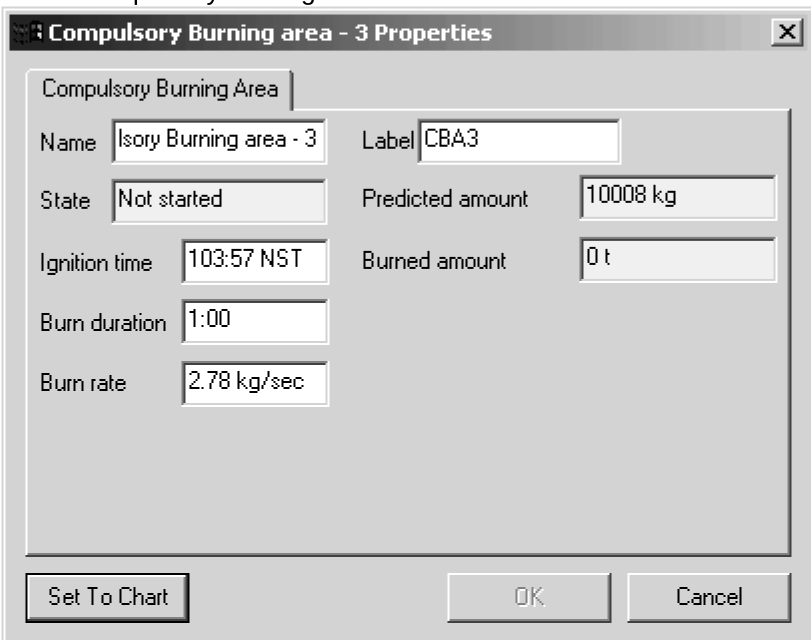
Burning



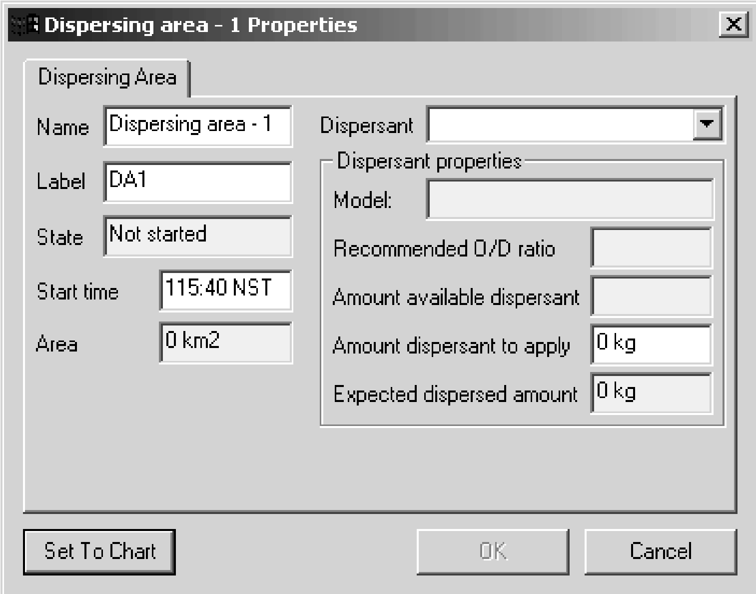
Status	Value
Not started	The process has not started yet
In progress	The process has been started
In model	The model in the process of calculation
Finished	The process is over

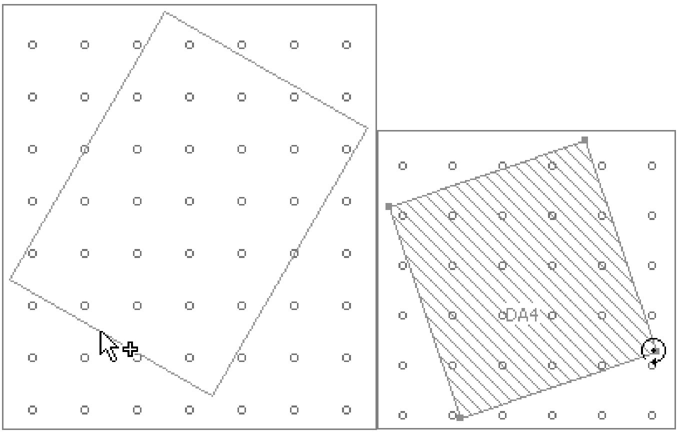


Compulsory burning area:



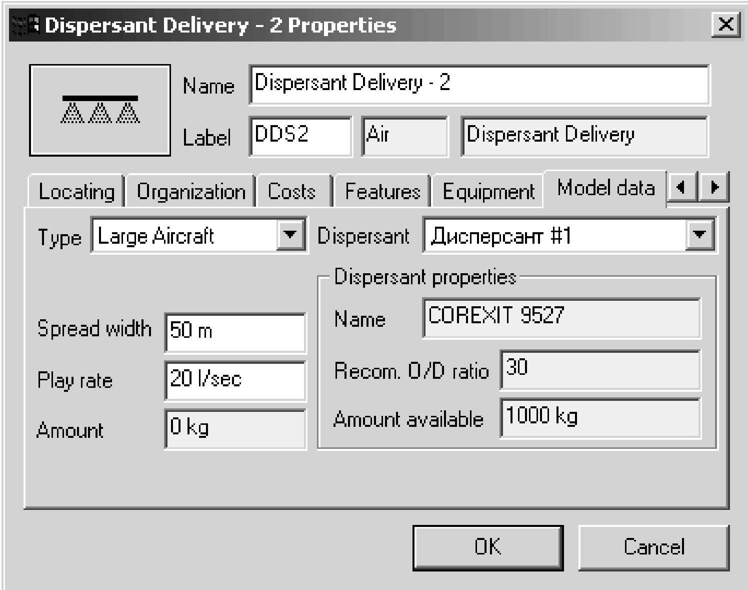
Using dispersants immediate use of dispersant

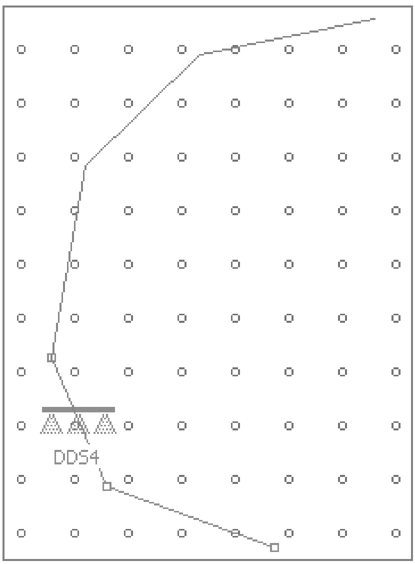




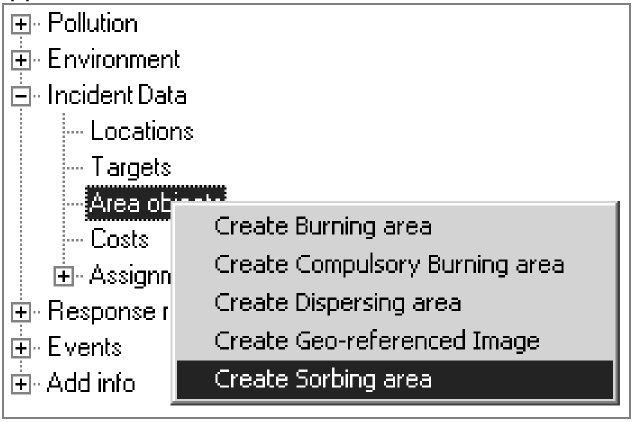
Command	Purpose
Properties	Opening the object properties menu
Hide/Show Label	Hiding/showing the object level
Move Label	Moving the object label
Delete	Deleting the object

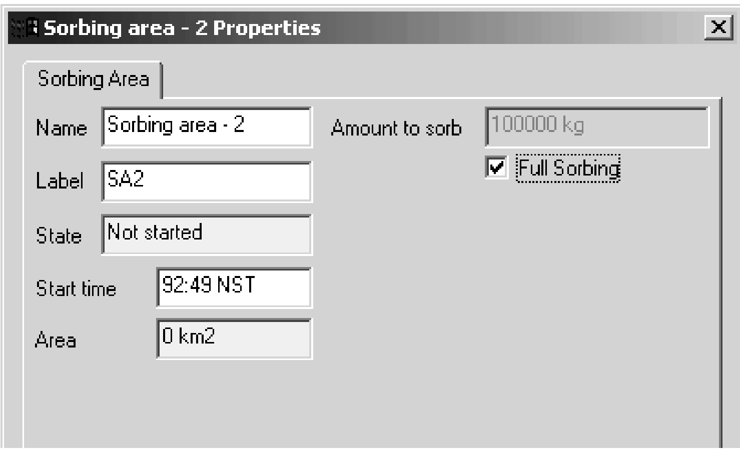
Using dispersants gradual use of dispersant





Sorbent Application

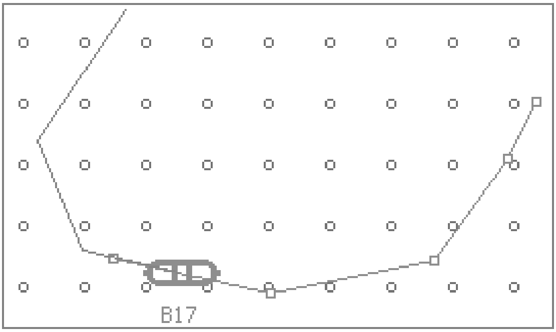


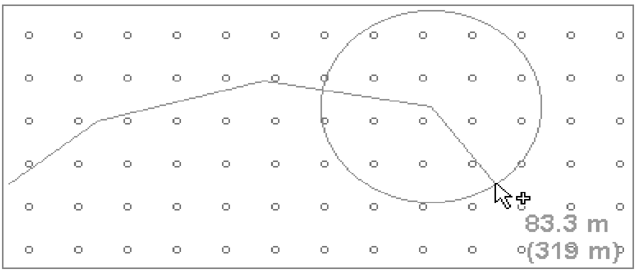


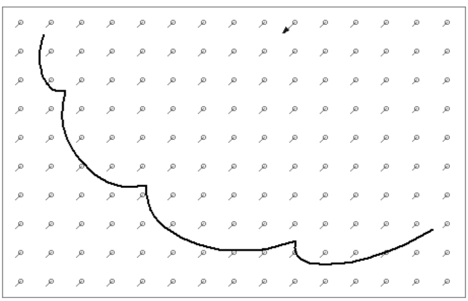
Command	Purpose
Properties	Opening the object properties menu
Hide/Show Label	Hiding/showing the object level
Move Label	Moving the object label
Delete	Deleting the object
Delete Points	Deleting object point(s)

9.5.16. Using booms

Task	Description
Oil containment and diversion	The deployed booms prevent spreading of oil slicks. The boom form is determined by location of anchor points and the “slack” parameter. Boom model characteristics determine its holding capacity
Oil collection	Trawling by the basic boom configurations: U, V, J. Movement of skimmers included in the trawling Order can be specified using the targets, see the section **7.3.3 Attaching Resources to Targets**
Use of sorbing booms	A sorbing booms is one able to absorb oil. The squeezing of such boom is performed at the moment of its retrieval, but in the PISCES II statistics, the amount of the collected oil rises gradually as it is absorbed by the boom. Application of sorbing booms combines oil collection and retaining, oil concentrating and deviating

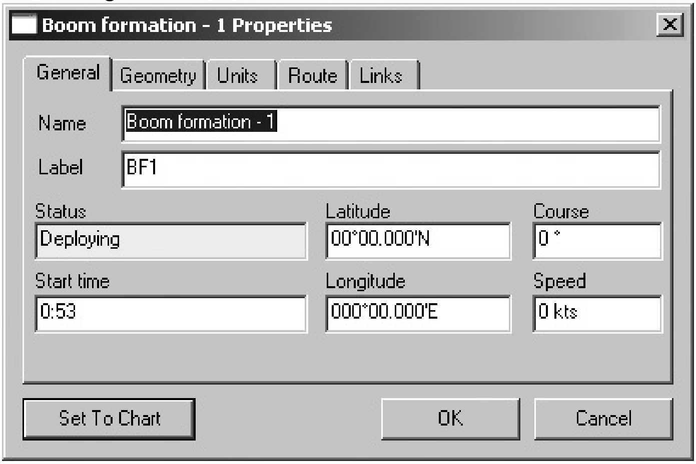






9.5.17. Use of boom formations

Creating Formations

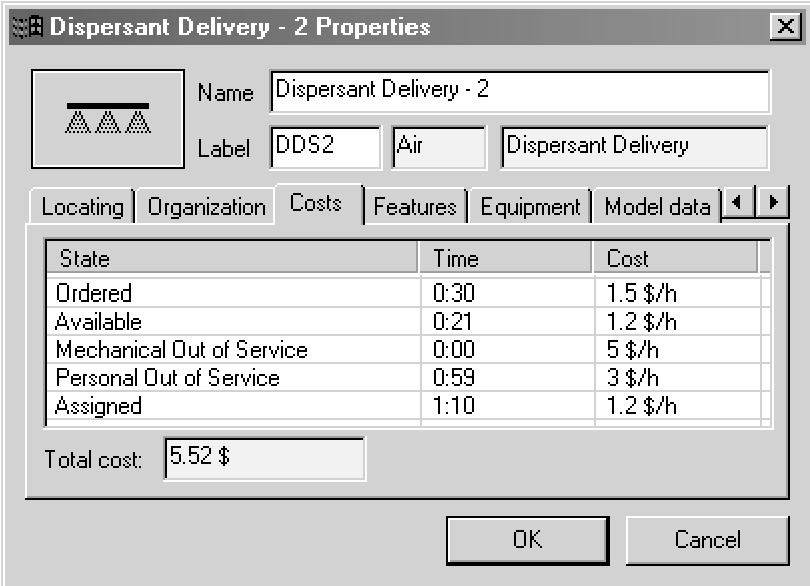


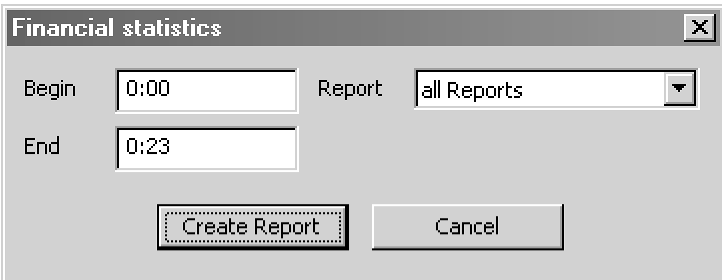
Parameter	**Meaning**
Name	Formation name
Label	Text label which will be shown on the chart
Status	Read only value. Shows the current formation status
Start time	Formation deployment time
Latitude, Longitude	Object's chart coordinates: latitude and longitude
Course	Read only value. Shows the direction of the object's motion
Speed	Read only value. Shows the object's motion speed

9.5.18. Using oil skimmers

Skimmer model	Dependence of oil skimming efficiency on the wave height		Dependence of oil skimming efficiency on the oil viscosity	
	Wave height (feet)	Efficiency (%)	Viscosity (cP)	Efficiency (%)
Threshold	0	100	0	85
	3	100	3000	70
	4	50	10000	5
	5	25		
	6	0		
Oleophilic	0	100	0	10
	3	100	500	40
	4	50	1500	90
	5	25	2500	60
	6	0	5000	10
Vacuum	0	100	0	50
	3	100	2500	60
	4	50	5000	50
	5	25	10000	40
	6	0		
Mechanical	0	100	0	0
	3	100	1000	20
	4	50	5000	40
	5	25	10000	90
	6	0		
Belt	0	100	0	0
	1.97	100	1000	20
	4.27	50	5000	40
	6.56	0	10000	90

9.5.19. Cost of operation





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