ΑΚΑΔΗΜΙΑ ΕΜΠΟΡΙΚΟΥ ΝΑΥΤΙΚΟΥ

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ΕΠΙΒΛΕΠΟΥΣΑ ΚΑΘΗΓΗΤΡΙΑ: ΠΑΝΑΓΟΠΟΥΛΟΥ ΜΑΡΙΑ

PROCEDURES DURING STORMY CONDITIONS

ΤΗΣ ΣΠΟΥΔΑΣΤΡΙΑΣ: ΡΟΒΕΡΤΟΥ ΙΩΑΝΝΑ

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Α/Α	*Ονοματεπώνυμο*	*Ειδικότης*	*Αξιολόγηση*	*Υπογραφή*
1				
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3				
ΤΕΛΙΚΗ ΑΞΙΟΛΟΓΗΣΗ				

Ο ΔΙΕΥΘΥΝΤΗΣ ΣΧΟΛΗΣ :

INTRODUCTION

“Fare wind and Calm Seas” – this is what a seafarer hopes for when he is sailing at high seas. However, nature is bound to show ups and downs, and rough weather may hit a vessel in open sea with no time to react. Even if there is a practice of sending pre weather warning to ships for route change or speed alternations, every seaman has experienced high swell and unfriendly side of the sea.

Heavy, rough, or stormy weather is a term used to describe extreme adverse weather conditions, which may affect the safety of the vessel, crew and/or cargo.

Navigation in heavy weather is defined as conditions with winds of Beaufort Scale 7 or more and a Significant Wave Height of 4 meters or more.

Time is a critical factor for reacting in a situation like rough weather. If a pre warning is available with the ship, then crew can do the preparation; however, if the warning period is short or if there is a sudden struck of rough waves and bad weather, then handling of the ship depends on the knowledge, training, skills and team effort of the ship’s personnel.

1 METEOROLOGY FOR SEAFARERS

Severe weather can occur under a variety of situations, but three characteristics are generally needed: a temperature or moisture boundary, (in the event of severe, prepicitaion- based events) instability in the atmosphere and moisture.

1.1 TEMPERATURE

1.1.1 Introduction

Air temperature may be monitored at various heights above the surface. Surface air temperature is monitored at 1.25m, the recommended height for instruments on land. Surface temperature is that monitored at the surface, and at land observing stations the surface may be turf, concrete or soil. At sea the surface temperature is monitored by voluntary observing ships or data buoys.

The air temperature recorded can in some circumstances reflect the influence of the underlying surface on a mass of air, and in particular the contrast which extracts between land and sea surfaces. On other occasions the air temperature reflects the horizontal movement of air associated with pressure systems.

1.1.2 Temperate and Polar Zone circulation; general circulation of the atmosphere

The general circulation of the atmosphere is the three dimensional flow of air on a global scale, with an associated transfer of energy. It is a highly complex system and subject to change both in space and time.

If it is assumed that the surface of the earth is uniform and the time of year equinoctial (spring or autumn), the idealized distribution of surface pressure and associated air flow will be as shown in Figure 1.1.

There is convergence, a net accumulation of air, at the surface at 0° and 60°N and S where the pressure is low. However there is divergence, a net loss of air, at the surface between 30° and 40°N and S, and at the poles where the pressure is high. In general, where there is convergence at the surface, there is divergence in the upper troposphere and air ascends between the two levels. Conversely air descends where there is divergence at the surface, and convergence in the upper troposphere.

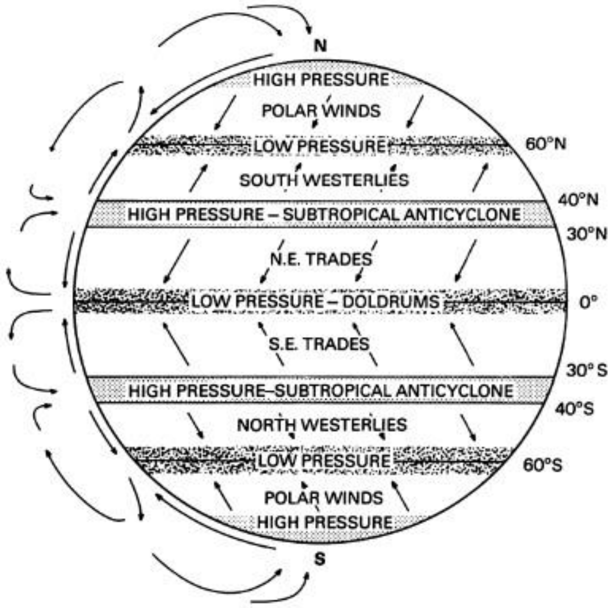


Figure 1.1 General circulation of the atmosphere - idealized

At 60° N and S two masses of air having different temperatures converge. The boundary between there masses is called a frontal zone or frontal surface, and where it intersects the surface of the earth it is called a front (Fig. 1.2). The frontal zone is inclined at an angle to the surface with the warm air tending to rise over the cold air.

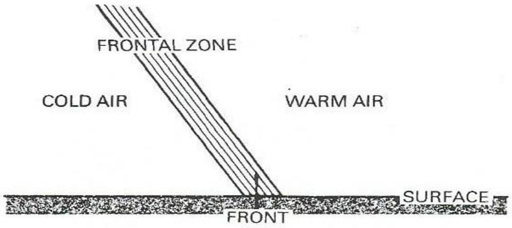


Figure 1.2 Frontal zone – Vertical section

The transfer of energy by the general circulation is related to the net radiation balance of the earth / atmosphere system, the balance being the difference between the total incoming solar radiation and outgoing terrestrial radiation. Annually there is a surplus of energy between 40°N and 40°S and a deficit in higher latitudes. However, the amount of energy transferred varies with the time of year. Some of major features of the general circulation can be identified on surface synoptic charts.

Pressure systems in temperate and polar zones play a critical part in determining weather and sea state conditions, and an understanding of the significance of the features on synoptic and prognostic (forecast) charts and in weather bulletins is essential.

1.2 FRONTAL DEPRESSIONS

A frontal depression is characterized by having a surface pressure distribution marked by one or more isobars enclosing an area of low pressure. The value of the pressure at the center, which varies throughout the life cycle of the depression and from one depression to another, generally ranges between 950 hPa is termed a deep depression.

Most frontal depressions develop on a frontal zone (Figure 1.3). Polar fronts are boundaries between polar and tropical air; arctic fronts between arctic and polar air; antarctic fronts between Antarctic and polar shown in Figure 1.3 for January and July. In January the polar fronts in the southern hemisphere are aligned approximately east-west. In contrast the polar fronts in the northern hemisphere are aligned with the eastern coastlines of North America and Asia, partly reflecting the contrasting influence of land and sea. In the Mediterranean the contrast in air masses is apparent in January, but scarcely exists in July where there is no frontal zone. In July frontal zones in the northern and southern hemispheres lie approximately east-west.

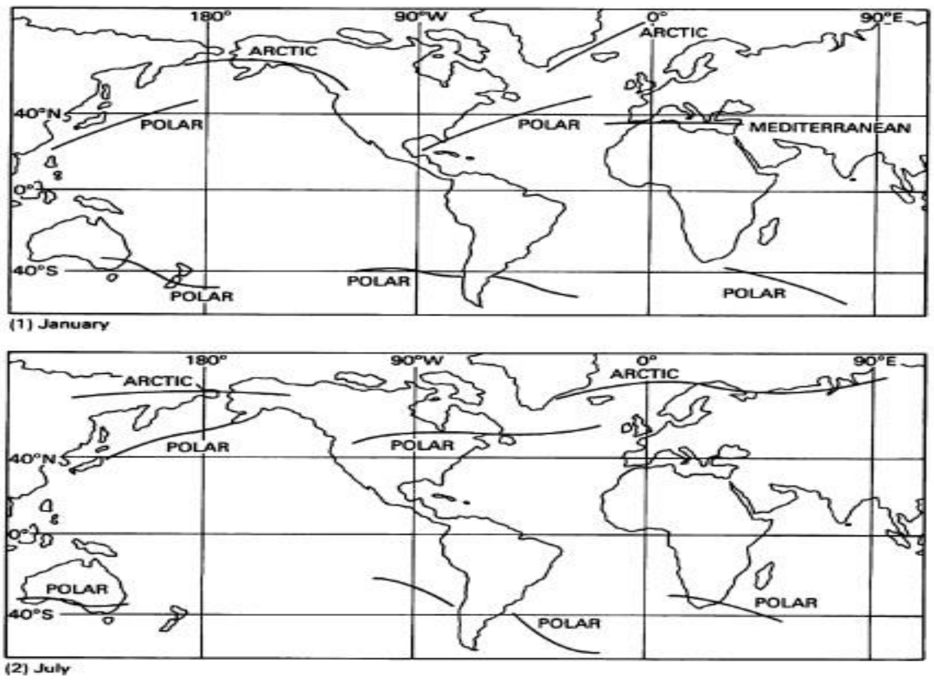


Figure 1.3 Mean position of Frontal Zones

1.2.1 Life Cycle Of a frontal depression

The formation, development and decay of a frontal depression, whose life cycle may vary in length from three to seven days, can be illustrated by a series of plan diagrams of a system at the surface of the earth (Figures 1.4 (1) to (6)).

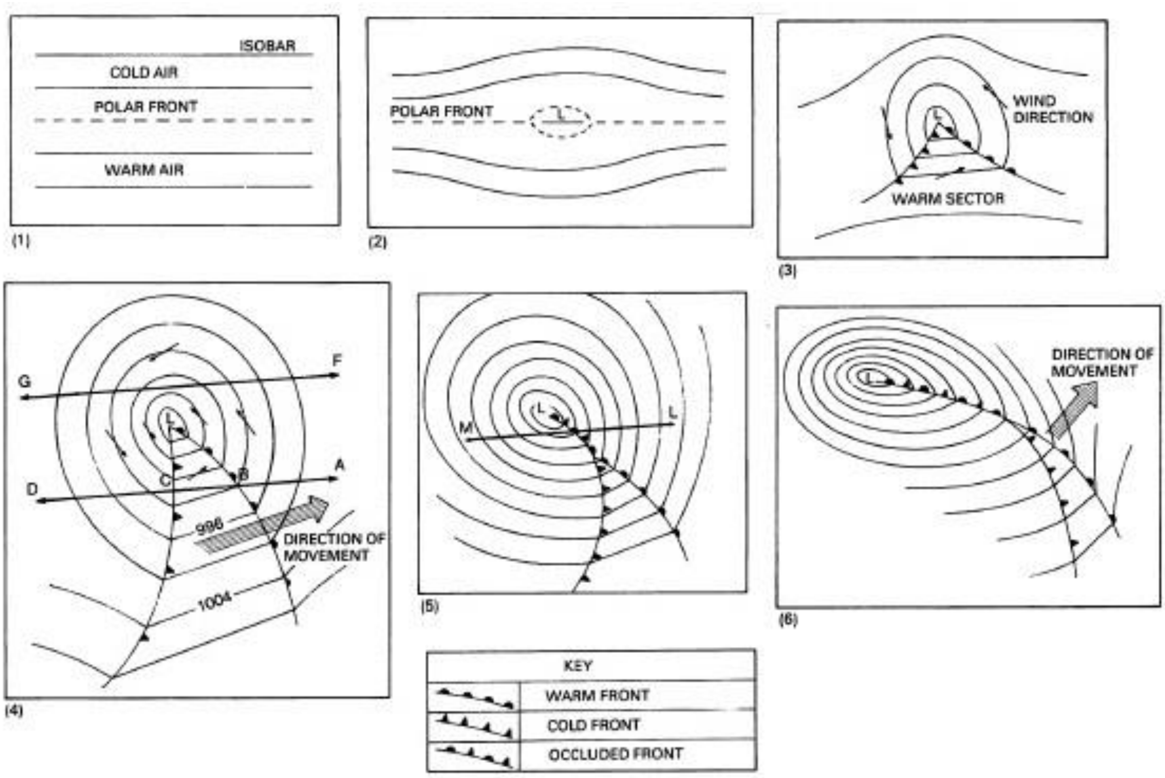


Figure1.4 Life cycle of a polar front depression, Surface view plan

1.2.2 Frontogenesis

The progressive separation of isobars indicates a decrease in pressure at a point on a frontal zone (Figure 1.4 (1) and (2)). A wave appears on the front and, if unstable, it continues to develop. The center of low pressure is at the apex of the wave and the surface air circulation develops a typical anticlockwise (northern hemisphere) and inward movement. Sections of the original front are now identified as the warm or cold front with an intervening warm sector (Figure 1.4 (3)). This process is termed frontogenesis. During these initial stages the amplitude of the wave increases, and the depression moves rapidly eastwards parallel to the isobars of the warm sector, sometimes at speeds of over 40knots (Figure 1.4 (3) and (4)). The position of the warm front t the surface marks the point at which warm air replaces cold air; the position of the cold front where cold air replaces warm air.

Within 24 hours of the initial wave formation, the depression usually reaches maturity (Figure 1.4 (4)) and its central pressure value has decreased (the depression has deepened). As the depression deepens so the pressure gradient becomes steeper and the wind speeds increase, this process continuing into the early stages of occlusion.

1.2.3 Frontolysis

The speed of advance of the cold front of a depression is greater than that of the warm front, hence the area of the intervening warm sector diminishes. As the warm sector is progressively lifted off the surface from the center of the depression outwards, an occluded front develops (Figure 1.4 (5)). The depression begins to fill, its central pressure value increasing, and simultaneously wind speeds decrease as the pressure gradient slackens. The speed of advance of the depression decreases and it may eventually become stationary, the occluded front pivoting around its center (Figure 1.4 (6)). Eventually the weak low pressure area and occluded front fade. The process from initial occlusion to the final fading of the front is termed frontolysis.

The life cycle of a frontal depression can be observed by studying a series of synoptic or prognostic surface charts. In Figure 1.5 (1)-(3), covering a period of 48 hours, depression A develops on the polar front and moves NNE, deepening as the amplitude of the wave increases.

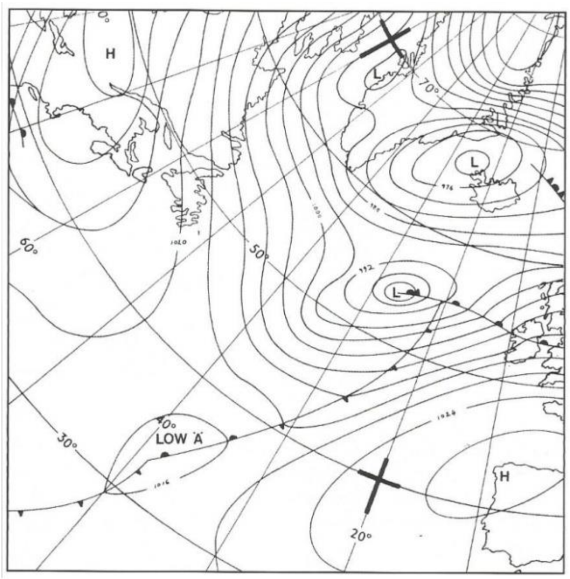


Figure 1.5 (1) Synoptic chart – 1200 UTC, Day 1

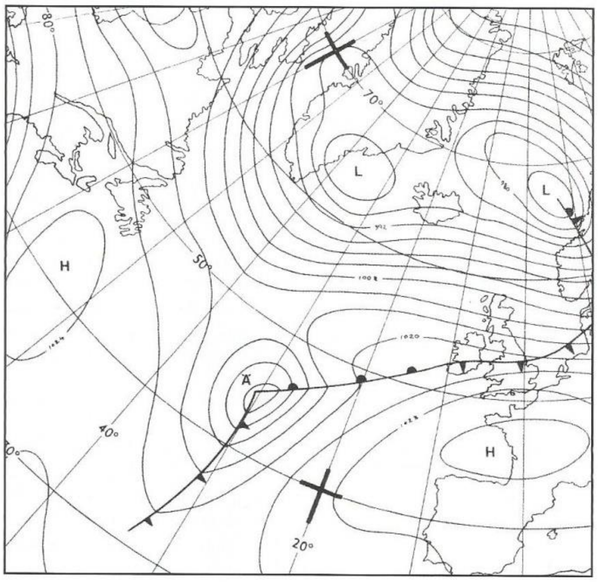


Figure 1.5 (2) Synoptic chart – 1200 UTC, Day 2

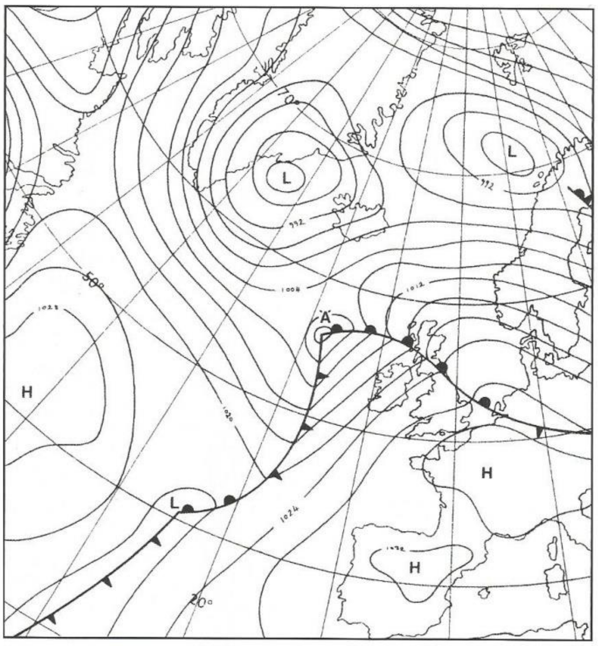


Figure 1.5 (3) Synoptic chart – 1200 UTC, Day 3

1.2.4 Jet steam

If a depression is to develop, the air flow in the upper troposphere must be divergent. This divergent flow is associated with a jet stream, a fast moving current of air with strong lateral and vertical wind shears which is located immediately below the tropopause. Figure 1.6 shows the relationship between the polar front jet stream and a frontal depression during the life cycle of the water.

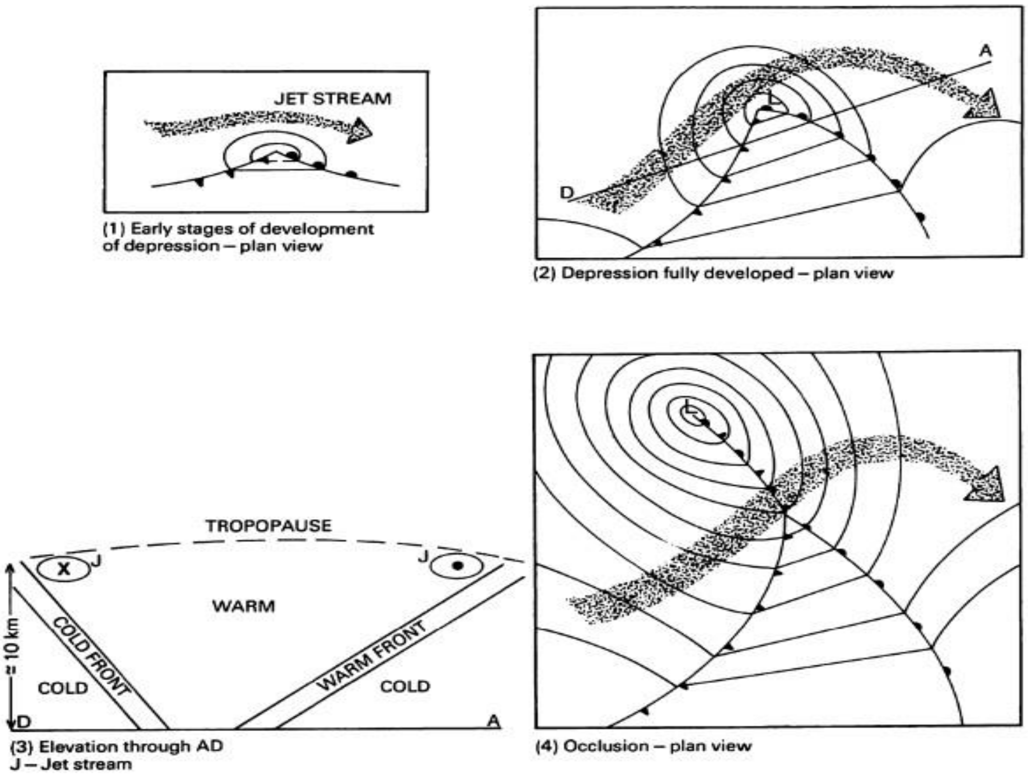
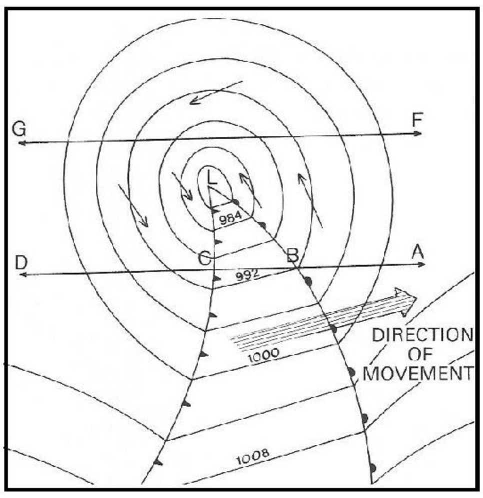


Figure 1.6 Polar front jet stream and a frontal depression

1.2.5 Anafronts and Katafronts

Within a frontal depression the warm air usually ascends relative to cold air. This movement is marked by the presence of active war and cold fronts termed anafronts. The clouds which develop are shown in the elevation in Figure 1.7(2) corresponding to line AD in Figure 1.7(1). On occasions the warm air ay descend relative to the cold air, and a relatively inactive front termed a katafront exists, with limited low level stratiform clouds.



(1) Plan of frontal depression.

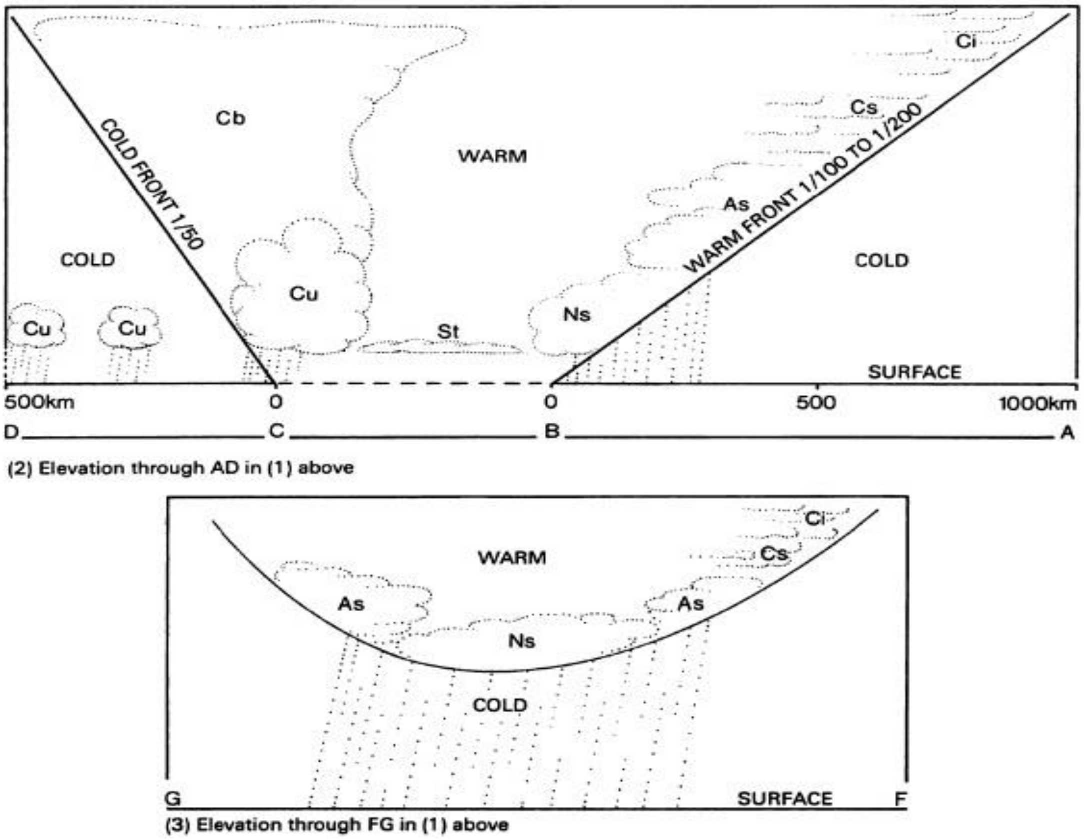


Figure 1.7 Plan and elevation of a typical frontal depression in the N. Hemisphere

1.3 OCCLUSIONS

Occlusions may be either warm or cold depending upon the temperature difference between the cold air originally behind the cold front and that of the cold air ahead of the warm front. At the beginning of the life cycle of a depression the two masses of cold air may well have been at the same temperature. However, the subsequent development and movement of a depression incorporates cold air from other sources resulting in the temperature difference.

If the air behind the occluded front is less cold than the air ahead, the occlusion is a warm occlusion (Figure 1.8 (2)). If the air is colder behind the front, then it is a cold occlusion (Figure 1.8 (3)). The cloud types associated with recently developed warm and cold occlusions are the same as those of the warm and cold fronts. With older occlusions, cloud and precipitation will be less significant as a result of frontolysis.

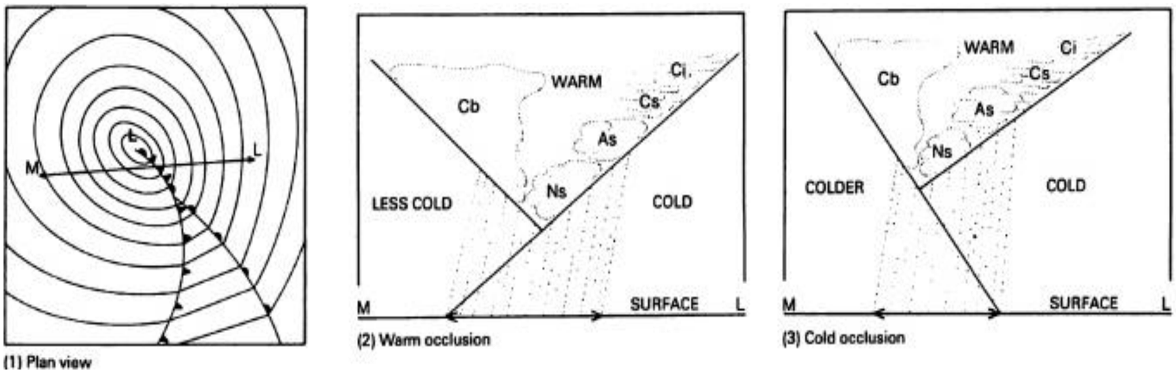


Figure 1.8 Warm and cold occlusions

1.4 AIR MASSES

An air ass is a large body of air whose temperature and relative humidity values are more or less uniform in a given horizontal plane. Its horizontal dimensions are of the order of hundreds or even thousands of square kilometers. The most suitable conditions for the development of an air mass are a combination of a uniform part of the earth's surface and the presence of a large anticyclone for at least three days. The slack surface pressure gradient, and hence low wind speeds, of the anticyclone enables the air mass to acquire its properties. Thus the source regions of air masses are generally found in the subtropical, temperature and polar zones, where uniform surfaces and anticyclonic conditions exist simultaneously. Air masses are therefore classified as Tropical, Polar or Arctic (Antarctic), to indicate their source regions and their relative temperatures. Arctic air masses originate within the Arctic circles, and are colder than the Polar air mass which originates to the south (north) if its region. Air masses are further sub-divided into maritime (high humidity), or continental (low humidity) as in the following table:

Air mass	*Abbreviation*	*Source*	*Temperature*	*Relative humidity*
Tropical maritime	Tm	Subtropical ocean areas e.g. Azores	High	Very High
Tropical continental	Tc	Subtropical deserts e.g. Sahara	Very high	Very low
Polar continental	Pc	Temperate continental area e.g. N Europe	Varies with season	Low
Polar maritime	Pm	Ocean areas latitude > 50°	Low	High
Arctic	A	Arctic ice cap	Very low	Low

Table 1.1 Characteristics of air masses

1.4.1 Modification of air masses

Once an air mass leaves its source region, it will no longer be in equilibrium with the underlying surface which may be either warmer or colder than the air mass. The mass will be heated or cooled, and both its temperature and environmental lapse rate will change. If it is heated by the surface, the environmental lapse rate increases and it becomes unstable, whereas if it is cooler by the surface, it decreases and it becomes stable. The relative humidity of the mass is also affected by changes in temperature, increasing when the mass is cooled, and decreasing when the mass is heated. However, when the mass is heated, evaporation from the surface occurs, counteracting the effect of heating on the relative humidity value. Therefore in establishing the final relative humidity value of air mass, both heating and evaporation effects must be taken into account.

1.5 WATER IN THE ATMOSPHERE

1.5.1 Water vapour

The quantity of water vapour present in the atmosphere is variable in both time and space. The actual water vapour content of a sample of air may be expressed by a number of terms:

1. Humidity Mixing Ratio: the ratio of the mass of water vapour to the mass of dry air (air without water vapour). Units are grams per kilogram.
2. Absolute Humidity: the ratio of the mass of water vapour to the volume occupied by the
3. Mixture of water vapour and air: The ratio is also known as the vapour density or vapour concentration. Units are grams per cubic meter.
4. Vapour pressure: the pressure exerted by the water vapour in the atmosphere, which forms part of the total atmospheric pressure. Units are hectopascals.

As its temperature increases, air has the capacity to hold more water vapour. Air is termed saturated when it contains the maximum amount of water vapour possible at a given temperature. Unsaturated air contains less, then the maximum amount of water vapour possible at its given temperature. Air is supersaturated when it contains more water vapour than is required to saturate it at a given temperature.

1.5.2 Relative humidity

A fourth term most frequently used to describe the water vapour content of the atmosphere is relative humidity. This is defined as the ratio of the mass of water vapour present to that which could be present if the air was saturated at the same temperature. The ratio is expressed as a percentage.

The relative humidity value for saturated air is always 100%, for unsaturated air less than 100%, and for supersaturated air, which may exist in the atmosphere under certain conditions, it is always greater than 100%.

Changes in relative humidity are not achieved solely by the decrease or increase of air temperature. Saturation can result from an increase in water vapour content, or by a simultaneous increase of water vapour content and decrease of air temperature.

1.5.3 Dew-point temperature

The dew-point temperature is the temperature to which a sample of air must be lowered in order to saturate it with respect to a plane liquid water surface, assuming constant pressure and water vapour content.

Below 0°C saturation is normally expressed with respect to a plane ice surface. The temperature at which this condition exists for a given sample of air is the frost point, pressure and water vapour content being constant

1.5.4 Evaporation

The water vapour content of the atmosphere is derived through the process of evaporation from the surface of the earth, and may also be the result of sublimation where there is ice and snow. Sources of water, from which evaporation occurs, include not only free water surfaces (oceans, lakes and rivers), but also soil and vegetation. Evaporation is expressed as a rate, being the depth of liquid water which changes into water vapour in a given period.

The rate of evaporation depends on:

1. Energy: ultimately derived from solar radiation absorbed by the surface.
2. Relative Humidity: when the air immediately above the surface is saturated, the evaporation rate will be zero, since no more water can be absorbed; if the air is unsaturated, then evaporation occurs.
3. Wind: when saturate air is replaced through air movement by unsaturated air, the evaporation rate increases. Evaporation can continue if the air in the surface once saturated, is replaced by unsaturated air from a higher level due to turbulence.
4. Water: despite all other conditions being favorable for evaporation, lack of water will prevent the optimum rate being achieved.

The most favorable conditions for evaporation in terms of water, energy availability, and atmospheric conditions, exist in latitudes 15°-30°, and the least favorable in Polar Regions. The result of evaporation is the transfer of energy from the surface of the earth to the atmosphere.

1.6 CLOUDS

1.6.1 Introduction

Clouds are collections of water droplets or ice crystals, or combination of these two states of water, suspended in the atmosphere. Knowledge of the many types of clouds and their occurrence provide a valuable source of information in forecasting the weather.

Cloud formation is mainly the result of air ascending and cooling adiabatically. The stability of the atmosphere plays an important part in the formation and development of clouds and their characteristics, since it controls the method of ascent of an air parcel.

1.6.2 Cloud types

The shapes of cloud within the troposphere may be stratiform (flattened or layered), cumuliform (heaped), curriform (hair or thread-like), or a combination of these. Cloud genera are illustrated in Picture 1.1.

CIRRUS (Ci)

CIRROSTRATUS (Cs)

CIRROSTRATUS (Cs) WITH HALO

CIRROCUMULUS (Cc)

ALTOSTRATUS (As)


ALTOCUMULUS (Ac)


STRATOCUMULUS (Sc)


NIMBOSTRATUS (Ns)


CUMULUS (Cu)


CUMULUS (Cu)


CUMULONIMBUS (Cb)


CUMULONIMBUS DEVELOPING FROM CUMULUS


AFTER 10 MINUTES


AFTER 40 MINUTES


CUMULUS (Cu) AND STRATOCUMULUS (Sc)


WATERSPOUT


OROGRAPHIC CLOUD

Picture 1.1 Cloud Genera

1.7 PRECIPITATION AND FOG

1.7.1 Forms of precipitation

Precipitation is the deposit on the earth's surface of water in liquid or solid state or a combination of both. The principal forms are:

1. Drizzle: Water droplets with diameters between 200 μm and 500 μm
2. Rain: Water droplets with diameters exceeding 500 μm
3. Snow or Snowflakes: Small ice crystals or aggregate of ice crystals
4. Hail: Balls of ice of varying size
5. Sleet: Mixture of rain and snow
6. Ice pellets, prisms or granular snow can occur. Usually, precipitation is associated with a cloud. On occasions it can be seen leaving the base of a cloud in vertical or inclined trails which do not reach the surface, which are termed fallstreaks or virga.

1.7.2 Visibility

For meteorological purposes horizontal visibility is defined as the greatest distance at which an object with specific characteristics can be seen and identified by the unaided eye in the daylight. At night it is assumed that the illumination of the object is raised to normal daylight level.

Visibility is assessed by viewing the horizon through 360° and recording the shortest distance. Land observing stations use objects at known distances in daytime and a visibility meter at night, thus making it possible to provide accurate visibility ranges (Table 1.2)

Visibility	Scale
If less than 5 km	0.1 km steps
If between 5 & 30 km	1 km steps
If over 30 km	5 km steps

Table 1.2 Visibility scale used on land

At sea the limited availability of objects often makes the estimation of visibility difficult and a coarser scale is used (Table 1.3):

Range Recorded in Steps			
km	n.mile	km	n.mile
< 0.05	< 0.03	2.0– 4.0	1.1– 2.2
0.05–0.2	0.03–0.1	4.0–10.0	2.2– 5.4
0.2 –0.5	0.1 –0.3	10.0–20.0	5.4–11.0
0.5 –1.0	0.3 –0.5	20.0–50.0	11.0–27.0
1.0 –2.0	0.5 –1.1	⩾50.0	⩾27.0

Table 1.3 Visibility scale used at sea

Visibility is reduced by the suspension of liquid or solid particles in the atmosphere. If the visibility is reduced to less than 1 km as a result of water droplets, the condition is termed fog, and if 1 km or greater it is termed mist. If visibility is reduced by the presence of solid particles the condition is termed haze, for which there is no upper limit to the value of the visibility range.

1.7.3 Fog

Fog forms when the difference between air temperature and dew point is less than 2.5°C. Fog can form in a number of ways, depending on how the cooling that caused the condensation occurred:

Radiation Fog: is formed by the cooling of land after sunset by thermal radiation in calm conditions with clear sky. The cool ground produces condensation in the nearby air by heat conduction, with the layer being less than 1 meter deep. Although conditions are favorable for the formation of radiation fog at sea, the diurnal ranges of both sea surface and air temperatures are too small for the air to be cooled below its dew point temperature. It will affect visibility only while drifting over estuaries and coastal water.

Advection fog: occurs when moist air passes over a cool surface by advection and it is cooled. It is common as a warm front passes over an area with significant snow-pack. It is most common at sea when moist air encounters cooler waters, including areas of cold water upwelling, such as along the California coast. Advection or sea fog is a frequent threat to the seafarer and its prediction is therefore important. As sea and dew-point temperatures are critical in its formation, their observation at frequent intervals is recommended, and should be recorded in graphical form (Figure 1.9).

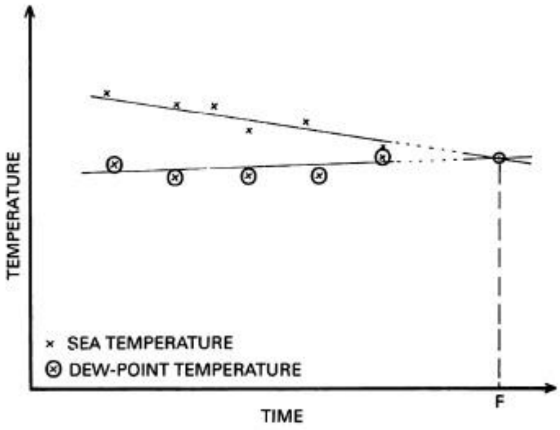


Figure 1.9 Forecasting sea fog

Frontal fog: forms as precipitation falls into drier air below the cloud and the liquid droplets evaporate into water vapor. The water vapor cools, the dew-point condenses and fog forms.

1.7.4 Haze

Haze is an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky. At sea, haze is often the result of movement of dust and sand particles from land. A particular example occurs, usually between November and May, off the north-west coast of Africa, where large quantities of dust from the Sahara are blown off-shore by the local wind, Harmattan. Salt particles, which are potential condensation nuclei, may also produce haze at sea when the relative humidity value of the atmosphere is too low for water droplets to develop.

1.8 WIND

1.8.1 Definition

Wind is defined as the horizontal movement of air across the surface of the earth. The direction from which it blows and its speed are its important characteristics. Wind direction is related to the True North [360°9T)], and it is recorded and coded in meteorological reports to the nearest 10° (T) clockwise from this direction. A wind blowing from the East will be recorded as 090° (T), whilst no wind or calm condition is recorded as 00. Wind speed is currently expressed in knots or meters per second.

1.8.2 Sea observations

In the 19th Century, Admiral Beaufort introduced the "Beaufort Scale", a scale from 0-12 called Beaufort Force numbers, each number corresponding to a range of wind speeds. The sea criteria are the wind waves which are generated by the wind which has been in existence for a reasonable period, and having an adequate fetch (the distance of open water over which the wind has blown). However, the wind is not the only factor influencing the sea state, and allowances should be made for tides, currents, depth of water and precipitation, where these are seen to affect the sea state. Tides opposing the direction of the wind waves will create more "lop", and an overestimate of wind speed is possible. Heavy precipitation flattens the sea and may lead to an underestimation. Wind direction is established by observing the direction from which the wind waves advance.

Waves generated by winds at some distance from, or at some time previously at the point of observation also affect the sea. This wave motion is called "swell", and is excluded when recording the Beaufort Force. Swell, in contrast to wind waves, has a long and generally low regular wave form. It may be at any angle to the wind waves, and more than one swell may exist at the same time. Thus swell gives a useful indication of conditions existing, or which existed at some distance in the direction from which it is coming. Swell generated by wind conditions in the Southern Oceans has often been observed in the Western Approaches to the British Isles. The presence of swell may also be one of the earliest indications of a tropical cyclone.

For meteorological purpose the period and height of wind waves and swell, and the direction from which the swell is coming are recorded. The period of a wave is the time taken for the passage of two successive crests past a point selected by the observer. The height of the wave is the vertical distance between the bottom of the trough and the top of the crest. As waves normally occur in groups, the height and period are accessed by observing two or more of the relatively large waves in each group, until at least ten such waves have been observed. The period is the average value of the recorded times, and the height is the average value of the heights observed. Picture 1.1 includes a guide to the classification of wind waves related to wind speed. Table 1.4 is a guide to the classification of swell waves.

Length		*Height*	
Description	*Length (m)*	*Description*	*Height (m)*
Short	0–100	Low	0–2
Average	100–200	Moderate	2–4
Long	> 200	Heavy	> 4

Table 1.4 Swell tables

Conditions at sea often preclude an accurate observation of the sea state and the use of the Beaufort Scale (Table 1.5). On these occasions the wind vane and anemometer, funnel smoke, and flags can be observed to establish the relative wind speed and direction. As the true wind is required, it is derived using a vector triangle (Figure 1.10). The vessel's course reversed and the relative wind direction are plotted relative to true north, using the vessel as the focal point of the triangle. The length of each line is scaled to represent speed. The third side of the triangle gives the true wind direction and speed.

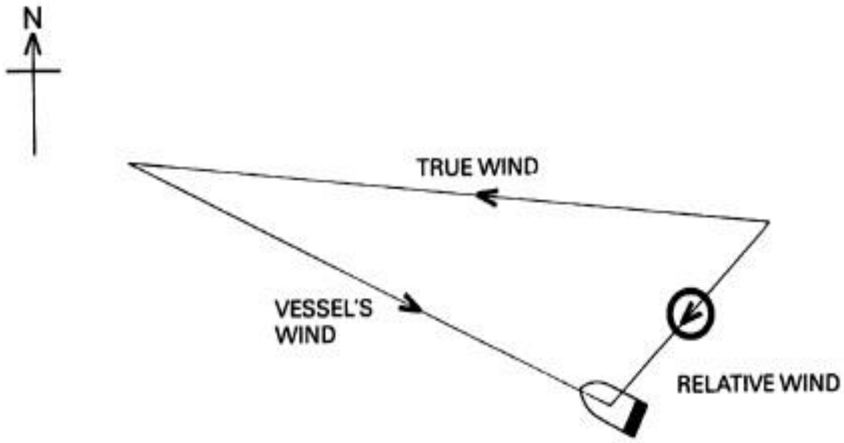


Figure 1.10 True wind vector triangle

If therer is no relative wind, the vessel's course and the speed reversed is the same as the true wind direction and speed (Relative wind – 00: Course 090° (T) – 10 knots: True Wind 270° (T) – 10 knots).

If the relative wind is from the bearing on which the ship is steering, the direction of the true wind is the vessel's course, and its speed is the difference between the vessel's speed and the relative wind speed (e.g. Relative Wind 270° (T) – 20 knots: Course 270° (T) – 10 knots: True Wind 270° (T) – 10 knots).

The siting of winds vanes and anemometers on a vessel pose problems in providing a free flow of air. The standard height of 10 meters is rarely practicable if the effect of the superstructure is to be avoided, and a compromise has to be accepted, with the consequent inaccuracy of readings on some bearings.

Force	*Description*	*Sea criterion*	*Wind speed (knots)*		*Wind waves (sea state)*		*Plate*
			Mean	*Limits*	*Description*	*Height (m)*	
0	Calm	Sea like a mirror.	0	<1	Calm	0–0.1	30
1	Light air	Ripples with appearance of scales are formed, but without foam crests.	2	1–3			31
2	Light breeze	Small wavelets, still short but more pronounced. Crests have a glassy appearance and do not break.	5	4–6	Smooth	0.1–0.5	32
3	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.	9	7–10			33
4	Moderate breeze	Small waves, becoming longer; fairly frequent white horses	13	11–16	Slight	0.5–1.25	34
5	Fresh breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.	19	17–21	Moderate	1.25–2.5	35
6	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.	24	22–27	Rough	2.5–4.0	36
7	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.	30	28–33	Very rough	4.0–5.5	37
8	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind.	37	34–40	High	5.5–7.5	38
9	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visiblity.	44	41–47	Very high	7.5–11.5	39
10	Storm	Very high waves with long overhanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes on a white appearance. The "tumbling" of the sea becomes heavy and shock-like. Visibility affected.	52	48–55			40
11	Violent storm	Exceptionally high waves (small and medium-sized ships might be for a time lost to view behind waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.	60	56–63	Phenomenal	>11.5	41
12	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.	—	>64			42

Note: Wave height data are for open sea conditions. In enclosed waters or when near land with an offshore wind, wave heights will be smaller and the waves steeper.

Table 1.5 Beaufort Scale

The bellow pictures (1.2) illustrate Beaufort Scale –wind forces from 0-12 at sea.

FORCE 0

FORCE 1

FORCE 2

FORCE 3

FORCE 4

FORCE 5

FORCE 6

FORCE 7

FORCE 8

FORCE 9

FORCE 10

FORCE 11

FORCE 12

SWELL AND WIND WAVES FORCE 2-3

EXTREME STORM WAVE, NORTH ATLANTIC, FORCE 12

Picture 1.2 Wind forces

1.9 LARGE SCALE AIR FLOWS

Surface winds may be either large scale air flows associated with pressure systenr, or air flows associated with local conitions, or a combination of both. The observation and recording of atmospheric pressure enable the distribution of pressure over an area of the surface to be established.

1.9.1 Pressure gradient

The change of pressure over unit distance at right angles to the isobars the horizontal pressure gradient (Figure 1.11). The gradient is steep when the isobars are close together, and slack when they are far apart.

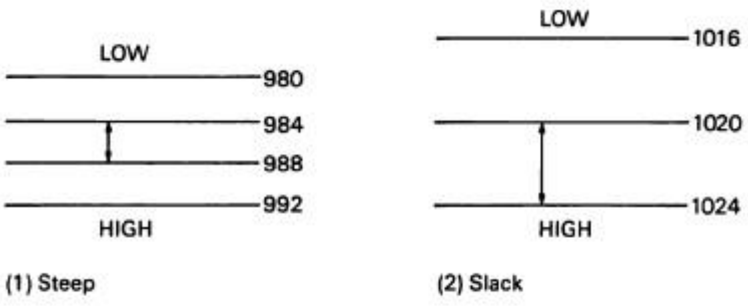


Figure 1.11 Horizontal pressure gradient

1.9.2 Pressure gradient force

When a horizontal pressure gradient exists, a force, termed the pressure gradient force, acts on the air which moves from high to low pressure at right angles to the isobars (Figure 1.12). However, for a number of reasons the actual air motion observed at the surface is seldom in the direction of it, or at the speed related to this force.

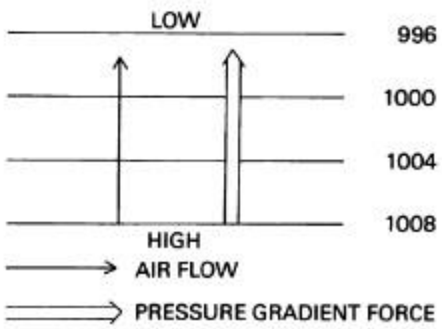


Figure 1.12 Pressure gradient force and air flow

1.9.3 Coriolis Force

The Coriolis or Geostrophic Force which relates to the rotation of the earth about its axis, causes an air particle to be deflected to the right of its line of motion in the northern hemisphere, and to the left of its line of motion in the southern hemisphere. The horizontal deflection effect is greater near the poles and smallest at the equator since the rate of change in the diameter of the circles of latitude when travelling north to south, increases the closer the object is to the poles. Rather than flowing directly from areas of high pressure to low pressure, as they would in a non-rotating system, winds and currents tend to flow to the right of this direction, north of the equator and to the left of this direction south of it. The effect is responsible for the rotation of large cyclones.

1.9.4 Geostrophic wind

When isobars are straight lines parallel to each other, the resultant horizontal motion, due to the action of the pressure gradient and Coriolis Forces, is termed the geostrophic wind (Figure 1.13). Its direction is parallel to the isobars and its speed is constant.

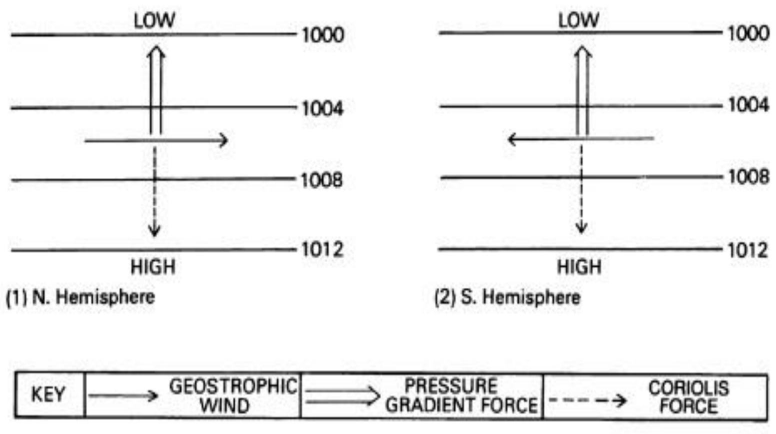


Figure 1.13 Geostrophic wind

1.9.5 Cyclostrophic force

When an air particle is following a curved path it will be subjected to the cyclostrophic Force which acts radically from the circle of rotation. The value of the force is directly dependent upon the speed of the air particle.

1.9.6 Gradient wind

The gradient wind is the horizontal air motion parallel to isobars which are curved, and is due to the action of the pressure gradient, Coriolis and cyclostrophic forces (Figure 1.14). Thus the direction of the gradient wind in each atmosphere is as follows in Table 1.6:

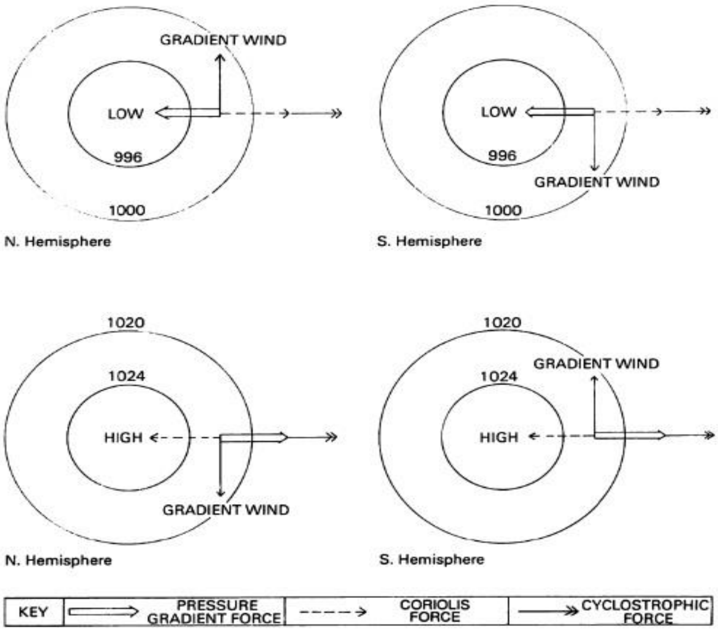


Figure 1.14 Gradient Wind

Pressure System	*N Hemisphere*	*S Hemisphere*
Low	Anticlockwise	Clockwise
High	Clockwise	Anticlockwise

Table 1.6 Direction of gradient wind

1.9.7 Friction

Air moving across the surface of the earth is affected by friction, and does not achieve the speed which in theory is directly related to the horizontal pressure gradient. As a result, the Coriolis and cyclostrophic forces have smaller values, and therefore neither geostrophic nor gradient wind exists. The pressure gradient force becomes dominant, and the net result is a cross-isobaric component of the surface air flow from high to low pressure. Thus the surface wind has an angle of indraught which is 10° to 15° over the sea (Figure 1.15). Over land the effect of friction is greater, and the angle of indraught is therefore larger.

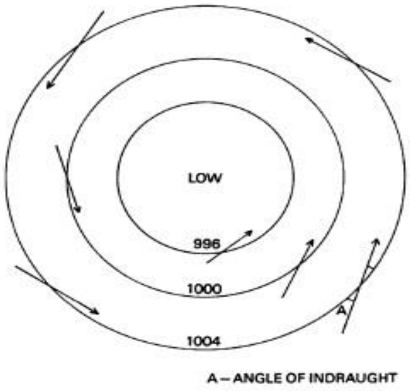


Figure 1.15 Angle of indraught

1.10 BUYS BALLOT'S LAW

In 1875, Buys Ballot formulated a law identifying the relationship between wind and pressure distribution. The law states that if an observer has his back to the wind, then low pressure will be to the left in the northern hemisphere, and to the right in the southern hemisphere.

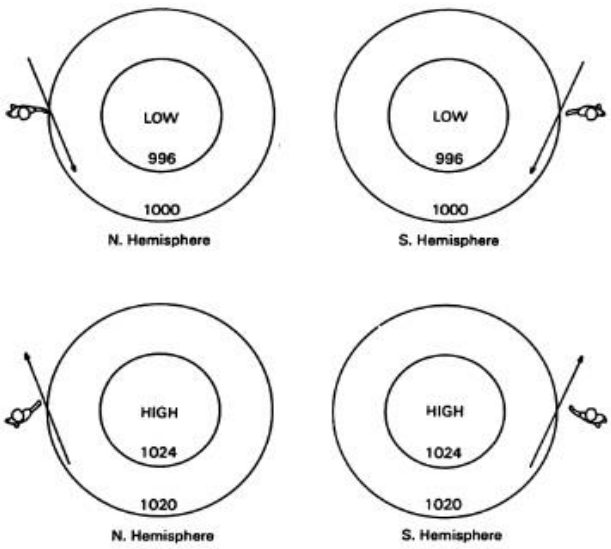


Figure 1.16 Buoys Ballot's Law

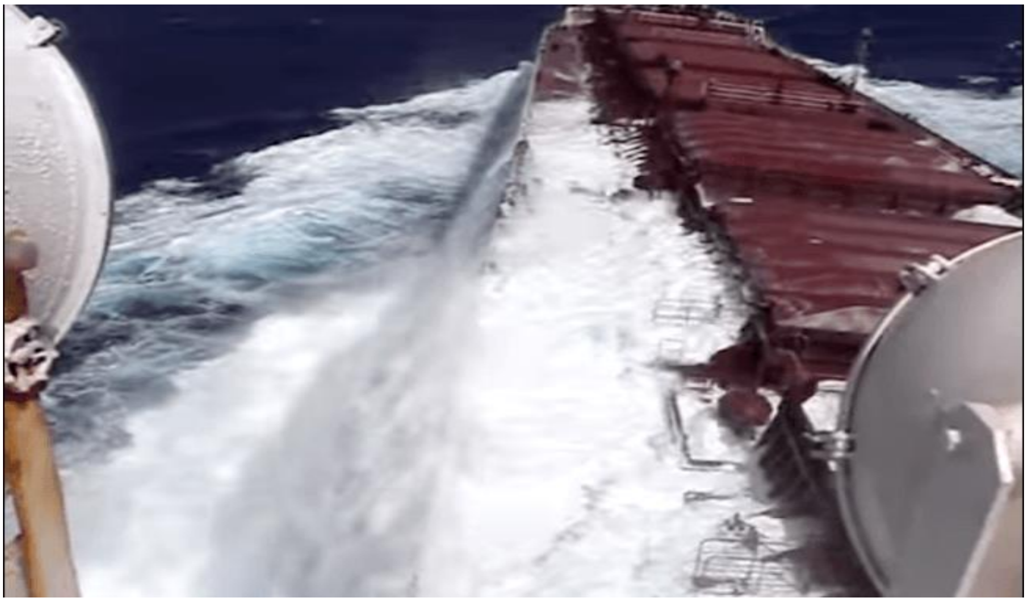
It follows that high pressure will lie on the right in the northern and on the left in the southern hemisphere (Figure 1.16). Under certain circumstances the number of points of the compass to the right or left of the wind in which the low pressure centre lies in important, particularly when assessing the position and movement of tropical cyclones.

1.11 ROGUE WAVES

A ship when at sea, faces lot of difficulties and hindrances, especially in its motion. The forces acting on the ship is what maintains the equilibrium of the ship. Storms and heavy winds are known as the factors which can affect the equilibrium of the ship. However, there is one more dangerous factor that can capsize the ship in no time – rogue waves.

Rogue waves are one of the most terrifying issues that are faced by ships since the start. Rogue waves, which are also termed as killer waves, are dangerous for all types and kinds of ships and ocean liners. Rogue waves usually occur in deep water and have a focusing affect created as a result of a number of waves joined together. Their height is twice the height of even significant waves. More than their height, it is the damage that they create is more massive.

Rogue waves are commonly known as freaky waves (Picture 1.3). The dangerous thing about these waves is that they appear without warning. Though rescue methods can be tried during the occurrence of these waves, they usually fail because at times these waves are so quick that precautionary measures fall short. However, it is to note that these waves are not the result of tsunami or earthquake.



Picture 1.3 Rogue Waves

Experts identify rogue waves as the ones which exceed the height of 25 m. These ways are highly potential and often catch the ships from a dangerous angle. Maximum damage is caused if these waves get the dangerous entry, which means that these waves go deep and attack the prominent base of the ship. Researchers say that nonlinear effects are the main cause of generation of these waves. Superimposition of small waves forms a big cluster which is commonly known as rogue waves. However, very few people are aware of the exact reason for generation of these waves. For any person, rogue wave is the most dangerous thing that can happen to a ship. People who have witnessed these waves have only one word to explain and that is devastating.

Earlier, the forecasting of rogue waves was next to impossible, but the technology advancements has made some prediction possible. Satellite tracking of wave formation and motion is one thing used for forecasting rogue waves. With the successful forecast, it has been possible to bring the precautionary measures into action and which has helped in the survival of the ship and the crew. Recent models of the ships are designed in a way to create deflection for these waves. This deflection at times is efficient in handling waves to a particular height. Gulf of Mexico is one such reason which has been frequently detected with such waves.

The reason for frequent formation of these waves is still a mystery for researchers and experts. With the sophisticated monitoring and modeling, chances of fighting these waves are now becoming possible. Moreover, many theories have been given on the formation of these waves, but the most famous one is the accumulation of small waves into a large and giant wave.

1.12 TROPICAL CYCLONES

A tropical cyclone I a rapidly rotating storm system characterized by a low-pressure center, a closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain. Depending on its location and strength, a tropical cyclone is referred to by names such as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression and simply cyclone.

1.12.1 The characteristics of a typhoon

Typhoons are one type of tropical cyclone. Tropical cyclones are categorized by maximum wind force, as listed below (Table 1.6).

	International Classification	Maximum Wind Force and Speed
Tropical Cyclone	Tropical Depression (T.D.)	Wind force:~7 / Speed:~33kts
	Tropical Storm (T.S.)	Wind force:8~9 / Speed:34~47kts
	Severe Tropical Storm (S.T.S.)	Wind force:10~11 / Speed:48~63kts
	Typhoon (T)	Wind force:12~ / Speed:64~kts

Table 1.6 Classification of the Tropical Cyclone

Typhoons are typically generated in the Northwestern Pacific Ocean (05N-15N, 130E-145E)

1.12.2 Typhoon movements

Typhoons tend to move along the boundary of an air mass:

• If the Ogasawara high pressure (is the one of the air mass. It exists in the southeast of Japan) will be independently, a typhoon will proceed to follow the high pressure on its right side. Also, after a typhoon passes latitude 30N, it will receive an additional impetus to head eastwards due to the influence of the prevailing Westerly

• When the Continental high pressure and the Ogasawara high pressure are opposed to each other, typhoons will tend to pass between them. However, when the Continental high pressure is greater than the Ogasawara high pressure and the front of the Continental high pressure is positioned over the southern coast of Honshu, a typhoon will tend to move along the Continental front.

1. Typically, in July typhoons will move toward the continent, in August they will pass along the Sea of Japan, and in September pass over the Japanese landmass.

2. If a low pressure exists ahead of the typhoon course, the typhoon will increase its speed and expand into the low pressure area, making it bigger and faster.

3. Variations in the position of the high/low pressures will influence the direction and strength of the typhoon.

4. One of the known ocean conditions for typhoon development is when the sea surface temperature is above 26C, at which point the ocean has sufficient thermal energy to transfer it to the atmosphere. Conversely, when the sea surface temperature is below 26C, typhoon development is inhibited.

5. The wind of a typhoon has an anticlockwise rotation focused on an eye. The wind becomes stronger in the right semicircle to the heading direction.

The right semicircle to the path of a typhoon (facing the direction toward which the typhoon is moving) is known as the dangerous semicircle because wind speed increases as wind direction and direction of typhoon movement are the same, and the ship may be blown towards the center of the typhoon.

The left semicircle to the path of a typhoon is called the navigable semicircle because wind speed decreases as the forward motion of the typhoon goes against wind direction and the wind blows the ship away from the typhoon path. Even though it is called the navigable semicircle, it nevertheless accompanies the storm area and sufficient care should be taken. (Figure 1.16)

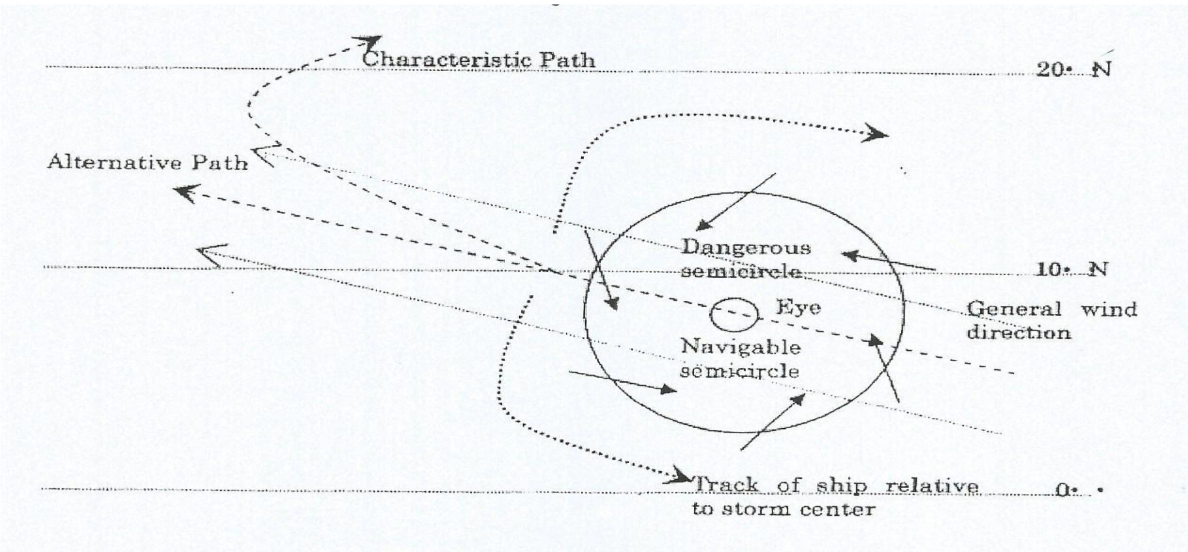


Figure 1.16 Typhoon Paths

1.13 ICEBERGS

Iceberg, mass of freshwater ice that is calved, or broken off, from a glacier or an ice shelf (a huge slab of permanent ice that floats on water near the edges of polar land masses) and that floats in the ocean or in a lake. Ice floats because it is less dense than water. A typical iceberg shows only about one-fifth of its total mass above the water; the other four-fifths is submerged. Icebergs can be large. The largest iceberg ever sighted was 335 km (208 mi) long and 97 km (60 mi) wide, about the size of Belgium. It was sighted in November 1956 by the crew of a United States Coast Guard icebreaker in the Ross Sea, off Antarctica. Icebergs pose a hazard to shipping and to offshore activities, such as offshore oil drilling, in polar and subpolar waters.

Icebergs can have many different forms, depending on their origin and age. They are usually classified as tabular (resembling a flat tabletop), rounded, or irregular. From massive tabular icebergs calved from ice shelves to small irregular bergs that have been weathered and scoured by wind and waves, they present spectacular sights in the polar and subpolar seas.

The icebergs that come from glaciers that flow to the sea are generally smaller than those from ice shelves. When the ice reaches the sea, pieces break off and fall into the water. The icebergs then drift away from the shore. Glaciers in Greenland and Alaska produce many such icebergs every year.

Icebergs are driven away from the shore by winds and ocean currents and slowly break up and melt. The smallest pieces disappear first, and the large tabular icebergs last the longest. On average, an iceberg lasts about four years, but many icebergs last much longer. Tabular icebergs often have spectacular caves in their sides, carved out by wave action. As an iceberg shrinks, it may tilt or roll over so that the smooth underside or lines etched out by the waves come into view. Icebergs transformed in this way often have fantastic shapes.

Each of the three major types of icebergs (tabular, rounded, and irregular) has numerous subcategories. Tabular icebergs show no signs of rollover and may be horizontal (totally flat), uneven, domed, tilted, or blocky. Rounded icebergs have been smoothed by the water and have rolled over. Irregular icebergs have angular or irregular features. Their shapes include pinnacled, pyramidal, drydock, castellated, jagged, blocky, roofed, and rounded. Drydock icebergs have a low sunken area in the middle that is often awash.

Antarctic icebergs initially move westward with the coastal current before entering the eastward Antarctic Circumpolar Current system, which carries them north where they melt in warmer waters. The northernmost sighting of an Antarctic iceberg was made in 1894 at latitude 27º south. Antarctic icebergs generally travel only as far north as latitude 35º south in the Atlantic and Indian oceans and latitude 45º south in the Pacific Ocean. At any time, tens of thousands of large icebergs may be in the Southern Ocean, as the southernmost portions of the Atlantic, Indian, and Pacific oceans are sometimes called. A survey made in 1965 counted 30,000 icebergs in an area of 4,400 sq km (1,700 sq mi). Near the coast of Antarctica many icebergs are stranded in shallow water, and ships trying to reach coastal research stations often must travel through spectacular iceberg alleys.

Satellites have been used to measure changes in the size of ice shelves. In the Antarctic Peninsula area, ice shelves are retreating rapidly, most likely because of a warmer climate in the region.

2 ORGANIZATION AND OPERATION OF METEOROLOGICAL SERVICES

2.1 INTRODUCTION

A forecast is a statement of the anticipated meteorological conditions for either an area, or fixed location, or along a route or routes for a specified period. The term was introduced by Admiral Fitzroy, the first head of the Meteorological Office in London on its establishment in 1854. Admiral Fitzroy invited vessels to observe conditions and report their findings to his office, where climatological records were to be compiled. It was appreciated at that time that an adequate and efficient network was essential for the production of accurate records and forecasts.

2.1.1 The World Meteorological Organization

At the present time, meteorological operations are worldwide under the guidance of the World Meteorological Organization (WMO), a technical agency of the United Nations formed in 1951 and based in Geneva.

The aims of the organization are to:

1. Assist in the establishment of networks of meteorological observing stations by encouraging worldwide cooperation.

2. Assist in the development of centers to provide meteorological observations.

3. Ensure the rapid exchange of data,

4. Further the application of meteorology to human activity (e.g. shipping)

5. Encourage research and training in meteorology.

In order to achieve these aims, WMO has established a number of commissions, each concerned with a specific field. One of these is the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). As the field is large, the Commission has three distinct program areas for observation, data management and services, and forecasting systems.

2.2 LAND OBSERVING NETWORK

One aim of WMO is that each nation should have a National Meteorological Center (NMC), often referred to as the Central Forecasting Office (CFO). Linked with the NMC, usually through a number of subordinate centers, are the land observing stations, which collect surface data. The range of meteorological elements and the frequency of observation will vary depending upon whether the observing station is classified as synoptic, auxiliary, climatological, agrometeorological or simply a health resort. Automatic Weather Stations (AWS), which are particularly valuable in inhospitable environments, are used extensively throughout the network. There are also a number of upper air stations which provide the NMC with data from upper air soundings. These stations record a full range of observations (atmospheric pressure, air temperature, humidity, wind direction and speed) daily at 0000 UTC and 1200 UTC, but at 0600 and 1800 UTC only wind direction and speed are monitored.

2.2.1 Data buoys and offshore installations

Mobile and fixed data buoys are deployed worldwide. These monitor and transmit surface observations. Data from this network is further enhanced by observations collected by offshore rigs and platforms, some of whom operate with meteorological centers, while others operate private automatic weather stations.

2.2.2 Voluntary Observing Ships

In 1853 an International Meteorological Conference held in Brussels, called for voluntary surface observations at sea. The present Voluntary Observing Ships (VOS) scheme has developed from this and is now under the direction of the Ship Observations Team (SOT) of JCOMM. The scheme classifies voluntary observing ships as selected, supplementary or auxiliary mobile sea stations. Since 2009 it has also included the VOS Climate Fleet (VOSClim). Each category in the scheme is subdivided to identify vessels equipped with a Automatic Weather Station (AWS).

2.3 SOLAS

2.3.1 SOLAS Chapter V, Regulation 5 Meteorological Services and Warnings

Contracting Governments undertake to encourage the collection of meteorological data by ships at sea and to arrange for their examination, dissemination and exchange in the manner most suitable for the purpose of aiding navigation. Administrations shall encourage the use of meteorological instruments of a high degree of accuracy, and shall facilitate the checking of such instruments upon request.

Arrangements may be made by appropriate national meteorological services for this checking to be undertaken, free of charge to the ship.

In particular, Contracting Governments undertake to carry out, in co-operation, the following meteorological arrangements:

2.1 to warn ships of gales, storms and tropical cyclones by the issue of information in text and, as far as practicable graphic form, using the appropriate shore-based facilities for terrestrial and space radiocommunications services.

2.2 to issue, at least twice daily, by terrestrial and space radiocommunication services, as appropriate, weather information suitable for shipping containing data, analyses, warnings and forecasts of weather, waves and ice. Such information shall be transmitted in text and, as far as practicable, graphic form including meteorological analysis and prognosis charts transmitted by facsimile or in digital form for reconstitution on board the ship's data processing system.

2.3 to prepare and issue such publications as may be necessary for the efficient conduct of meteorological work at sea and to arrange, if practicable, for the publication and making available of daily weather charts for the information of departing ships.

2.4 to arrange for a selection of ships to be equipped with tested marine meteorological instruments (such as a barometer, a barograph, a psychrometer, and suitable apparatus for measuring sea temperature) for use in this service, and to take, record and transmit meteorological observations at the main standard times for surface synoptic observations (i.e. at least four times daily, whenever circumstances permit) and to encourage other ships to take, record and transmit observations in a modified form, particularly when in areas where shipping is sparse.

2.5 to encourage companies to involve as many of their ships as practicable in the making and recording of weather observations; these observations to be transmitted using the ship's terrestrial or space radiocommunications facilities for the benefit of the various national meteorological services.

2.6 the transmission of these weather observations is free of charge to the ships concerned.

2.7 when in the vicinity of a tropical cyclone, or of a suspected tropical cyclone, ships should be encouraged to take and transmit their observations at more frequent intervals whenever practicable, bearing in mind navigational preoccupations of ships' officers during storm conditions.

2.8 to arrange for the reception and transmission of weather messages from and to ships, using the appropriate shore-based facilities for terrestrial and space radiocommunications services.

2.9 to encourage masters to inform ships in the vicinity and also shore stations whenever they experience a wind speed of 50 knots or more (force 10 on the Beaufort scale).

2.10 to endeavour to obtain a uniform procedure in regard to the international meteorological services already specified, and as far as practicable, to conform to the technical regulations and recommendations made by the World Meteorological Organization, to which Contracting Governments may refer, for study and advice, any meteorological question which may arise in carrying out the present Convention.

3. The information provided for in this regulation shall be furnished in a form for transmission and be transmitted in the order of priority prescribed by the Radio Regulations. During transmission "to all stations" of meteorological information, forecasts and warnings, all ship stations must conform to the provisions of the Radio Regulations.

4. Forecasts, warnings, synoptic and other meteorological data intended for ships shall be issued and disseminated by the national meteorological service in the best position to serve various coastal and high seas areas, in accordance with mutual arrangements made by Contracting Governments, in particular as defined by the World Meteorological Organization's System for the Preparation and Dissemination of Meteorological Forecasts and Warnings for the High Seas under the Global Maritime Distress and Safety System (GMDSS).

2.4 THE GLOBAL TELECOMMUNICATION SYSTEM (G.T.S)

The Global Telecommunication System (G.T.S) is defined as: "The co-ordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange and distribution of observations and processed information within the framework of the World Weather Watch." - WMO No 49 Technical Regulations.

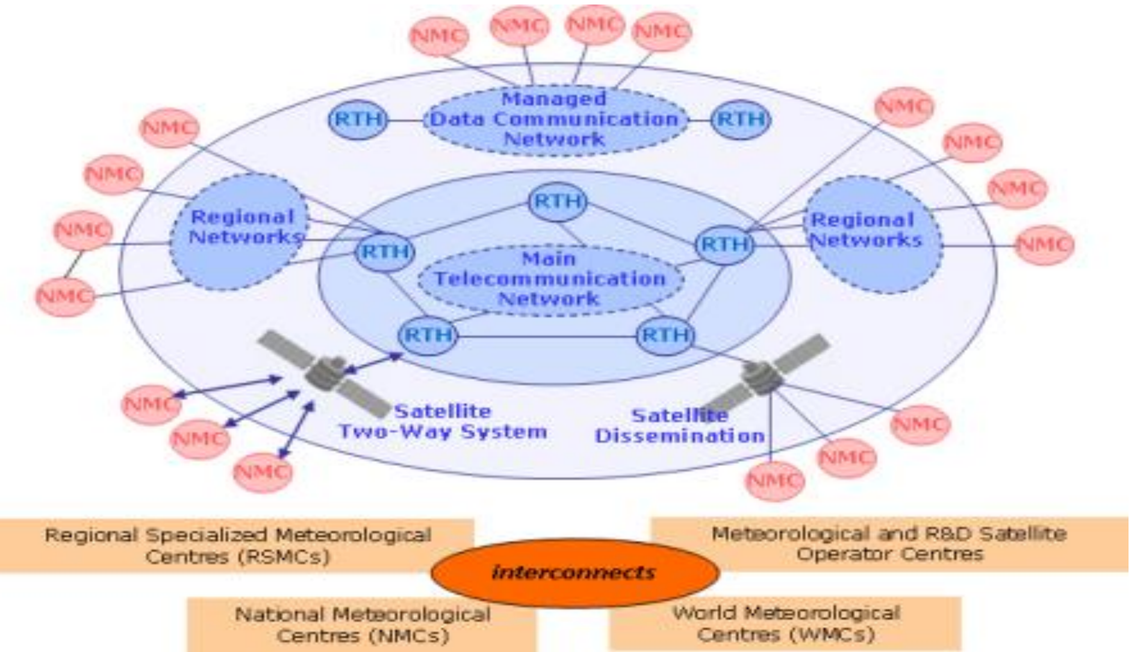


Figure 2.1 Structure of the Global Telecommunication System

WMO's Global Telecommunication System (G.T.S) is the communications and data management component that allows the World Weather Watch (W.W.W) to operate through the collection and distribution of information critical to its processes. It is implemented and operated by National Meteorological Services of W.M.O Members and International Organizations, such as ECMWF and EUMETSAT. As decided by Congress and the Executive Council the G.T.S also provides telecommunication support to other W.M.O programs, facilitating the flow of data and processed products to meet requirements in a timely, reliable and cost-effective way, ensuring that all Members have access to all meteorological and related data, forecasts and alerts (Figure 2.1). This secured communication network enables real-time exchange of information, critical for forecasting and warnings of hydrometeorological hazards in accordance with approved procedures.

The GTS has a hierarchical structure on three levels: The Main Telecommunication Network (MTN), linking together three World Meteorological Centres (W.M.Cs) (Melbourne, Moscow and Washington) and 15 Regional Telecommunication Hubs (R.T.Hs) (Algiers, Beijing, Bracknell, Brasilia, Buenos Aires, Cairo, Dakar, Jeddah, Nairobi, New Delhi, Offenbach, Toulouse, Prague, Sofia and Tokyo) see Figure 1. This core network has the function of providing an efficient, rapid and reliable communication service between the Meteorological Telecommunication Centres (M.T.Cs).

The Regional Meteorological Telecommunication Networks (R.M.T.Ns) is an integrated network of circuits covering the six W.M.O regions - Africa, Asia, South America, North America, Central America & the Caribbean, South-West Pacific, Europe and Antarctic - and interconnecting the MTCs thus ensuring the collection of observational data and regional selective distribution of meteorological and other related information to Members. Until the integrated network is completed, HF-radio-broadcasts may be used in order to meet the requirements of the W.W.W for the dissemination of meteorological information.

The National Meteorological Telecommunication Networks (N.M.T.Ns) enable the National Meteorological Centres (N.M.Cs) to collect observational data and receive and distribute meteorological information on a national level.

Satellite-based data collection and/or data distribution systems are also integrated in the G.T.S as an essential element of the global, regional and national levels of the G.T.S. Data collection systems operated via geostationary or near-polar orbiting meteorological/environmental satellites, including ARGOS, are widely used for the collection of observational data from Data Collection Platforms. Marine data are also collected through the International Maritime Mobile Service and through INMARSAT. International data distribution systems operated either via meteorological satellites such as the Meteorological Data Distribution (M.D.D) of METEOSAT, or via telecommunication satellites, such as RETIM or FAX-E via EUTELSAT are efficiently complementing the point-to-point GTS circuits. Several Countries, including Argentina, Canada, China, France, India, Indonesia, Mexico, Saudi Arabia, Thailand and the USA, have implemented satellite-based multi-point telecommunication systems for their national Meteorological Telecommunication Network.

The MTCs function is to accommodate the volume of meteorological information and its transmission within the required time limits for global and interregional exchange of observational data, processed information and any other data required by its Members. Regional Telecommunication Hubs (R.T.Hs) on the M.T.N perform an interface function between the R.M.T.Ns and the M.T.N.

The G.T.S is an integrated network of surface-based and satellite-based telecommunication links of point-to-point circuits, and multi-point circuits, interconnecting meteorological telecommunication centers operated by countries for round-the-clock reliable and near-real-time collection and distribution of all meteorological and related data, forecasts and alerts. This secured communication network enables real-time exchange of information, critical for forecasting and warning of hydrometeorological hazards.

W.M.O G.T.S is the backbone system for global exchange of data and information in support of multi-hazard, multipurpose early warning systems, including all meteorological and related data; weather, water and climate analyses and forecasts; tsunami related information and warnings, and seismic parametric data. W.M.O is building on its G.T.S to achieve an overarching W.M.O Information System (W.I.S), enabling systematic access, retrieval, and dissemination and exchange of data and information of all W.M.O and related international Programs.

From 1 February 1999 all passenger vessels and all cargo ships of 300 gross tonnage and upwards on international voyages must comply with the GMDSS, and be fitted with all applicable satellite and radiocommunications GMDSS equipment, according to the sea area (or areas) in which the ship operates, for sending and receiving distress alerts and M.S.I, and for general communications. Under the GMDSS requirements, all ships are required to be equipped with Inmarsat and/ or NAVTEX receivers, to automatically receive M.S.I.

For broadcast purposes, the world's oceans are divided into 16 areas of responsibility, called either Metareas (Picture 2.1) (for meteorological information) or Navareas(for navigational warnings) each the responsibility of a National Meteorological Service (N.M.S), named Issuing Service. Other NMS may provide some information, as Preparation Services. The Joint W.M.O/I.O.C Technical Commission for Oceanography and Marine Meteorology (J.C.O.M.M) coordinates the dissemination of warnings and weather and sea bulletins according to a broadcast schedule.

Picture 2.1 Limits of METAREAS

2.4.1 International Mobile Satellite Organization - INMARSAT

The International Mobile Satellite Organization (Inmarsat), previously the International Maritime Satellite Organization, was established by IMO in 1976 to operate satellite maritime communication systems and has become a privately owned company, while retaining its public sector obligations to the maritime distress and safety system.

Three types of Inmarsat ship earth station terminals are recognized by the GMDSS: the Inmarsat A, B and C. The Inmarsat A and B, an updated version of the A, provide ship/shore, ship/ship and shore/ship telephone, telex and high-speed data services, including a distress priority telephone and telex service to and from rescue coordination centres. The Inmarsat C provides ship/shore, shore/ship and ship/ship store-and-forward data and telex messaging, the capability for sending preformatted distress messages to a rescue coordination centre, and the SafetyNET service. The Inmarsat C SafetyNET service is a satellite-based worldwide maritime safety information broadcast service of high seas weather warnings, navigational warnings, radionavigation warnings, ice reports and warnings generated by the International Ice Patrol, and other similar information not provided by NAVTEX. SafetyNET works similarly to NAVTEX in areas outside NAVTEX coverage.

MSI can be made available on one or several Ocean areas within the footprints (0 elevation) of the Inmarsat satellites located at 55.5W (Atlantic Ocean Region West = AOR(W)), 18.5W (Atlantic Ocean Region East = AOR(E)), 63E (Indian Ocean Region = IOR and 180E (Pacific Ocean Region W = POR).

2.4.2 Navigational Telex - NAVTEX

Navigational Telex, also known as NAVTEX, is an international, automated system for instantly distributing maritime navigational warnings, weather forecasts and warnings, search and rescue notices and similar information to ships. A small, low-cost and self-contained "smart" printing radio receiver installed in the pilot house of a ship or boat checks each incoming message to see if it has been received during an earlier transmission, or if it is of a category of no interest to the ship's master. If it is a new and wanted message, it is printed on a roll of adding-machine size paper; if not, the message is ignored. A new ship coming into the area will receive many previously-broadcast messages for the first time; ships already in the area which had already received the message won't receive it again. No person needs to be present during a broadcast to receive vital information.

2.4.3 Very High Frequency – V.H.F

Staying tuned into the weather is an important role for the master of the vessel. Keeping ahead of wind warnings and activating timely operating restrictions are vital for ensuring the safety of your passengers and crew.

Most coastal radio stations provide regular local weather forecasts on VHF radio, with instructions and broadcast times announced regularly on Channel 16. Announcement is first made on 156.800/156.800MHz (ch16) before moving to the working frequency. The broadcasts include local coastal waters forecasts, warnings and observations. Provision is also made for mariners to call in with questions or updates.

2.4.4 Facsimile

Facsimile, radiofax, also known as weatherfax and HF fax (due to its common use in the short waves), is an analogue mode for transmitting images in grayscale. It is also related to slow-scan television (SSTV). The term weatherfax was coined after the technology that allows the transmission and reception of weather charts (surface analysis, forecasts, and others) from a transmission site (usually the meteorological office) to a remote site (where the actual users are).

Facsmile machines were used in the 1950's to transmit weather charts across the United States via land-lines first and then internationally via HF radio. Radio transmission of weather charts provides great flexibility to marine and aviation users, for they now have the latest weather information and forecasts at their disposal to use in the planning of voyages.

Radiofax relies on facsimile technology, where printed information is scanned line by line and encoded into an electrical signal which can then be transmitted over land-line or via radio waves to great distances. Since the amount of information transmitted per unit time is directly proportional to the bandwidth available, the speed at which a weather chart can be transmitted varies depending on the quality of the media used for transmission.

Today radiofax charts and images are available via FTP or HTTP downloads from sites in the Internet, such as the ones hosted by the National Oceanic and Atmospheric Administration (NOAA). Radiofax transmissions are also broadcast by NOAA from multiple sites in the USA at regular daily schedules. Radio weatherfax transmissions are particularly useful to shipping, where there are limited facilities for accessing the Internet. The German Meteorological Service (DWD) is another major producer of FAX charts, which are also transmitted on HF frequecies from a location near Kiel.

Facsimile is primarily used worldwide for the dissemination of weather charts, satellite weather images, and forecasts to ships at sea. The oceans are covered by coastal stations in various countries.

In the United States, fax weather products are prepared by a number of offices, branches, and agencies within the National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA).

- Tropical and hurricane products come from the Tropical Analysis and Forecast Branch, part of the Tropical Prediction Center/National Hurricane Center. They are broadcast over US Coast Guard communication stations NMG, in New Orleans, LA, and N.M.C, the Pacific master station on Point Reyes, CA. After Hurricane Katrina damaged NMG, the Boston Coast Guard station

N.M.F added a limited schedule of tropical warning charts. NMG is back at full capability, but NMF continues to broadcast these.

- All other products come from the Ocean Prediction Center (O.P.C) of the National Weather Service (N.W.S), in cooperation with several other offices depending on the region and nature of information. These also use N.M.G, N.M.C, and N.M.F, plus Coast Guard station N.O.J in Kodiak, Alaska, and Department of Defense station KVM70 in Hawaii.

2.5 SPOS WEATHER ROUTING

2.5.1 Introduction

Ship Performance Optimization System (SPOS) Onboard is the world's leading onboard weather routing system. With SPOS Onboard the ship's route can be optimized, taking into account sea conditions such as wind, waves and swell, current and other weather elements.

SPOS has proven to be the most accurate and reliable weather routing system in the world with timely updates ensuring that the crew is always aware of their surroundings and the weather forecast. SPOS is designed to enable captain and crew to adjust the route calculations depending on the weather information provided and the ship's specific characteristics. The captain can then chart the optimum route (both in terms of safety and efficiency) for his ship in prevailing conditions.

SPOS Onboard ensures vessels navigate the globe safely and efficiently, reducing fuel consumption and emissions, contributing to a clean environment.

SPOS has been designed to improve vessel performance and increase safety for crew, vessel and cargo. Instead of providing the master with a predefined route, SPOS provides detailed weather information onboard, as well as advice and support during the planning and execution of ocean voyages.

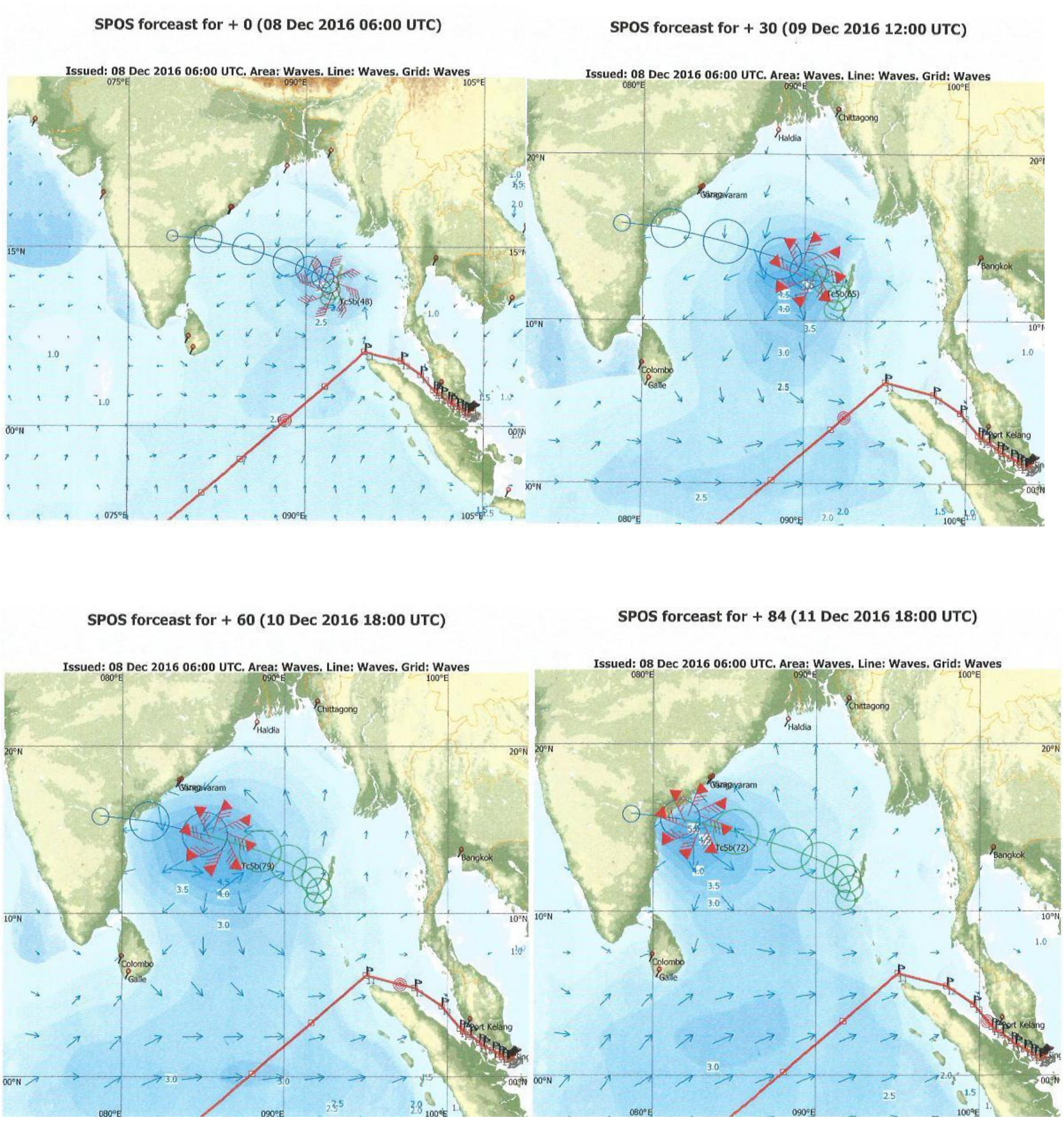
2.5.2 Forecasts

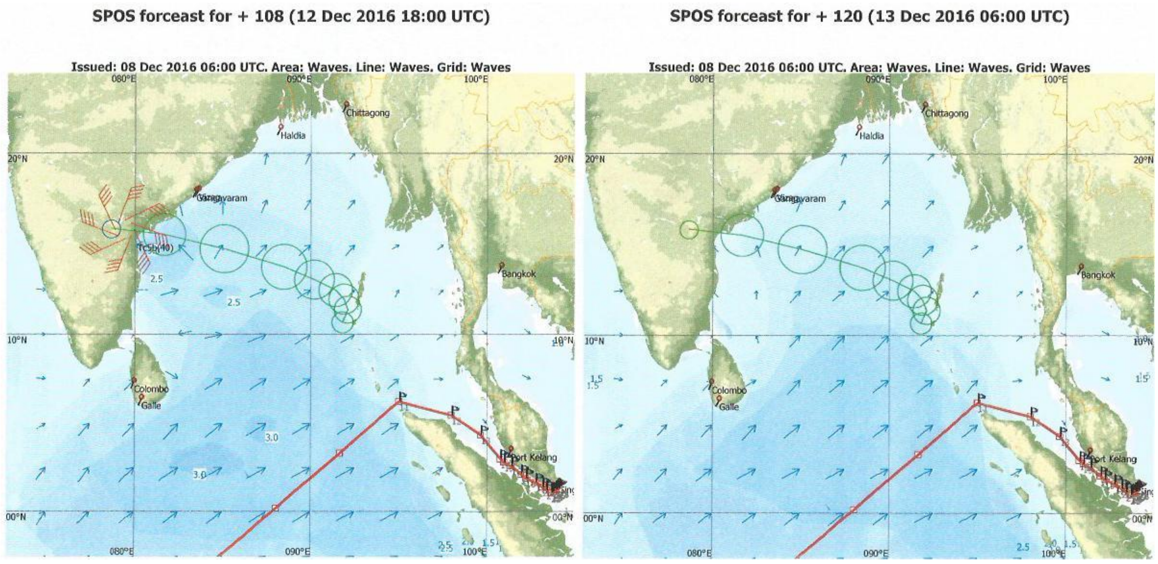
Weather forecasts are received twice daily via e-mail or http download and weather maps can be displayed on screen or printed. (Picture 2.2) Captain and crew can enter and update vessel and voyage data during transit.

SPOS calculates the optimum route and sets out alternatives. Taking into account weather, ocean current, speed curve, fuel curve and ship characteristics. SPOS onboard weather and voyage planning covers several SEEMP (Ship Energy Efficiency Management Plan) related measures including speed reduction, voyage execution, fixed ETA planning and damage avoidance.

2.5.3 Key benefits of SPOS

- Reliable weather data
- Efficient voyage and ETA planning
- Saves fuel and time
- Easy tool for comparing speed and route alternatives
- Increased safety level for masters and crew
- Implementation in SEEMP regulation
- 24/7 weather operations support





Picture 2.2 Typhoon life circle- SPOS forecast

2.6 FORECASTING RULES

A shipmaster should not, in general, need to make his own forecast if he has received a direct weather forecast, or a forecast map for his area. However, it may be that an adequate forecast is not available for a particular area, in which case the following rules will enable a reasonable reference to be drawn about the weather conditions to be expected.

A) If a weather map is available:

A series of weather maps will enable simple deductions to be made about the future movement of pressure systems using the rule of persistence. This assumes that future movements and changes in intensity of pressure systems may be estimated from past developments. The shorter the interval between weather maps, the better the estimate that can be made of future developments, but in any case forecasts for a greater period than 6 hours ahead will not be reliable.

Even if only one map is available, useful deductions can still be made. For example:

-Frontal depressions tend to move in families, each depression following its predecessor but in a slightly lower latitude.

-A depression with a warm sector tends to move with the wind parallel to the isobars in the warm sector at about three- quarters of the wind speed.

-Depressions tend to move with the wind around large, well established anticyclones.

-An occluded depression tends to move slowly and irregularly.

-If the depression has a large warm sector it has a tendency to deepen.

-As a depression occludes the deepening processes decrease.

-A non-frontal depression tends to move with the strongest wind, circulating around it.

-A front, which is crossed by isobars which are close together, will probably be fast moving.

-A front, which is parallel to the isobars, will be slow-moving.

-Warm fronts move at about half the speed of the wind at the front.

-Small anticyclones usually move faster than large ones.

B) Even without a weather map, the observer who notes carefully the weather changes taking place, can form for a period of about 6 hours ahead, a useful estimate of the weather to come. The following points should be of assistance:

-A falling barometer is an indication of bad weather to come.

-A rising barometer does not necessarily indicate good weather to come. In unsettled conditions, a rapid rise can quickly be followed by a rapid fall. In general, if the barometer rises and stays high for at least 12 hours, 24 hours of settled weather may be expected. If it stays high for 24 hours, several days of settled weather may be expected.

-If cirrus cloud approaches from the west, and at the same time the barometer is falling, and the wind is backing (North Hemisphere), then bad weather may be expected.

-Fast-moving, high clouds often indicate that bad weather is to follow.

-If after the passage of a cold front the barometer falls and the wind backs (North Hemisphere), further bad weather may be expected.

3 PROCEDURES AFTER RECEIVING STORM WARNINGS

3.1 INTRODUCTION

The prime reason for which every seafarer is wished “Smooth sailing and Calm seas” before boarding a vessel is to keep them safe from storms.

Rough weather situation has been faced at least once or more by every seafarer during the course of his/her career. Some of the most common forms of heavy or rough weather are tropical depressions or storms, typhoons, cyclones, hurricanes etc, generated due to varying atmospheric pressures over different parts of the earth. (Picture 3.1)

Picture 3.1 Rough weather on board

Beaufort wind scale criteria classify strong winds as near gale, gale, strong gale, storm, violent storm and hurricane based on ascending magnitude of wind force. Movement of sun causes pressure belts to shift and thus varying temperatures over land masses and water bodies causes pressure differences.

Tropical depressions occur often in middle latitudes and tropical cyclones that originate in the Inter Tropical Convergence Zone. A depression may often develop and travel in any direction whereas tropical storms are mostly found to follow predicted path (a curve formed based on predicted positions of a storm centre) in both the hemispheres.

Tropical storms recurve after following a particular track (a curve formed by previous known positions of a storm centre). It is therefore very important for a mariner to predict the location, magnitude and path of the storm, which are required to avoid these regions or navigate with caution while in navigating these areas.

3.1.1 Needed actions

Following are a few precautions which seafarers must follow while encountering tropical storms or navigating in areas of their frequent occurrence.

1. Use Available Information: Tropical storms and depressions are formed by pressure and temperature variations. A mariner has access to information regarding seasonal areas and frequency of occurrence through Maritime Safety information via EGC, Admiralty Sailing Directions, Ocean passages of the world and several other means. Thus if prior information is available regarding the legs of a voyage where rough weather is expected a sheltered passage or alternate route can be carefully planned to divert the vessel timely when required.

2. Study Weather Report: Often weather report and weather fax give warnings well in advance about unsettled weather conditions. Thus a careful selection of Nav Areas and type of weather reports by the navigating officer can be instrumental in obtaining early warning about a storm. Frequent observations from various meteorological instruments and prevailing weather onboard can be used to confirm weather reports.

3. Keep Away From Centre of Storm: Once presence of a storm or depression is confirmed. It is vital to establish distance of the vessel from it, location of the eye of the storm, centre of the depression, and storm's track and path (Figure 3.1). Buoy Ballot's law states – Face the wind and centre of low pressure will be from 90 degrees to 135 degrees on your right hand in N hemisphere and on your left hand in S hemisphere. It is advisable to keep at least 250 miles away from the centre of a storm however some companies prescribe specific distances in their Safety Management Manuals.

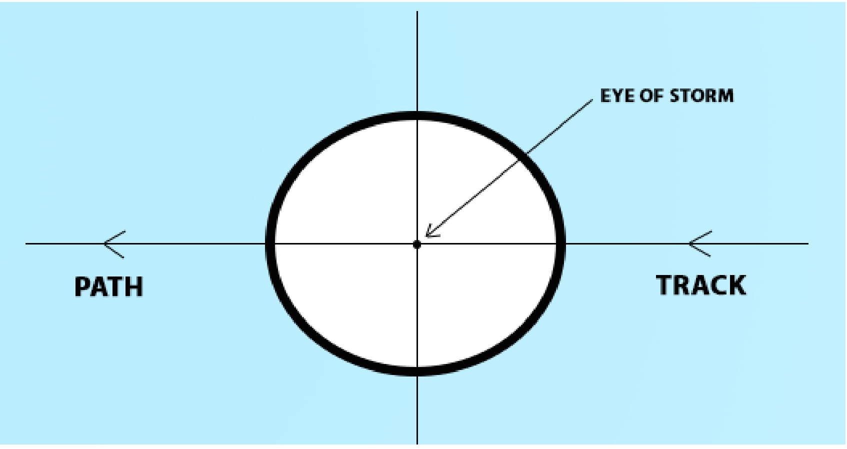


Figure 3.1 Path and track

4. Check Stability Of The Vessel: A prudent check is required on the stability condition of the vessel and its compliance with intact stability criteria. Damage stability conditions to be evaluated carefully before beginning of a voyage as it will assure compliance with damage stability requirements. A vessel can thus take heavy weather ballast while or before proceeding to rough weather areas. Heavy weather ballast provides additional stability to the vessel and by lowering the centre of gravity makes vessel more stable as the GM (the vertical distance between Centre of Gravity and the Metacentre) increases (Figure 3.2). Heavy weather ballast tanks are designated onboard vessels and if those tanks carried oil previously they must be crude oil washed before carrying heavy weather ballast in them.

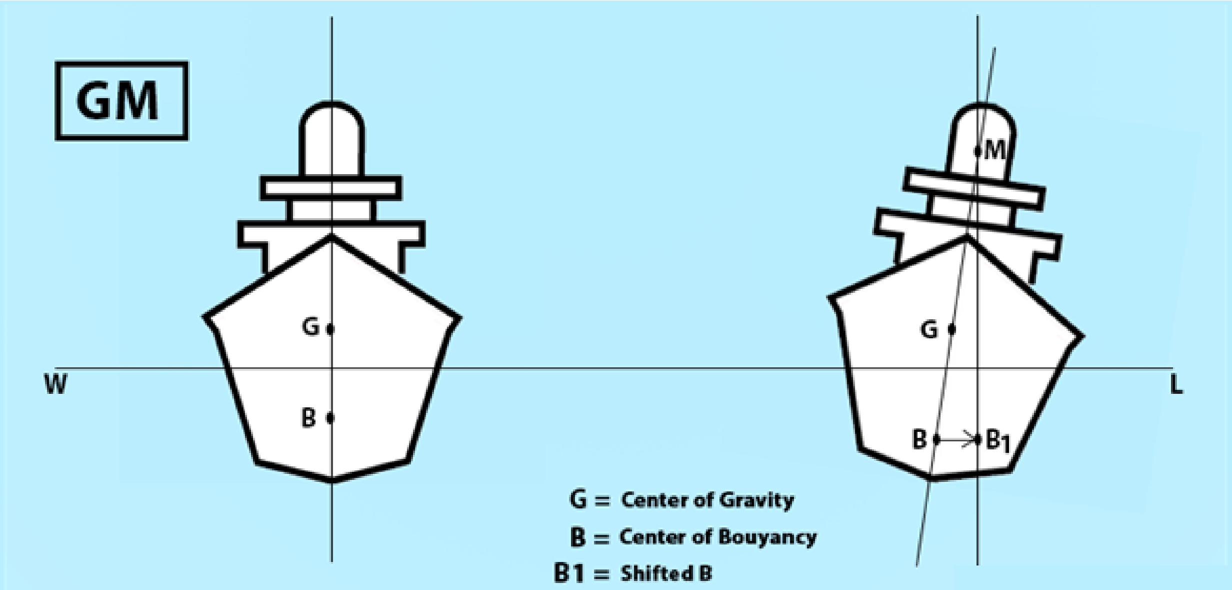


Figure 3.2 Vessel stability

5. Use Ballast Tanks to minimize Free Surface Effect: As a part of good seamanship all the ballast tanks which are slack can be pressed up to minimize the free surface effect which will also help to increase the GM. Well planned stowage of cargo, ballast or both can minimize the number of slack or partly filled tanks.

6. Be Careful While Changing Speed, Angle, and Direction: Often waves associated with a storm or depression causes reduction in intact stability of vessel with a threat of capsizing or rolling of vessel to very large angles. IMO circular MSC 1228 provides guidelines with respect to careful reduction of speed, changing the angle and direction of encounter and adjusting encounter period of waves to avoid parametric or synchronous rolling motions.

7. Secure Loose Equipment/Cargo on Deck: For vessels with lesser freeboard, decks are washed frequently by seas with greater magnitudes. Thus securing of various loose equipment on deck, additional lashings to be taken to strengthen and prevent their loss being washed away into the sea. Safety lifelines can be rigged on vessels carrying cargoes on deck. Additional lashing must be taken to secure anchors, lifeboats, lifebuoys and life rafts.

8. Secure Weather and Water Tight Openings: Various weather tight and water tight openings like side scuttles, hatch covers, portholes, doors, manholes to be securely closed to prevent any ingress of water. Leaking, damaged gaskets or inadequate securing for covers of such openings may affect the integrity of compartment they are protecting. Alarms and indicators for closing of remote watertight doors and openings are provided on Navigation bridge, their operational state to be confirmed prior beginning of the voyage.

9. Secure Doors Forward of Collision Bulkhead: Special emphasis to be provided to secure the doors and openings forward of the collision bulkhead for e.g. forepeak store and hatches, vents and openings forward. These spaces often house forward mooring equipment and associated electrical or hydraulic machinery. Spurling pipe covers need to be cemented well in advance. Bilge alarms in such remote compartments should be tried out regularly to give an early warning of any ingress of water or flooding. Any openings in subdivisions of watertight compartments which can cause progressive flooding must be secured.

10. Drains and Scuppers Must Be Free: All drains on deck and scuppers for drainage of water must be free to prevent any accumulation of water on deck.

11. Secure Aerials and Antennas: Antennas, aerials, stay wire clamps and lashing to be inspected before the wind speed picks up. Winds of gale force and above can easily break and blow away aerials. Storms are associated with lightning and thundering thus all aerials and antennas to be earthed and any low insulation alarms to be investigated carefully.

12. Machinery control:

-If engine room is on UMS mode, man the engine room and make sure sufficient man power is available.

-Monitoring all the parameters of the main propulsion plant and auxiliary power plant machineries.

-After getting rough weather warning, all the spares in the engine room are to be stowed and lashed properly.

-In bad weather, propeller will come in and out of water and will fluctuate the main engine load. Hence rpm is to be reduced or main engine control setting is to be put on rough weather mode.

-Keep Check on RPM To Avoid Load Fluctuation on Main Engine: Due to unsettled movement of vessel often load fluctuations on the main engine are observed. A careful setting of RPM can help to keep the fluctuations on the main engine within permissible limits.

-Always make sure for correct sump level of all the machineries as during rough sea ship will roll, resulting in false level alarm which can even trip the running machine and lead to dangerous situation in bad weather.

-Level of all the important tanks is to be maintained so that pump inlet should not loose suction at any time.

-Stand by generator is to be kept on load until the bad weather situation stops.

-Water tight doors in the machinery spaces to be closed.

-All trays are to be avoided from spilling in event of rough weather

13. Steering control:

- Rough weather and hostile sea conditions have adverse effects on the performance of the auto-pilot. Uncontrolled yawing of the ship can result in excessive rudder movement. Modern auto-pilot system has Weather control option in which the system automatically adjusts the setting to adapt to the changing weather and sea conditions. It also provides an option for the user to manual set a specific value.

-One person should go and check all the oil levels, linkages and other important parameters of the steering gear in the steering room.

-If one motor is running, switch on other motor and run both of them together to get maximum available torque to turn the rudder.

-Sufficient man power including senior officers to be present in the bridge.

14. Inform All Departments: All the departments deck, engine and galley should be informed well in advance of any storm warning so that all the deck, engine and galley stores, hospitals, sick bays and work areas are lashed and secured. Any major overhaul jobs, working aloft or lifting of heavy machinery on deck and engine room using overhead or deck crane can be postponed or avoided.

15. Other common precautions

-It is to be instructed to the crew not to go out on open deck in rough weather.

-All openings in the deck for cargo and other spaces to be kept shut.

-All opening to the accommodation to be kept shut.

-Shaft tunnel and other internal access space are to be used to go to steering room or other compartment.

-Everyone must be aware of his/her duties pasted in the muster list.

-Elevator to be switched off as during rolling and pitching trip may occur and can cause trapping of the person inside.

-Always wear all the PPE's and use railings and other support while walking through any part of the ship to avoid trips and fall.

16. Morale of the Crew To Be Kept High: The morale of the crew should be kept high as often heavy rolling and pitching causes giddiness, nausea and reduced appetite amongst crew members.

3.2 COLD WEATHER PRECAUTIONS

As the winters set in, in the northern hemisphere things start to get a little difficult for the seafarer as the ship moves towards sub-zero temperature, making cold weather precautions for ships extremely important.

Right from the Captain and Chief Engineer to the OS and Motorman, situations become more challenging than in the tropical weather. However, since a vessel can be expected to go anywhere across the globe, it is imperative that entire on board staff is familiar with the precautions to be taken as the vessel approaches cold weather or freezing temperatures (Picture 3.2).

These extreme temperatures will depend upon the region rather than the month of the year; hence the ship is expected to have sufficient stock of certain stores so that emergency stocks are not requested from the shore office in areas where they may not be available.

Picture 3.2 Frozen vessel

Following are some cold weather precautions for ships (all types of ships)

1. Start By Draining The Fresh Water Lines On Deck: After final use, few days before entering low temperature area ensure that ALL the Fresh Water lines from Wheelhouse down to the upper deck are drained and the root valve inside accommodation is shut. Include the line on the monkey Island as well as it is often forgotten. Leave the hydrant valves in open position.

2. Drain the fire line: Just like the FW line, drain the Fire Line on deck as well and leave the after most hydrants open so that entire water of the line is drained.

3. Check anchor wash valves: Recheck that Anchor wash valves are open as well.

4. Check deck machinery: Carry out a final check of the Deck Machinery, topping up levels in the gear case of winches and windlass. Top up the Hydraulic Oil tank for Forward and Aft machinery. When the temperatures and weather is extremely low it is likely that personnel in charge of the mooring operations will forget to make basic checks.

5. Monitor glands: In case the deck machinery is steam driven, you will do well to nip up all the glands and repack if some were leaking in normal condition. You may also use the opportunity to change any leaky gaskets, as in low temperatures it will only get worse.

6. Do greasing and lubrication: Carry out a greasing and lubrication routine of open gears and wires if found dry.

7. Keep oil warm: Before the deck machinery is to be actually used, start the Hydraulic Pumps in the Bosun Store and Steering Gear Room at least 1 hour in advance and allow at least one winch to run idling at slow speed. This will keep the oil warm by circulating.

8. Follow correct procedure for FRAMO system: In case you have a FRAMO system for Cargo as well as deck machinery and Bow thrusters, you need to follow the correct procedure for recirculation and pre warming the oil.

9. Try out cranes: Try out cranes to see that all the pulleys are moving in sheaves and will not give you're a surprise when required.

10. Try out overboard and sea suction valves: In the engine Room try out all the overboard and sea suction valves for proper operation.

11. Try out the steam blow off valves: Try out the Steam Blow off valves fitted on the sea chest and keep the steam pipe meant for the purpose near the sea chest. This valve is used very rarely and that too in very low temperatures when the sea is actually frozen.

12. Check the steam coils: Check the Steam Coils for Accommodation Air conditioning and drain the lines few days in advance. Due to not using, sometimes offensive gases are entrapped in the line from the boiler to the evaporation unit. Check that the air damper for fresh air is free and can be moved when required.

13. Try out the lifeboats: Try out the Lifeboats to see that sheaves are in proper operation and the gear is operating to satisfaction.

14. Check the coolant of the lifeboat engine: Check the coolant of the Lifeboat engine to see that it has sufficient concentration of anti freeze, much below the temperature that you expect to encounter. Try out the lifeboat engine and check the fuel tank level. Regularly check to see the charging condition of Life Boat Engine starting batteries.

15. Check emergency generator and engine: In the same way as for LB Engine; carry out a comprehensive check of the Emergency Generator and Engine Coolant, Fuel Level, Starting devices (both main and second start device).

16. Check pre warming heater for M/E jacket cooling water: Engineers may also use this opportunity to see that the Pre Warming heater for M/E Jacket Cooling water is functioning well, as this will be the most important piece in port of if running on Super slow speed in low temperature condition. Similar to as suggested on deck you may check all leaky steam gaskets and valve glands and repair them before valves are actually in use.

17. Order sufficient winter protective accessories: Order sufficient Woolen Parkas, gloves, innerwear etc. to avoid issues related to hypothermia. It is always better to order median sizes. It is a good practice to have them checked before use for proper condition, working of zips etc.

3.3 TROPICAL REVOLVING STORM (T.R.S)

All seafarers are well familiar with the term 'T.R.S' or Tropical Revolving Storm – an intense rotating depression (a region of low pressure at the surface) which develops over the tropical oceans. It consists of a rotating mass of warm and humid air and creates thunderstorms with strong winds, flooding rain, high waves, damaging storm surge etc. Conventional forces are involved, normally stretching from the surface of such a depression up to the tropopause (Picture 3.3)

Picture 3.3 Tropical Revolving Storm formulating

Some of the important characteristics of a Tropical Revolving Storm (TRS) that are:

-They appear smaller size than temperate depressions

-They form near the Inter Tropical Convergence Zone, a zone of instability

-They have nearly circular isobars

-No fronts occur (a front is the boundary between two air masses, often distorted by warmer air bulging into the colder air)

-They result in a very steep pressure gradient

-They have great intensity

The precursory signs of a TRS, so that a better appraisal of the actions to be taken can be formulated are:

1. Warning and alerting messages: The Radio/Telex/NAVTEX and all other means at hand should be set on the right frequencies and monitored closely, for they broadcast comprehensive warnings with respect to known storms. Refer to the respective ALRS Volumes for more data and frequencies of radio stations in the vicinity. The Telex, although barely used, is also a very important tool that is high on accuracy.

All storms may not be detected by the coast meteorological stations, in which all shipboard equipment and observation is key in averting disaster.

2. Swell: When there is no sight of intervening land, the sea might generate swell within a TRS, indicating an early warning of the formation of the same. Normally, the swell approaches from the direction of the storm.

3. Atmospheric pressure: Monitor the barometer closely in case you are suspicious of a brewing storm. If the corrected barometer reading falls below 3 mb or more for the mean reading for that time of the year (check the Sailing Directions for accurate information of pressure readings), you can expect a (Tropical Revolving Storm) T.R.S. Note that the barometer used must be corrected for latitude, height, temperature etc. to achieve maximum possible accuracy and efficiency.

4. Wind: Wind direction and speed is generally fairly constant in the tropics. Variation from the normal direction for the area and season, and increasing wind speed, are indications of the approach of a Tropical Revolving Storm, i.e., an appreciable change in the direction or strength of the wind indicates a Tropical Revolving Storm (T.R.S) in vicinity.

5. Clouds: A very candid and colorful sky at sunrise and sunset may be a sign of a brewing T.R.S. Presence of cirrus clouds is visible at a considerable distance of 300 to 600 miles from the TRS and as you approach the TRS, the clouds get lower and cover a bigger area (altostratus), generally followed by cumulus clouds as you get closer to the Tropical Revolving Storm (T.R.S).

6. Visibility: Although it might sound like an oxymoron, exceptionally good visibility exists when a T.R.S is lurking in proximity.

7. Radar: The radar gives a fair warning of a Tropical Revolving Storm (T.R.S) about 100 miles prior to approaching the T.R.S. The eye may sometimes be seen on the screen. An area of rain surrounds the eye (the eye of the storm is the storm center) causing appreciable clutter on the radar screen. Remember that though the signs might be visible on the radar, by the time it does become visible on the radar, the vessel is probably already experiencing high seas and gale force winds and rough weather overall. Action is to be taken before such a situation arises.

3.4 COURSE OF ACTIONS TO BE TAKEN IN CASE OF A STORM

Although it is unlikely to sail into a storm with all navigational aids and communication systems in place (shore based as well as ship based), shore personnel generally chalk out an alternate passage plan to avoid such a storm in good time (in liaison with the company and assigned route). However, in the event that the TRS is staring right in the face, it is probably entirely up to the mercy of the sea or maybe, it is not intense enough, and can be handled by the captain’s experience and knowledge.

-The bearing of the eye (storm center)

-The path that the storm is following

-When an observer faces the wind, the eye will be 100° to 125° on his right hand side (in the Northern hemisphere) when the storm is about 200 miles away

-It is assumed generally that the storm is not moving towards the equator and if in a latitude lower than 20 deg., it is likely to have an Eastern constituent

-A storm moving in an unusual or haphazard path is likely to move slowly

3.4.1 Avoiding actions

-Keep at least 50 miles off from the center of the storm. If possible, it is best to be at least 200 miles off to avoid any possibility of danger altogether

-Make good speed. A vessel speeding in the vicinity of 20 knots, following a course taking her away from the eye, can easily outstrip an approaching Tropical Revolving Storm (TRS). TRS move rather slow. This ought to be done before the wind increases to the point that her movement becomes restricted and speeding or any maneuver becomes cumbersome.

-As mentioned earlier, a swift fall in pressure indicates a brewing TRS. A vessel should continue on her course unless the barometer reading falls down by 5 mb or, by 3 mb in addition to high force wind.

-If the vessel is trailing the storm (behind the storm), i.e., in the navigable semicircle, there should be sufficient time and sea room to move away from the eye

3.5 ACTIONS TO BE TAKEN ACCORDING TO HEMISPHERES

3.5.1 Northern Hemisphere

-In case that the wind is veering, the vessel is likely to be in the dangerous semicircle. The vessel should proceed with maximum speed keeping the wind at 10° to 45°, on the starboard bow (depending on the speed). The vessel should turn to starboard as the wind veers.

-In case that the wind direction is steady or backs, such that the vessel is in the navigable semicircle, the wind must be brought well on the starboard quarter and vessel should proceed with maximum speed. Turn to port as the wind veers.

3.5.2 Southern Hemisphere

-In case the wind is backing, the vessel is likely to be in the dangerous semicircle. The vessel should proceed with maximum speed keeping the wind 10° to 45°, on the port bow (depending on the speed). The ship should turn to port as the wind backs.

-In case the wind direction is steady or backs, such that the vessel is in the navigable semicircle, the wind should be brought well on the port quarter and the vessel should proceed with maximum speed. Turn to starboard as the wind backs.

If the vessel in port and a Tropical Revolving Storm (T.R.S) approaches, it is best to put out to sea. Staying put at the berth, especially with other vessels in proximity can be highly dangerous. With the best mooring practices put in position, it very doubtful that ship might be safe from the effects of the storm.

3.6 RESTRICTED VISIBILITY

One of the most important duties of a ship’s officer on watch (OOW) is safe and smooth navigation of the ship. During its voyage, a ship has to sail through different weather and tidal conditions. It’s the duty of the navigating officer to know and understand the ship’s sailing route well in advance and prepare for the same accordingly.

One of the most dangerous conditions to navigate a ship is restricted visibility because of fog, heavy rain or dust storm. When the ship’s officer gets information regarding such upcoming weather condition, he or she should take all the necessary precautions to ensure that the ship sails through restricted visibility area without confronting any kind of collision or grounding accident.

3.6.1 Navigation through restricted visibility areas

Navigating the ship through restricted visibility area is a critical task which must be carried out with utmost caution and care the officer on watch. Mentioned below are ten important points that must be taken into consideration for safe navigation of the ship through restricted visibility area (Pictures 3.4, 3.5).

Picture 3.4 Restricted Visibility

1. Know your Ship inside-out: An efficient navigating officer must know each and every aspect of his or her ship in order to prevent any kind of accident. From dimensions to the characteristics of the ships, the officer should know how the ship will behave under different circumstances. For restricted visibility situation, it is important that the OOW know the stopping distance of the ship at any particular RPM in order to control the ship during emergencies.

2. Inform the Master : During restricted visibility, it is important that the master is on the bridge. The OOW must call or inform the master regarding the navigating condition. The officer should also inform the engine room and ask the duty engineer to man the engine room incase it is on "unmanned" mode.

3. Appoint Adequate Man Power: It is important that enough man power is present on the bridge in order to keep a close watch on the ship's course. Additional personnel must be appointed as "lookout" at different locations on the ship. If there is traffic in the area, the officer must inform the engine room to have enough manpower so that the engine is also ready for immediate maneuvering.

4. Keep the Fog Horn Ready : Ensure that the fog horn is working properly for the restricted area. If the horn is air operated, drain the line prior to opening the air to the horn.

5. Reduce Speed: Reduce the speed of the ship depending on the visibility level. If the visibility is less, bring down the ship to maneuvering RPM.

6. Ensure Navigation Equipment and Light Are Working Properly: Ensure that all important navigating equipment and navigation lights are working properly during restricted visibility. The OOW must ensure that the navigation charts are properly checked for correct routeing and a good radar watch is carried out.

7. Stop All Other Works: Though it's obvious, but never multi-task during restricted visibility even if there are more than sufficient people present on the bridge. Also stop all other deck work and order the crew to go to their respective rooms. This is to prevent injury to personnel working on open deck in case collision or grounding takes place.

8. Open/Close Bridge Doors: Ensure that the bridge door is kept open and is without any obstruction for easy bridge wing access (Considering that the bridge wing is not enclosed). Also, in case of dust or sand storm, close all the bridge openings.

Picture 3.5 Restricted Visibility

9. Shut Ventilation: If the ship is passing through a sand storm, the ventilation fans and accommodation/ engine room ports must be closed to avoid sand particles from entering bridge, accommodation and engine room.

10. Follow All Procedures: Follow all the important procedures for restricted visibility as mentioned in COLREG Rule -19. Also monitor channel 16 in the radio and ensure that all important parameters of the ship such as latitude and longitude, time, speed etc. are noted in the log book.

3.7 COLREG 19/2

3.7.1 Section III – Conduct of vessels in restricted visibility, Rule 19

This Rule applies to vessels not in sight of one another when navigating in or near an area of restricted visibility.

Every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. A power-driven vessel shall have her engines ready for immediate maneuver.

Every vessel shall have due regard to the prevailing circumstances and conditions of restricted visibility when complying with the Rules of section I of this part.

A vessel which detects by radar alone the presence of another vessel shall determine if a close-quarters situation is developing and/or risk of collision exists. If so, she shall take avoiding action in ample time, provided that when such action consists of an alternation of course, so far as possible the following shall be avoided:

a) An alternation of course to port for a vessel forward of the beam, other than for a vessel being overtaken.

b) An alternation of course towards a vessel abeam or abaft the beam.

Except where it has been determinate that a risk of collision does not exist, every vessel which hears apparently forward of her beam the fog signal of another vessel, or which cannot avoid a close- quarters situation with another vessel forward of her beam, shall reduce her speed to the minimum at which she can be kept on her course. She shall, if necessary, take all her way off and in any event navigate with extreme caution until danger of collision is over.

3.8 MAN OVERBOARD

Man overboard is a situation where in a ship's crew member falls out at sea from the ship, no matter where the ship is sailing, in open seas or in still waters in port. A seafarer has to be very careful while performing his duties onboard vessel as it can never be taken for granted that a person cannot fall off the ship due to bad weather, swell in the sea, accidents, and due to negligence during.

A man overboard is an emergency situation and it is very important to locate and recover the person as soon as possible as due to bad weather or rough sea, the crew member can drown or else due to temperature of the cold water the person can get hypothermia.

Hypothermia is a situation where in there is an extensive loss of body temperature due to prolonged contact of body with cold water and the body's normal metabolism and functions get affected. A person will get unconscious after 15 minutes in water with temperature of 5˚C.

Alarm for Man Overboard: There is a dedicated alarm signal used onboard vessels and it is the same for all vessels sailing in international waters.

Three prolong blast on the ship's electrical bell and ship's whistle is an alarm signal used for man overboard emergency situation.

Action to be taken during Man Overboard Situation: The initial and early sighting of the fallen crew plays a vital role in increasing the percentage of saving his/her life.

3.8.1 Actions to be taken when a man overboard is sighted

-The first and foremost thing is Never to lose the sight of fallen person and inform others onboard by shouting "Man overboard" along with side of the ship i.e. port of starboard side until someone informs the bridge and raises an alarm.

-As soon as bridge officer knows the situation, raise the 'man overboard alarm' and hoist signal flag "O" to inform all the ship staff and other ships about the vicinity.

-Then, throw a lifebuoy with smoke float, light (and SART if available) near to the fallen person.

-Post a constant look out with binoculars for continuous watch on man overboard.

-Ship's engine must be slowed down and ship should be turned toward the fallen crew for recovery maneuver. Engine has to be on standby all the time.

-Care must be taken to maneuver the ship carefully as not to hit the fallen crew with ship.

-Keep ready the rescue boat and muster the rescue team.

-Rescue the man overboard and put the person in Thermal protective Aid (TPA) to avoid extra body heat loss.

-Start the first aid as required.

4 VESSEL CONSTRUCTIONS

4.1 STRENGTHENING AGAIST DYNAMIC LOADING

4.1.1 Loads acting on fore and aft regions of vessels

It is worthwhile to mention that in most of the places describing the preliminary design of ship's hull structures, utmost priority is given to the midship section, thanks to the global stresses such as maximum hull girder bending and buckling loads taken into account.

However, the fore and aft parts of the ship are not to be taken for granted as they are the critical zones subjected to local loads such as panting, pounding, green water, wave slaps, whipping, propeller-induced vibrations, just to name a few (Picture 4.1). Most of these loads are incident on the fore part, but the construction of the aft part is also equally important.

Picture 4.1 Wave slap

1. The common local loads acting on ships: Before delving deeper into the structural arrangements prior to the requirement, let's first go through some of the common stress problems encountered in these regions.

2. Panting: Panting refers to the contiguous bellowing-in and bellowing-out nature of the ship's hull plating due to variable water pressure distribution caused as a result of waves. This effect is accentuated in the forward region when the ship surges headway through. The ship bow region is the most affected area where the entire vessel encounters the wave systems for the first time. The dynamic wave pattern has variable hydrostatic pressure distribution point to point which unfortunately falls incongruous for a solid hull plate. Although, panting is still said to exist throughout the entire length of the hull, the effect dies away as the wave system at the bow starts losing its energy from the bow shoulder onwards (towards the aft).

3. Green water or wave slap: The waves encountered by a ship on rough sea states are highly unpredictable. These giant waves can go up to tremendous heights and upon interaction with the ship's forward, end may lash itself on to the exposed weather deck in an event marked as the wave slap/green water. However, more than the inner hull arrangements in the fore end, more concentration needs to be given in case of the deck strengthening in this case.

4. Pounding: These forces are induced due to the 'Slamming' motion of the ship triggered due to heaving or high pitching motions .This situation is further aggravated in case of empty or light ballasted conditions of ships. This intense pounding stresses incident on the plating spread over a large area extending a considerable amount of length even behind the forward collision bulkhead. Slamming can be mostly bow-flare slamming, stern slamming or bottom slamming.

5. Whipping: Whipping loads are a class of low cycle and high frequency stress-inducing loads caused due to slamming motions of the ship as above. But they are said to be an outcome of impact loads which are a resultant of the pounding loads.

4.2 IMPACT LOADS

As the name suggests, impact loads act all of a sudden and are of large intensity in response to the natural structural response of the entire ship hull. The oncoming waves hitting the fore part of the hull generate a large amount of impact pressure creating impact loads which in turn generate a pattern of rapid vibrations onto the material in what we call as whipping.

Impact loads also depend on the relative motion between the vessel and the water surface. Thus, pertaining to suitable design, velocity constraints and surge direction are key determinants of the net effect of impact loads.

In rough sea states, the bow of the ship performs an oscillatory motion, as mentioned in Pounding. The fore bottom floor emerges from the water and again plunges into the sea. This incessant emergence and hitting the water may spark off a vibration in the hull girder. These high-frequency vibrations cause severe loading on the entire structure and may sometimes exceed the wave-induced stress, and aggravate the situation when both are superimposed. Whipping thus is a straightforward outcome of slamming which can also induce higher girder bending moments and fatigue damage to the entire structure of the ship. Hence, it is very much wise if this is controlled beforehand at the fore region without allowing it to propagate.

4.3 OTHER EFFECTS

Other effects occure due to vibrations caused by ship's propeller and machinery aft spark, off various unwanted local stresses in the stern. The fore and aft end constructions thus are needed to be taken special care of as sometimes these loads can lead to massive structural failure.

4.3.1 Fore end

Despite the multitude of stresses localized in this region, most of its structural arrangements have been kept in line with the chief problems of panting and pounding as these are the two most grave problems encountered in this case, proving to be the causal factors for most of the ship structural failures.

Segments comprising fore end construction and strengthening of ship structure:

1. Fore Peak Tank
2. Stem
3. Stiffening in the form of frames, breast hooks, wash plates, deep radius floors, pillars, panting stringers, panting beams, variety of stringers and girders. Their scantlings, material allowance and proper positioning of these strengthening arrangements dictate the "structural resilience" in light to all the localized loadings
4. Chain Lockers
5. Decks
6. Bow (Bulbous, clipper, X-bow etc.)

Fore peak tank, as the name suggests, forms the foremost watertight tank principally used for ballasting.

Some of the chief stiffening components include panting beams, panting stringers, angle pillars, breast hooks, perforated flats, centerline wash bulkhead. Moreover, the floors at the bottom and stringers running longitudinally along the sides at given intervals are also existent (Figure 4.1). However, an essential feature of the fore arrangement is the deviation in scantlings and positions of the net 'Panel-stiffening' arrangement in light of its requisite strength to sustain these load-condition vagaries.

As the load parameters are more pronounced in the fore part bearing, a stake of local as well as global stresses (especially in due regard to the pressing problems of panting and pounding) are highly unpredictable, the ship designer has to pay more attention to this part to make it more "fit".

Furthermore, from the strength point of view, if the loading is hindered at this point, its effects on the remaining length of the ship become less domineering. The Classification societies for ships around the world have prepared a consensus regarding the dimensional allowance that may be purported to these plate stiffening arrangements for higher load-sustaining capacity.

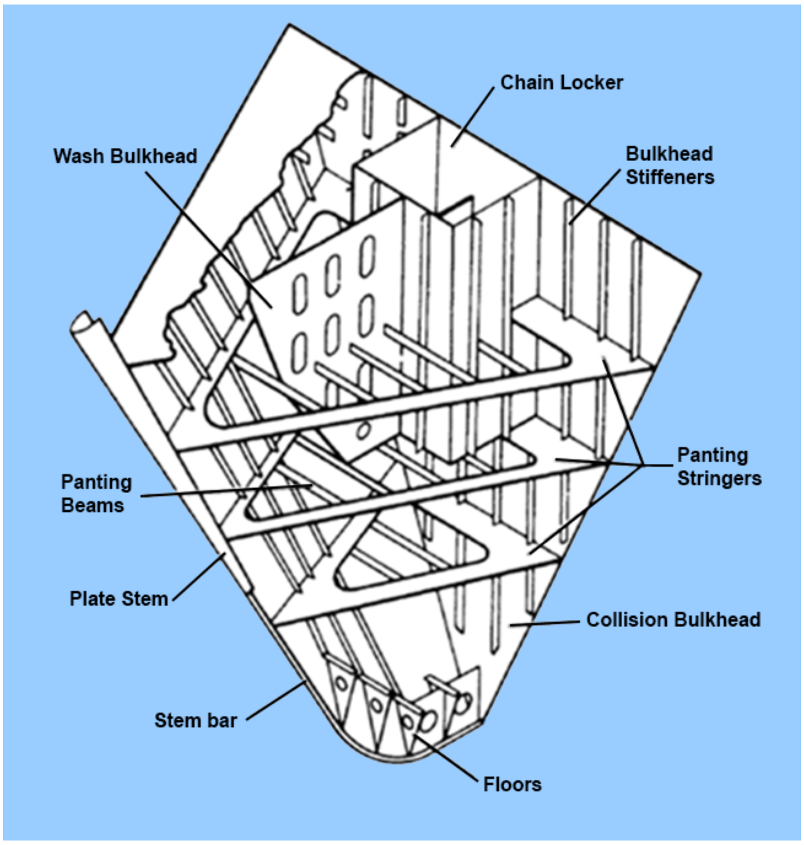


Figure 4.1 Forward end arrangement

4.3.2 Specially applied stiffening measures

-Panting stringers are longitudinal stiffening members formed in a closed rounded-triangular shape (peak being the fore end) by the side stringers on both sides and the collision bulkhead at its end.

-A perforated bulkhead often exists at the centerline. Although its main function is dedicated to cargo storage and reduction of Free Surface Effects, they add to the longitudinal strength of the fore peak tank. Most of the time the angle pillars along with the panting beams are joined to the wash bulkhead. They are also very useful when the unsupported span of panting beams become large.

-Sometimes for fuller form ships like bulk carriers, the fore part is stiffened by large perforated non-watertight flats to cater to enhanced transverse strength.

-Breast hooks to stiffen the stem plate and behave as the support tip of the panting and side stringers (Figure 4.2). They also play the pivotal role of transverse strengthening of a large number of plates in the forward and side regions. However, the usability of breast hooks become pointless when there are tween decks.

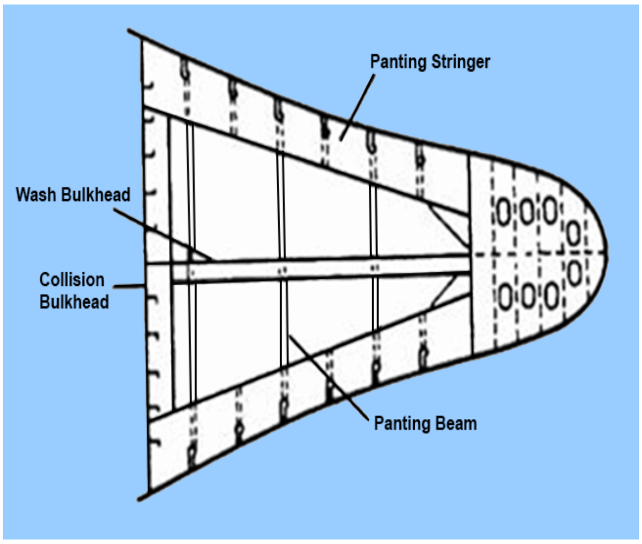


Figure 4.2 Plan of forward panting arrangement

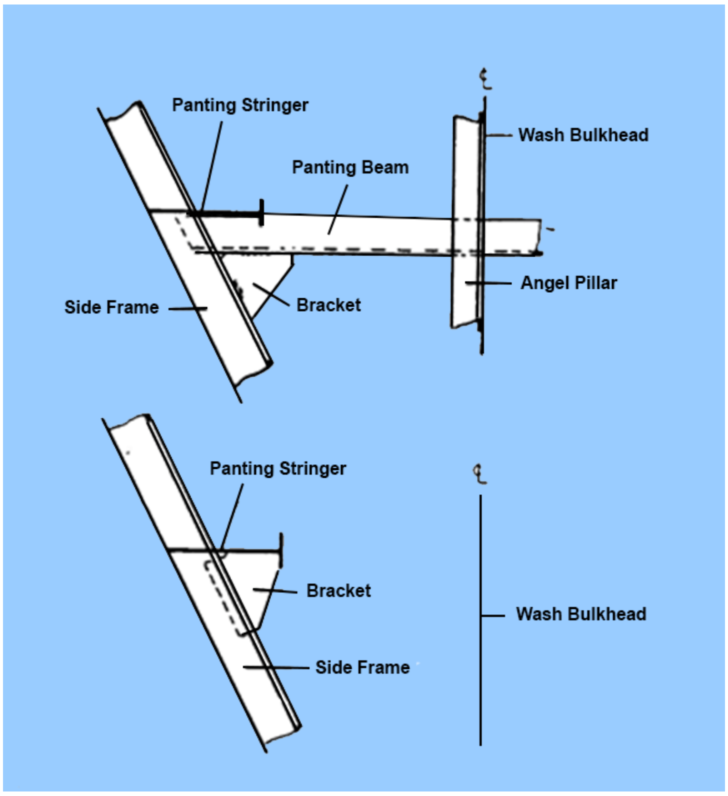


Figure 4.3 Transverse view of fore end panting arrangements

Although most of the above-adopted measures are suffice to sustain high pounding loads, some extra modification are ought to be made, especially with due respect to the bottom structures.

The forward bottom plating may be subject to buckling loads due to slamming/pounding. This effect is much more adverse in winter and is the most pronounced in planning vessels that is having a higher Froude Number. Thus while designing them, the stiffening arrangements are done in accordance to the Speed-to-length relationships (Figure 4.3).

4.3.3 Aft end

The aft end is subject to reduced impact of local loads as compared to fore part. But still similar reinforcements are made in adjunct to the fore part. Even though, the aft part is characterized by several entities such as an aft peak tank, stern frame, rudder, rudder stock, propeller and its ancillaries. However we limit our description only to the stiffening arrangements done to the stern frame in light of resisting localized forces generated in the backward region such as propeller-induced vibrations, sternward wave disturbances and to some extent, panting and pounding (Figure 4.4).

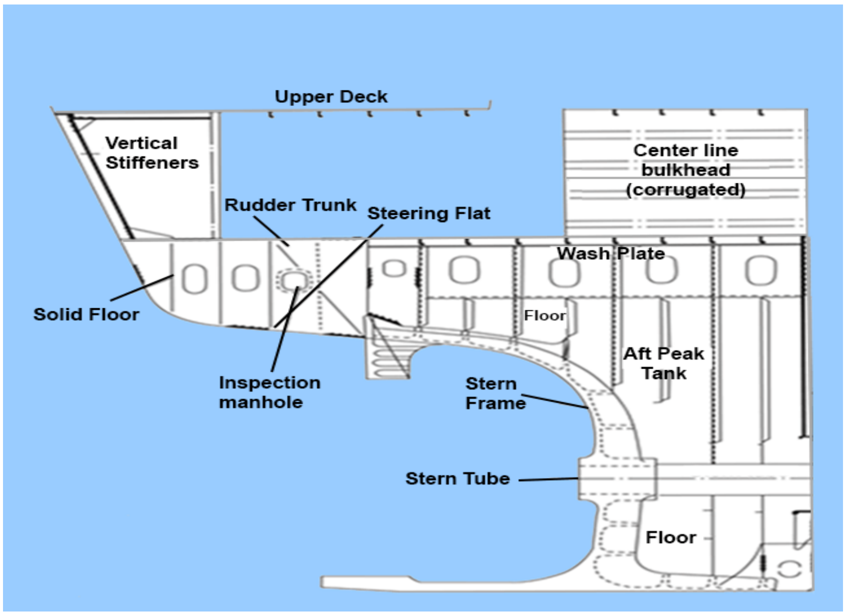


Figure 4.4 Aft end arrangement

-One interesting feature of aft end stiffening arrangements is Cant beams. Cant beams are instrumental in providing longitudinal as well as transverse strength to the stern arrangement. They are radial in nature and are directly welded to the shell plating giving a kind of web frame structure. Cant beams are often coupled with cant frame providing additional strength.

-Apart from cant beams there are solid floors existent at every frame flanking the centerline girder.

-Tween decks along with the upper poop deck, if provided with adequate stiffening can bolster the longitudinal strength.

-Moreover, a set of closely running stringers join to the first main frame while the deck girders support the deck plating.

-In some vessels, panting stringers are also present at the aft peak mainly spaced within 2.5 meters according to the conventional classification rules.

-As compared to bow construction, transverse frames are more in girth and depth aft.

-One crucial point to be noted is that while there is a transom stern instead of a conventional rounded one, there is no requirement of cant beams. The transom plate while well stiffened vertically is suffice to resist local loads to a commendable extent.

Along with the rest of the ship, designers take a lot of care in designing aft and fore end constructions with adherence to panting and pounding. Sometimes, the “strength-absorbing capacity” of them are helpful in even protecting the entire ship from structural failure.

Remember Titanic? Most naval architects and experts around the globe now theoretically speculate that the ship met its misfortune only because it had damaged principally along the sides (as it had grazed past the large iceberg in an attempt to avoid it). But instead, if judiciously it had rammed into the iceberg, the highly-strengthened fore part would have sustained maximum of the impact. Even if the fore peak tank would have flooded, still the heavy watertight collision bulkhead could have withstood the hydrostatic pressures and prevented flooding inside the rest of the ship.

Over the years, ships have suffered intense load problems in the fore and aft regions causing damage. Fortunately, modern day load predictability techniques and FEM tools have opened up many avenues for innovative, fool proof and safe designs. Most of the modern design ships have high sustainability towards abnormal local loads even in very rough sea states. More advanced strengthening measures optimized with cost have made ships safer.

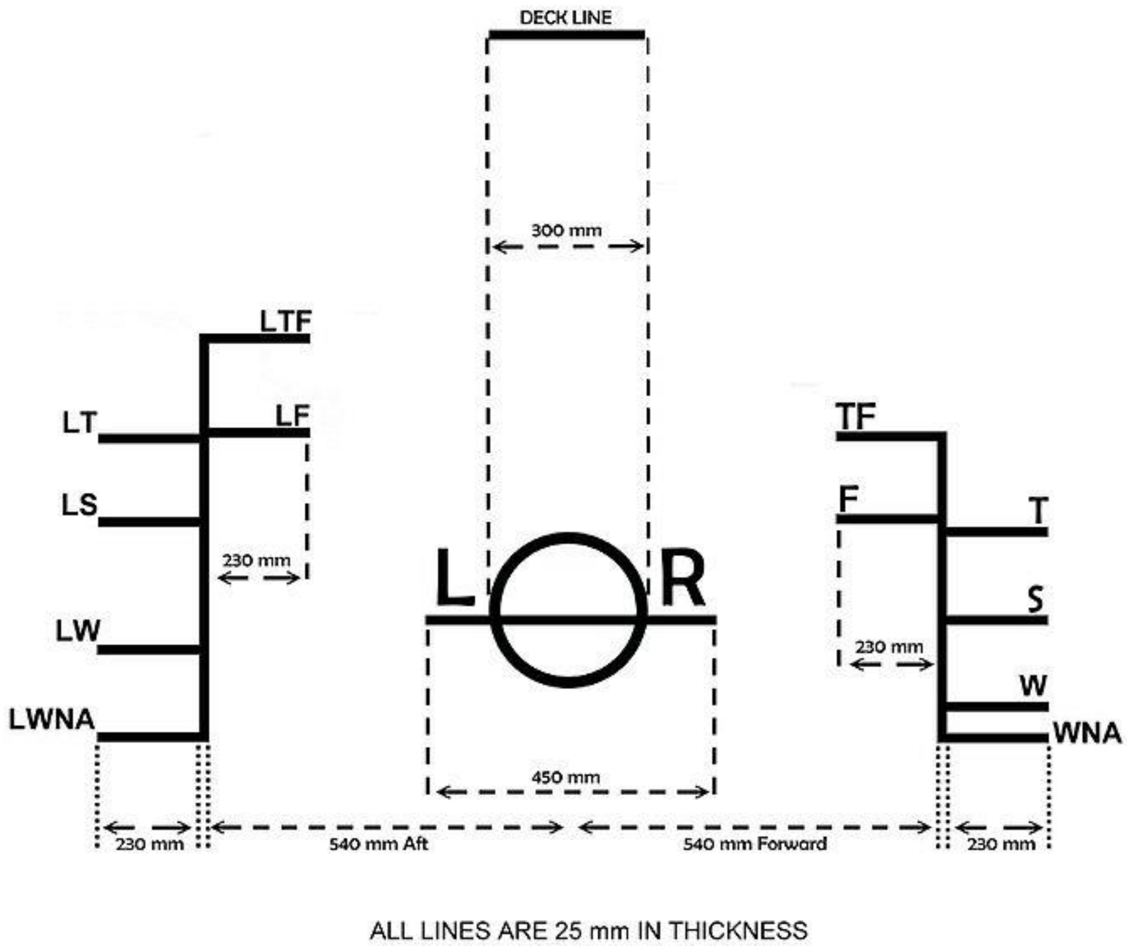
4.4 LOAD LINES

4.4.1 Purpose and necessity of Load Lines

The fundamental purpose of a Load Line is to allot a maximum legal limit upto which a ship can be loaded. By prescribing such limits, the risk of having the vessel sailing with inadequate freeboard and buoyancy can be limited. A vessel should be having sufficient freeboard at all times, any exceptions made will result in insufficient stability and excessive stress on the ship’s hull. This is where load lines play an important role, as it makes the task of detecting whether the vessel is over-loaded and it’s freeboard tremendously easy and effortless.

However, since the buoyancy and immersion of the vessel largely depends on the type of water and it's density, it is not practical to define a standard freeboard limit for the ship at all times. For this reason, the convention has put regulations which divide the world into different geographical zones each having different prescribed load line.

For example, a vessel sailing in Winter on North Atlantic Ocean will have a greater freeboard than on a voyage in Tropical Zones and Fresh waters (Picture 4.2).



Picture 4.2 Load lines, Plimsol Line

As we have already defined above, Load Line is a special marking positioned amidships. All vessels of 24 meters and more are required to have this Load line marking at the centre position of the length of summer load water line.

There are two types of Load line markings:-

1. Standard Load Line marking – This is applicable to all types of vessels.
2. Timber Load Line Markings – This is applicable to vessels carrying timber cargo.

These marks shall be punched on the surface of the hull making it visible even if the ship side paint fades out. The marks shall again be painted with white or yellow colour on a dark background / black on a light background. The complete Load line markings consist of 3 vital parts:

1. Deck Line – It is a horizontal line measuring 300mm by 25mm. It passes through the upper surface of the freeboard.

2. Load Line Disc – It is 300mm diameter and 25mm thick round shaped disc. It is intersected by a horizontal line. The upper edge of the horizontal line marks the ‘Summer salt water line’ also known as ‘Plimsol Line’.

3. Load Lines – Load lines are horizontal lines extending forward and aft from a vertical line placed at a distance of 540mm from the centre of the disc. They measure 230mm by 23mm. The upper surfaces of the load lines indicate the maximum depths to which the ships maybe submerged in different seasons and circumstances.

5 VESSEL TYPES IN ROUGH WEATHER

5.1 TANKER PRACTICE FOR COLD WEATHER

In addition to the above general cold weather precautions for ships , a tanker vessel (Picture 5.1) requires some extra precautions as it has some very specialized equipment fitted:

1. PV Breaker: It's a very important equipment for a tanker. Check the liquid inside for temperature tolerance of at least -15°c or more if going to more extreme region. Add additional anti-freeze if required and record it in the Deck Maintenance log if one is maintained as per your SMS.

2. Deck Seal: Is normally fitted with a heating coil. Mostly it has only one coil for steam entry and exit, so don't get alarmed. Carry out an inspection of the Deck Seal and the heating coil if not done earlier. Open steam to see that none of the weld- joints or gaskets or valve glands and flange gaskets are not leaking.

3. Heating Coils: If yours is a product tanker you will have a lot of heating coils for the cargo tanks. You may have pressure tested these if you are planning to carry heated cargo. Ensure that each and every coil is COMPLETELY empty of water. As a thumb rule keep the Main Deck In/OUT valve and main steam inlet valve to the tank and return condensate valve shut; apart from this keep ALL the tank valves, including the drain valves OPEN. Please stick to this very seriously to avoid a catastrophe in case you wake up one fine morning to snow on deck.

4. ODME sampling pump and pipeline: We assume that you have already shut the fresh water supply from the Engine Room to the Pump Room. Now take additional precautions and drain the sampling pump casing by opening the drain plug. Drain the connected FW and sample lines too.

5. Cargo Stripping Pump: It is possible that last time this was used, someone may not have emptied the steam side and the steam lines. Do that now, by first ensuring that Steam supply from E/R is shut.

6. Tank Cleaning Heater**:** Though not much at risk due to proximity with the E/R bulkhead. It still might be a wise thing to drain the steam lines and also lower the Sea Water side to a controlled extent.

7. IG Line Pressure Sampling Line: Shipyards are fond of fitting a 8-10mm line from the IG line to the pressure switch and indicator. This sometimes gets choked if there is condensate in the line. Please open the line from both ends and blow through to ensure clear. PRECAUTION: Do not blow INTO the pressure switch.

8. Record Cargo Temperature: Regularly if you are carrying heated cargo. It can be done twice from Cargo Control Console if the temperature indicator is reliable. Cold weather if associated with sprays on deck or rough weather brings down the cargo temperature must faster.

Picture 5.1 M/T sailing at frozen sea

5.2 CARE OF CARGO ON CONTAINER SHIPS AT ROUGH SEA

On container ships, cargo is carried in standardized containers, which are placed one over the other and secured using lashing.

While at sea, the ship is subjected to heavy rolling and pitching, which can not only disturb the cargo but also upset the stability of the ship. Parametric rolling – a unique phenomenon on container ships, must be carefully dealt with in order to ensure safety of cargo containers at sea.

Keeping a watch on the loaded cargo containers when the container ship is sailing is as equally important as preparing a container ship for loading cargo. Also, officers must know all the important equipment tools which are used to handle cargo on container ships.

The following Important points must be considered for taking care of cargo containers while at sea:

1. Check lashing: Proper container lashing is one of the most important aspects of securing cargo safely on the ships. Every officer in charge of cargo loading and unloading must know and understand the important points for safe container lashing (Picture 5.2).

Picture 5.2 Lashing containers

Moreover, when the ship is sailing, lashing must be checked at least once a day and tightened whenever necessary.

If the ship is about to enter rough sea or in case of heavy weather, lashing should be frequently checked and additional lashing must be provided wherever required.

2. Checking containers with dangerous goods: Cargo containers carrying dangerous goods must be checked at regular intervals of time, especially in bad weather. Dangerous goods containers must be frequently checked for leakages or damages while the ship is sailing.

3. Checking refer containers: Refer containers must also be checked and monitored at least twice daily for proper functioning. Frequent monitoring is required in case of special refer cargo containers or containers which are suspected to malfunctioning.

4. Avoid Wet Damage of Cargo: Adverse weather condition might result into damage of cargo because of leakages from water and oil systems. Such kind of damage to container ships is known as wet damage. Water from rains might also get accumulated inside the cargo hold and damage the cargo in lower tier containers in the cargo hold.

Regular sounding of cargo hold bilges is of utmost importance for early detection of problems related to water or oil ingress in cargo holds.

Bilges must be checked once a day in normal weather condition and at regular intervals of time in rough weather. When the ship is at port, cargo hold bilges must be drained into holding tanks.

Regular rounds of the cargo deck compartment must be made to check the condition of lashing and cargo containers.

Sometimes, it might so occur that in spite of taking all the necessary precautions, damage to cargo or the ship's hull would take place. In such cases, the master of the ship must take the necessary precautions to minimize the damage. He should also report the same to the company and make necessary entries in the ship's log book.

A master's report on the damages sustained must also be made along with a sea protest which is to be produced at the next port.

5.3 RO-RO VESSELS' STABILITY AFFECTED BY WEATHER

A Ro-Ro vessel is one of the most sought after cargo ships to work on. Providing both cargo and passengers carrying capabilities, Ro-Ro ships reaches ports more frequently and have shorter voyages.

However, there are things that make Ro-Ro ships dangerous to work on. Ro-ro ships have been criticized for a number of reasons, mainly because of one single reason – safety of the ship, making it very dangerous due to weather-linked reasons.

1. The Problem of Stability: If a vessel maintains its stability at sea then it is safer to sail. However, the problem with the Ro-Ro ship is its design, which includes cargo in upper decks and accommodation at even higher levels.

Even a minor shift of cargo in the Ro-Ro vessel can become a major threat to the stability of the ship. Similarly, hull failure leading to flooding can result in capsize of the vessel in no time. The effects of wind and bad weather on high accommodation can also disturb the ship's stability.

2. High Freeboard: In Ro-Ro ships which carry only cargo, the general arrangement of cargo access door is close to the water line. In the event of listing, the door can get submerged leading to high chances for ingress of water inside the ship which will lead to capsize (Picture 5.3).

3. Cargo Access Door: As discussed above the effect of listing of the ship leads to ingress of water if the cargo doors are open or damaged. One weak point of Ro-Ro vessel is that sometimes the cargo door itself is used as a ramp which makes the ship more vulnerable to damages.

4. Lack of Bulkheads: The subdivision of Ro-Ro ship from inside lacks from the transverse bulkheads, leading to lower water tight integrity when water ingress or flooding takes place. Lack of bulkhead also leads to spreading of fire more quickly as no subdivision is present to contain the fire.

Picture 5.3 Ro- Ro capsizes

5. Location of Life Saving Appliances (LSA): When a ship is to be abandoned, life raft and lifeboats are used to leave the ship as soon as possible. The location of lifeboat and life rafts on Ro-Ro ships is usually very high, which makes it even difficult to lower them at sea especially when the ship is listing.

6. Weather condition: Another reason which acts externally on the Ro-Ro vessel is the rough weather, which may result in reduction in the stability and cause heavy rolling of the ship. Heavy rolling has lead to capsizing of ships in the past.

7. Cargo stowage: Cargo stowage is very important operation on Ro-Ro vessel for any loose cargo (trailer, cars etc.) can give rise to a chain reaction leading to heavy shift in cargo position. The trucks and trawlers loaded on board also carry cargo inside them and any shift of that cargo can also lead to listing of the ship.

8. Cargo Loading: It is very difficult to have a sequential loading of cargo as cargo arrives on terminals at different intervals and due to lack of time on port. This further leads to uneven cargo distribution, something for which nothing can be done about. Lack of proper cargo distribution has been the reason for several ship accidents in the past.

5.4 BULK CARRIERS

Several maritime accidents in the past have involved bulk carrier ships mainly because of the failure of ship’s structure which resulted from deterioration of ship’s hull, corrosion, fatigue, effects of cargo, water ingress etc.

1. Reinforcing the corrugated transverse bulkhead**:** Reinforcing the corrugated transverse bulkhead installed between No.1 and No.2 cargo holds and the double bottom of No. 1 hold. This ensures water tight integrity to be maintained at all time even when side hold or bottom is damaged.

2. Water Ingress Alarm: Checking and maintaining an active water ingress alarm in the cargo hold as per SOLAS requirement at all times. Also check and maintain water ingress alarm in area located at the forward of the cargo area.

3. Hull Survey: A complete hull survey of bulk carriers as per IACS condition to maintain the strength of the ship's hull.

4. Avoiding Deck Wetness: Increasing the Integrity of fore-deck fittings on bulk carriers to avoid the problem of deck wetness i.e. flowing of water on ship's deck due to rough weather, also known as green water loading (Picture 5.4).

Picture 5.4 Bulk carrier , deck wetness due to high waves

5. Fitting Bulwark: Fitting of suitable bulwark in the fore part of the ship as per the requirement to avoid green water condition.

6. Reinforcing Hatch Cover**:** Reinforce the hatch cover which is located at the forward of the ship within 0.25L, where L is length of the ship.

7. Maintain Water Tightness: Maintaining water tightness of all the hatch covers to avoid water ingress.

8. Double Skin Side Shell Frame: Side shell frame to be double skin ensuring extra safety in case of structural damage.

9. Cargo Hatch Cover Alarm: Installing Alarm for opening and closing of hatch cover for additional safety.

10. Anti Corrosion Paint: A good anti corrosive coating on the ship's structure to avoid damage due to corrosion.

11. Cargo shift: Cargo shift has always remained as one of the greatest dangers on bulk carriers. This problem is greater for ships carrying grain cargoes. Grain settles by about 2% of its volume. Because of this settling, small void spaces exist on the top of grain surface. These void spaces permit the grain to shift. The free flowing characteristics of grain reduce the stability of any ship carrying it. Trimming is undertaken to reduce the danger of cargo shifting. Rolling can also cause shifting of cargo from one side to the other and reduce her positive stability resulting in the vessel to capsize.

At ocean going in rough sea in ballast condition, ballast cargo hold has to be fully filled with water in heavy ballast condition; slack conditions is not permitted, to avoid structural damage of hatch cover and hull due to slashing (Picture 5.5).

Picture 5.5 Bulk carrier at rough sea, laden condition

6 DRAGGING ANCHOR

6.1 REASONS OF DRAGGING ANCHOR

The main reason for a vessel dragging its anchor is because of rough weather conditions. In such situations, it is extremely important for seafarers to collect all necessary information to familiarize with the situation and prevent dragging of anchor as much as possible. Some important parameters that need to be considered are:

-Prevailing weather condition of that particular area

-Safe position for anchoring the vessel

-Wind and tidal behavior of that area

-Contact information of port authorities in case of assistance required etc.

Picture 6.1 Vessel at anchorage

At most ports, it is inevitable for a vessel to wait at anchorage(Picture 6.1) and the time at anchorage can be for days or even weeks. During such times, the master and ship crew should identify possible dangers to the ship and make all the necessary preparations.

A vessel dragging anchor is a threat to its own and also to other vessels in the vicinity, often leading to an emergency situation such as collision, grounding or stranding, depending on the maneuverable condition of the ship.

In such situations, a quick assessment of the situation can only be achieved by a vigilant bridge watch, contingency plan to tackle any emergency, quick response and good judgment of the situation. It may take some time to weigh the anchor and restore the vessel to its full maneuverable condition, but no serious accident should happen if there is enough sea room and time to do so.

6.2 PREVAILING ACTIONS

Following points should be considered by a seafarer prior anchoring where dragging anchor is predicated:

-Take on heavy weather ballast, taking in to account the stability of the vessel and depth of water below the keel

-Pay out more anchor cable depending on the size of the vessel and weather condition

-Keep a safe distance from other anchored ships, shoals and other dangers, leaving room for maneuvering.

-Weigh anchor and shift the vessel to different position away from the vicinity of other vessels, provided prior permission is received from VTS of that area, port authorities and owner's orders

-Increase the efficiency of the bridge team by adding an extra lookout

-Keep the main engines standby for maneuverability

6.3 HOW TO ASSESS THE VESSEL IS DRAGGING ITS ANCHOR

-Check the ship's position at frequent intervals, to confirm if the vessel is outside the swinging circle. Use all available means, both visual and electronic equipment such as GPS, RADAR and ECDIS, to make the appraisal of the situation. If the vessel deviates from the circle, it is likely to be dragging its anchor

-The bow cannot stand against the wind

-Check anchor chains for slipping, a small pole with a cloth as flag like arrangement can be tied to the links to understand the slipping of anchor chains

-Extra vibration and weight on anchor cable

-Check the speed over ground (SOG) when the vessel is swinging, the SOG can increase variably and this should not be misinterpreted

-Check the course recorder for figure of eight motion locus

-Also monitor the position and distance of vessels nearby. In case if they are dragging counter measures to be taken to safe guard own vessel

6.4 ACTIONS TO BE TAKEN WHEN DRAGGING ANCHOR

-Master to be informed, do not hesitate to call him at any time of the day, his experience and decision making authority is vital in any give situation

-Inform engine room and start the main engine with the permission from the master and give power to windlass if it is not already given. Make the vessel ready for maneuvering

-Stop all cargo operations and prepare vessel for maneuvering. Let go cargo barges and crane barges if they are alongside

-Inform and alert Vessel traffic system (V.T.S) and other vessels nearby about the condition and inform about the actions taken. Seek permission for re-anchoring

-Start heaving up the anchor and once the vessel’s maneuverability is restored, shift the anchorage position where drifting can be safer or take to the open sea

-Deploy more cables or drop a second anchor (not recommended for big vessels) before the speed of dragging of the vessel increases. This can stop the small vessel from dragging anchor at very early stage before the ship is pressed to leeward side with increasing speed

-Use bow thrusters, main engine and steering to maneuver. It becomes more difficult to weigh anchor when the vessel is pressed more to the leeward side and takes considerable amount of time. Use bow thrusters for stemming the wind. Do not override the anchor especially in shallow waters as the vessel may impact on the anchor during pitching.

-If the scenario permits, let the vessel drag in a controlled manner. But this is not recommended in areas where offshore work such as oil and gas operations are being carried out, which can result in damaging the submerged pipe lines, cables etc.

-Release the bitter end and let go the anchor completely, when weighing of anchor is not possible. A ship without minimum of 2 anchors is not considered to be sea worthy, a careful assessment is to be made prior making this decision

-Call (tugs) for assistance. This is possible only if the weather permits

Most accidents collision or grounding happens while the vessel is at anchor mainly because of no early prediction of dragging anchor. Time plays a vital role in area of high vessel density and this time lapse results in difficulty in restoring the maneuverability of the vessel. Ensure that proper contingency plan is set in place to control such incidents and avoid arising of any emergency due to dragging anchor.

7 OPERATIONS

7.1 HELICOPTER OPERATIONS

Fair weather condition is an inevitable factor in helicopter operations. The helicopter team will foresee the expected weather conditions prior the operations. However, the ship's officers should also consider the same at that time. This includes:

1. Wind Direction and Speed: The speed and direction of wind has great impact on helicopter operations. During the operation, officers have to keep an eye on wind direction and speed. Extreme wind conditions will be very unsuitable for landing/winching of the helicopter.

2. Sky Condition: Estimate the condition of the sky. Clear or partial sky is favorable for operations.

3. Visibility: Clear visibility is best suited for the operations. Restricted visibility is unfavorable; in such cases extra care should be given.

4. Precipitation: Rain, fog, drizzle and snow conditions are not favorable for helicopter operations. More attention and care is needed when conducting operations in such conditions.

5. Sea State: The state of the sea should also be taken into account. Rough sea and heavy currents is found adverse for helicopter operations. In such cases, necessary allowance and counteracting actions should be taken to maintain a given steady course.

7.2 BERTHING OPERATION

Decent weather conditions play an important role for all critical marine based operations to be safely accomplished and port operations are considered no different. When heavy weather makes a fall at port, the operations have to be aborted indefinitely amounting to loss in time and money. So a constant vigilant check should be maintained by all involved parties for the weather forecasts and all communication recorded appropriately. Dry Cargo ships may have to stop the cargo operation batten down their hatches during rain adding to additional delays. Weather clauses are hence included in the contract note to protect all parties from paying up either demurrage or dispatch.

Before planning the mooring operation, master consider the weather condition by taking factors such as wind and current. The ship's master and responsible officer must have the details of current and future weather data before commencing the mooring operation.

8 CIRCULARS AND INCIDENT REPORTS

8.1 LOSS PREVENTION CIRCULAR NO. 13-08: MOORED VESSELS BREAKING OUT FROM THEIR BERTHS

8.1.1 Introduction - Instructions

GARD has investigated several P&I and H&M incidents involving moored vessels breaking out from their berths, following a recent increase in the frequency of such incidents. The consequences of these incidents range from personal injury, significant contact damage to the vessel including ranging and grounding damage, damage to adjacent vessels, shore/terminal structures to pollution damage to the environment. The majority of these incidents occurred during periods of adverse weather, with high winds acting on vessels with large windage areas.

Wind speeds recorded in the above incidents ranged from 63 km/h to 120 km/h (Beaufort force 7- 12), although in one case the actual wind speed was estimated to have been much higher due to the funneling effect of container stacks ashore. In many cases additional mooring lines were deployed in anticipation of high winds, ultimately to no avail.

In one case the vessel moorings were even supplemented by shore lines with load monitoring, however, the vessel still broke free due to excessive loads on the lines, seemingly as a result of abnormal tidal flow caused by restricted under keel clearance. Even tugs could not prevent her from ultimately grounding. In another case, the vessel did get tugs to hold her alongside the berth, only to stand them down prematurely. The second time the vessel came off the berth she grounded resulting in substantial bottom damage. Ports around the world have various berth layouts and mooring facilities and are exposed to different wind, tidal and swell conditions.

It is important that the Master takes into consideration the key critical aspects of any given port along with the vessel’s characteristics, in order to ensure that the vessel is adequately moored to withstand the anticipated mooring forces, even in normal conditions. It is equally important that the Master is ready to take extra precautions to keep the vessel alongside in adverse weather, tidal and swell conditions and is ready and able to vacate the berth safely when conditions make it difficult for moorings to cope.

8.2. RISK ASSESSMENTS

Whilst incidents of this nature may involve reports of defective mooring equipment or lack of attention to moorings, investigations suggest that in many incidents a proper risk assessment was not undertaken. It is recommended that appropriate risk assessments are carried out, taking into consideration the vessel's characteristics, type, size, trading pattern and the prevailing weather conditions. Factors to be taken into consideration include, but should not be limited to, the following examples of wind, tidal, swell and weather related factors

• Wind loads exerted onto a vessel's superstructure and hull above the waterline, which can form a large proportion of the total load on the mooring system depending on the moored vessel's location and characteristics.

• Wave loads on a vessel, which can vary depending on the vessel's response to waves of varying periods and heights. Of special concern are moorings in relatively shallow water depths, in low tide and high wave conditions. These conditions can lead to violent vessel behavior at the moorings (breaking waves, excessive motions, snatch loads etc.) and in extreme cases, loss of under-keel clearance in wave troughs for larger, deeper draft vessels

• Forces resulting from steady currents in combination with other loadings, especially at low water levels in breaking wave conditions, which can also exert substantial loads on a ship's mooring system.

• The effect of wind against tide or current and the effect of a change in tide direction on moorings.

• Tidal surges before, during and after storms, which may be well away from the area in which the vessel is berthed, causing unusually large tidal ranges and lower than expected water levels. Examples of port/berth related factors

• Characteristics and history of the port and berth and any unusual occurrences.

• Peculiar features of the berth such as overhanging berthing arrangements, obstruction by gantry cranes, wind funnelling effects from shore structures.

• Design/type, position, quality and adequacy of shore mooring equipment, including storm moorings and fenders, and of tugs.

• Exposure at the berth to wind, tide and swell conditions.

• Delay in the availability of shore mooring equipment, mooring gangs, pilots and tugs etc. in normal as well as emergency situations.

• Proximity of other vessels and hazards in the vicinity of the berth.

• Effect of passing vessels on vessels moored alongside.

• Availability of storm bollards, which may not be useable during cargo operations if moorings restrict working on the berth.

• Port/terminal procedures in the event of extreme conditions and their suitability. Examples of vessel related factors • Size/type of vessel, notably the windage area (including windage area due to cargo or containers if applicable) and the related effects of the same with changes in wind, tidal and swell conditions.

• Design/type and condition of mooring equipment, its limitations and weakness.

• Suitability of the mooring pattern - number of lines, lengths, angles and leads and the ability to maintain even tension on the lines.

• Manning level/crew availability for normal as well as adverse weather conditions.

• Weather forecast and warnings - reliability and frequency.

• Readiness of engines, thrusters, anchors and power on deck.

• Availability, condition and readiness of additional moorings.

For example, some winch brakes are designed to render under excessive load to avoid the dangers of parting lines. OCIMF recommends that the winch break be set at 60% MBL (Minimum Breaking Load) of the mooring line. If the winch starts to render then the design conditions are being exceeded.

It is recommend that the Master carries out a proper risk assessment for the different mooring conditions and loadings to suit their specific vessel characteristics and mooring location in normal as well as adverse weather conditions. The Master is encouraged to be proactive in requesting information from the port, pilots and agents and in establishing how warnings will be broadcast by the port. However, he should not rely wholly on information from other parties. In the event that deteriorating conditions are forecast, the Master should make timely decisions to ensure that the vessel is brought to a state of immediate readiness. Amongst other things the Master will want to ensure that, before conditions become extreme, the vessel is fully manned, is appropriately ballasted for heavy weather (with due regard to under keel clearance at the berth and in the port), has engines ready, and is in close contact with the terminal and port authorities in relation to timing and availability for stoppage of cargo operations, deployment of additional (storm) moorings, and for tugs, pilots etc. Most importantly, the Master will need to decide whether to remain alongside or depart from the berth to sea or a safe anchorage. It is worth bearing in mind that additional precautions such as extra mooring lines may not prevent a ship from breaking free from her moorings. Last, but by no means least, it is also worth remembering that mooring stations can be very dangerous places in bad conditions, hence another good reason not to delay departure from the berth until it is dangerously late.

8.3 REAL LIFE INCIDENTS

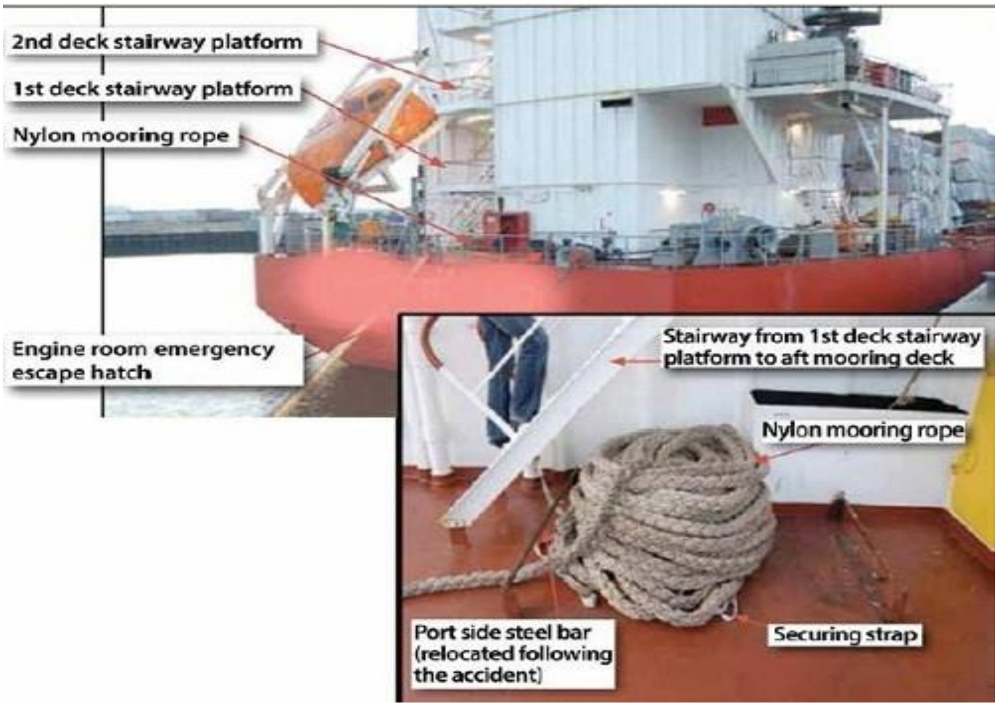
8.3.1 Incident Report: Crew washed overboard and not recovered

An accident on board a ship during rough weather threw the crew overboard while they were attempting to secure the nylon mooring lines at the aft deck. Despite the best efforts of the vessel and search and rescue (SAR) services, the two men could not be recovered.

As the vessel encountered force 9 winds with a 6 meter head sea, it was discovered that nylon mooring lines on the aft deck were becoming unsecured. These lines represented a danger to the ship if they were to be washed overboard since nylon lines will sink and could entangle the propeller.

The plan was for two crew members to access the aft deck, each wearing a lifejacket and a safety harness. One end of a fire-fighter's lifeline was attached to the safety harness securing ring and the other secured to a handrail on the external stairway platforms (Picture 7.1). It was intended that any slack in the lifelines would be manually taken up by other crew positioned on these stairway platforms.

As the two crew members began their work on the aft mooring deck a large wave was shipped, the force of which washed them overboard and caused the safety crew to release their grip on the lifelines. As they were washed away, their lifelines parted.



Picture 7.1 Arrangement

The same wave crossed the first deck stairway platform, forcing one crew member to the deck and causing another's lifejacket to inflate. Despite the best efforts of the vessel and search and rescue (SAR) services, the two men could not be recovered.

Lessons been learned:

1. No heavy weather checklist was available and none was required to be completed as part of the vessel's safety management system.

2. Previous occurrences of the aft mooring ropes coming loose had not been formally recorded, possibly because there had been no adverse consequences.

3. The loose nylon mooring rope presented a significant risk of it fouling the vessel's propeller owing to its inherent tendency to sink.

4. The need for a designated enclosed means for stowing the coiled aft mooring ropes had not been recognized.

5. The vessel's safety management system contained no detailed requirements with regard to sending crew on deck in heavy weather.

6. The crew possibly underestimated the potential wave height that could have been expected in the prevailing weather conditions.

7. No designated lifelines were provided on board for use in sending crew on deck in heavy weather.

8. The crew overestimated the strength of the fire-fighter's lifelines and their ability to manually control their loading in the prevailing conditions.

9. The strength of the fire-fighter's lifelines was insufficient to withstand the loading exerted on them by the large wave that washed the crew members overboard.

10. Although both men had been wearing lifejackets that had inflated, neither was able to survive their exposure to the heavy weather conditions.

8.3.2 Ship's O.S. loses life while rigging pilot ladder

The deck crew was preparing the starboard pilot boarding ladder in combination with the accommodation ladder due to the freeboard of 10.2 meters.

Strong winds were blowing so the deck crew put their safety helmets away. They started to pay out and secure the pilot ladder to a height of one and a half meters above the water. After the pilot ladder was secured the crew lowered the accommodation ladder to about five meters below the main deck.

An experienced ordinary seaman (OS) then went down the accommodation ladder in order to set the railings and the lower platform. He was wearing an inflatable life jacket (manual release) and had secured himself on a lifeline with safety harness. The pilot embarkation station was properly illuminated.

At one point, the crew on deck realized something was wrong; they then saw the victim lying in the water still attached to the lifeline and obviously unconscious. The bridge was informed and a life buoy with safety line was thrown into the water. First attempts to pull the OS out of the water were unsuccessful due to the headway of the vessel and the soaked winter clothes of the victim. Only after more crew arrived on scene was it possible to pull him out of the water a few meters and, after about 10 minutes, the victim was retrieved on board. Despite immediate artificial respiration and heart massage the victim passed away.

Lessons been learned :

1. The length of the lifeline was about 9.75 meters. During the accident the platform was only about five meters below the main deck; this allowed a free fall of more than four meters.

2. None of the deck crew assisting had seen the OS fall as they were attending to other duties. Best practices require constant surveillance of a person working over the side on a vessel underway.

3. The victim sustained head injuries and became unconscious after the fall, which hindered his rescue and survival. A helmet with chin strap could have prevented the head injuries.

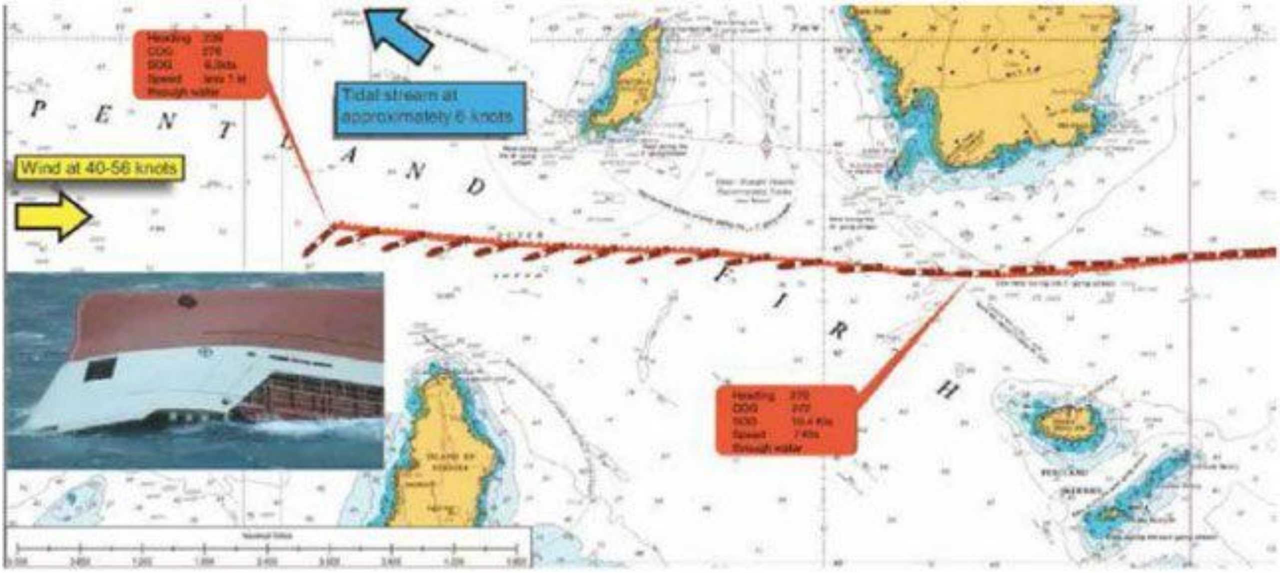
4. The heavy weather conditions and the fact that the combination ladder was on the windward side of the vessel increased risk for this operation. Yet, the company permit to work on deck in heavy weather states that the operation should be aborted if crew are at risk.

5. Course and speed alterations may have been possible to mitigate the weather influences at the ship’s starboard side.

8.3.3 Cement carrier capsizes and loses all crew

A small cement carrier with a crew of eight was loaded with cement and underway across the North Sea on a passage plan that brought the vessel through the Pentland Firth. Having spent 24 hours heading into deteriorating weather and increasingly heavy seas, the Master first reported that there would be a two-hour delay to the arrival time at Liverpool bar buoy. The next day, in consequence of increasingly bad weather, his report stated that there would be a further 10 hours delay to the arrival time.

As the vessel entered Pentland Firth (figure below), it was on a heading of 270° (COG of 272°) and SOG of 10.6kt. Once inside the Pentland Firth, the vessel was sighted by the crew of a nearby ferry. The cement carrier appeared to be upright and making slow headway, pitching heavily into the large waves. Later that afternoon the vessel's AIS transmissions ceased. The data from the last received transmission showed a heading of 239°, a COG of 276° and SOG of 6.3kt. Such a SOG, however, would have meant a speed through the water of less than one knot, rendering the vessel unmanageable and at the mercy of the ferocious oncoming waves (Picture 7.2).



Picture 7.2 Course illustration

The hull of the capsized cement carrier was spotted and reported to the local coastguard 25 hours later. The damaged vessel soon sank. Search and rescue (SAR) activities were undertaken, but no surviving crew members were found.

The official accident report found, among other things, that:

• On one past occasion when the vessel entered the Firth with an opposing flood tide, the same Master held position by stemming the stream, and waited for it to ease. From this it can be deduced that the Master understood the tidal risks and actions were normally taken to abort or avoid the unfavorable tidal conditions in the Firth.

• On another occasion of rough weather in Pentland Firth, during the alteration of course across the sea, the vessel had heeled excessively and suffered a cargo shift, resulting in a significant list to port. The vessel was brought back upright using the ballast tanks. The Master's decision to proceed into the Firth on this (final) occasion, with very unfavorable conditions, was inconsistent with his previous actions.

• The extraordinarily violent sea conditions were created by gale force winds opposing a strong ebb tidal stream. Such conditions were predictable and passage through the Pentland Firth should not have been attempted.

• The cement carrier was loaded to its draught marks, but the density of its bulk cargo was not properly considered. As a result it is likely that its stability did not meet the minimum criteria set by the IMO. Potential reductions in its righting levers would have made the cement carrier more vulnerable to capsize in a heeling situation.

Lessons been learned:

1. Always adopt a conservative approach to weather – your life depends on it.

2. Never bring your vessel to a point where maneuverability is lost.

BIBLIOGRAPHY

Frampton, R. (2015). *Meteorology for seafarers,* 4th edition *:* Brown, Son and Ferguson Ltd

Brown, R.B.P(2016). *Brown's Nautical Almanac, 139th edition :* Brown, Son and Ferguson Ltd

Brown, R.B.P(2017). *Brown's Nautical Almanac, 140th edition :* Brown, Son and Ferguson Ltd

William, E. G.(2010). *Stability and trim for the ship's officer, 4th edition :* Shiffer Publishing Ltd

IMO (2015). *GMDSS Manual, 8th edition :* Polestar Wheatons Ltd

IMO (2004), *COLREG- Collision on the International Regulations for Preventing Collisions at Sea, 1972, Consolidated edition :* IMO

Καραπιπέρης Λ.Ν. (2006),*Ναυτική Μετεωρολογία*, Ίδρυμα Ευγενίδου, Βιβλιοθήκη του Ναυτικού

NEDA Maritime Agency Co Ltd, QMS Documents

NEDA Maritime Agency Co Ltd, Seminar about Typhoons

NEDA Maritime Agency Co Ltd, Emergency Plan – Emergency Cases, Heavy Weather Damage

NEDA Maritime Agency Co Ltd, Bridge and Deck Handbook , Bridge – 17, *Navigation in Heavy Weather- Storm*

NEDA Maritime Agency Co Ltd, ECR Handbook, ECR – 09 , *Heavy Weather – Storm*

Marine Insight- The Maritime Industry Guide , www.marineinsight.com

www.wikipedia.com