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MANMAR

Manual of Marine Weather Observations

**Eighth Edition
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Canada 

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Foreword

The *Manual of Marine Weather Observations* (MANMAR) prescribes the legacy information on the procedures, equipment and coding formats used in the observation of marine weather phenomenon and the preparation of marine weather reports. MANMAR is the standard for the legacy manually observed Voluntary Observing Ship (VOS) program. The VOS program has been discontinued within Canada. The Meteorological Service of Canada (MSC) currently supports the Automated Voluntary Observing Ship program (AVOS) and will support visiting VOS ships from other jurisdictions on a *best efforts* basis. Contact your regional Port Meteorological Officer (PMO) for further information (see Appendix B).

MANMAR is currently used within MSC as a reference for the SHIP data format and historical VOS program observing procedures.

Important note: MANMAR is made publicly available for users of marine weather services for informational purposes only. MSC no longer supports the legacy MANMAR equipment and instrumentation described in this manual (including Sea Surface Temperature equipment, Screens, Barographs). MSC does not provide, repair, replace, or calibrate any of the legacy equipment referenced in MANMAR.

Amendments to MANMAR will be issued when warranted. All holders of the manual are responsible for keeping their copies current. When amendments have been entered, they are recorded on the page headed *Record of Amendments*.

Inquiries on the content of this manual should be directed to the Meteorological Service of Canada through appropriate channels.

Editor's Note: A new edition of MANMAR was published mainly due to the substantial formatting, stylistic and structural changes required to remediate this manual for clarity and accessibility.

The following typographical and stylistic conventions are used throughout this manual:

- Code forms, symbolic letters and code figures, as well as example form entries, have been printed in 14 point dark blue Courier New font.
- Notes have been printed in aqua shaded boxes, preceded by the bolded indication "Note."
- Blank table cells have been marked with an *en dash* "—" to indicate to assistive technology users that these cells may be ignored.

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Record of Amendments

Number	Effective date	Entered by	Date of entry

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Record of Revisions

Revisions applied by amendment to MANMAR Eighth Edition listed by section with description of changes.

Note: Change bars are used to identify new and revised content in affected sections.

Section	Revision description

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Chapter 1 General information

1.1 Introduction

All mariners should be aware of the great necessity of weather observations at sea in preparing the weather forecasts and other bulletins that are used by the mariner themselves. Weather reports from any area, at any time, form the raw material from which weather bulletins are made. A lack of reports from any area would mean greatly curtailed weather service to mariners and indeed to many other interests as well. While it is true that weather satellites are now furnishing data on a global basis, a large volume of data on cloud patterns and structure, and that their remote sensing capabilities are increasing all the time, they still do not give us a complete weather picture. They do not, for example, provide information on visibility, weather (rain, snow, fog, etc.), pressure, air temperature, dew point, etc..

Government Services therefore depend almost exclusively on merchant and other ships to provide detailed weather information over water areas of the world.

Chapter V, Regulation 5 of the *International Convention for the Safety of Life at Sea* (SOLAS) states that contracting governments undertake to warn ships of gales and tropical storms; to issue daily weather bulletins by radio, containing data of existing weather conditions, forecasts and information to enable simple weather charts to be prepared at sea; to arrange for the reception and transmission by coastal radio stations of weather messages to and from ships; to arrange for certain ships to be equipped with tested meteorological instruments (such as a barometer, a barograph, a psychrometer, and suitable apparatus for measuring sea temperature), and to take meteorological observations at standard synoptic hours, and to encourage other ships to take observations in a modified form, particularly in areas where shipping is sparse. See Appendix A for excerpts from SOLAS, Chapter V.

1.2 Organization of the Canadian weather observing fleet

By tradition, weather observing on shipboard has always been voluntary on the part of the ship's officers. The legacy manually observed Voluntary Observing Ship program (VOS) has been discontinued within Canada, however visiting VOS ships from other jurisdictions are supported on a *best efforts* basis. Although no remuneration is paid, most mariners who participate in the VOS program realize that if the ships at sea did not make reports, no weather bulletins would be available to them by radio.

In the past, vessels under the supervision of Environment and Climate Change Canada (ECCC) who had been recruited for manually observing the marine weather were divided into two classes — Selected Ships and Auxiliary Ships.

1.2.1 Selected ships

Selected Ships are those which were issued with a complete set of tested meteorological instruments and report all aspects of weather conditions. The instruments were supplied to the ship on a loan basis, usually consisting of the following:

- A precision aneroid barometer
- A marine barograph
- A marine screen with wet and dry thermometres, or a sling psychrometer
- A sea temperature bucket with thermometres.

1.2.2 Auxiliary ships

Auxiliary ships may or may not be issued with certified meteorological instruments, depending on their operating route and length of service, and report only basic weather elements.

1.3 Code used for recording and transmission of sea station weather messages

In order to reduce transmission time and costs, weather reports are coded in the World Meteorological Organization (WMO) *FM 13–XIV Ext. SHIP, Report of surface observation from a sea station*. This code is made up of several code groups each consisting of five code figures. The position of numbers in a given group determines the element of weather which these numbers represent. The symbolic form of the code is specified in sections 1.3.1 and 1.3.2.

1.3.1 Code groups reported by selected ships

Selected ships shall transmit the following groups:

$M_i M_i M_j M_j$ $D \dots D$ $YYGGi_w$ $99L_a L_a L_a$ $Q_c L_o L_o L_o L_o$ $i_R i_x h V V$ $N d d f f$
 $[00 f f f]$ $1s_n T T T$ $2s_n T_d T_d T_d$ $4 P P P P$ $5 a p p p$ $7 w w W_1 W_2$ $8 N_h C_L C_M C_H$
 $222 D_s v_s$ $0 s_s T_w T_w T_w$ $2 P_w P_w H_w H_w$ $[3 d_{w1} d_{w1} d_{w2} d_{w2}]$ $[4 P_{w1} P_{w1} H_{w1} H_{w1}]$
 $[5 P_{w2} P_{w2} H_{w2} H_{w2}]$ $[6 I_s E_s E_s R_s]$ $[8 s_w T_b T_b T_b]$ $[ICE \ c_i S_i b_i D_i z_i]$

Note: Code groups in square brackets [] are reported only if available.

1.3.2 Code groups reported by auxiliary ships

Auxiliary ships shall transmit the following groups:

$M_i M_i M_j M_j$ $D \dots D$ $YYGGi_w$ $99L_a L_a L_a$ $Q_c L_o L_o L_o L_o$ $i_R i_x h V V$ $N d d f f$
 $[00 f f f]$ $1s_n T T T$ $4 P P P P$ $7 w w W_1 W_2$ $[222 D_s v_s]$ $[2 P_w P_w H_w H_w]$
 $[3 d_{w1} d_{w1} d_{w2} d_{w2}]$ $[4 P_{w1} P_{w1} H_{w1} H_{w1}]$ $[5 P_{w2} P_{w2} H_{w2} H_{w2}]$ $[6 I_s E_s E_s R_s]$ $[ICE \ c_i S_i b_i D_i z_i]$

Note: Code groups in square brackets [] are reported only if available.

1.4 Interpretation of the symbols in the FM 13–XIV Ship code

Table 1—1: Symbols and interpretation for the FM 13–XIV ship code

Symbol	Interpretation
$M_i M_i M_j M_j$	Identifier for a ship report (BBXX)
D D	Ship's radio call sign
YYGGi_w	
YY	Day of the month (UTC)
GG	Hour of observation (UTC)
i _w	Indicator for units of wind speed, and whether measured or estimated. In Canada always coded as "4".
99L_aL_aL_a	
99	Numerical indicator for report of ship's position
L _a L _a L _a	Latitude in degrees and tenths of a degree
Q_cL_oL_oL_oL_o	
Q _c	Quadrant of globe
L _o L _o L _o L _o	Longitude in degrees and tenths of a degree, hundreds included
i_Ri_xhVV	
i _R	Indicator for inclusion or omission of precipitation data (group 6RRRt _R)
i _x	Indicator for the type of station operation and for present and past weather data (group 7wwW ₁ W ₂)
h	Height, above sea, of the base of the lowest cloud
VV	Horizontal visibility
Nddff	
N	Fraction of the celestial dome covered by cloud (in oktas of sky covered)
dd	True direction, in tens of degrees, from which the wind is blowing
ff	Wind speed in knots (kt)

Symbol	Interpretation
00fff	
00	Numerical indicator for supplementary wind speed group
fff	Wind speed in knots, when speed equals or exceeds 99 kt
1s_nTTT	
1	Numerical indicator for air temperature group
s _n	Sign of air temperature group
TTT	Air temperature in degrees and tenths of a degree Celsius
2s_nT_dT_dT_d	
2	Numerical indicator for dew point temperature group
s _n	Sign of dew point temperature
T _d T _d T _d	Dew point temperature in degrees and tenths of a degree Celsius
4PPPP	
4	Numerical indicator for mean sea level pressure group
PPPP	Mean sea level pressure in hectopascals and tenths of a hectopascal
5appp	
5	Numerical indicator for pressure tendency group
a	Characteristics of the pressure tendency during the three hours preceding the time of observation
ppp	Amount of pressure tendency during the three hours preceding the time of observation, in tenths of a hectopascal
7_{ww}W₁W₂	
7	Numerical indicator for weather group
_{ww}	Present weather
W ₁	Past weather (primary type)
W ₂	Past weather (secondary type)

Symbol	Interpretation
8N_hC_LC_MC_H	
8	Numerical indicator for cloud group
N _h	Total amount of all C _L clouds or, if no C _L clouds, total amount of all C _M clouds
C _L	Clouds of stratocumulus, stratus, cumulus and cumulonimbus types
C _M	Clouds of altocumulus, altostratus, and nimbostratus types
C _H	Clouds of cirrus, cirrocumulus, and cirrostratus types
222D_sv_s	
222	Numerical indicator for ship's course and speed group
D _s	Ship's course (true) made good during the three hours preceding the time of observation
v _s	Ship's average speed made good during the three hours preceding the time of observation
0sT_wT_wT_w	
0	Numerical indicator for sea temperature group
s _s	Sign of sea surface temperature
T _w T _w T _w	Sea-surface temperature in degrees and tenths of a degree Celsius
1P_{wa}P_{wa}H_{wa}H_{wa}	
1	Numerical indicator for instrumental wave data group
P _{wa} P _{wa}	Period in seconds, of sea waves, obtained by instrumental methods
H _{wa} H _{wa}	Height of sea waves, in units of 0.5 m, obtained by instrumental methods
2P_wP_wH_wH_w	
2	Numerical indicator for wind wave group
P _w P _w	Period in seconds, of sea waves (non-instrumental)
H _w H _w	Height of sea waves (non-instrumental)
3d_{w1}d_{w1}d_{w2}d_{w2}	
3	Numerical indicator for the swell direction group
d _{w1} d _{w1}	True direction, in tens of degree, from which the predominant swell waves (first system) are coming
d _{w2} d _{w2}	True direction, in tens of degree, from which secondary swell waves (second system) are coming

Symbol	Interpretation
4P_{w1}P_{w1}H_{w1}H_{w1}	
4	Numerical indicator for predominant swell group
P _{w1} P _{w1}	Period, in seconds, of predominant swell waves (first system)
H _{w1} H _{w1}	Height of predominant swell waves (first system)
5P_{w2}P_{w2}H_{w2}H_{w2}	
5	Numerical indicator for secondary swell group
P _{w2} P _{w2}	Period, in seconds, of secondary swell waves (second system)
H _{w2} H _{w2}	Height of secondary swell waves (second system)
6I_sE_sE_sR_s	
6	Numerical indicator for ice accretion group
I _s	Type of ice accretion on ships
E _s E _s	Thickness of ice accretion on ships in centimetres
R _s	Rate of ice accretion on ships
70H_{wa}H_{wa}H_{wa}	
70	Numerical indicator for instrumental wave height group
H _{wa} H _{wa} H _{wa}	Height of waves, in units of 0.1 m, obtained by instrumental methods
8s_wT_bT_bT_b	
8	Numerical indicator for wet-bulb temperature group
s _w	Indicator for the sign and type of measurement of sea surface temperature
T _b T _b T _b	Wet-bulb temperature in degrees and tenths of a degree Celsius
ICE + c_iS_ib_iD_iz_i	
ICE	Code word indicator for the ice group
c _i	Concentration or arrangement of sea ice
S _i	Stage of development of sea ice
b _i	Ice of land origin
D _i	Bearing of principal ice edge
z _i	Present ice situation and trend of conditions over preceding three hours

1.5 Making a record of the observations

All meteorological observations made at sea are recorded permanently in special logbooks for future use. Entries should be made in the logbooks neatly and legibly, preferably in black ball point pen. If it is desired to retain a copy of the weather records permanently on board the ship, observers may enter their observations first in a *Rough Copy* for retention and then copy the records into a *Fair Copy* which is returned to Environment Canada Headquarters. Instructions for making the individual entries will be found in the following chapters as each element of the weather observation is discussed. Meteorological observations made at sea may also be recorded in a digital ship log which may be burned to a compact disc or emailed directly to the PMO.

Please be sure to fill in the information on the ship's officers in the spaces provided on the inside of the front cover of the log book.

The Principal Observing Officer is the officer who has agreed to be responsible for the overall conduct of the ship's weather program. They ensure that the observations are taken, transmitted, and recorded in the log, and are responsible for the care and maintenance of meteorological instruments loaned to the ship. Normally they are unable to carry out all aspects of the program alone, but have the assistance of other ship's officers.

Other Observing Officers are other ship's officers who took any active part in the weather program by taking observations when the Principal Observing Officer was unable to do so. Under Radio Officer(s) enter the names of the Radio Officers who were responsible for transmitting the weather messages to coastal receiving stations.

When the ship's meteorological log is filled it should be signed by the Principal Observing Officer and the Captain in the space provided near the back of the log.

1.6 Return of logbooks

When the meteorological log is filled, it should be held on board until collected by the Canadian Port Meteorological Officer. However if the ship will not be calling at a Canadian port for some considerable time it should be mailed to the Port Meteorological Officer (see Appendix B) or to Meteorological Service of Canada Headquarters (4905 Dufferin Street, Toronto, ON M3H 5T4). In any event, the logbook should be returned by mail when the last observation for the calendar year has been entered in it. A new log should be started at the beginning of each year.

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Chapter 2 Observational routines

2.1 Introduction

Chapter 2 provides suggestions as to how the observer may complete their observation as quickly and efficiently as possible so that there will be a minimum of interference with other ships duties. For example, should the elements be observed in the order in which they occur in the coded report, or is some other order to be preferred? The experienced observer will have worked out a routine that suits them best, but the observer to whom weather observing is a new venture may well wonder where to start. There is no set order in which the various elements must be observed, except that the reading of the barometer should be the last observation made, and the reading made as close as practicable to the standard synoptic hour.

An experienced observer on a selected ship can usually complete their observation in 15 min or less. However a beginner should allow at least 30 min for the observation until they develop skill; this will not take long. Hence the observation should be started from 15–30 min before each main synoptic hour, that is not later than 2345, 0545, 1145, and 1745 UTC. The information for several of the elements is recorded regularly in the ship's log by the officer on watch as part of their regular duties. This probably includes wind speed and direction, visibility, waves, and ships position, course and speed. When the time for the observation arrives, it is only a matter of extracting this information from the log or revising it slightly if it is not precisely up to date.

The elements that make up a weather observation may be divided naturally into two divisions — those which may be made indoors in the chart room, and those for which it is necessary to go outdoors. Chapters 3–13 provide detailed instructions on observing, coding, and recording various weather elements.

2.2 When observations should be made

Weather observations at sea should be made four times a day as close as practicable to the standard synoptic hours of 0000, 0600, 1200, 1800 UTC. As the observations require some time to complete, they should be commenced a few minutes before these standard hours. The length of time required to make the observation will depend on the experience of the observer, but it should be arranged that all work is completed as close to the standard hour as possible.

In addition to the four daily observations taken at the standard synoptic hours, ships navigating within Canada and within the 200 SM zone of Canadian and US coastlines are requested to take supplementary observations at the intermediate synoptic hours of 0300, 0900, 1500, and 2100 UTC.

2.2.1 Procedure on single-operator ships

On ships carrying only one radio officer, it may happen that the officer's watch keeping period ends at or slightly before a standard synoptic hour. In such a case to ensure transmission of a message to a coastal station before the radio officer goes off duty, the observing officer should arrange to have their observation completed earlier than usual but not earlier than one hour before a standard synoptic time. The element of the observation denoting the time (*GG*) should be altered accordingly. E.g., if the observation is completed at 0508 UTC, then *GG* should refer to 0500 UTC, i.e., *GG* = 05. It is emphasized however, that this procedure should be adopted only in the particular circumstances described, and that the adherence to the standard synoptic hours is most desirable.

When it is impracticable to follow the procedures above (e.g. the radio officer has gone off duty earlier than one hour before the standard synoptic time) an observation should be taken and transmitted at one of the intermediate synoptic hours of 0300, 0900, 1500, or 2100 UTC. For example, if the radio officer is scheduled to complete their watch at 2200 UTC, then the observation should be taken and the message transmitted at 2100 UTC.

When an observation is taken at 0300, 0900, 1500, or 2100 UTC, it is desirable that an observation be taken at the next main standard synoptic time, i.e., 0600, 1200, 1800, or 0000 UTC, in order to ensure its transmission to a coastal station for climatological purposes.

Observations made at any of the standard times 0000, 0600, 1200, or 1800 UTC can be transmitted up to four hours after the time of observation if this arrangement will fit in with the radio officer's watch hours. An observation received four hours late is much better than receiving no weather message at all. In the southern hemisphere, in the North Atlantic, and in areas where few reports are received from ships, an observation message may be transmitted as much as 12 h after the time of observation.

2.2.2 Non-routine reports

Ships observing officers are encouraged to send **SPREP** and **STORM** reports even if the above conditions were forecast. These reports will aid marine forecasters in verifying their forecasts.

2.2.2.1 Special weather report — **SPREP**

It is important that observed, significant changes in weather conditions be entered into the forecast system as soon as possible. Significant weather developments frequently occur between the standard times of observation, therefore it is important to identify those changes and relay special weather reports to the forecast office without delay. A special weather report is identified by the code word **SPREP**. The observation and message format is the same as for a standard observation, except the word **SPREP** and one space will immediately precede the ship's call sign to assure the immediate attention of the forecaster.

Example: **SPREP** D....D YYGGi_w

A special weather report (**SPREP**) should be sent whenever one or more of the following criteria are met:

Wind

- Mean wind speed doubles to 25 kt or more since the previous main or intermediate synoptic hour.
- Mean wind speed increases to 34 kt (gale force) or more and gale warnings are not in effect.

Visibility

- Prevailing visibility decreases to 0.5 SM or less from 2 SM or more.

Waves

- Combined seas (wind, waves, and swell) become hazardous or increase to 2–3 m (7–10 ft) or more in excess of those forecast.

Ice

- Ice forms on the ship's superstructure.

2.2.2.1.1 Ships on the Great Lakes

A special weather report (**SPREP**) should be sent whenever one or more of the following criteria are met:

Wind

The wind with a mean speed of 25 kt or more:

- Increases in mean speed by 10 kt, or more, and is sustained for at least 10 min; or,
- changes direction by 90°, or more, and this change is sustained for at least 10 min.

Visibility

- Prevailing visibility decreases to ½ NM or less.

Waves

- Wave height increases by 1.5 m (5 ft) from the height observed at the previous main synoptic hour.

Ice

- Ice forms on the ship superstructure.

Weather

- A funnel cloud (water spout or tornado) is sighted
- Other hazardous weather conditions are encountered but are not mentioned in the latest forecast (MAFOR)

2.2.2.2 Storm report — **STORM**

When storm (wind) conditions are encountered at sea, whether forecast or not, a **STORM** report should be issued. The observation and the message format is the same as for a standard observation, except the word **STORM** and one space will immediately precede the ship's call sign. A **STORM** report should be sent hourly if the storm has not been forecast, or at least every three hours if experiencing storm conditions which have been forecast.

A storm report (**STORM**) should be sent whenever the mean wind speed increases to 48 kt or more.

Example: **STORM** D....D YYGGiw

2.3 Where should observations be made

Weather observations should be made anywhere on the oceans and seas of the world, even when within sight of a coast, providing navigational duties will permit. Ships destined for or departing from inland ports in Canada, such as Quebec or Montreal, should if possible continue to make observations in the Gulf of St. Lawrence and St. Lawrence River. Ships should also make observations while on inland lakes and rivers.

In the less frequently traveled ocean areas of the world meteorological reports from ships are necessarily much scarcer than in such well-traveled areas as the North Atlantic sea lanes. Vast expanses of the eastern half of the South Pacific are rarely traversed by ships of any kind, consequently observations from this region are almost non-existent. If your ship is operating in one of these “sparse” areas your cooperation in making all possible reports will be greatly appreciated by the meteorological services which receive your reports. In general these sparse areas consist of the South Pacific, the South Atlantic, the Indian Ocean, the North Atlantic north of 60°, and from the equator to 30° N, between 20° W to 60° W. The North Pacific Ocean south of 30° N is also quite sparsely covered. A map displaying these sparse areas is published by the World Meteorological Organization; this map may be obtained from any Port Meteorological Office (see Appendix B). It is also possible to lookup the latest data sparse areas by visiting the JCOMMOPS (Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology, Observing Programmes Support Centre) online maps — <http://www.icommops.org>.

2.3.1 Indoor observations

Elements that can be observed or determined indoors are:

- YY — day of the month
- GG — time
- i_w, i_r, i_x — indicators
- $L_a L_a L_a$ — latitude
- Q_c — quadrant of the Globe
- $L_o L_o L_o L_o$ — longitude
- $T_d T_d T_d$ — dew point
- PPPP — sea level pressure
- a and ppp — pressure tendency and amount
- D_s and v_s — ship’s course and speed
- I_s and R_s — cause and rate of ice accretion

2.3.2 Outdoor observations

It will be necessary to go outdoors for the following elements taking into consideration the safety of the observer during dangerous weather conditions:

- N — total cloud amount
- dd and ff — wind speed and direction (when estimated)
- VV — visibility
- ww — present weather
- W_1 and W_2 — past weather
- TTT — air temperature, also wet bulb temperature, from which $T_d T_d T_d$ is determined
- h and $N_h C_L C_M C_H$ — cloud data
- $T_w T_w T_w$ — sea surface temperature
- $P_w P_w, P_{w2} P_{w2}, P_{wa} P_{wa}, H_w H_w, H_{w2} H_{w2}, H_{wa} H_{wa}, d_{w1} d_{w1}, d_{w2} d_{w2}$ — wave data
- $E_s E_s$ — thickness of ice accretion
- c_i, S_i, b_i, D_i, z_i — ice data

2.4 Suggested routine for selected ships

If a sling psychrometer is being used, saturate the muslin sleeve of the wet bulb thermometer with fresh water. Then take the sling psychrometer, sea temperature bucket and a pad and pencil (also a flashlight at night) and go out on the bridge. If you have assigned another crew member to take the sea temperature from a lower deck, call them first and have them telephone the reading back to you later. Make sure they know how to read the thermometer to the desired degree of accuracy.

While whirling the psychrometer estimate the direction and force of the wind; the visibility in miles or yards; cloud amounts; cloud types, and wet bulb thermometers. Check on which code figure will be used for present weather.

Go back into the chart room and code the information you have just written down in rough, directly into the meteorological log. From this you can dispose of the elements h, VV, N, dd, ff, TTT , the wet bulb temperature (not coded), $T_d T_d T_d, ww, N_h C_L C_M C_H, T_w T_w T_w$, and the wave groups.

The remaining elements can be determined indoors. On the basis of the weather during the previous six hours code W_1 and W_2 (past weather). Code the identification information in groups 1, 2, 3, and 4 and the ships course and speed. Observe the characteristic and the amount of pressure tendency from the barograph and code a and ppp . Finally read the barometer, apply the scale correction and the sea level correction, and code $PPPP$.

Check to see that the weather has not changed since you were outdoors. If precipitation has begun or ended, or fog has cleared or set in during the interval, change the values of ww and VV accordingly.

The observation is now complete and may be copied onto Form 63–9400, ships Radiogram Form, and handed to the radio officer for transmission.

2.5 Routine for auxiliary ships

The outdoor observations for auxiliary ships consist only of the total cloud amount, wind speed and direction (when estimated), air temperature, and ice accretion and sea ice (when observed). The remaining elements, identification information, visibility, present and past weather, and sea level pressure, can be determined from the chart room.

Taking a weather observation is not difficult, and with only a small amount of experience can be completed in a few minutes. Watching the weather is an essential part of the ship's officer's normal duties at all times, and they will be well aware of how many elements should be coded without making extra efforts, by the time the actual observation is made.

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Chapter 3 Identification information

3.1 Recording identification information

3.1.1 Group $M_i M_i M_j M_j$

This group identifies what type of message is being transmitted $M_i M_i M_j M_j$ is always coded **BBXX**, which identifies that the message is a **SHIP** weather report.

3.1.2 **SPREP** or **STORM** indicator

The word **SPREP** will be used to indicate that a special weather report is being used. The word **STORM** is used to indicate that a storm report is being filed.

3.1.3 Group **D D**

The ships radio call sign group identifies the source of the weather report, which enables forecasters ashore to follow the progress of a particular ship, and the weather it is experiencing during the course of a voyage.

Enter the ships radio call sign (or alternative) in the **D D** column of the logbook. The ships radio call sign is included in the weather message to identify the particular ship from which the message originated.

Note (1): If it is desired not to reveal the radio call sign, the code word **SHIP** may be used as a substitute.

Note (2): In the case of observations from a drilling rig at sea, the radio call sign shall be replaced by the word **RIGG**.

Note (3): In the case of observations from an oil or gas producing platform at sea, the radio call-sign shall be replaced by the code word **PLAT**.

3.1.4 Group **YYGGi_w**

3.1.4.1 **YY** — Date of the month

The symbol **YY** indicates the date of the month on which the observation is made.

Note (1): Both the month and the date are reckoned according to Coordinated Universal Time (UTC) and not to the local time on the ship. For example, the UTC time of an observation made on August 7 at 2000 local time in longitude 150° W would be August 8, 0600 UTC. Hence the date recorded is August 8, i.e. **YY = 08**.

Note (2): The date associated with the 0000 UTC observation is that for the day coming up, not for the day that just ended.

3.1.4.2 GG — Actual time

The symbol GG indicates the actual time of the observation to the nearest synoptic hour UTC. As the whole observation takes some time to complete, the actual time at which the barometer was read should be used as the basis for determining GG. Normally the observation should be completed and the barometer read before and as close as possible to the standard synoptic hours of 0000, 0600, 1200, 1800 UTC. Hence GG will normally be coded as 00, 06, 12, 18.

Example (1): If the barometer reading (the last element of the observation to be observed) is made at 2235 UTC then code GG as 00.

Example (2): Ships are sometimes requested to make observations intermediately between the standard hours. If for such an observation the barometer was read at 1448 UTC then code GG as 15.

3.1.4.3 i_w — Source and units of wind speed

The symbol i_w indicates whether the wind speed is estimated (usually from the appearance of the sea surface) or is measured by means of an anemometer, and whether the wind speed as reported in the message is in units of metres per second, or knots. Table 3—1 specifies code figures used for indicating the source and units of wind speed. In most instances only code figure 3 or 4 will be used.

Table 3—1: WMO code table 1855 — Specification of code figure i_w

Code Figure	Specification
0	Wind speed estimated (metres per second)
1	Wind speed obtained from anemometer (metres per second)
3	Wind speed estimated (knots)
4	Wind speed obtained from anemometer (knots)

3.1.5 Group 99 $L_a L_a L_a$

3.1.5.1 99 — Numerical indicator figure

Weather messages originating from all ships always contain the figures 99 to indicate the data on the ships position follows.

3.1.5.2 $L_a L_a L_a$ — Latitude of the ship

The symbol $L_a L_a L_a$ indicates the latitude of the ship (north or south) at the time of observation expressed in degrees and tenths of a degree. Latitude is usually expressed in degrees and minutes. To convert minutes of latitude to tenths of a degree, divide the number of minutes by six, disregarding the remainder.

Example: Suppose the latitude is 24° 44' (north or south) $44' = 44/6$ or 7 tenths of a degree. Therefore $24^\circ 44' = 24.7$ and $L_a L_a L_a$ is coded as 247.

3.1.6 Group $Q_c L_o L_o L_o$

3.1.6.1 Q_c — Quadrant of the Globe

The symbol Q_c indicates the quadrant of the globe in which the observation was made. It is necessary because the latitude and longitude figures alone do not indicate whether the latitude is north or south, or the longitude east or west. Q_c is coded according to Table 3—2.

Table 3—2: WMO code table 3333 — Specification of code figure Q_c

Code Figure	Latitude	Longitude
1	North	East
3	South	East
5	South	West
7	North	West

Example: If the ship was at 10° S, 165° W at the time of the observation then Q_c would be coded as 5. For positions on the equator and on the Greenwich or 180th meridian either of the two appropriate figures may be used.

3.1.6.2 $L_o L_o L_o L_o$ — Longitude of the ship

The symbol $L_o L_o L_o L_o$ indicates the longitude of the ship (east or west) at the time of observation expressed in tenths and hundredths of a degree, with the hundredths figure expressed as either 0 or 1. Minutes of longitude are converted to tenths of a degree in the same manner as for latitude (see 3.1.5.2).

Example (1): For longitude $0^{\circ}15'$ (0.25°) code $L_o L_o L_o L_o$ as 0002

Example (2): For longitude $8^{\circ}40'$ (8.65°) code $L_o L_o L_o L_o$ as 0086

Example (3): For longitude $62^{\circ}32'$ (62.55°) code $L_o L_o L_o L_o$ as 0625

Chapter 4 Visibility

4.1 Introduction

Visibility is defined as the greatest distance at which a dark object of suitably large dimension can be seen and identified when observed against a background of sky or fog, or in the case of night observations, could be seen and identified if the general illumination were raised to the normal daylight level. It should be emphasized that the criterion of identifying an object should be used, and not merely seeing the object without recognizing what it is.

If the atmosphere were perfectly transparent, it would be possible within the limits imposed by the earth's curvature, to identify objects at exceedingly great distances. This ideal situation rarely occurs in nature as there are always some tiny particles of solid or liquid matter suspended in the atmosphere. Light rays coming from an object at a given distance from the observer are scattered by these suspended particles, the amount of scattering depending on the concentration of the particles. In a dense concentration, as in thick fog, light may be totally scattered in a distance as small as 50 m rendering objects at this distance invisible. Some conditions that may reduce the visibility in the atmosphere are fog, mist, haze, smoke, snow, moderate or heavy rain, and blowing spray.

4.2 Observing visibility

At land stations there are almost always a number of objects or landscape features at known distances from the station that can be used as visibility *markers*. The visibility is then estimated by noting the most distant of these objects that is visible. On the high seas such markers are usually absent, making the estimation of visibility more difficult.

When the visibility is very low as in dense fog, it may not be possible to distinguish one end of the ship when standing at the other. In this case objects on the ship itself can be used as markers. On ships more than 50 m (164 ft) long, code figure 90 can be determined in this way, and on ships more than 200 m (656 ft) long code figures 90 and 91 can be determined. For the higher ranges the appearance of nearby ships if present, and a sufficient portion of their superstructures appear above the horizon, can be a useful guide. For example, if a vessel 5 NM distant as determined by radar, is also visible to the eye, then the visibility is more than 5 NM, and VV would be coded 97, 98, or 99, the figure chosen depending on the observer's judgment of the appearance of the distant ship and the atmosphere in general. If however the ship is not visible to the eye, then the visibility is less than 5 NM, in which case the code figure chosen for VV would be from 90 to 96, the choice again being left to the judgment of the observer. This same method may be applied to the appearance of land when coasting.

When out of sight of land and other ships the only visibility marker available is the horizon. The distance of the horizon can be found easily, as under normal atmospheric conditions it depends only on the height above the sea surface from which it is observed. To a high degree of accuracy the distance is given by the relations:

$$\begin{aligned} \text{Horizon distance (kilometres)} &= 3.84 \times \sqrt{h \text{ in metres}} \\ \text{Horizon distance (nautical miles)} &= 1.14 \times \sqrt{h \text{ in feet}} \end{aligned}$$

Where

h = the height of the observer's eye above the sea surface

Table 4—1 gives the horizon distance when viewed from various heights.

Table 4—1: Distance to the horizon at sea

Height of eye above the sea surface (metres)	Height of eye above the sea surface (feet)	Horizon distance (kilometres)	Horizon distance (nautical miles)
2	6.6	5.4	2.9
4	13.1	7.7	4.1
6	19.7	9.4	5.1
8	26.2	10.9	5.8
10	32.8	12.1	6.5
12	39.4	13.3	7.2
14	45.9	14.4	7.7
16	52.5	15.4	8.3
18	59.1	16.3	8.8
20	65.6	17.2	9.2
22	72.2	18.0	9.7
24	78.7	18.8	10.1
26	85.3	19.6	10.5
28	91.9	20.3	10.9
30	98.4	21.0	11.3

Example: If the horizon cannot be distinguished from a height of 15 m (49 ft) but can just be seen from a height of 6 m (19.7 ft), then the visibility would be estimated as 9.4 km (5.1 NM) and **VV** would be coded as **96**.

If the horizon appears sharp and clear from all heights on the ship, the visibility is probably greater than 50 km (27 NM). In cases of exceptional clearness of the atmosphere stars may be seen to rise or set at night with the unaided eye. In this instance the visibility may be more than 200 km. The use of the horizon as a visibility marker cannot always be relied upon, as abnormal refraction may cause a misleading appearance of the horizon. However, it is the only method available in some circumstances.

4.2.1 Visibility during darkness

The ability to see at night depends on the amount of illumination that is received from the stellar system, especially the moon. On a cloudy night at sea with no moon, the surrounding sea cannot be seen at all. Under such conditions it should not be assumed that the visibility has necessarily deteriorated, for the visibility is governed by the presence or absence of such obstructions to vision as fog, haze, snow, etc..

If present, the appearance of lights on shore or lights of nearby ships may be used as a guide in determining night-time visibility. The distance at which a light can be seen depends on its intensity or candle-power, and the transparency of the atmosphere. For example, if the equivalent daylight visibility is 100 km (50 mi.), then a 100 candle-power light can just be seen at a distance of 20 km (10 mi.) at night. If the visibility is reduced to 500 m (550 yd) by fog, then the same light can just be seen at a distance of 900 m (980 yd). It is a general rule that when the visibility is low (less than 1 km) most lights can be seen for a distance that is greater than the equivalent daylight visibility.

The visibility recorded after dark should be the same as that recorded for the last daylight observation unless there is evidence to indicate that the visibility has deteriorated in the interval. The appearance of a *loom* around the vessel's navigation lights is frequently a guide to deteriorating visibility.

4.2.2 Non-uniform visibility

When the visibility is the same, say 6 NM in all directions from the ship, then **VV** would be coded **97**. However atmospheric conditions may be such that the visibility differs in various directions. Under such non-uniform conditions the maximum visibility common to one half or more of the horizon circle is reported. This is called prevailing visibility. Example (1) and Example (2) illustrate where the prevailing visibility rule can be applied.

Example (1): The ship is on the edge of a fog bank. From northwest to southeast (in a clockwise direction) the visibility is reduced to 500 yd by the fog. From southeast to northwest (in a clockwise direction) the visibility in the clearer air is six miles. The prevailing visibility by the above definition is six miles and **VV** would be coded as **97**.

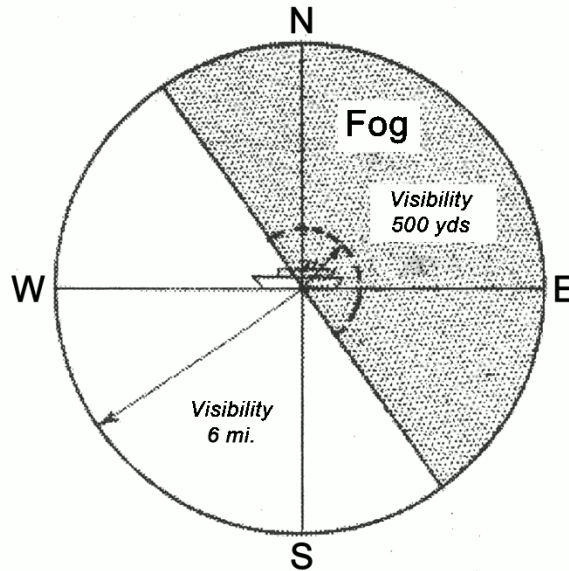


Figure 4—1: First example of non-uniform visibility

Example (2): A more complex situation is represented. Here the visibility is different in each of the four sectors of the horizon circle. However, the maximum visibility that is common to one half or more of the horizon circle is three miles. This visibility is common to the sector from southeast through west to north. Therefore the prevailing visibility is three miles and \overline{VV} would be coded as 96.

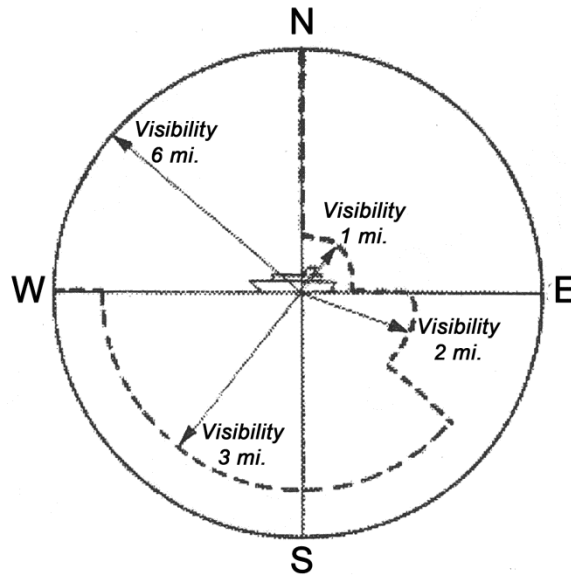


Figure 4—2: Second example of non-uniform visibility

When the visibility has been determined in terms of kilometres or metres (or nautical miles or yards), it is then converted to code figures by means of Table 4—4. These code figures are then entered in Column 13 of the meteorological log.

4.2.3 Land station visibility code

Visibility shall be reported at land stations in statute miles (SM), and at ocean stations in nautical miles (NM). The code figures used by land stations provide for reporting the visibility in greater detail. The code is given in Table 4—2 so that marine observers may decode the reports from such stations.

Table 4—2: Visibility code used by land stations

Code figure	Visibility (kilometres)	Visibility (nautical miles)
00	< 0.1	< 0.05
02	0.2	0.1
04	0.4	0.2
06	0.6	0.3
08	0.8	0.4
10	1.0	0.5
12	1.2	0.6
14	1.4	0.8
16	1.6	0.9
20	2.0	1.1
24	2.4	1.3
28	2.8	1.5
32	3.2	1.7
36	3.6	1.9
40	4.0	2.2
44	4.4	2.2
48	4.8	2.6
56	6	3.2
58	8	4.3
60	10	5.4
61	11	5.9
63	13	7.0
64	14	7.6
66	16	8.6
68	18	9.7
69	19	10.3
71	21	11.3
72	22	11.9
74	24	13.0
76	26	14.0
77	27	14.6
79	29	15.6
80	30	16.2

Code figure	Visibility (kilometres)	Visibility (nautical miles)
81	40	21.6
82	40	21.6
83	45	24.3
84	50	27.0
85	55	29.7
86	60	32.4
87	65	35.1
88	70	37.8
89	> 70	> 37.8

Note (1): " < " means "less than."

Note (2): " > " means "greater than."

4.3 Recording visibility information

4.3.1 Group $i_r i_x h V V$

4.3.1.1 i_r — Precipitation group indicator

The symbol i_r indicates whether a group containing data on the amount of precipitation is included or omitted from the message. Since most ships are not equipped to measure precipitation i_r will always be coded as 4, which indicates that the precipitation group is not included because the amount is not available. The figure 4 has been preprinted for this group in Column 10 on the meteorological log.

4.3.1.2 i_x — Station type indicator

The symbol i_x indicates whether the station is manned or automatic, and also whether the group $7_{ww}W_1W_2$ is included or omitted from the message. Since the $7_{ww}W_1W_2$ group is mandatory for selected and auxiliary ships, i_x will be coded as 1 (manned station, $7_{ww}W_1W_2$ included). On very rare instances $i_x = 3$ (manned station, $7_{ww}W_1W_2$ omitted) may be used. This code figure is to be entered in Column 11 on the meteorological log.

4.3.1.3 h — Base of lowest cloud

The symbol h indicates the base of the lowest cloud observed. For marine purposes the surface is considered to be the surface of the water.

Table 4—3 specifies code figures for the base of the lowest cloud observed. The selected code figure is to be entered in Column 12 on the meteorological log.

Note: Auxiliary Ships are not required to report the cloud height, therefore h is coded as /.

Table 4—3: WMO code table 1600 — Specification of code figure [h](#)

Code figure	Height (metres)	Height (feet)
0	0–50	160 or less
1	50–100	160–330
2	100–200	330–650
3	200–300	650–1000
4	300–600	1000–2000
5	600–1000	2000–3300
6	1000–1500	3300–4900
7	1500–2000	4900–6600
8	2000–2500	6600–8200
9	Greater than 2500, or no clouds	Greater than 8200, or no clouds
\	Sky obscured by fog, snow or clouds cannot be seen	Sky obscured by fog, snow or clouds cannot be seen

4.3.1.4 **VV** — Visibility

The symbol **VV** is used to indicate visibility. The code figures for **VV** run from **90** to **99**, thus forming ten different ranges of visibility that can be reported. In practice the visibility is first estimated in terms of kilometres or metres (or nautical miles or yards if desired). Table 4—4 specifies code figures for visibility. The selected code figure is to be entered in Column 13 on the meteorological log.

Table 4—4: WMO code table 4377 — Specification of code figure **VV**

Code figure	Visibility (kilometres)	Visibility (nautical miles)
90	< 0.05	< 55 yd.
91	0.05	55 yd.
92	0.2	220 yd.
93	0.5	550 yd.
94	1	0.5 NM
95	2	1 NM
96	4	2 NM
97	10	5 NM
98	20	11 NM
99	≥ 50	≥ 27 NM

4.3.2 Special weather report — SPREP

A special weather report (SPREP) should be sent whenever the prevailing visibility decreases to 0.5 NM or less from 2 NM or more. The observation and message format are the same as for a standard observation except the word SPREP will immediately precede the ship's call sign.

Chapter 5 Wind

5.1 Introduction

Wind is the effect produced by the horizontal motion of air across the surface of the earth or at any altitude above the surface. The movement of air is caused by differences in the atmospheric pressure between two localities. Air tends to move from an area of relatively high pressure to one of relatively low pressure and can be compared to the flow of water downhill. However the air does not flow directly from high to low pressure, but moves at a small angle to the direction of the lines of equal pressure called *isobars* on a weather map. The speed of the wind is directly proportional to the rate at which the atmospheric pressure is changing across the earth's surface. If the pressure changes rapidly in a horizontal direction the wind is strong; if it changes slowly the wind is light. Over water where weather observations are more scattered than on land, accurate wind reports are of great value because they assist a forecaster in determining the direction and spacing of isobars on a weather map.

5.2 Observing the wind

The direction and speed of the wind are determined by estimation or measurement. The true wind can be estimated by the appearance of the water surface. At night when the water surface cannot be seen, the apparent wind (i.e. the wind experienced on board when the ship is underway) can be estimated from its effect on the person or the rigging, flags, etc.. This estimate must then be corrected to allow for the ship's forward motion. Certain ships of Canadian registry are provided with a wind measuring device called an *anemometer*. On a moving ship this instrument measures the apparent wind from which the true wind can be obtained by means of a simple computing device.

The mean direction and speed of the wind over the ten-minute period immediately preceding the observation is reported for [ddff](#). If the ten-minute period includes a discontinuity in the wind data (i.e., an abrupt change in direction and/or speed) only data obtained after the discontinuity shall be used for reporting the mean values; hence the time period in these circumstances will be correspondingly reduced.

5.2.1 Estimation of the wind from the appearance of the sea surface

5.2.1.1 Wind Speed

At sea, wind speed is usually expressed on a scale from 0 to 12, called the Beaufort Scale of wind force and was first devised by Sir Francis Beaufort of the British Navy in 1808. As used today the numbers on the scale, which correspond to ranges of wind speed, are related to the corresponding state of the sea surface (see Table 5—1). This table is based on the assumption that the observation is made in the open ocean, well removed from land, and that the wind has been blowing long enough from a constant direction to raise the appropriate sea (this may take 24 h or more on the open ocean).

Table 5—1: Beaufort wind force scale

Beaufort Number	Mean wind speed (kt)	Limits of wind speed (kt)	Descriptive terms	Appearance of the sea if the fetch and duration of the blow have been sufficient to develop the sea fully	Probable wave height	Probable maximum wave height
0	0	< 1	Calm	Sea like a mirror	0 m	0 m
1	2	1–3	Light air	Ripples with the appearance of fish scales are formed, but without foam crests	0.1 m	0.1 m
2	5	4–6	Light breeze	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break	0.2 m (4 in.)	0.2 m (4 in.)
3	9	7–10	Gentle breeze	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses	0.6 m (2 ft)	0.6 m (2 ft)
4	13	11–16	Moderate breeze	Small waves, becoming longer; fairly frequent white horses	1 m (3 ft)	1.5 m (5 ft)
5	19	17–21	Fresh breeze	Moderate waves, taking a more pronounced long form; many white horses are formed (chance of some spray)	2 m (6.5 ft)	2.5 m (8 ft)
6	24	22–27	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray).	3 m (10 ft)	4 m (13 ft)
7	30	28–33	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind	4 m (13 ft)	5.5 m (18 ft)

Beaufort Number	Mean wind speed (kt)	Limits of wind speed (kt)	Descriptive terms	Appearance of the sea if the fetch and duration of the blow have been sufficient to develop the sea fully	Probable wave height	Probable maximum wave height
8	37	34–40	Gale	Moderately high waves of greater length; edges of crests begin to break into the spindrift; the foam is blown in well-marked streaks along the direction of the wind	5.5 m (18 ft)	7.5 m (25 ft)
9	44	41–47	Strong gale	High waves; dense streaks of foam along the direction of the wind; crests begin to topple, tumble, and roll over; spray may affect visibility.	7 m (23 ft)	10 m (33 ft)
10	52	48–55	Storm	Very high waves with long over-hanging 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.	9 m (29.5 ft)	12.5 m (41 ft)
11	60	56–63	Violent storm	Exceptionally high waves (small and medium sized ships might be for a time lost to view behind the waves); the sea is completely covered with long white patches of foam flying along the direction of the wind; everywhere the edges of the wave crests are blown into froth; visibility affected	11.5 m (38 ft)	16 m (52 ft)
12	–	64 and over	Hurricane	The air is filled with foam and spray; sea completely white with driving spray; visibility very seriously affected	14 m (46 ft)	–

Table 5—1 is useful as a general guide in estimating wind force but cannot be accurate under all circumstances. The state of the sea surface criteria may be thought of as a steady-state condition on the open sea. Good judgment is necessary to decide to what extent they should be modified when disturbing factors are present. The following circumstantial considerations must be taken into account:

- Precipitation, especially if heavy, produces a smoothing effect.
- Waves running into shallow water increase in steepness, and hence increase in their tendency to break. White horses will therefore not have the same significance as on the high seas, and this should be remembered when estimating the force of an on-shore wind close to shore.
- With an off-shore wind the fetch or the distance up-wind over which the wind is able to act on the water from nearly the same direction, must be considered. Waves are not raised instantaneously, but result from the wind blowing over a distance (*fetch*) and throughout a period of time. The maximum effect of an off-shore wind can be only reached at some considerable distance off-shore. Close in-shore the wind may therefore be stronger than would be estimated from the appearance of the sea surface using Table 5—1.
- If the wind has just sprung up, or is increasing, its force will be greater than that indicated by the appearance of the sea surface. This is due to the fact that it takes some time for the waves to build up their steady-state condition. Conversely, if the wind is decreasing the appearance of the sea will give an over-estimate of the wind speed.
- Wind-driven waves show a greater tendency to break when superimposed on the crest of a swell. In particular if rapid changes of wind are taking place the cross-patterns of waves from different directions will tend to produce more white horses than appropriate to the strength of the wind blowing at the time.
- In tidal waters it is well known that the disturbance of the sea is greater when the wind is against the tide than when it is with the tide.
- It should be remembered that swell waves are not to be considered when estimating wind speed and direction, only those waves raised by the wind blowing at the time of any significance.

After the Beaufort Force of the wind has been determined, it must be converted to knots, as these are the units used for **ff** in the International Ship Code. The observer may obtain this conversion from Column 2 of Table 5—1 which gives the mean corresponding to each Beaufort Force. Column 3 of Table 5—1 may be used to obtain a finer estimate of the actual wind speed. For example, if the observer judges the wind to be over Force 7 but not quite Force 8, it might be reported as having a mean speed of 33 kt which is the upper limit of speed for Force 7.

5.2.1.2 Wind Direction

Wind direction is determined from the orientation of the wave crests, and from the faint lines of foam which lie in the direction of the wind. If the observer sights along the lines of the wave crests, and then turns through 90° into the wind, the observer will then be facing the direction of the true wind. This direction, relative to true north, is then coded for **dd** (see 5.3.1.2). As lines of foam (which appear when winds of Force 7 or higher have been blowing for some time) lie parallel to the direction of the true wind, they may also be used to determine **dd**.

5.2.2 Estimation of the apparent wind

The direction of the apparent wind is easily judged by turning so as to face directly into the wind when standing in an exposed location. The direction should be estimated to the nearest ten degrees off the starboard or port bow.

The speed of the apparent wind may be estimated to some degree of accuracy by noting the “feel” of the wind in the face and body; the effects produced on halliards, flags, and pennants; the angle at which smoke rises from the funnel; and the intensity and character of the sound of the wind in the rigging. The observer should stand in a well-exposed position on the windward side of the ship.

Table 5—2: Effects of apparent wind on ship board — may be used as a guide in estimating the Beaufort Force of the apparent wind. It describes the effects on the person and objects on the ship produced by Beaufort Forces from 0 to 8. Table 5—2 was prepared from experience gained on the Canadian Ocean Ship C.G.S. *St. Stephen*.

Table 5—2: Effects of apparent wind on ship board

Beaufort Force	Approximate wind speed (kt)	Effect of apparent wind
0	< 1	Smoke rises straight up
1	1–3	Barely perceptible smoke drift
2	4–6	Wind barely felt on face (a tendency to overestimate wind needs to be avoided when the temperature is below 0 °C); smoke rises at 80°
3	7–10	Wind felt on the face (a tendency to overestimate wind needs to be avoided when the temperature is below 0 °C); smoke rises at 70°; taut halliards shake slightly; pennant extends and flaps
4	11–16	Slight pressure of wind felt on face; smoke rises at 50°; slack halliards curve and sway but do not assume fixed bent position; taut halliards do not bend but whip slightly; no noticeable sound in rigging; flapping of pennant more marked at fly end; heavy flag flaps limply but does not extend
5	17–21	Wind felt on face as if close to ordinary electric fan; stings face if temperature below 1 °C; smoke rises at 30°; slack halliards whip while bending continuously to leeward; taut halliards maintain slightly bent position; low whistle in rigging; heavy flag does not extend but flaps along entire length
6	22–27	Wind stings face in temperatures below 2 °C; slight effort to maintain balance against wind; smoke rises at 15°; both slack and taut halliards whip slightly in bent position; a low moaning rather than a whistle is heard in the rigging; heavy flag begins to extend and flaps more vigorously
7	28–33	Wind stings face in temperatures below 3 °C; necessary to lean slightly into the wind to maintain balance; loose oilskins begin to inflate and pull against the strength of one's arms; smoke rises at 5° to 10°; there is still a slight whip in the halliards; whistling and medium moaning heard in the rigging; heavy flag extends full length and flaps at fly only; loose canvas protectors around bridge whip slightly against supports
8	34–40	The head is pushed back by the force of the wind if allowed to relax; oilskins inflate and pull strongly; halliards rigidly bent; loud whistle in rigging; heavy flag flies straight out and whips from the hoist; loose canvas dodgers or protectors held tight against supports

Note: Facts that would determine forces above Force 8 in Table 5—2 could not be distinguished except that the noise in the rigging increased in volume until at Force 10 normal conversation could not be heard at a distance of one or two metres.

When the speed and direction of the apparent wind are known, the true wind can be found either by referring to Tables 5—3 to 5—7, or by constructing a vector diagram as illustrated in Figure 5—1. To construct a diagram proceed as follows:

- 1) Draw a vector AB equal to the speed of the ship on a scale of 1 cm to the knot or any other convenient scale.
- 2) From the point B draw a vector BC equal in length to the speed of the apparent wind, and at an angle X to the vector AB , such that X equals the direction of the apparent wind relative to the ship's bow.
- 3) Join the points A and C producing this line to D . The length of the vector AC then is equal to the speed of the true wind and the angle Y is the direction of the true wind relative to the ship's bow.
- 4) The direction of the true wind relative to true North must now be obtained. If the wind is on the starboard side, add the direction of the true wind in degrees off the bow to the true heading of the ship (0 – 360° system), subtracting 360° if the sum exceeds 360 . If the wind is on the port side, subtract the direction of the true wind in degrees off the bow from the true heading of the ship adding 360° to the heading before the subtraction if it is the smaller of the two figures. The result in each case will be the direction of the true wind referred to true North.

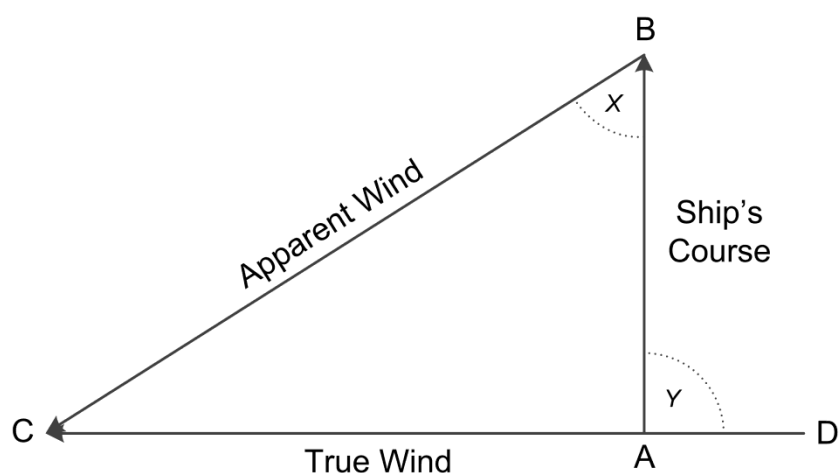


Figure 5—1: Graphical method of obtaining true wind from the apparent wind — illustration of case where the apparent wind is forward of the beam

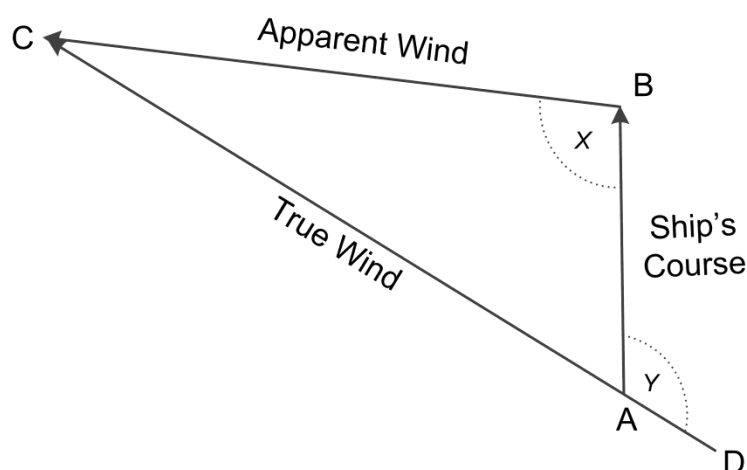


Figure 5—2: Graphical method of obtaining true wind from the apparent wind — illustration of case where the apparent wind is abaft of the beam

5.2.3 Estimation of the true wind from the apparent wind

On dark nights it is often not possible to estimate the force and direction of the wind by the appearance of the sea surface. Under these conditions the observer may obtain an estimate of the true wind by judging the speed of the apparent wind and its direction relative to the ship's bow, and then making allowance for the ship's course and speed.

The apparent wind is the wind which an observer experiences on a moving ship. It is the result of two motions — the actual motion of the air (the true wind) and the motion of the ship. Consider the case of a ship proceeding at a speed of 15 kt in calm air. An observer on board would experience a wind of 15 kt from dead ahead due solely to the motion of the ship. With a true wind of 15 kt blowing from dead astern, an observer on this ship would experience a dead calm, as the ship was moving at the same speed as the surrounding air and in the same direction.

The following three rules relating to the apparent wind and true wind hold true under all circumstances.

- The direction of the true wind is always on the same side as, but further from the bow than the apparent direction.
- The speed of the true wind is greater than the speed of the apparent whenever the apparent direction is abaft of the beam.
- The speed of the true wind is less than the apparent whenever the apparent direction is forward of the beam.

5.2.4 Shipboard measurement of the wind

5.2.4.1 The anemometer

An anemometer is an instrument which measures the speed of the apparent wind, and the direction from which it is blowing relative to the ship's course. A common type of anemometer measures the wind speed by means of a set of three cups which rotate about a vertical axis. The force of the wind on the cups causes them to rotate at a speed which is proportional to the speed of the apparent wind. Thus the greater the wind the faster the cups will rotate. The wind direction is measured by means of a vane which also turns on a vertical axis so that it is always pointing directly into the wind. The cup wheel and wind vane are connected electrically to speed and direction dials located in the chartroom of the wheel house.

5.2.4.2 The service type U2A anemometer

Certain ships of Canadian registry are fitted with a service type U2A anemometer on a loan basis. The cup wheel and wind vane are mounted on either end of a U-shaped arm as illustrated in Figure 5—3. This U-arm is mounted as high and as forward on the ship as possible, so that the unit is in a flow of air relatively undisturbed by the ship's superstructure. The instrument requires 115 volt, 60 cycle power to operate the direction unit. The speed unit supplies its own power by means of a small permanent magnet generator which is operated by the rotating cupwheel.

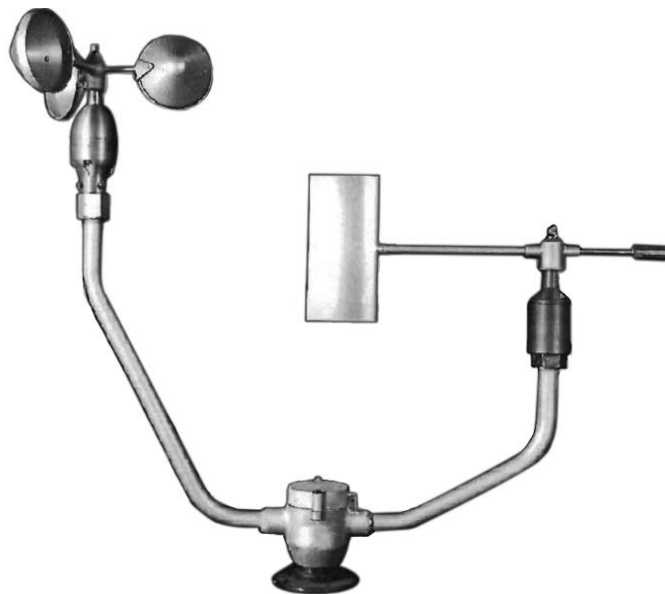


Figure 5—3: Cup wheel and wind vane assembly of the U2A anemometer

The wind speed and direction dials are mounted in a small cabinet located conveniently in the chartroom or wheel house. These dials are illustrated in Figure 5—4. The wind speed dial is calibrated in nautical miles per hour, from 0 to 100 kt. The wind direction dial is calibrated in tens of degrees from 010° to 360°. The direction indicated by the dial will be the direction of the apparent wind in relation to the heading of the ship, and not to north. Thus an indication of 360° represents an apparent wind from dead ahead; 090° represents a wind on the starboard beam; 180° represents a wind from dead astern; and 270° represents a wind from the port beam.

5.2.4.2.1 Reading the wind speed and direction dials

To read the direction of the apparent wind, turn the power switch to the *ON* position. The pointer of the direction dial will usually fluctuate over a range of directions and the observer will have to watch (or glance at periodically) the dial for ten minutes in order to mentally determine the mean direction. The mean direction is expressed in degrees as read from the dial.

The speed of the apparent wind is read from the wind speed dial. However the pointer will fluctuate over a range of speeds due to the gusts and lulls of the wind. Therefore the observer will have to watch (or glance at periodically) the dial for ten minutes in order to mentally determine the mean speed. Mean speed is expressed in knots.



Figure 5—4: Wind speed and direction dials of U2A anemometer

5.2.4.3 Computing the true wind

For meteorological and navigational purposes the apparent wind as read from the anemometer is of little value. Therefore, it is necessary to determine the true wind knowing the apparent wind and the ship's course and speed.

The apparent wind is the combined effect of the true wind and the wind caused by the forward motion of the ship. This latter wind is called the *heading wind*. Therefore:

$$\textit{Apparent Wind} = \textit{True Wind} + \textit{Heading Wind}$$

However, the *heading wind* is equal to the ship's speed but opposite in direction, therefore:

$$\textit{Heading Wind} = -\textit{Ship's Velocity}$$

Hence:

$$\textit{True Wind} = \textit{Apparent Wind} + \textit{Ship's Velocity}$$

Winds and the ship's velocity are vector quantities; that is they are not fully described until two features are stated — direction and speed. We cannot add two vectors simply by adding their directions and their speeds; they must be added vectorially. The addition of the apparent wind and the ship's velocity to obtain the true wind is accomplished by means of the True Wind Computer which is supplied to ships equipped with anemometers.

The True Wind Computer is illustrated in Figure 5—5. It consists of an Oval-shaped plastic base plate on which is printed a direction and speed grid, and a clear plastic rotating disc which can be moved in a slot in the base plate.

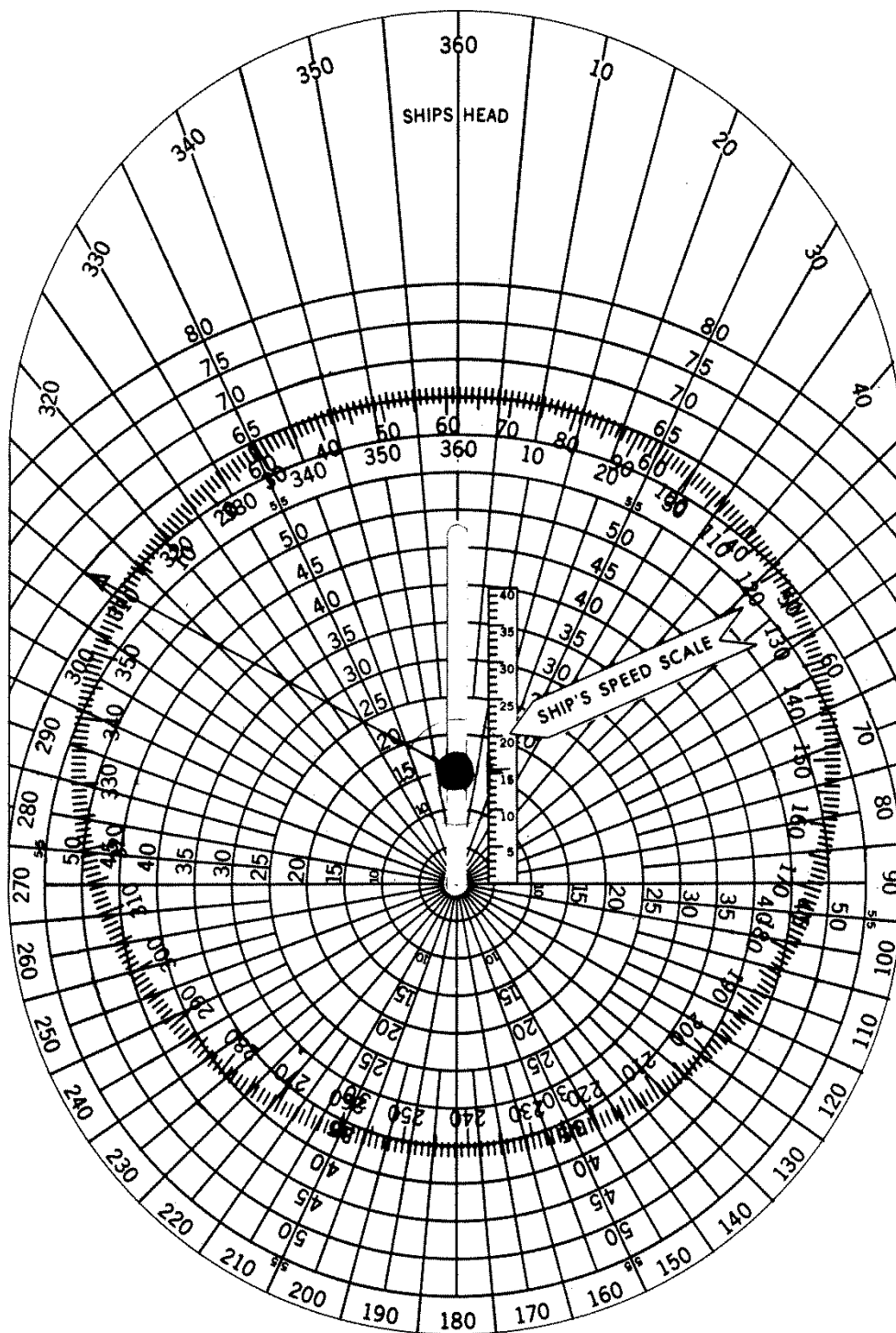


Figure 5—5: The True Wind Computer

5.2.4.3.1 How to use the computer

Instructions are printed on the back of the computer. Although these instructions are clear and the operation of the computer is very simple, it may be advisable to work out another example step by step. The following information will be used in this example:

- Ship's Heading: 290° True
- Ship's Speed: 17 kt
- Apparent wind direction as read from the anemometer: 110°
- Apparent wind speed as read from the anemometer: 32 kt

Four steps to use the true wind computer:

- 1) Slide the rotating disc along the slot until the short horizontal index line is opposite the ship's speed (17 kt) on the vertical ship's speed scale. Then rotate the disc until the ship's true heading (290°) on the green scale of the disc is directly over the 360° line of the base plate (see Figure 5—6).
- 2) With a nylon tipped pen or grease pencil, make a dot on the rotating disc at the intersection of the radius line for the apparent wind direction (110°) and the apparent wind speed (32 kt), utilizing the grid printed on the base plate (see Figure 5—6).
- 3) Slide the rotating disc to the bottom of the slot until the short horizontal index line is opposite zero on the vertical ship's speed scale. Now rotate the disc until the dot plotted in step two lies directly on the 360° line of the base plate (in many cases, simply set the dot over the center of the slot) (see Figure 5—7).
- 4) Now using the green scale of the rotating disc read the direction of the true wind over the 360° line of the base plate (063° True). Then read the speed of the true wind where the dot lies on the circular speed scale of the base plate (41 kt) (see Figure 5—7).

Hence in this example `ff` is coded as `41` and, since the true wind direction is 063°, `dd` is coded as `06`.

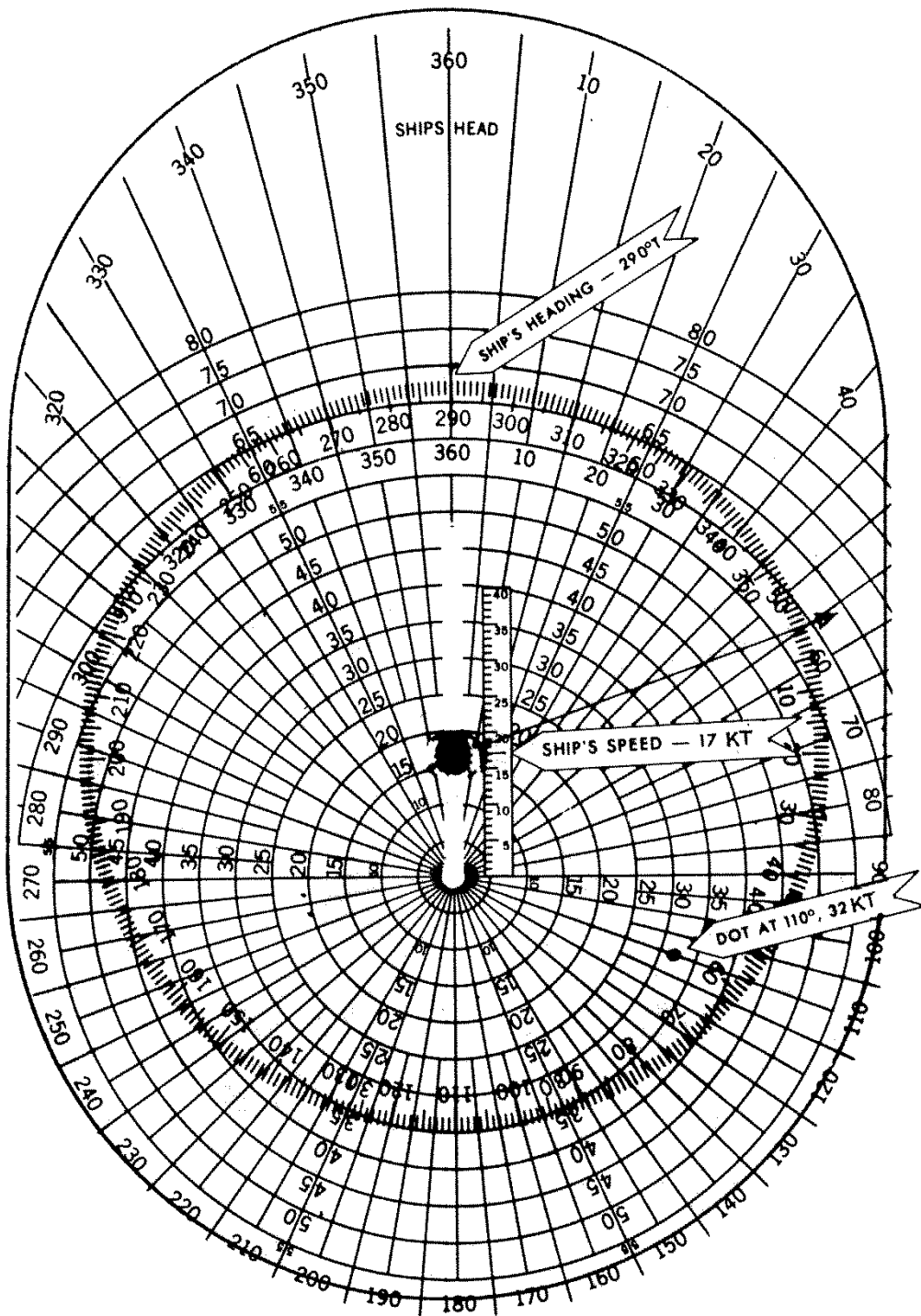


Figure 5—6: Example of how to use the True Wind Computer (steps one and two)

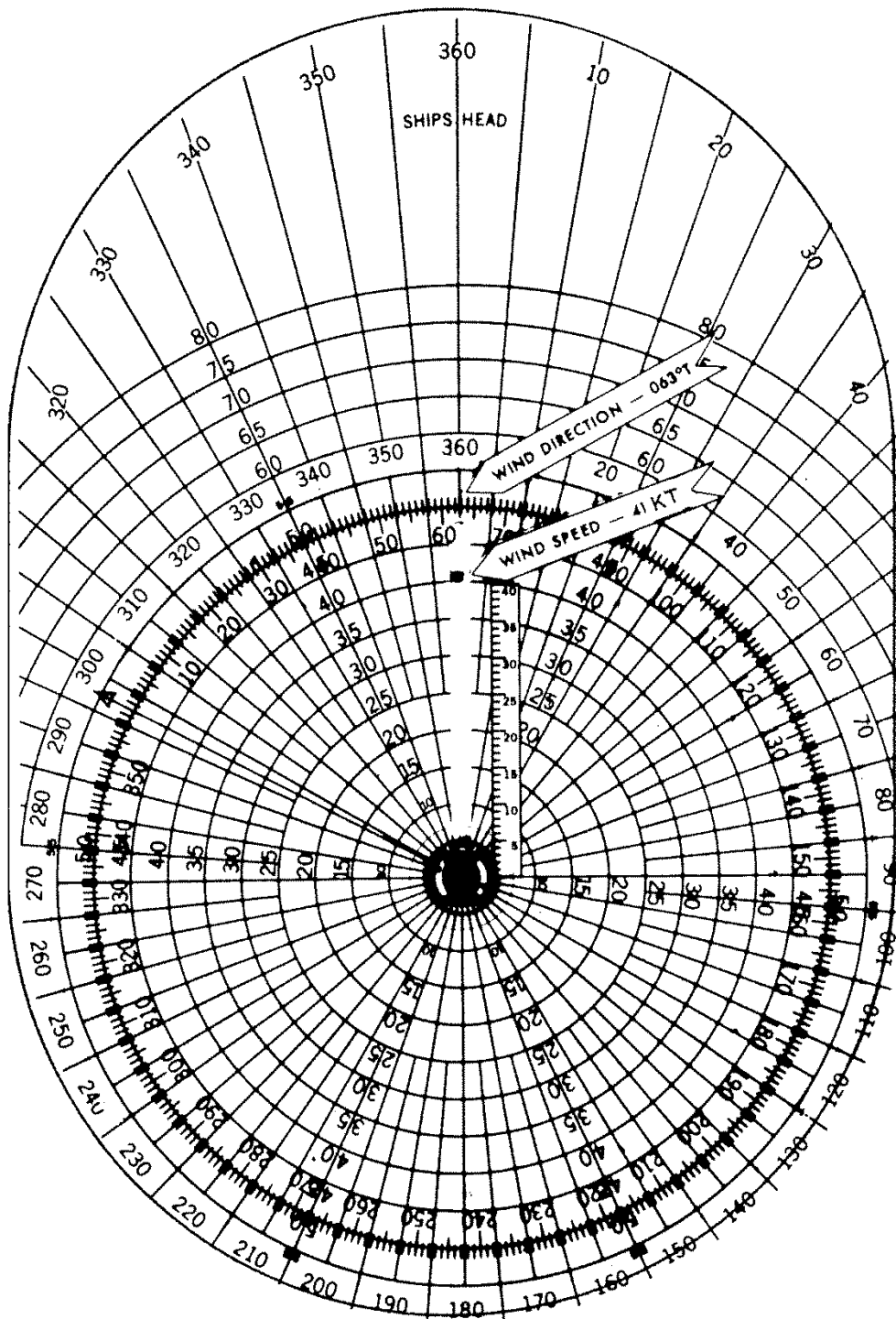


Figure 5—7: Example of how to use the True Wind Computer (steps three and four)

5.2.4.3.2 Further hints on using the computer

When the dot as plotted in Step (2) comes quite close to the center of the rotating disc, the accuracy of the final answer often suffers for that reason. In order to have the dot further away from the center of the disc and thus ensure an accurate answer, simply multiply the ship's speed and the apparent wind by two (or even three is possible) for the purpose of carrying out the computation. The directions (ship's course and apparent wind direction) do not change. However, do not forget to divide the answer obtained for the wind speed by two (or three) to arrive at the actual true wind speed.

Example: With ship's course and speed of 240° true at 12 kt, and apparent wind of 350° at 11 kt, the dot would actually fall on the metal retaining nut. If we multiply the above speed by three, using 36 kt for the ship's speed and 33 kt for the apparent wind speed (no change in the ship's course or apparent wind direction) the dot falls well away from the metal part. The answer obtained for the true wind is 119° at 7 kt. However the true wind speed is actually $7/3$ or 2 kt.

When the dot, as plotted in Step (2), falls precisely at the center of the rotating disc the true wind is calm. In this case code `dd = 00` and `ff = 00`.

Sometimes with very strong winds the dot, as plotted in Step (2), will fall completely outside the rotating disc. If this happens simply divide the ship's speed and the apparent wind speed by two for the purpose of carrying out the computation. However do not forget to multiply the answer obtained for the wind speed by two to arrive at the actual true wind speed.

Note: The ship's speed and apparent wind speed must both be in knots. If the ship's speed is reckoned in miles per hour, change it to knots by subtracting the amount shown in the following list:

If 0–3 miles per hour, then subtract 0

If 4–11 miles per hour, then subtract 1

If 12–18 miles per hour, then subtract 2

If 19–26 miles per hour, then subtract 3

5.2.4.4 Tables for determining force and direction of the true wind when the apparent wind is known

Table 5—3: True wind force and direction from a moving vessel — Speed = 5 kt

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
0	180°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T
True Force	3	0	2	3	4	5	6	7	8	9	10°T	11°T
10°	174°T	96°T	24°T	15°T	13°T	13°T	12°T	12°T	11°T	11°T	11°T	11°T
True Force	1	1	2	3	4	5	6	7	8	9	10	11
20°	167°T	100°T	44°T	30°T	27°T	25°T	24°T	23°T	22°T	22°T	22°T	22°T
True Force	1	1	2	3	4	5	6	7	8	9	10	11
30°	163°T	105°T	62°T	45°T	39°T	37°T	36°T	34°T	33°T	33°T	33°T	32°T
True Force	1	1	2	3	4	5	6	7	8	9	10	11
40°	161°T	110°T	75°T	59°T	52°T	49°T	47°T	45°T	45°T	44°T	44°T	43°T
True Force	2	1	2	3	4	5	6	7	9	10	11	12
50°	158°T	115°T	86°T	70°T	64°T	60°T	58°T	56°T	56°T	54°T	54°T	54°T
True Force	2	2	3	4	4	6	6	8	9	10	11	12
60°	156°T	120°T	96°T	82°T	75°T	71°T	69°T	67°T	66°T	65°T	65°T	64°T
True Force	2	2	3	4	5	6	7	8	9	10	11	12
70°	157°T	125°T	105°T	92°T	85°T	82°T	79°T	77°T	76°T	75°T	75°T	74°T
True Force	2	2	3	4	5	6	7	8	9	10	11	12
80°	157°T	130°T	112°T	101°T	95°T	92°T	89°T	88°T	87°T	86°T	85°T	84°T
True Force	2	2	3	4	5	6	7	8	9	10	11	12
90°	158°T	135°T	121°T	111°T	105°T	102°T	99°T	98°T	97°T	96°T	95°T	94°T
True Force	2	3	3	4	5	6	7	8	9	10	11	12
100°	159°T	139°T	128°T	119°T	114°T	111°T	109°T	107°T	106°T	105°T	104°T	104°T
True Force	2	3	3	4	5	6	7	8	9	10	11	12
110°	162°T	145°T	134°T	127°T	123°T	120°T	118°T	117°T	116°T	115°T	114°T	114°T
True Force	2	3	4	4	5	6	7	8	9	10	11	12
120°	164°T	150°T	142°T	135°T	131°T	129°T	128°T	126°T	125°T	124°T	123°T	123°T
True Force	2	3	4	5	6	6	7	8	9	10	11	12
130°	167°T	155°T	148°T	142°T	140°T	138°T	137°T	135°T	135°T	134°T	134°T	134°T
True Force	3	3	4	5	6	7	8	9	9	10	11	12

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
140°	169°T	160°T	155°T	150°T	148°T	147°T	146°T	145°T	144°T	144°T	143°T	143°T
True Force	3	3	4	5	6	7	8	9	10	10	11	12
150°	172°T	165°T	160°T	158°T	156°T	155°T	154°T	154°T	154°T	153°T	153°T	153°T
True Force	3	3	4	5	6	7	8	9	10	10	11	12
160°	174°T	170°T	168°T	166°T	164°T	164°T	163°T	162°T	162°T	162°T	162°T	162°T
True Force	3	3	4	5	6	7	8	9	10	11	12	>12
170°	177°T	175°T	173°T	173°T	172°T	172°T	171°T	171°T	171°T	171°T	171°T	171°T
True Force	3	3	4	5	6	7	8	9	10	11	12	>12
180°	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T
True Force	3	3	4	5	6	7	8	9	10	11	12	>12

Note:

“°T” = True direction of wind, degrees off bow

“True Force” = True force of wind, Beaufort scale

“Apparent force” = Apparent force of the wind, Beaufort Scale

“>” = Greater than

Table 5—4: True wind force and direction from a moving vessel — Speed = 10 kt

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
0°	180°T	180°T	180°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T
True Force	3	2	1	2	3	4	5	6	8	9	10	11
10°	178°T	170°T	140°T	36°T	22°T	17°T	15°T	14°T	13°T	13°T	12°T	12°T
True Force	3	2	1	2	3	4	5	6	8	9	10	11
20°	175°T	162°T	127°T	59°T	40°T	33°T	29°T	27°T	26°T	25°T	24°T	23°T
True Force	3	2	2	2	3	4	5	7	8	9	10	11
30°	173°T	156°T	123°T	75°T	56°T	48°T	43°T	40°T	38°T	37°T	36°T	35°T
True Force	3	2	2	3	4	5	6	7	8	9	10	11
40°	171°T	153°T	123°T	88°T	70°T	61°T	56°T	53°T	50°T	49°T	47°T	46°T
True Force	3	3	3	3	4	5	6	7	8	9	10	11
50°	170°T	151°T	126°T	97°T	81°T	73°T	68°T	64°T	62°T	60°T	58°T	57°T
True Force	3	3	3	3	4	5	6	7	8	9	10	11
60°	169°T	150°T	129°T	106°T	92°T	84°T	79°T	75°T	73°T	71°T	69°T	68°T
True Force	3	3	3	4	5	5	6	7	8	9	11	12
70°	169°T	151°T	132°T	113°T	101°T	94°T	89°T	86°T	83°T	81°T	79°T	78°T
True Force	3	3	4	4	5	6	7	8	9	10	11	12
80°	168°T	152°T	136°T	120°T	110°T	104°T	99°T	96°T	93°T	91°T	89°T	88°T
True Force	3	3	4	4	5	6	7	8	9	10	11	12
90°	168°T	153°T	140°T	127°T	118°T	112°T	108°T	105°T	103°T	101°T	99°T	98°T
True Force	3	4	4	5	6	6	7	8	9	10	11	12
100°	169°T	156°T	145°T	133°T	126°T	121°T	117°T	114°T	112°T	111°T	109°T	108°T
True Force	4	4	4	5	6	7	8	8	9	10	11	12
110°	170°T	158°T	148°T	139°T	133°T	129°T	125°T	123°T	121°T	120°T	118°T	117°T
True Force	4	4	4	5	6	7	8	9	10	11	11	> 12
120°	171°T	161°T	153°T	145°T	140°T	136°T	134°T	132°T	130°T	129°T	128°T	127°T
True Force	4	4	4	5	6	7	8	9	10	11	12	> 12
130°	172°T	164°T	157°T	151°T	147°T	144°T	142°T	140°T	139°T	137°T	136°T	136°T
True Force	4	4	5	5	6	7	8	9	10	11	12	> 12
140°	173°T	167°T	162°T	157°T	154°T	151°T	150°T	148°T	147°T	146°T	145°T	145°T
True Force	4	4	5	6	7	7	8	9	10	11	12	> 12

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
150°	175°T	170°T	166°T	163°T	160°T	159°T	157°T	156°T	155°T	155°T	154°T	154°T
True Force	4	4	5	6	7	8	8	9	10	11	12	> 12
160°	177°T	173°T	171°T	169°T	167°T	166°T	165°T	164°T	164°T	163°T	163°T	162°T
True Force	4	4	5	6	7	8	8	9	10	11	12	> 12
170°	178°T	177°T	176°T	174°T	173°T	173°T	172°T	172°T	172°T	172°T	171°T	171°T
True Force	4	4	5	6	7	8	8	9	10	11	12	> 12
180°	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T
True Force	4	4	5	6	7	8	9	9	10	11	12	> 12

Note:

“°T” = True direction of wind, degrees off bow

“True Force” = True force of wind, Beaufort scale

“Apparent force” = Apparent force of the wind, Beaufort Scale

“>” = Greater than

Table 5—5: True wind force and direction from a moving vessel — Speed = 15 kt

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
0°	180°T	180°T	180°T	180°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T
True Force	4	3	2	1	2	3	4	6	7	8	9	10
10°	179°T	175°T	169°T	126°T	38°T	24°T	19°T	16°T	15°T	14°T	13°T	13°T
True Force	4	3	3	1	2	3	4	6	7	8	9	10
20°	177°T	171°T	159°T	115°T	63°T	46°T	37°T	32°T	30°T	28°T	26°T	25°T
True Force	4	3	3	2	3	4	5	6	7	8	9	11
30°	176°T	167°T	152°T	116°T	79°T	63°T	53°T	47°T	43°T	41°T	39°T	37°T
True Force	4	4	3	3	3	4	5	6	7	8	10	11
40°	175°T	164°T	148°T	118°T	90°T	76°T	67°T	61°T	57°T	54°T	51°T	49°T
True Force	4	4	3	3	4	4	5	6	8	9	10	11
50°	174°T	162°T	146°T	121°T	99°T	87°T	79°T	73°T	69°T	65°T	63°T	61°T
True Force	4	4	4	4	4	5	6	7	8	9	10	11
60°	173°T	161°T	146°T	125°T	107°T	97°T	89°T	84°T	80°T	76°T	74°T	72°T

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
True Force	4	4	4	4	5	5	6	7	8	9	10	11
70°	173°T	161°T	147°T	129°T	114°T	106°T	99°T	94°T	90°T	87°T	84°T	82°T
True Force	4	4	4	4	5	6	7	8	9	10	11	12
80°	172°T	161°T	148°T	134°T	121°T	114°T	108°T	103°T	100°T	97°T	94°T	92°T
True Force	4	4	4	5	6	6	7	8	9	10	11	12
90°	172°T	162°T	150°T	138°T	127°T	121°T	116°T	112°T	109°T	106°T	104°T	102°T
True Force	4	4	5	5	6	7	8	8	9	10	11	12
100°	173°T	163°T	153°T	143°T	134°T	128°T	124°T	120°T	117°T	115°T	113°T	111°T
True Force	4	5	5	6	6	7	8	9	10	11	11	> 12
110°	173°T	164°T	156°T	147°T	140°T	135°T	131°T	128°T	126°T	124°T	122°T	121°T
True Force	4	5	5	6	7	7	8	9	10	11	12	> 12
120°	174°T	166°T	159°T	152°T	146°T	142°T	139°T	136°T	134°T	132°T	131°T	129°T
True Force	4	5	5	6	7	8	8	9	10	11	12	> 12
130°	175°T	168°T	162°T	156°T	151°T	148°T	146°T	144°T	142°T	141°T	139°T	138°T
True Force	4	5	5	6	7	8	9	10	10	11	12	> 12
140°	175°T	170°T	166°T	161°T	157°T	155°T	153°T	151°T	150°T	149°T	148°T	147°T
True Force	4	5	6	6	7	8	9	10	11	11	12	> 12
150°	176°T	173°T	169°T	166°T	163°T	161°T	160°T	158°T	157°T	157°T	156°T	155°T
True Force	5	5	6	7	8	8	9	10	11	11	> 12	> 12
160°	178°T	175°T	173°T	171°T	169°T	168°T	167°T	166°T	165°T	165°T	164°T	163°T
True Force	5	5	6	7	8	8	9	10	11	12	> 12	> 12
170°	179°T	177°T	176°T	175°T	174°T	174°T	173°T	173°T	173°T	172°T	172°T	172°T
True Force	5	5	6	7	8	8	9	10	11	12	> 12	> 12
180°	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T
True Force	5	5	6	7	8	8	9	10	11	12	> 12	> 12

Note:

“°T” = True direction of wind, degrees off bow

“True Force” = True force of wind, Beaufort scale

“Apparent force” = Apparent force of the wind, Beaufort Scale

“>” = Greater than

Table 5—6: True wind force and direction from a moving vessel — Speed = 20 kt

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
0°	180°T	180°T	180°T	180°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T	0°T
True Force	5	4	4	2	1	2	4	5	6	7	8	10
10°	179°T	177°T	174°T	161°T	111°T	46°T	28°T	21°T	18°T	16°T	15°T	14°T
True Force	5	4	4	3	2	2	4	5	6	7	9	10
20°	178°T	174°T	166°T	148°T	108°T	70°T	50°T	40°T	35°T	32°T	29°T	28°T
True Force	5	4	4	3	3	3	4	5	6	7	9	10
30°	177°T	171°T	161°T	141°T	111°T	84°T	67°T	57°T	51°T	46°T	43°T	41°T
True Force	5	4	4	4	3	4	5	6	7	8	9	10
40°	176°T	169°T	158°T	138°T	114°T	95°T	80°T	71°T	64°T	60°T	56°T	53°T
True Force	5	4	4	4	4	4	5	6	7	8	9	11
50°	175°T	167°T	156°T	137°T	118°T	103°T	91°T	83°T	76°T	72°T	68°T	65°T
True Force	5	5	4	4	4	5	6	7	8	9	10	11
60°	175°T	166°T	155°T	139°T	123°T	110°T	100°T	93°T	87°T	83°T	79°T	76°T
True Force	5	5	5	5	5	6	6	7	8	9	10	11
70°	174°T	166°T	155°T	141°T	127°T	117°T	109°T	102°T	97°T	93°T	89°T	87°T
True Force	5	5	5	5	6	6	7	8	9	10	11	12
80°	174°T	166°T	156°T	143°T	132°T	123°T	116°T	110°T	106°T	102°T	99°T	97°T
True Force	5	5	5	6	6	7	8	8	9	10	11	12
90°	174°T	166°T	157°T	146°T	137°T	129°T	123°T	119°T	115°T	111°T	108°T	106°T
True Force	5	5	6	6	7	7	8	9	10	10	11	12
100°	174°T	167°T	159°T	149°T	141°T	135°T	130°T	126°T	123°T	120°T	117°T	115°T
True Force	5	5	6	6	7	8	8	9	10	11	12	> 12
110°	175°T	168°T	161°T	153°T	146°T	141°T	137°T	134°T	130°T	128°T	126°T	124°T
True Force	5	6	6	7	7	8	9	10	10	11	12	> 12
120°	175°T	169°T	163°T	156°T	151°T	147°T	143°T	140°T	138°T	136°T	134°T	132°T
True Force	5	6	6	7	8	8	9	10	11	11	> 12	> 12
130°	176°T	171°T	165°T	160°T	156°T	152°T	149°T	147°T	145°T	143°T	142°T	140°T
True Force	5	6	6	7	8	8	9	10	11	12	> 12	> 12
140°	176°T	172°T	168°T	164°T	161°T	158°T	156°T	154°T	152°T	151°T	150°T	149°T
True Force	6	6	6	7	8	9	10	10	11	12	> 12	> 12

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
150°	177°T	174°T	171°T	168°T	165°T	163°T	162°T	160°T	159°T	158°T	157°T	156°T
True Force	6	6	7	7	8	9	10	10	11	12	> 12	> 12
160°	178°T	176°T	174°T	172°T	170°T	169°T	168°T	167°T	166°T	165°T	165°T	164°T
True Force	6	6	7	7	8	9	10	11	11	12	> 12	> 12
170°	179°T	178°T	177°T	176°T	175°T	174°T	174°T	174°T	173°T	173°T	172°T	172°T
True Force	6	6	7	7	8	9	10	11	11	12	> 12	> 12
180°	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T
True Force	6	6	7	8	8	9	10	11	11	> 12	> 12	> 12

Note:

“°T” = True direction of wind, degrees off bow

“True Force” = True force of wind, Beaufort scale

“Apparent force” = Apparent force of the wind, Beaufort Scale

“>” = Greater than

Table 5—7: True wind force and direction from a moving vessel — Speed = 25 kt

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
0°	180°T	180°T	180°T	180°T	180°T	180°T	0°T	0°T	0°T	0°T	0°T	0°T
True Force	6	5	4	4	2	1	2	4	5	6	8	9
10°	179°T	178°T	175°T	169°T	153°T	101°T	47°T	29°T	23°T	19°T	17°T	16°T
True Force	6	5	5	4	3	2	3	4	5	6	8	9
20°	178°T	175°T	170°T	160°T	138°T	104°T	70°T	52°T	43°T	37°T	33°T	31°T
True Force	6	5	5	4	3	3	4	4	6	7	8	9
30°	178°T	173°T	167°T	153°T	132°T	108°T	85°T	69°T	59°T	53°T	48°T	45°T
True Force	6	5	5	4	4	4	4	5	6	7	9	10
40°	177°T	171°T	164°T	150°T	131°T	121°T	95°T	82°T	73°T	66°T	61°T	58°T
True Force	6	5	5	5	4	5	5	6	7	8	9	10
50°	176°T	170°T	162°T	148°T	131°T	116°T	103°T	93°T	85°T	78°T	73°T	70°T
True Force	6	6	5	5	5	5	6	7	8	8	10	11
60°	176°T	169°T	161°T	148°T	133°T	121°T	110°T	102°T	95°T	89°T	84°T	81°T

Apparent direction of wind	Apparent force 1	Apparent force 2	Apparent force 3	Apparent force 4	Apparent force 5	Apparent force 6	Apparent force 7	Apparent force 8	Apparent force 9	Apparent force 10	Apparent force 11	Apparent force 12
True Force	6	6	6	6	6	6	7	7	8	9	10	11
70°	176°T	169°T	160°T	148°T	136°T	126°T	117°T	110°T	104°T	99°T	94°T	91°T
True Force	6	6	6	6	6	7	7	8	9	10	11	12
80°	176°T	169°T	161°T	150°T	139°T	131°T	123°T	117°T	112°T	108°T	104°T	101°T
True Force	6	6	6	6	7	7	8	9	9	10	11	12
90°	176°T	169°T	161°T	152°T	143°T	136°T	129°T	124°T	120°T	116°T	113°T	110°T
True Force	6	6	6	7	7	8	8	9	10	11	12	> 12
100°	176°T	170°T	163°T	154°T	146°T	141°T	135°T	131°T	127°T	124°T	121°T	118°T
True Force	6	6	7	7	8	8	9	10	10	11	12	> 12
110°	176°T	170°T	164°T	157°T	151°T	145°T	141°T	137°T	134°T	131°T	129°T	127°T
True Force	6	6	7	7	8	9	9	10	11	11	> 12	> 12
120°	176°T	171°T	166°T	160°T	155°T	150°T	147°T	144°T	141°T	139°T	136°T	135°T
True Force	6	7	7	8	8	9	10	10	11	12	> 12	> 12
130°	177°T	172°T	168°T	163°T	159°T	155°T	152°T	150°T	148°T	146°T	144°T	142°T
True Force	6	7	7	8	8	9	10	11	11	12	> 12	> 12
140°	177°T	174°T	170°T	166°T	163°T	160°T	158°T	156°T	154°T	153°T	151°T	150°T
True Force	6	7	7	8	9	9	10	11	12	> 12	> 12	> 12
150°	178°T	175°T	173°T	170°T	167°T	165°T	163°T	162°T	161°T	160°T	159°T	158°T
True Force	6	7	7	8	9	10	10	11	12	> 12	> 12	> 12
160°	178°T	177°T	175°T	173°T	171°T	170°T	169°T	168°T	167°T	166°T	166°T	165°T
True Force	6	7	7	8	9	10	10	11	12	> 12	> 12	> 12
170°	179°T	178°T	178°T	177°T	176°T	175°T	175°T	174°T	174°T	173°T	173°T	173°T
True Force	6	7	7	8	9	10	10	11	12	> 12	> 12	> 12
180°	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T	180°T
True Force	6	7	8	8	9	10	10	11	12	> 12	> 12	> 12

Note:

“°T” = True direction of wind, degrees off bow

“True Force” = True force of wind, Beaufort scale

“Apparent force” = Apparent force of the wind, Beaufort Scale

“>” = Greater than

5.2.5 Wind shifts

A wind shift is defined as a change in the direction of the wind of 45° or more, taking place in less than 15 min, and with a sustained speed of 10 kt or more after the wind shift.

Wind shifts are often associated with the passage of a cold front during which the following phenomena may be experienced:

- 1) Gusty winds shifting in a clockwise direction in the Northern hemisphere (e.g. southwest shifting to northwest) and counter-clockwise in the Southern hemisphere (e.g. northwest shifting to southwest)
- 2) rapid drop in dew point
- 3) drop in air temperature
- 4) rise in pressure
- 5) In summer: lightning, thunder, heavy rain showers, and possible hail
- 6) In winter: frequent rain or snow squalls with cloud heights changing rapidly

When a fast ship overtakes a slow-moving cold front, items (1), (2), (3), and (4) will occur in the reverse of the manner described. For example, the wind will shift counter-clockwise in the Northern hemisphere, and the dew point will rise rapidly. Items (5) and (6) may be encountered in the frontal zone. Wind shifts may also occur without precipitation.

Wind shifts should be noted in the Remarks column of the meteorological log giving the time (UTC) when the wind began to shift and the wind direction before and after the shift.

5.2.6 Squalls

A squall is defined as a sudden increase in wind speed by at least three stages of the Beaufort Scale (by 16 kt if facilities are available for measuring the wind speed), the speed rising to Force 6 (or 22 kt or more) and lasting for at least one minute then diminishing. Squalls are often associated with cold fronts. In such cases they occur in a line (the line of the front) and are accompanied in a typical case by a sharp fall in temperature, a veer of the wind, and a roll shaped cloud with a horizontal axis. These phenomena are collectively known as a line squall.

A squall by definition is a wind phenomenon, but may be accompanied by a rain shower. In the present weather code (symbol **ww**), a squall is reported by using code figure 18 (see Chapter 8). This code figure applies only if no precipitation has occurred with the squall. If precipitation (e.g. a rain shower) has occurred with the squall, then some code figure describing the precipitation should be used instead.

5.3 Recording wind information

When the wind is estimated, enter the two code figures for **dd** in Column 19. Enter the number of the Beaufort Force of the true wind in the upper shaded half of Column 20, and the corresponding speed in knots (**ff**) in the lower unshaded half of Column 20. No entries are to be made in Columns 14 to 17 if the wind is estimated.

When the wind is measured with an anemometer, Columns 14 to 17 must be completed as follows:

Column 14 — Enter the ship's course (true) at the time of the observation to three figures in the 0–360° system, e.g., **040**, **240**. Note that 360° = North. If the ship is hove, enter its heading in the same manner.

Column 15 — Enter (in knots) the ship's speed at the time of observation

Column 16 — Enter the direction of the apparent wind as read from the direction dial of the anemometer. Use the three figure 0–360° system (e.g., 020°, 170°, 330°).

Column 17 — Enter the speed of the apparent wind as read from the speed dial of the anemometer. The indicated speed is in knots.

When the true wind has been computed enter the code figures for **dd** in Column 19, and for **ff** in the lower unshaded half of Column 20. No entry is required for the upper shaded half of Column 20.

When the computed true wind speed equals or exceeds 99 kt, enter **99** in the lower half of Column 20 and enter the actual wind in Column 22.

Example: If the computed true wind speed was 110 kt, then the entry in Column 22 would be **110**.

5.3.1 Group **Nddff**

5.3.1.1 **N** — Total cloud amount

The symbol **N** indicates the amount of sky (celestial dome) covered by the clouds irrespective of type. The code specifications for **N** are given in Table 5—8. The code figure for **N** is to be entered in Column 18.

Table 5—8: WMO code table 2700 — Specification of code figure N

Code Figure	Oktas (eighths)	Tenths
0	0/8	0/10
1	1/8 or less, but not 0/8	1/10 or less, but not 0/10
2	2/8	2/10–3/10
3	3/8	4/10
4	4/8	5/10
5	5/8	6/10
6	6/8	7/10–8/10
7	7/8 or more, but not 8/8	9/10 or more, but not 10/10
8	8/8	10/10
9	Sky obscured by fog and/or other meteorological phenomena	Sky obscured by fog and/or other meteorological phenomena
/	Cloud cover is indiscernible for reasons other than fog or other meteorological phenomena, or observation is not made	Cloud cover is indiscernible for reasons other than fog or other meteorological phenomena, or observation is not made

5.3.1.2 dd — Mean wind direction

The symbol **dd** indicates the mean direction referred to true north from which the wind is blowing expressed in tens of degrees on a scale from 00 to 36. Code figures **00** are used when the wind is calm. Code **01** = N 10° E (010°), and so on in ten degree steps through **09** = East (090°), **18** = South (180°), **27** = West (270°), around to **36** = North (360°). **99** = Variable direction (not used when the wind speed is more than 5 kt).

5.3.1.3 ff — Mean wind speed

The symbol **ff** indicates the mean speed of the wind over the water surface directly in knots. When the wind is calm **ff** is coded **00**.

If the wind speed equals or exceeds 99 kt (which may occur in a hurricane) **ff** is coded **99** and the additional group **00fff** is added immediately following **Nddff**. The actual wind speed is then encoded as **fff**. For example a wind speed of 99 kt is encoded **Ndd99 00099**; a wind speed of 115 kt is encoded **Ndd99 00115**.

5.3.2 Special weather report — **SPREP**

A special weather report (**SPREP**) should be sent whenever:

- the mean wind speed doubles to 25 kt or more since the time of the previous main or intermediate synoptic hour; or
- the mean wind speed increases to 34 kt (gale force) or more and gale warnings are not in effect.

The observation and message format is the same as for the standard observation, except the word **SPREP** will immediately precede the ship's call sign.

5.3.2.1 Great Lakes **SPREP** criteria

A special weather report (**SPREP**) should be sent whenever the wind with a mean speed of 25 knots or more:

- increases in mean speed by 10 kt or more and is sustained for at least ten minutes; or
- changes direction by 90° or more and this change is sustained for at least 10 minutes.

The observation and message format is the same as for a standard observation except the word **SPREP** will immediately precede the ship's call sign.

5.3.3 Storm report — **STORM**

A **STORM** report should be sent whenever the mean wind speed increases to 48 kt or more.

Chapter 6 Temperatures

6.1 Introduction

Many kinds of temperature are found in the science of meteorology, but only four kinds are involved in ships' weather observations, and only three of these occur in the full weather message of a Selected Ship. These four temperatures are:

- The dry bulb temperature (reported by all ships)
- The wet bulb temperature (recorded, but not reported, by Selected Ships only)
- The dew point temperature (reported by Selected Ships only)
- The sea surface temperature (reported by Selected Ships only)

6.2 Observing the air temperatures

6.2.1 The marine screen

The dry bulb and wet bulb thermometers are mounted side by side in a specially designed marine screen as shown in Figure 6—1. The key feature of the screen, which is made of wood, is that the vertical walls are composed of louvers that protect the thermometers from direct radiation and precipitation, but allow a relatively free air flow to reach the thermometers. The screens are painted white to reflect radiation.



Figure 6—1: Marine screen

6.2.1.1 Position of the marine screen

The screen is attached to a mounting board by means of a dual tongue and staple arrangement. The mounting board is designed so that it can be clamped to an outside rail by means of U-bolts. The position of the screen requires great attention. It cannot be emphasized enough that the required temperature is taken from free air over the water surface and affected as little as possible by the heat from the ship. Therefore the screen should always be on the windward side of the ship so that the flow of air reaches it before passing over any other part of the ship. The screens are portable; hence if only one screen is issued, it may be necessary to move the screen from the starboard to the port mounting board, or vice versa, if the wind shifts or the ship alters course.

The ship is a source of local heat. Radiation takes place from the hull and from sunny decks, deck houses, etc., especially in the tropics. Radiation of heat, or warm draughts of air, may be felt from galleys, engine and boiler rooms, stoke hold and funnel. The thermometer screen should be located as far as possible from all such sources of local heating that will tend to cause false air temperatures, particularly on days when the relative wind is light. A position close to the bridge will avoid some of these heat sources.

6.2.2 Dry bulb thermometer

The dry bulb temperature, expressed in degrees Celsius, is a measure of the amount of heat in the air. If the heat content of the air is high, the dry bulb temperature will also be high, and if the air contains very little heat, the dry bulb temperature may be quite low. This is the temperature that is indicated by a standard thermometer when properly ventilated and shielded from the direct rays of the sun.

6.2.3 Wet bulb thermometer

The wet bulb temperature, expressed in degrees Celsius, is a measure of the amount of moisture, in the form of invisible water vapour, contained in the air. As the name implies it is measured by a standard thermometer whose bulb is covered by a muslin sleeve that has been moistened by pure water.

The principle of the wet bulb thermometer is as follows: water evaporates from the muslin cover passing into the air in the form of invisible water vapour, contained in the air. In so doing it absorbs heat from the thermometer bulb and the mercury it contains. The thermometer therefore indicates a lower temperature than that of the dry bulb thermometer. The difference between the readings of the dry and the wet thermometers is called the depression of the wet bulb.

If the air contains nearly all the moisture it can possibly hold, evaporation from the muslin will be slight and the depression of the wet bulb will be small. However, if the air is very dry, containing little moisture, evaporation will be quite rapid and the depression of the wet bulb will be quite large. In hot dry desert climates depressions of over 25 °C have been observed, but at sea the depression is seldom more than 5 °C. If the air contains all the moisture it can possibly hold, there is no evaporation from the muslin, and the dry and wet bulb thermometers will read the same. When this condition exists the air is said to be saturated.

Provided that the wet bulb is adequately moistened and given proper ventilation, its reading will always be equal to or less than that of the dry bulb when the air temperature is above freezing. Under certain conditions when the air temperature is below freezing and there is ice on the wet bulb, its reading may be slightly higher than the dry bulb. This is called a negative depression and usually occurs with fog or precipitation. Negative depressions are rare so if one is observed the observer should double-check to see if the muslin is properly iced, that there are no breaks in the mercury column, and that the thermometers have been adequately ventilated.

6.2.3.1 Operation of the wet bulb thermometer

The wet bulb thermometer requires careful attention to obtain correct readings. One end of a length of special rayon tubing is slipped around the bulb of the thermometer. The remainder of the tubing, which may be two feet or more in length, is immersed in the water container, so that it keeps the bulb moist by capillary action. The length of the tubing between the bulb and the opening of the water container should be as short as possible, to reduce evaporation from the tubing to a minimum.

6.2.3.2 Water supply

It is important that the water used in the water container be pure. Ordinary water contains substances in solution, and if such water is used these substances will be deposited on the tubing as it evaporates. The free flow of water to the bulb will be retarded and the wet bulb will then read higher than it should. Distilled water, which may be available from the ship's radio office is preferred. If distilled water cannot be obtained, condenser water from the engine room may be used.

6.2.3.3 Wet bulb below freezing

At temperatures below 0 °C, the water on the rayon tubing freezes, and therefore it becomes useless in conducting water to the bulb from the water container. Under these conditions the rayon tubing must be removed from the bulb, and replaced by a muslin sleeve. The muslin must then be given a thin coating of ice by wetting it with ice-cold water using a plastic squeeze bottle, or by immersing the bulb and muslin for a second in water. This should be done about half an hour before a reading is taken, to allow the water to freeze completely and the temperature to gradually fall to a true ice-bulb reading.

While the water is freezing on the muslin, the wet bulb thermometer usually remains steady at 0 °C, and then cools gradually to the true wet bulb readings when all the water is frozen. If, after wetting the muslin, the wet bulb reading falls directly with no pause at 0 °C, it is probable that the water has not frozen (i.e., the water is supercooled). Supercooled water on the wet bulb will result in an incorrect reading and cause serious errors in the dew point calculation. To make certain that the water on the wet bulb freezes, it is best to touch the muslin with a piece of ice, snow or other cold object to initiate freezing after the muslin is wetted.

Note: Do not allow too much ice to accumulate on the wet bulb, nor allow it to pile up around the top of the bulb on the edge of the muslin, this will result in incorrect readings. If it is noticed that ice is building up, immerse the wet bulb in a small container of warm water to reduce the ice. This should be done well before the reading is taken as noted above.

6.2.3.4 Changing the rayon tubing or muslin sleeve

The rayon tubing or muslin sleeve should be changed at least once a week, and more often if it becomes dirty or contaminated by salt spray. The presence of salt in the water will cause the thermometer to read too high, and if spray has reached the screen, the tubing or sleeve should be changed. To change the rayon tubing, cut the tubing off at the opening of the water container, pull out a few inches, and fit the end over the bulb, after first wiping the bulb clean. If it is required to be changed, the muslin sleeve should be entirely replaced.

6.2.4 Reading the thermometers

All thermometers must be read with care, as precise readings are necessary not only for general accuracy but also for practical reasons, e.g., the computation of the dew point temperature. When reading a thermometer, the eye should be at the same level as the end of the mercury column, otherwise there will be an error due to parallax.

The thermometers have scale markings for each half degree Celsius, the whole degree lines being slightly longer than the half degree lines. On Selected and Auxiliary Ships the readings should be estimated as far as possible to the nearest one tenth (0.1) of a degree Celsius (typical readings might be 22.0, 12.1, 5.2, -8.3, -15.4 °C). When temperatures are low (below 0 °C) it is especially important that precise readings be made, as a small error in either the dry bulb or wet bulb readings can cause a rather large error in the dew point.

6.2.4.1 Separated mercury column

Occasionally it will be found that the mercury column of the thermometer separates in one or more places. If there is a break in the column remove the thermometer from the screen (or from the rubber bucket if it is the sea thermometer) and swing it briskly downward at arm's length with the bulb end away from you, until the column is again continuous. If this fails to reunite the column, hold the thermometer vertical and tap the bulb end smartly on a surface that is not too hard, such as a book or note pad. If both of the above methods fail, immerse the bulb in a warm bath until the top of the mercury just reaches the small expansion chamber at the top of the capillary tube. The thermometer must be removed quickly however, as the expanding mercury will break the thermometer. If the mercury column cannot be reunited by any of the above methods, the thermometer should be stored away and returned to the Port Meteorological Officer.

6.2.5 Correction cards

Even high quality thermometers may not give correct readings at all temperatures, so each thermometer is calibrated at MSC Headquarters and a correction card is issued which shows the amount to be added or subtracted from the observed reading to obtain the true temperature. Before entering the dry and wet bulb readings in the log, apply the correction shown by the card to the observed readings.

Example (1):

$$\begin{aligned}\text{Dry bulb temperature as read} &= 24.2\text{ }^{\circ}\text{C} \\ \text{Correction at this temperature} &= +0.6\text{ }^{\circ}\text{C} \\ \text{Corrected dry bulb temperature} &= 24.8\text{ }^{\circ}\text{C}\end{aligned}$$

Example (2):

$$\begin{aligned}\text{Wet bulb temperature as read} &= 20.3\text{ }^{\circ}\text{C} \\ \text{Correction at this temperature} &= -0.4\text{ }^{\circ}\text{C} \\ \text{Corrected wet bulb temperature} &= 19.9\text{ }^{\circ}\text{C}\end{aligned}$$

6.2.6 Dew point temperature

The dew point temperature is a measure of the moisture content of the air. The dew point is the temperature at which air becomes saturated with water vapour if it is cooled without any addition or removal of water vapour. When air is cooled to its dew point temperature the water vapour contained in it begins to condense into visible water droplets. This is the reason why clouds or fog form, or the familiar sweat appears on cold water pipes and on the outside of cold beverage glasses. The dew point temperature is expressed in degrees Celsius. It is always equal to (if the air is saturated) or lower than the dry bulb temperature. The greater the spread between the dry bulb and the dew point the drier the air is.

6.2.6.1 Determining the dew point temperature

The dew point temperature is determined from a set of tables, as there is no simple kind of thermometer that will measure the dew point directly. The table on the back of the Selected Ships Code Card (Form 63–9407) may be used. This table lists values of the dew point temperature for specific values of the dry bulb temperature and depression of the wet bulb.

To find the dew point, first determine the depression of the wet bulb by subtracting the corrected wet bulb temperature from the corrected dry bulb temperature.

Example (1):

$$\begin{aligned}\text{Corrected dry bulb} &= 23.3\text{ }^{\circ}\text{C} \\ \text{Corrected wet bulb} &= 20.1\text{ }^{\circ}\text{C} \\ \text{Depression} &= 3.2\text{ }^{\circ}\text{C}\end{aligned}$$

Example (2):

Corrected dry bulb = -7.6°C

Corrected wet bulb = -8.2°C (*wet bulb should be frozen*)

Depression = 0.6°C

In the tables select the tabulated dry bulb that is nearest to the actual corrected dry bulb (if the actual dry bulb temperature is exactly halfway between two tabulated temperatures, use the higher tabulated temperature if above zero, and the cooler tabulated temperature if below zero). Then proceed to the right across this row to the column headed by the depression that is nearest to the actual depression (again, if the actual depression is exactly halfway between two tabulated depressions use the higher tabulated depression.) The figure at the intersection of this row and column will be the dew point temperature.

Table 6—1: Examples of dew point calculations

Corrected dry bulb $^{\circ}\text{C}$	Corrected wet bulb $^{\circ}\text{C}$	Depression $^{\circ}\text{C}$	Use tabulated dry bulb $^{\circ}\text{C}$	Use tabulated depression $^{\circ}\text{C}$	Dew point $^{\circ}\text{C}$
27.0	22.0	5.0	27	5.0	20
23.1	20.7	2.4	23	2.5	19
18.5	15.0	3.5	19	3.5	13
13.9	11.0	2.9	14	3.0	9
8.5	5.3	3.2	9	3.2	2
5.6	3.2	2.4	6	2.4	0
2.5	0.9	1.6	3	1.6	-1
0.2	-2.5	2.7	0	2.8	-8
-5.2	-6.7	1.5	-5	1.6	-11
-9.7	-10.8	1.1	-10	1.2	-17
-11.2	-11.1	-0.1	-11	-0.2	-12
-16.5	-16.3	-0.2	-17	-0.2	-18

Note: All calculations in Table 6—1 are rounded to the nearest integer.

6.2.7 The AES sling psychrometer

Although most ships will be equipped with marine screens, there may be a few ships that will continue to use the AES (Atmospheric Environment Service) sling psychrometer as the temperature measuring device, for economical or practical reasons. The following instructions are provided for those ships using the AES sling psychrometer.

The AES sling psychrometer consists of two standard thermometers mounted side by side on a frame attached to a handle so that it can be whirled to provide adequate ventilation for the thermometers. The instrument is issued complete with the two standard thermometers to Selected Ships. On Auxiliary Ships, only the dry bulb thermometer is required, so one thermometer is removed from the sling and used as a spare.

6.2.7.1 Preparing the wet bulb for the sling psychrometer

A clean muslin sleeve is placed over the bulb of the thermometer nearest the handle of the sling. This will be the wet bulb thermometer. Immediately before operating the psychrometer, moisten the muslin thoroughly on all sides with the purest water available. Distilled water is preferred, but if this cannot be obtained, water from the condenser may be used.

6.2.7.2 Operating the sling psychrometer

The position of the observer on the ship when making the temperature observation is most important. It cannot be too strongly emphasized that it is the temperature of the free air that is required, and not of that affected by heat from the ship. The most suitable position is on the windward side of the ship where the air will come directly to the observer from the sea before passing over any part of the ship. The observer should also keep clear of local sources of heat on the ship such as engine and boiler room ventilators, funnel, or even warm decks heated by the sun. A position on the bridge will avoid most of these sources of heating and is also convenient.

With the wet bulb adequately moistened, whirl the psychrometer at a rate of about four revolutions per second. Stand clear of obstructions while whirling. The psychrometer should also be shielded from the direct rays of the sun if possible, and also from precipitation and spray. Whirl for about one minute then read the thermometers immediately, starting first with the wet bulb. Whirl again for another ten seconds and read the thermometers again. If the readings are unchanged from the first time, record these as the official temperatures. If the readings are different at the second reading, continue the whirling and reading until two successive sets of readings are the same.

6.2.7.3 Reading the sling psychrometer

The thermometers should be read with care. As stated before they should be read immediately after the whirling is stopped and should be shielded from direct solar radiation while being read. Never grasp the thermometer by the bulb end, as the heat from the hand will cause the readings to increase very rapidly. When reading a thermometer make sure that the line of sight from the eye to the end of the mercury column makes an angle of 90° with the thermometer, otherwise there will be an error due to parallax. The thermometers have scale markings for each half degree Celsius, the whole degrees lines being slightly longer than the half degree lines. On Selected and Auxiliary Ships the readings should be estimated as far as possible to the nearest one tenth (0.1) of a degree Celsius. Thus typical readings might be 22.0, 12.1, 5.2, -8.3, -15.4. When temperatures are low (below 0°C) it is especially important that precise readings be made, as a small error in either the dry bulb or wet bulb reading can cause a large error in the dew point.

6.3 Recording dry bulb temperature information

6.3.1 Group **1** s_n **TTT**

6.3.1.1 **1** — Numerical indicator figure

The figure **1** represents the group indicator and is always entered in Column 23.

6.3.1.2 s_n — Indicator of whether temperatures are positive or negative

The symbol s_n is to indicate whether reported temperatures are positive or negative. It is coded as follows in Column 24:

- $s_n = 0$ — temperature is 0 °C, or positive (above 0 °C)
- $s_n = 1$ — temperature is negative (below 0 °C)

6.3.1.3 **TTT** — Dry Bulb temperature

The symbol **TTT** is used to indicate the dry bulb temperature and is coded in Column 25. In the case of Selected and Auxiliary Ships **TTT** represents the dry bulb temperature in degrees and tenths of a degree Celsius. To illustrate how **TTT** is coded for various temperatures the following examples with the corresponding coding of s_n are given:

24.8 °C — **TTT** = **248** and $s_n = 0$

8.1 °C — **TTT** = **081** and $s_n = 0$

0.6 °C — **TTT** = **006** and $s_n = 0$

0.0 °C — **TTT** = **000** and $s_n = 0$

-0.7 °C — **TTT** = **000** and $s_n = 1$

-4.2 °C — **TTT** = **042** and $s_n = 1$

-15.5 °C — **TTT** = **155** and $s_n = 1$

6.4 Recording dew point temperature information

6.4.1 Group $2s_nT_dT_dT_d$

6.4.1.1 2 — Numerical indicator figure

The figure 2 indicates that figure group $s_nT_dT_dT_d$ is being included in the report. This figure is always entered in Column 26.

6.4.1.2 s_n — Indicator of whether temperatures are positive or negative

The symbol s_n indicates whether temperatures are positive or negative. It is coded as follows:

- $s_n = 0$ — Temperature is 0 °C, or positive (above 0 °C)
- $s_n = 1$ — Temperature is negative (below 0 °C)

6.4.1.3 $T_dT_dT_d$ — Dew point temperature

The symbol $T_dT_dT_d$ indicates the dew point temperature. Since this symbol makes provision for three figures, it is possible to report the dew point to the nearest tenth of a degree. This degree of precision is not practical on board ship, as extremely accurate dry and wet bulb temperatures, and also greatly expanded psychrometric tables would be required. Therefore the dew point is reported in whole degrees only. Since the tenths value is not available, the third code in $T_dT_dT_d$ is entered as /. The code figure for $T_dT_dT_d$ is to be entered in Column 28 of the meteorological log.

Note: Only Selected Ships report the dew point temperature.

Some dew point coding examples are given below:

21 °C — $T_dT_dT_d = 21/$ and $s_n = 0$

4 °C — $T_dT_dT_d = 04/$ and $s_n = 0$

0 °C — $T_dT_dT_d = 00/$ and $s_n = 0$

-9 °C — $T_dT_dT_d = 09/$ and $s_n = 1$

-25 °C — $T_dT_dT_d = 25/$ and $s_n = 1$

6.5 Recording wet bulb temperature information

6.5.1 Group $8s_wT_bT_bT_b$

6.5.1.1 8 — Numerical indicator figure

The figure 8 represents the group identifier and is always entered in Column 67.

6.5.1.2 s_w — Sign and type of wet bulb temperature

The symbol s_w indicates the sign and type of wet bulb temperature reported. Table 6—2 specifies code figures for the sign and type of wet-bulb temperature reported. The appropriate code figure for s_w is to be entered in Column 68 on the meteorological log.

Table 6—2: WMO code table 3855 — Specification of code figure s_w

Code figure	Specification
0	Positive or zero measured wet-bulb temperature
1	Negative measured wet-bulb temperature
2	Iced bulb measured wet-bulb temperature
3	Not used
4	Not used
5	Positive or zero computed wet-bulb temperature
6	Negative computed wet-bulb temperature
7	Iced bulb computed wet-bulb temperature

6.5.1.3 $T_bT_bT_b$ — Wet bulb temperature

The symbol $T_bT_bT_b$ represents the wet bulb temperature value in degrees and tenths. Code figures for wet bulb temperature are to be entered in Column 69.

Note: The Wet Bulb Temperature is recorded but not reported by Selected Ships only.

6.6 Observing the sea surface temperature

The sea surface temperature is the temperature of the water in the surface layer of the sea expressed in degrees Celsius. The preferred method of measuring the sea surface temperature is by means of a special sea temperature bucket lowered into the water over the side of the ship. If this method is not practical the sea surface temperature may be obtained from the thermometer located in the engine room intake pipe of the ship.

6.6.1 The sea temperature bucket

The preferred method of measuring the sea surface temperature is by means of a sea temperature bucket that is illustrated in Figure 6—2 and Figure 6—3. The bucket consists of two rubber cylinders, one inside the other. In the older model of the bucket, an armored thermometer is wedged inside the inner cylinder. Water enters the inner cylinder at the top, flows past the thermometer, and leaves the inner cylinder through openings at its base. The water then passes upward between the cylinders and leaves the bucket through the circular holes that can be seen near the top of the bucket. Thus there is a continual flow of water past the thermometer when the bucket is in use. The newer model of the bucket does not contain a thermometer. The sea temperature is measured by immersing the thermometer into the bucket sample after it is hauled aboard.

If the thermometer of the older bucket breaks, remove the six screws at the base of the bucket and take out the wooden plug. Remove the brass sheath containing the broken thermometer through the bottom of the bucket (it cannot be removed from the top). Insert a new sheath and thermometer, and replace the plug and screws. Return the broken thermometer in its sheath to a Port Meteorological Officer.



Figure 6—2: The sea temperature bucket and thermometer



Figure 6—3: Removing and replacing the thermometer from the sea temperature bucket

6.6.1.1 Handling the bucket

In the case of the older model of bucket, attach an appropriate length of $\frac{1}{4}$ in. rope to the brass bridle at the top of the bucket. When making the observation it is better to cast the bucket from the lowest deck so that the threat of breaking the thermometer will be reduced to a minimum. Lower the bucket over the side of the ship until it is almost touching the water; swing the bucket backward and forward in a large arc, letting it enter the water at the forward extremity of the swing. Haul the bucket out of the water as soon as the rope returns to the vertical — do not allow the bucket to drag through the water as the rapid in-rush of water and lateral shocks caused by skipping may break the thermometer. It is especially desirable to take this precaution when the ship's speed is in excess of ten knots or in heavy seas. Immerse the bucket three or four times in the above manner to ensure that the thermometer and the bucket itself assumes the same temperature as the water. If there seems to be a great difference between sea and air temperature (as in winter when the air may be far below freezing but the water is well above freezing) six or more immersions may be required. Finally, haul the bucket aboard being careful not to let it strike the side of the ship as the severe lateral shocks will break the thermometer. Read the thermometer immediately.

6.6.1.2 Reading the sea thermometer

When the bucket is hauled aboard it will still be filled with water. Do not empty it yet. Pull the thermometer out as far as it will come and read it. The thermometer is of the magnifying type, so turn it until the mercury column appears as wide as possible. The thermometer has scale markings for every half of a degree Celsius. The readings should be estimated as far as possible to the nearest one tenth (0.1) of a degree Celsius. Thus typical readings might be 15.1, 7.3, 0.4. When the reading has been taken empty the bucket and push the thermometer back in.

If you are using the newer model bucket that does not contain the thermometer as an integral part, draw a sample of sea water more or less according to the instructions given above. Make sure the bucket has been immersed long enough for it to take on the same temperature as the water. Haul the sample aboard and insert the thermometer into the bucket as quickly as possible. When the top of the mercury column comes to rest (the thermometer is then at the same temperature as the sample) take a reading. The thermometer should then be stored in a safe and convenient place.

6.6.2 Correction cards

A correction card is issued with each sea thermometer, as very few instruments read correctly at all temperatures. Referring to the card for the specific thermometer in use apply the correction that is indicated for the observed temperature to obtain the true or corrected temperature.

6.6.3 Engine room intake temperature

The sea temperature can be obtained by reading the thermometer located in the main engine room intake pipe of the ship. However this method is not recommended for the following reasons:

- Engine room intake openings may be as much as 3 m (10 ft) or more below the water line. For meteorological purposes it is the temperature of the surface water that is wanted and not at a depth of several metres. The difference may be slight if the sea is not smooth, but in calm weather there may be an appreciable change in water temperature with depth.
- If the thermometer is inserted into the pipe at some distance from the opening, the sea water may absorb heat from the interior of the engine room, and so raise the temperature
- Intake thermometers are not Meteorological Service of Canada instruments so their accuracy is unknown.
- Intake thermometers are usually graduated every two degrees Fahrenheit only, making it very difficult to estimate temperature any closer than to whole degrees. In addition the thermometer is sometimes relatively inaccessible in the engine room and an error may result due to the difficulty in reading.

When the sea is rough, or in large fast vessels, it is not always practicable to use the bucket method however, and in such cases an engine room intake reading is acceptable if the thermometer is read carefully. If the intake reading is measured in degrees Fahrenheit, change this temperature to degrees Celsius. It is also advisable to have the instrument verified by a Port Meteorological Officer.

At the top of the right hand page of the meteorological log, always indicate the method used in taking the sea temperature.

6.7 Recording sea surface temperature information

6.7.1 Group $0s_sT_wT_wT_w$

6.7.1.1 0 — Numerical indicator figure

The figure 0 indicates that the figure group $s_sT_wT_wT_w$ is being included in the report. This figure is recorded in Column 48 on the meteorological log.

6.7.1.2 s_s — Sign and type of sea surface temperature

The symbol s_s indicates the sign and type of sea surface temperature measurement. Table 6—3 specifies code figures for the sign and type of sea surface temperature measurement. The appropriate code figure for s_s is to be entered in Column 49 on the meteorological log.

Table 6—3: WMO code table 3850 — Specification of code figure s_s

Code figure	Sign	Type of measurement
0	Positive or 0	Intake
1	Negative	Intake
2	Positive or 0	Bucket
3	Negative	Bucket
4	Positive or 0	Hull contact sensor
5	Negative	Hull contact sensor
6	Positive or 0	Other
7	Negative	Other

6.7.1.3 $T_wT_wT_w$ — Sea surface temperature

$T_wT_wT_w$ — This symbol represents the actual sea surface temperature in degrees and tenths of a degree Celsius and is recorded in Column 50.

Note: Selected and Great Lakes Ships should report this data on the meteorological log; Auxiliary Ships are not required to report this data.

For example, when sea surface temperature is:

19.4 °C — $T_wT_wT_w = 194$

4.2 °C — $T_wT_wT_w = 042$

0.8 °C — $T_wT_wT_w = 008$

-0.9 °C — $T_wT_wT_w = 009$

-1.4 °C — $T_wT_wT_w = 014$

Note: Water temperatures on the Great Lakes and most of the St. Lawrence River will not fall below 0 °C. Hence if a negative reading is obtained, it is an indication that the thermometer is inaccurate. In the lower St. Lawrence estuary and the Gulf, the water temperature may fall slightly below 0 °C but never lower than about -1.5 °C.

Chapter 7 Pressure

7.1 Introduction

Atmospheric pressure results from the fact that under specified conditions, a given volume of air has a definite weight. The atmospheric pressure at sea level is actually the weight of a vertical column of air of unit cross section, extending from sea level to the outermost extremities of the earth's atmosphere. If the cross sectional area of this column is one square inch, its weight will be about 15 pounds. We say then that the sea level pressure is about 15 pounds per square inch. In meteorology today, pressure is not expressed in pounds per square inch, but in a unit known as a *hectopascal* (hPa) which is the same as the old term millibar. One hectopascal is a pressure of 1000 dynes per square centimetre, where the dyne is a metric unit of force. Expressed in hectopascals, the pressure of the atmosphere at sea level is about 1000 hPa, but may vary from about 960 hPa to 1050 hPa.

7.2 Measurement of pressure — Barometer

Pressure is measured by means of a barometer, of which there are two types in general use — the mercury barometer and the aneroid barometer. The mercury barometer is highly accurate and retains its accuracy over long periods of time. However, the mercury barometer is slightly more difficult to read than the aneroid, and at least three corrections must be applied to the readings. The aneroid barometer is easy to read, and requires that only one correction be applied to its readings. Aneroids usually do not retain their accuracy for long periods however and should be checked against a standard barometer at least once every three months. Selected Ships are normally issued with a precision aneroid barometer because of its greater accuracy. Auxiliary Ships normally use the ship's own barometer, but a precision instrument may be issued in certain circumstances.

7.2.1 The mercury barometer

Although mercury barometers are not used to measure the pressure on Canadian weather reporting vessels, a brief account of this instrument will be given here for the sake of completeness. In its simplest form a mercury barometer is made by completely filling with mercury a glass tube about one metre long and closed at one end. The open end of the tube is then immersed in a small cistern also containing mercury, and the tube is held upright. The mercury in the tube falls, leaving a vacuum at the top of the tube, until the weight of the mercury column just balances the atmospheric pressure exerted on the free surface of the mercury in the cistern. The length of the mercury column rises or falls as the atmospheric pressure increases or decreases. The pressure is then directly proportional to the length of the mercury column (in the past pressure was measured in units of length, e.g. 750.1 mm of mercury, or 29.53 in. of mercury). The measuring scales of most mercury barometers are graduated in millibars (or hPa) which are true units of pressure.

7.2.1.1 Corrections to mercury barometers

For a given sea level pressure, the length of the mercury column is not constant, but varies to some extent according to the temperature of the mercury, the height of the instrument above sea level, and the latitude. In order that the barometer readings all over the world may be compared, it is necessary to adjust the readings so that they will be related to standard conditions of temperature, latitude and altitude. The following corrections must therefore be applied.

7.2.1.1.1 Temperature correction

Mercury expands as its temperature increases, and contracts as its temperature decreases, so that the same atmospheric pressure is balanced by a longer column when the mercury is warm, and a shorter column when the mercury is cold. A correction is applied to obtain the reading which the barometer would show at standard temperatures of 12 °C or 0 °C depending on whether the barometer was made before or after 1954. A universal formula for the temperature correction cannot be given as the amount of the correction depends on the design of the instrument.

7.2.1.1.2 Latitude correction

The force of gravity is least at the equator because the earth's surface in this region is farthest from the earth's center of gravity, and also because the vertical component of the centrifugal force due to the earth's rotation is greatest here. The force of gravity is greatest at the poles as they are closest to the earth's center of gravity and the vertical centrifugal force is zero. In low latitudes the mercury in the barometer will actually weigh less than in higher latitudes, and will require a greater length of the mercury column to balance a given pressure. This effect is not desirable, so all readings are corrected to what they would be within the standard latitude of 45° (North or South). The correction is subtracted in latitudes less than 45°, and added in latitudes greater than 45°. To a high degree of accuracy, the latitude correction is given by the formula:

$$C = -0.00259p \cos 2\theta$$

where:

C = correction in hPa

p = observed pressure in hPa

θ = latitude

The correction does not change greatly with pressure, so an average pressure of 1000 hPa can be assumed. An approximate formula for the latitude correction is then:

$$C = -5 / 2 \cos 2\theta$$

7.2.1.1.3 Sea level correction

The pressure at any level is the weight of the vertical column of air of unit cross section above the given level. Hence the pressure will be greater at sea level than say at the top of a nearby lighthouse, where a certain weight of the air is below the observer and cannot contribute to the pressure recorded by his instrument. Pressure cannot be compared therefore, unless a correction is applied to obtain the pressure which the instrument would indicate if it were located at a standard level in the atmosphere. This standard level is sea level, and the correction is called the sea level correction. Its value depends of course on the altitude of the barometer above sea level, and also the temperature of the outside air. Since the pressure is greater at sea level than at any higher level, this correction is always added. Table 7—1 lists the values of sea level correction for various values of height above sea level, and air temperature. For example the correction to be added when the height of the barometer is 12.2 m (40 ft) above the sea surface and the outside temperature is 20 °C, is 1.4 hPa.

Table 7—1: Correction of pressure in millibars to mean sea level for outside air temperatures from -20 °C to 30 °C

Height of barometer (metres)	Height of barometer (feet)	-20 °C	-10 °C	0 °C	10 °C	20 °C	30 °C
1.5	5	0.2	0.2	0.2	0.2	0.2	0.2
3.0	10	0.4	0.4	0.4	0.4	0.4	0.3
4.6	15	0.6	0.6	0.6	0.6	0.5	0.5
6.1	20	0.8	0.8	0.8	0.7	0.7	0.7
7.6	25	1.0	1.0	1.0	0.9	0.9	0.9
9.1	30	1.2	1.2	1.2	1.1	1.1	1.0
10.7	35	1.5	1.4	1.4	1.3	1.3	1.2
12.2	40	1.7	1.6	1.5	1.5	1.4	1.4
13.7	45	1.9	1.8	1.7	1.7	1.6	1.6
15.2	50	2.1	2.0	1.9	1.9	1.8	1.7
16.8	55	2.3	2.2	2.1	2.0	2.0	1.9
18.3	60	2.5	2.4	2.3	2.2	2.2	2.1
19.8	65	2.7	2.6	2.5	2.4	2.3	2.3
21.3	70	2.9	2.8	2.7	2.6	2.5	2.4
22.9	75	3.1	3.0	2.9	2.8	2.7	2.6
24.4	80	3.3	3.2	3.1	3.0	2.9	2.8
25.9	85	3.5	3.4	3.3	3.2	3.1	3.0
27.4	90	3.8	3.6	3.5	3.4	3.2	3.1
29.0	95	4.0	3.8	3.7	3.5	3.4	3.3
30.5	100	4.2	4.0	3.9	3.7	3.6	3.5

In addition to the temperature, latitude, and sea level corrections, it is usually necessary to apply another small *index correction* which is brought about by differing values of the capillarity of mercury and other effects. The index correction may vary slowly with time. It can be determined by comparing the ship's barometer with a standard instrument.

As an example of how the corrections are applied in a typical case, suppose the mercury barometer reads 1024.2 hPa in latitude 23° N, at a height of 12.5 m (41 ft) above sea level. The outside air temperature is 26 °C, and the index correction is -0.2 hPa.

Uncorrected reading = 1024.2 hPa

Index correction = -0.2 hPa

= 1024.0 hPa

Temperature correction = -2.3 hPa (obtained from tables prepared for instrument)

= 1021.7 hPa

Latitude correction = -1.8 hPa

= 1019.9 hPa

Sea level correction = +1.4 hPa (see Table 7— 1)

Corrected barometer reading = 1021.3 hPa

If the barometer is equipped with a *Gold Scale*, the determination of the total correction is quite simple. The Gold Scale uses a kind of slide-rule which enables the corrections to be applied mechanically and dispenses with the use of tables.

7.2.2 The aneroid barometer

The principle by which the aneroid barometer functions is the balancing of atmospheric pressure by the elasticity of metal. The fundamental part of the instrument consists of a small circular capsule or bellows which has been partially exhausted of air and hermetically sealed. As the atmospheric pressure rises, the ends of the bellows are squeezed inwards under the increased pressure. Conversely, as the pressure falls, the ends of the bellows expand due to the decreased pressure. By means of a system of levers and springs the movement of these ends causes a pointer to rotate over a graduated dial. Hence the pressure can be read directly

Aneroid barometers have the advantage of being relatively easy to read, and require no corrections for change in temperature or latitude. The instruments are compensated for temperature changes by leaving a calculated amount of air in the metal box or by means of a bimetallic lever. The principal of the instrument does not involve the force of gravity, so latitude corrections are not necessary. In general however the aneroid does not retain its accuracy over as long a period as the mercury barometer. It is therefore necessary to compare its readings with a standard barometer at fairly frequent intervals (at least once every three months is recommended), to ensure that changes in the elasticity of the metal have not altered its readings.

7.2.2.1 The Belfort aneroid barometer

The standard pressure measuring instrument which is issued to Canadian Selected Ships is the Belfort aneroid barometer (shown in Figure 7—1). The Belfort is a precision instrument which has been found to retain its accuracy over a relatively long period. It is of robust construction and is well suited to use on shipboard.



Figure 7—1: The Belfort aneroid barometer

7.2.2.1.1 Mounting the Belfort aneroid barometer

The Belfort aneroid should always be mounted in a vertical position by screwing it to a bulkhead, through an anti-vibration mounting ring, if necessary. It should never be mounted horizontally. The height of the barometer above the deck should be the mean height of the eyes of the observers who will be using it. It is better to mount the instrument slightly too low than too high.

On Selected Ships the barometer is adjusted to read the actual atmospheric pressure at the level of the instrument. On Auxiliary Ships the barometer is adjusted to read the approximate sea level pressure.

7.2.2.1.2 Reading the Belfort aneroid barometer

Before taking a reading, tap the face of the barometer gently with the finger to release any static friction in the bearings.

When reading the barometer the line of sight from the eye to the end of the pointer should be perpendicular to the face of the barometer, otherwise there may be an error in the reading due to parallax. You will notice that there is a mirror in the form of a narrow ring on the barometer face just inside the hectopascal scale. When making a reading move the eye so that the pointer hides its reflection in the mirror. The line of sight will then be perpendicular to the face and the parallax error will be minimized. Read the indicated pressure, estimating to the nearest tenth of a hectopascal.

7.2.2.2 Corrections to aneroid barometers

If the barometer is properly adjusted, only two corrections are necessary to obtain the sea level pressure — a scale correction and a sea level correction.

7.2.2.2.1 Scale correction

As stated previously aneroid barometers do not retain their accuracy over as long a period as mercury barometers. In the course of time, the pressure indicated by the aneroid may depart from the true value to some degree. Therefore, Canadian Port Meteorological Officers compare the aneroid with a portable standard barometer at every opportunity, and determine the correction which must be applied to the readings. This is the Scale Correction. It is entered on the Barometer Tag (Form 63–2237) which is then affixed to the aneroid for future reference.

7.2.2.2.2 Sea level correction

The correction is exactly the same as for the mercury barometer, and is applied for the same reason — to reduce the barometer reading to the standard reference level, which is mean sea level. This correction varies slightly with temperature and also with the loading of the ship. It can be obtained from Table 7—1.

Note: Most Auxiliary Ships need not use the sea level correction as their barometers are adjusted to read the approximate sea level pressure directly.

To illustrate the method of applying these two corrections consider the following two examples:

Example (1): The barometer as read is 1002.3 hPa; the scale correction is +0.2 hPa; the height of the barometer is 13.7 m (45 ft); and the outside air temperature is 22 °C.

Barometer as read = 1002.3 hPa

Scale Correction = +0.2 hPa

= 1002.5 hPa

Sea Level Correction = +1.6 hPa (from Table 7— 1)

Sea Level Pressure = 1004.1 hPa

Example (2): The barometer as read is 992.7 hPa; the scale correction is -0.3 hPa; the height of the barometer is 6.1 m (20 ft); and the outside air temperature is -5 °C.

Barometer as read = 992.7 hPa

Scale correction = -0.3 hPa

= 992.4 hPa

Sea Level Correction = +0.8 hPa (from Table 7— 1)

Sea Level Pressure = 993.2 hPa

7.3 Measurement of variations in pressure — Barograph

A barograph is an instrument which measures and provides a continuous record of the variations in the atmospheric pressure. A barograph is issued to Selected Ships only, and it is used to measure the *pressure tendency* which is one of the elements included in the weather message from Selected Ships. Pressure tendency is a graphic description of the trace of the pressure recorded for the last three hours on the barograph.

The barograph is constructed exactly on the same principle as the aneroid barometer. The movements of the ends of an evacuated metal bellows under changing pressure are transmitted through a system of levers to an arm on the end of which is a fiber-tipped, self-inking pen. A chart on which the pen writes is fastened around a circular drum which rotates by means of clock-work once in approximately three days. The chart, called a *barogram*, thus provides a continuous record of the atmospheric pressure over a three day period.

The standard barograph now issued to Canadian Selected Ships is the AES (Atmospheric Environment Service) Type B Marine Barograph illustrated in Figure 7—2. This is a precision instrument which has been especially adapted for use on shipboard. In rough weather at sea, high winds and the up and down motion of the ship would cause the pen arm to oscillate vertically. Thus instead of the trace being a fine line, it is a ribbon of appreciable width. To overcome this effect the Type B barograph has been fitted with a damping device which consists of a dashpot and piston arrangement attached to the leverage system. The piston moves in a special oil inside the dashpot and resists short-period oscillations, thus damping them out like a shock absorber. A much finer trace on the chart is obtained during periods of rough weather.

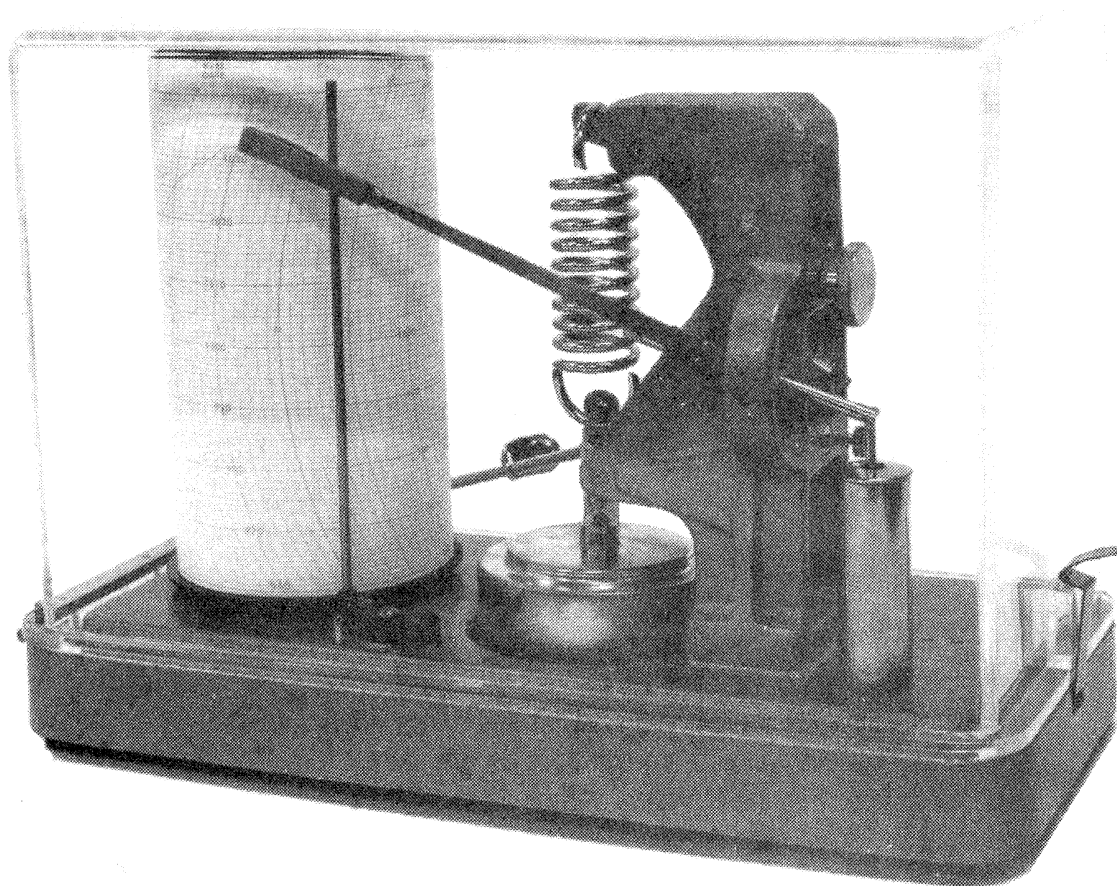


Figure 7—2: The marine barograph

7.3.1 Mounting the barograph

The barograph is placed on a mounting tray which has been firmly fastened to the chart room table or specially constructed shelf. A wooden tray, complete with four foam rubber pads, is supplied with the instrument. The purpose of the foam rubber padding is to absorb vibration. The plastic cover of the barograph on older models, must be supported when open; otherwise the cover places an undue strain on the hinges and may even topple the instrument from a shelf or table causing damage. The drawer of the AES instrument shelf, can be pulled out to support the plastic cover.

Note: Always mount the barograph athwartships so that the pen will be less likely to swing off the chart when the ship is rolling.

7.3.2 Operation of the barograph

7.3.2.1 Clock winding

The barograph clock drum is directly driven and the clock drum revolves slightly less than one revolution for each chart changing (slightly less than two half turns on the winding key will compensate for this clock drum rotation). Any winding slightly more or less than this will eventually cause over winding or under winding, however the change in tension of the winding key will be readily apparent before these extremes are reached. In view of the above, the following rules should be observed when winding the clock:

- The clock should be wound two half turns each time the chart is changed (one revolution of the drum) If the clock has stopped, as might occur when the ship is in port for extended periods, give about seven half turns to resume operation.
- If the clock eventually becomes over wound or under wound, as indicated by tension on the winding key, the winding should be omitted or two extra half turns given as may be necessary.
- The clock should never be tightly wound.

Observance of the above rules will result in the clock operating only in the central part of its range where its operation is optimum.

7.3.2.2 Changing the barograph chart

The barograph chart, Form 63-9611, is illustrated in Figure 7—3 with specimen entries and a typical trace.

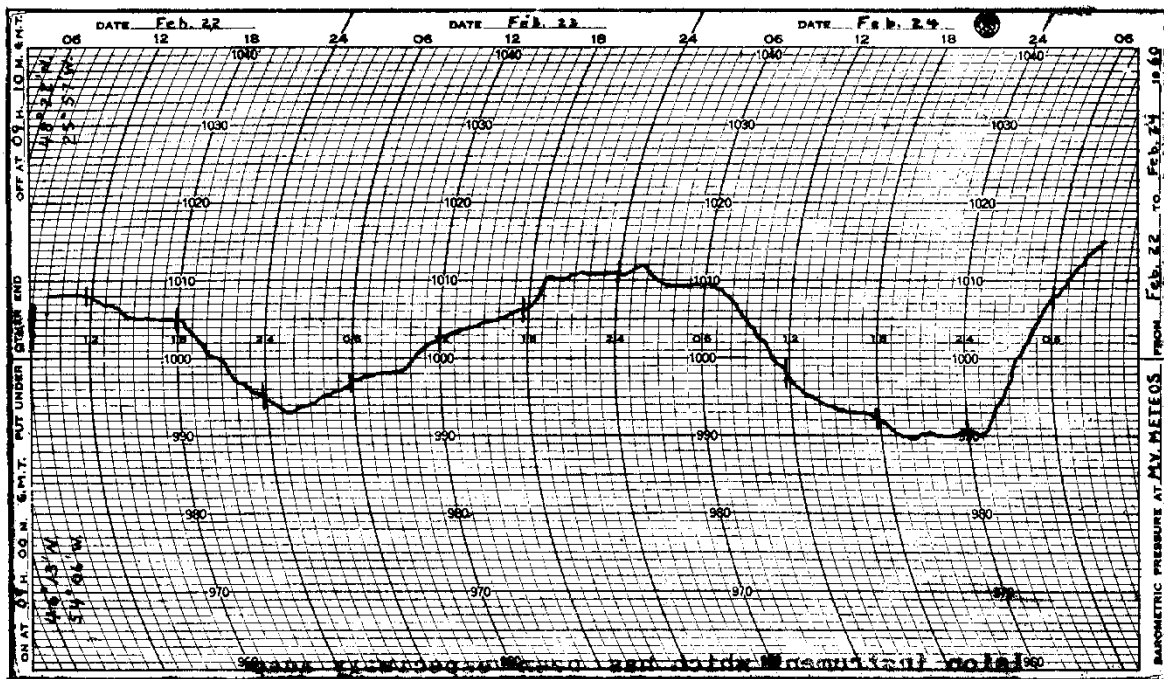


Figure 7—3: Barograph chart — Form 63-9611

When changing charts the following procedure is recommended:

- 1) Write all pertinent data on the new chart including time on (UTC) with position, dates, name of ship, and dates covered by the record
- 2) Raise the plastic cover and lift the pen from the old chart by means of the pen lifter.
- 3) Remove the knurled nut and lift the drum from the clock.
- 4) Wind the clock.
- 5) Wrap the new chart around the drum so that the outer end of the overlap points in the direction of motion of the pen relative to the drum (this will ensure that the pen will not catch on the edge of the chart if allowed to override). Make sure that the bottom edge of the chart is everywhere touching the flange on the drum, and that the chart overlap is directly above the chart retainer hole in the flange.
- 6) Clamp the chart in position with the chart retainer and replace the drum on the clock.
- 7) Start the locking nut on the spindle but do not turn it down tightly. There is no backlash.
The clockworks may be damaged if the drum is rotated after the nut is tightened.
Bring the pen toward the chart until it is almost touching the paper; turn the drum until the correct time (UTC) is under the pen; then tighten the lock nut to ordinary thumb and finger tightness — very little pressure is required. If any adjustment is needed loosen the nut first.

7.3.2.3 The marks

At observation time read the pressure as indicated by the pen and then time mark the chart. This is done by pushing gently on a stud on the right hand end of the barograph. This stud is behind the dashpot and about level with the top of the pot.

7.3.2.4 Barograph pens

Disposable nylon-tipped pens with a self-contained supply of ink, are now in general use. These pens draw out a thin trace which makes it easier to determine the characteristic and amount of the tendency. Sometimes however the trace is too faint. If this is the case simply stroke the tip of the pen lightly on fine sand paper two or three times. After about a year, more or less, the ink supply will dry up, and the pen is then to be discarded.

7.4 Recording pressure information

In the case of Selected Ships pressure data is to be entered in Columns 29 and 30 of the meteorological log. In Column 29 enter the pressure as it is read from the barometer. The corrections that are applied to this reading are entered in Column 30. In the upper half of the space in this column enter the scale correction and in the lower half enter the sea level correction.

7.4.1 Group 4PPPP

7.4.1.1 4 — Numerical indicator figure

The figure 4 indicates that figure group PPPP is being included in the report. This figure is to be entered in Column 31 of the meteorological log.

7.4.1.2 PPPP — Sea level pressure

The symbol PPPP indicates the sea level pressure in hectopascals and tenths with the initial 1 omitted when the pressure is 1000 hPa or more. The appropriate code figure for PPPP is to be entered in Column 32 on the meteorological log.

Note: Selected and Auxiliary Ships report code figures for PPPP.

The following sea level pressure examples illustrate how PPPP is coded:

1034.9 hPa — PPPP = 0349

1001.4 hPa — PPPP = 0014

1000.0 hPa — PPPP = 0000

998.2 hPa — PPPP = 9982

971.1 hPa — PPPP = 9711

7.4.2 Group 5appp

7.4.2.1 5 — Numerical indicator figure




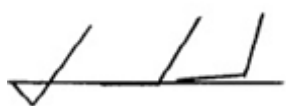

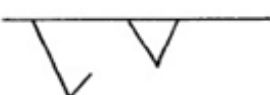
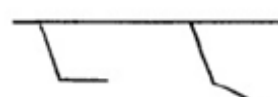
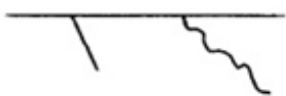

The figure 5 indicates that figure group appp is being included in the report. This figure is to be entered in Column 33 of the meteorological log.

7.4.2.2 a — Characteristic of the tendency

The symbol a indicates, by means of a code figure from 0–8, the characteristic of the tendency during the three hours preceding the time of observation. Table 7—2 gives graphic and word descriptions of the traces which are represented by each code figure. The appropriate code figure for a is to be entered in Column 34 on the meteorological log.

Note: Only Selected Ships report code figures for a.

Table 7—2: WMO code table 0200 — Specification of code figure [a](#)

Code figure	Graphic representation	Characteristic	Atmospheric pressure
0		Increasing, then decreasing	Same as, or higher than, three hours ago
1		Increasing then steady, or increasing then increasing more slowly	Higher than three hours ago
2		Increasing steadily or unsteadily	Higher than three hours ago
3		Decreasing or steady, then increasing; or increasing then increasing more rapidly	Higher than three hours ago
4		Steady	Same as three hours ago
5		Decreasing, then increasing	Same as, or lower than, three hours ago
6		Decreasing then steady, or decreasing then decreasing more slowly	Lower than three hours ago
7		Decreasing steadily or unsteadily	Lower than three hours ago
8		Steady or increasing then decreasing; or decreasing, then decreasing more rapidly	Lower than three hours ago

7.4.2.3 **ppp** — Net amount of atmospheric pressure change

The symbol **ppp** indicates the net amount by which the atmospheric pressure has changed in the three hours preceding the time of observation. It is expressed in tens and tenths of hectopascals and is obtained by comparing the readings of the barometer (not corrected to sea level) made at the time of observation and three hours previously. If the height of the observing platform changes significantly during a three hour period (e.g. due to the raising or lowering of an oil drilling rig) then the tendency amount is obtained from the difference between the sea level pressure at the time of observation and three hours previously. Code the characteristic of the tendency as 2, 4, or 7 as appropriate. The appropriate code figure for **ppp** is to be entered in Column 35 on the meteorological log.

Note: Only Selected Ships report code figures for **ppp**.

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Chapter 8 Present and past weather

8.1 Introduction

The weather group $7wwW_1W_2$ refers to the various phenomena, which are occurring or are present in the atmosphere. There are three basic types of reportable meteors:

- hydrometeors (any kind of liquid or solid precipitation, fog or mist)
- lithometeors (haze, smoke, dust, etc.)
- electrometeors (lightning, thunder).

8.2 Recording present and past weather information

8.2.1 Group $7wwW_1W_2$

The group $7wwW_1W_2$ is mandatory for selected and auxiliary ships and is included in all weather messages. Present Weather (ww) is coded with a code figure between 00 and 99 inclusive. Past Weather (W_1W_2) use code figures 0 to 9 inclusive.

8.2.1.1 7 — Numerical indicator figure

The figure 7 indicates that figure group wwW_1W_2 is being included in the report. This figure is always recorded in Column 36.

8.2.1.2 ww — Present weather

The term *present weather* refers to the atmospheric phenomena that are occurring at the time of observation, or which have occurred during the hour (60 min) preceding the time of observation. The atmospheric phenomena reported for present weather include precipitation (rain, drizzle, hail, etc.), obstructions to vision (fog, mist, haze, smoke, duststorm, sandstorm, drifting and blowing snow, and dust whirls), squalls, thunderstorms, lightning, and funnel clouds.

The symbol ww indicates present weather and is coded in Column 37. Since this is a two-figure code, it is possible to report one hundred different types of present weather by using the code figures from 00 to 99 . At sea however, such phenomena as dust storms, sandstorms, drifting and blowing snow, and dust whirls are rarely observed. Hence only about 85 different types of present weather are applicable to marine observations.

8.2.1.2.1 Code specifications for present weather

The present weather code ([ww](#)) may be divided conveniently into two distinctive parts. If precipitation of any kind is occurring at the ship at the time of observation, then the appropriate code figure between [50](#) and [99](#) inclusive is selected. If precipitation is not occurring at the ship at the time of observation then the code figure from [00](#) to [49](#) inclusive is selected.

There are further subdivisions within these two main parts. In the [50](#) to [99](#) part there are divisions that are used to report thunderstorms at the time of observation, thunderstorms during the past hour, showery precipitation, solid precipitation, rain, and drizzle. In the [00](#) to [49](#) part there are divisions for reporting fog, precipitation during the past hour but not at the time of observation, precipitation seen at a distance, mist and haze, change in the condition of the sky, and others.

In general the highest code figure that is applicable to present weather conditions or weather conditions during the past hour is used to code [ww](#).

Note: An exception is that code [17](#) shall take precedence over codes [20](#) to [49](#) inclusive. If two types of weather are occurring simultaneously, the one with the higher code figure is reported. For example fog and rain sometimes occur together. Rain has a higher code figure than fog so it is reported in [ww](#), irrespective of how dense the fog may be.

8.2.1.2.2 Detailed code specifications for present weather

The following list provides a description of the type of weather represented by the code figures for [ww](#). Descriptions of the listed phenomena are given in section 8.3.

Note: In referring to precipitation intensity *slight* refers to *light*.

[ww](#) = [00](#) to [49](#) — No precipitation at the time of observation

[00](#) to [03](#) — Characteristic change in the state of the sky during the past hour. No weather except clouds.

- [00](#) — Cloud development not observed or not observable
- [01](#) — Clouds generally dissolving or becoming less developed during the past hour
- [02](#) — State of the sky as a whole unchanged during the past hour
- [03](#) — Clouds generally forming or becoming more developed during the past hour.

04 to 10 — Smoke, haze, dust, spray, mist

- 04 — Visibility reduced by smoke, e.g. forest fire, industrial smoke, or volcanic ashes. Smoke from your own or other ships is not to be considered.
- 05 — Visibility reduced by haze
- 06 — Visibility reduced by widespread dust in suspension in the air.

Note: This is rarely observed at sea but may be experienced in certain areas, notably the Red Sea, the eastern North Atlantic in the vicinity of the Cape Verde Islands, and in the Indian Ocean northwest of Australia. In these areas dust is sometimes carried out to sea from desert regions, and may impair the visibility.

- 07 — Blowing spray at the ship
- 08 — Dust whirls. These will never be observed at sea.
- 09 — Dust storm or sandstorm observed during the past hour. This is not observed at sea except possibly in the Red Sea.
- 10 — Mist. Report this code figure only if mist is present and the visibility is 0.5 SM or more.

11 and 12 — Shallow fog

At sea these code figures usually refer to the type of fog known as *sea smoke*. As a rule it form in a shallow layer over the sea surface when the air temperature is much colder than the sea temperature. To report these code figures, the horizontal visibility must not be restricted at a height of 10 m (33 ft) above the sea surface. If it is choose a code figure between 40 and 49. The fog must also be thick enough that the visibility in the fog would be less than 0.5 SM.

- 11 — Patches of shallow fog at the ship as described above
- 12 — More or less continuous shallow fog at the ship, as described above

13 — Lightning seen at the time of observation, or within 15 min preceding the scheduled time of observation, but no thunder is heard.

14 to 16 — Precipitation within sight but not occurring at the ship

- 14 — Precipitation in sight but not reaching the sea surface. This phenomena, where the precipitation evaporates before reaching the surface, is called *Virga*.
- 15 — Precipitation within sight, that reaches the sea surface, and is more than 3 SM from the ship.
- 16 — Precipitation within sight, that reaches the sea surface, and is 3 SM or less from the ship, but not at the ship.

17 — Thunder heard at the time of observation, or within 15 min preceding the scheduled time of observation, but no precipitation at the ship.

18 — Squalls, occurring during the past hour or at the time of observation. Do not report this code figure if precipitation has occurred with the squall(s).

19 — Waterspout(s) (called *funnel cloud(s)* on land) observed during the past hour or at the time of observation.

20 to 29 — Precipitation, fog or thunderstorm

Precipitation, fog or thunderstorm at the ship during the past hour, but not at the time of observation (20–24 not falling in the form of showers).

- 20 — Drizzle (not freezing) or snow grains during the past hour.
- 21 — Rain (not freezing) during the past hour.
- 22 — Snow during the past hour.
- 23 — Rain and snow mixed during the past hour.
- 24 — Freezing drizzle or freezing rain during the past hour.
- 25 — Shower(s) of rain during the past hour.
- 26 — Shower(s) of snow, or of rain and snow mixed during the past hour.
- 27 — Shower(s) of hail, or of hail and snow mixed during the past hour.

Note: Hail may be considered to mean any one of the combination of hail, snow pellets, or ice pellets type (b).

- 28 — Fog with visibility less than 0.5 SM, during the past hour.
- 29 — Thunderstorm, with or without precipitation, has occurred at the ship during the past hour, but neither thunder nor precipitation is occurring at the time of observation. If thunder has been heard during the 15 min preceding the scheduled time of observation, use code figures 17 or 95–99 as appropriate.

30 to 39 — Duststorm, sandstorm, or drifting and blowing snow

These phenomena will rarely be observed at sea except possibly in the Red Sea. Also a ship working in an extensive ice field may observe drifting or blowing snow on the ice surface.

- 30 — Slight or moderate duststorm or sandstorm that has decreased during the past hour.
- 31 — Slight or moderate duststorm or sandstorm that has no appreciable change during the past hour.
- 32 — Slight or moderate duststorm or sandstorm that has increased during the past hour.
- 33 — Severe duststorm or sandstorm that has decreased during the past hour.
- 34 — Severe duststorm or sandstorm that has shown no appreciable change during the past hour.
- 35 — Severe duststorm or sandstorm that has increased during the past hour.
- 36 — Slight or moderate drifting snow. Visibility at eye level not affected.
- 37 — Heavy drifting snow. Visibility at eye level not affected.
- 38 — Slight or moderate blowing snow. Visibility 5/16 SM or more.
- 39 — Heavy blowing snow. Visibility less than 5/16 SM.

40 to 49 — Fog at the time of observation

To report these code figures, the visibility in the fog must be less than 0.5 SM. If not use code 10 (mist).

- 40 — Fog bank at a distance at the time of observation, but not at the ship during the past hour. The fog extending to a level above that of the observer.
- 41 — Fog in patches.
- 42 — Fog, sky visible, has become thinner during the past hour.
- 43 — Fog, sky invisible, has become thinner during the past hour.
- 44 — Fog, sky visible, no appreciable change in density during the past hour.
- 45 — Fog, sky invisible, no appreciable change in density during the past hour.
- 46 — Fog, sky visible, has begun or become thicker during the past hour.
- 47 — Fog, sky invisible, has begun or become thicker during the past hour.
- 48 — Fog, depositing rime, sky visible.
- 49 — Fog, depositing rime, sky invisible.

ww = 50 to 99 — Precipitation occurring at the ship at the time of observation

50 to 59 — Drizzle

- 50 — Slight intermittent drizzle, not freezing.
- 51 — Slight continuous drizzle, not freezing.
- 52 — Moderate intermittent drizzle, not freezing.
- 53 — Moderate continuous drizzle, not freezing.
- 54 — Heavy intermittent drizzle, not freezing.
- 55 — Heavy continuous drizzle, not freezing.
- 56 — Slight drizzle, freezing.
- 57 — Moderate or heavy drizzle, freezing.
- 58 — Drizzle and rain mixed, both slight.
- 59 — Drizzle and rain mixed, either or both moderate or heavy.

60 to 69 — Rain

Note: If the rain is occurring in the form of a shower use code figures 80 to 84 as appropriate.

- 60 — Slight intermittent rain, not freezing.
- 61 — Slight continuous rain, not freezing.
- 62 — Moderate intermittent rain, not freezing.
- 63 — Moderate continuous rain, not freezing.
- 64 — Heavy intermittent rain, not freezing.
- 65 — Heavy continuous rain, not freezing.
- 66 — Slight rain, freezing.
- 67 — Moderate or heavy rain, freezing.
- 68 — Rain or drizzle with snow, both slight.
- 69 — Rain or drizzle with snow, either or both moderate or heavy.

70 to 79 — Solid precipitation not in showers

Note: If snow is falling in the form of a shower, use code figures 85 or 86 as appropriate.

- 70 — Slight intermittent fall of snowflakes.
- 71 — Slight continuous fall of snowflakes.
- 72 — Moderate intermittent fall of snowflakes.
- 73 — Moderate continuous fall of snowflakes.
- 74 — Heavy intermittent fall of snowflakes.
- 75 — Heavy continuous fall of snowflakes.
- 76 — Diamond dust, with or without fog.
- 77 — Snow grains, with or without fog.
- 78 — Isolated star-like snow crystals, with or without fog.
- 79 — Ice pellets type (a).

80 to 90 — Precipitation in the form of showers, occurring at the time of observation

- 80 — Slight rain shower.
- 81 — Moderate or heavy rain shower.
- 82 — Exceptionally heavy or torrential rain shower. Such showers occur mostly in tropical regions.
- 83 — Shower of rain and snow mixed, both slight.
- 84 — Shower of rain and snow mixed, either or both moderate or heavy.
- 85 — Slight snow shower.
- 86 — Moderate or heavy snow shower.
- 87 — Shower of slight snow pellets or light ice pellets type (b) with or without rain or snow.
- 88 — Shower of moderate or heavy snow pellets, or moderate or heavy ice pellets type (b), with or without rain or snow.
- 89 — Shower of hail, with or without rain or snow, and without thunder.
- 90 — Shower of moderate or heavy hail, with or without rain or snow, and without thunder.

91 to 94 — Precipitation at the time of observation and thunder has been heard

Precipitation at the time of observation and thunder has been heard during the past hour, but not during the 15 min preceding the scheduled time of observation. Precipitation may be either showery or non-showery at the time of observation.

- **91** — Slight rain at the time of observation.
- **92** — Moderate or heavy rain.
- **93** — Slight snow, or rain and snow mixed or hail, or snow pellets, or ice pellets type (b). The precipitation type(s) are slight.
- **94** — Moderate or heavy snow, or rain and snow mixed, or hail, or snow pellets or ice pellets type (b). One or more of the precipitation types are moderate or heavy.

95 to 99 — Thunderstorm with precipitation at the time of observation

Use one of these code figures if the last thunder was heard during the 15 min preceding the scheduled time of observation.

- **95** — Thunderstorm with rain and/or snow but without hail, snow pellets, or ice pellets at the time of observation.
- **96** — Thunderstorm with hail, snow pellets, or ice pellets type (b) at the time of observation. Rain or snow may also be occurring.
- **97** — Heavy thunderstorm, with rain and/or snow but without hail, snow pellets or ice pellets at the time of observation.
- **98** — Thunderstorm combined with duststorm or sandstorm at the time of observation (this occurrence is very unlikely at sea).
- **99** — Heavy thunderstorm with hail, snow pellets, or ice pellets type (b) at the time of observation. Rain or snow may also be occurring.

8.2.1.2.3 Pictorial guide for the selection of present weather

Due to the many types of weather which it is possible to report in the [ww](#) code, and the fact that in general the type having the highest code figure applicable must be selected. The pictorial guide presented in Figure 8—1 may be of some assistance to the observer in making the proper choice of present weather.

The guide consists of two basic sets of boxes, each box containing weather types having a common characteristic. The guide is very simple to use. If precipitation is occurring at the time of observation, start at the top of the right hand set of boxes noting the general description of the weather in each box in succession, on alternate sides of the central line, stopping at the box which describes the actual weather which has been experienced. A range of code figures is given in this box. Now refer to these code figures in the previous section and pick out the one code figure which best describes the actual weather. In performing this last operation it is usually best to start at the highest figure of the range and work backwards until the appropriate figure is found and use it to code [ww](#).

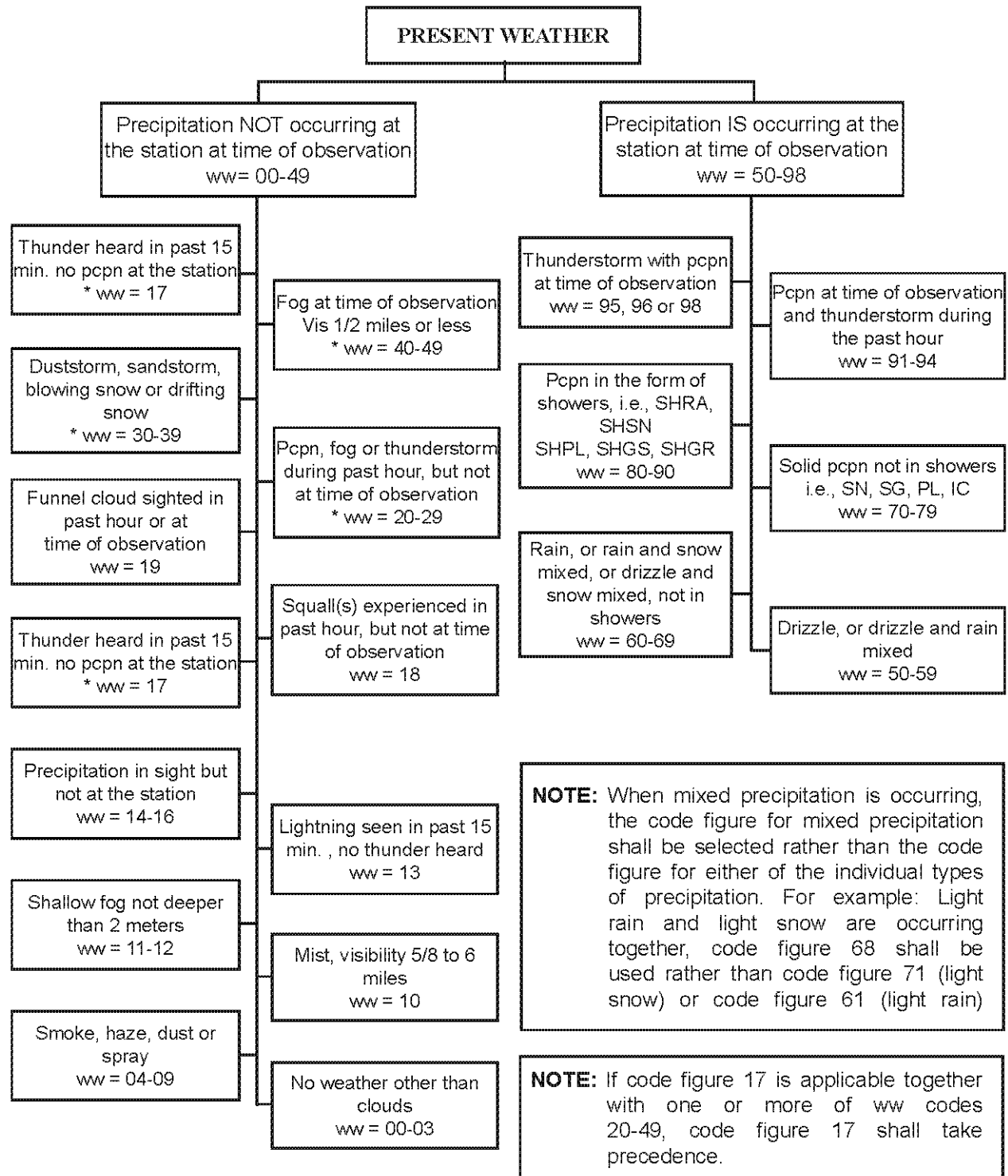


Figure 8—1: Pictorial guide for the selection of present weather

Note: If no precipitation is occurring at the time of observation, start at the top of the left hand set of fourteen boxes and proceed as outlined above.

8.2.1.3 W_1W_2 — Past weather

The term *past weather* refers to the type, or types of weather, usually different from that being reported by WW (present weather), which have occurred since the previous main synoptic hour (0000, 0600, 1200, 1800 UTC). Hence for an observation made at 0600 UTC, the past weather period began six hours ago at 0000 UTC. For an observation made at one of the intermediate hours, say 2100 UTC, the past weather period began three hours ago at 1800 UTC.

The symbol W_1W_2 refers to past weather with W_1 entered in Column 38 of the meteorological log and W_2 entered in Column 39 of the meteorological log.

Table 8—1: WMO code table 4561 — Specification of code figures W_1 and W_2

Code figure	Specification
0	Cloud covering $\frac{1}{2}$ or less of the sky throughout the appropriate period
1	Cloud covering more than $\frac{1}{2}$ of the sky during part of the appropriate period and covering $\frac{1}{2}$ or less during part of the period
2	Cloud covering more than $\frac{1}{2}$ of the sky throughout the appropriate period
3	Sandstorm, duststorm or blowing snow (prevailing visibility less than $\frac{5}{8}$ NM)
4	Fog, or freezing fog, or thick haze (prevailing visibility less than $\frac{5}{8}$ NM)
5	Drizzle or freezing drizzle
6	Rain or freezing rain
7	Snow or rain and snow mixed (i.e., SN, RASN, SG, PL, IC)
8	Shower(s) (i.e., SHRA, SHSN, SHPL, SHGS, SHGR)
9	Thunderstorm(s) with or without precipitation

8.2.1.3.1 How to report past weather

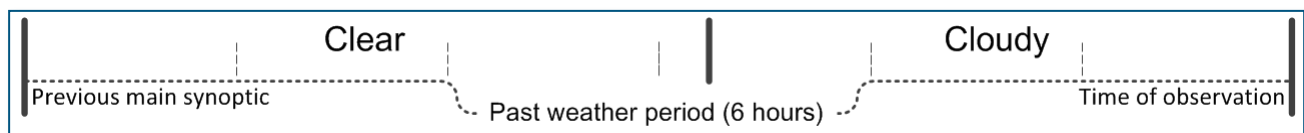
The appropriate code figures for \bar{W}_1 and \bar{W}_2 are selected according to the following four principles:

- 1) The code figures for \bar{W}_1 and \bar{W}_2 and ww together should give as complete a description as possible of the weather that has occurred since the previous main synoptic hour.
- 2) \bar{W}_1 and \bar{W}_2 should describe the types of weather, usually different from those being reported by ww (present weather), which occurred since the previous main synoptic hour.
- 3) If two or more different types of reportable weather occurred during the past weather period, then the type having the highest code figure (the primary type) will be reported by \bar{W}_1 , and the type having the second highest code figure (the secondary type) will be reported by \bar{W}_2 .
- 4) If it is possible to only report one type of weather in the past weather period (different from that reported by ww) then this type will be reported by both \bar{W}_1 and \bar{W}_2 .

8.2.1.3.2 Examples showing how to code \bar{W}_1 and \bar{W}_2 for different weather situations

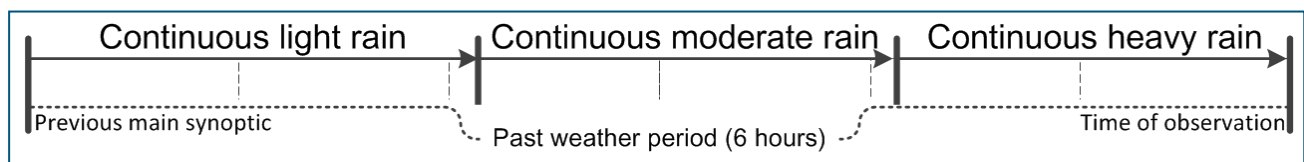
The following graphic examples of weather situations during a six hour period between main synoptic observations will illustrate how the foregoing general rules are applied in coding \bar{W}_1 and \bar{W}_2 . The proper coding for ww , \bar{W}_1 and \bar{W}_2 is given for each example. Similar reasoning would apply if the past weather period was three hours, or any other interval.

Example (1):



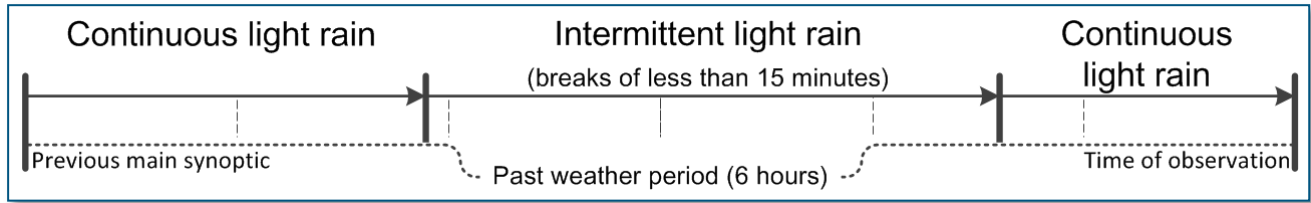
Group $7ww\bar{W}_1\bar{W}_2$ not included (no weather of significance).

Example (2): $ww = 65$; $\bar{W}_1 = 6$; $\bar{W}_2 = 6$

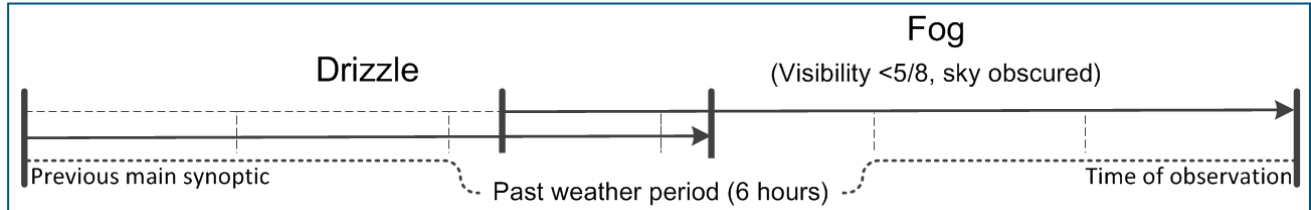


The report of rain in ww , \bar{W}_1 and \bar{W}_2 , shows that rain has been continuous throughout the entire weather period and no other past weather type has occurred.

Example (3): $ww = 61$; $W_1 = 6$; $W_2 = 6$

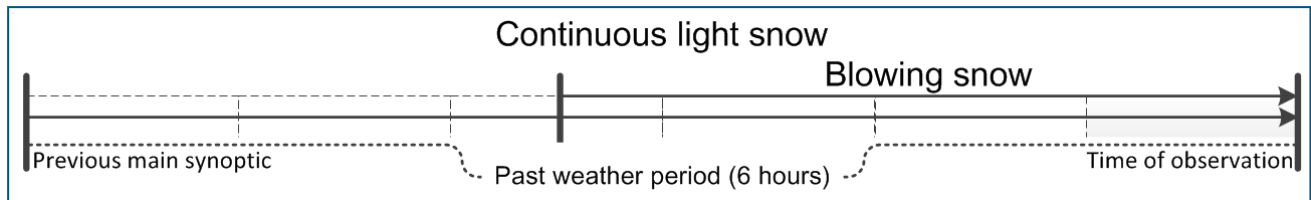


Example (4): $ww = 45$; $W_1 = 5$; $W_2 = 5$



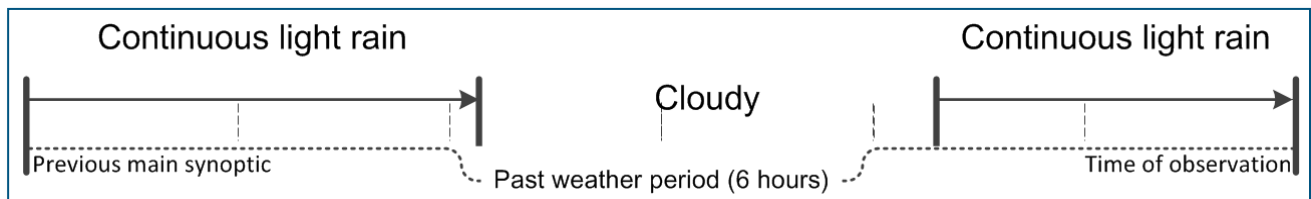
Present weather is sky obscured, visibility < 5/8 in fog for the past hour or more, so ww is encoded 45. W_1 and W_2 are used to report the weather (drizzle) prevailing before ww (fog) began and are thus encoded 55.

Example (5): $ww = 71$; $W_1 = 7$; $W_2 = 3$



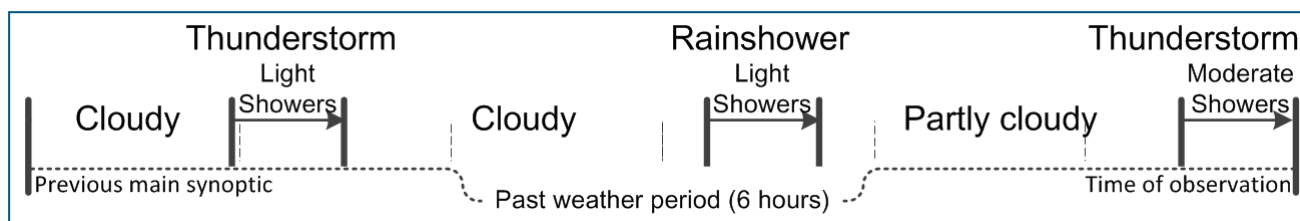
In addition to continuous light snow throughout the period, blowing snow is the only other reportable weather type (if the snowfall began at the time of the previous main synoptic hour).

Example (6): $ww = 61$; $W_1 = 6$; $W_2 = 2$



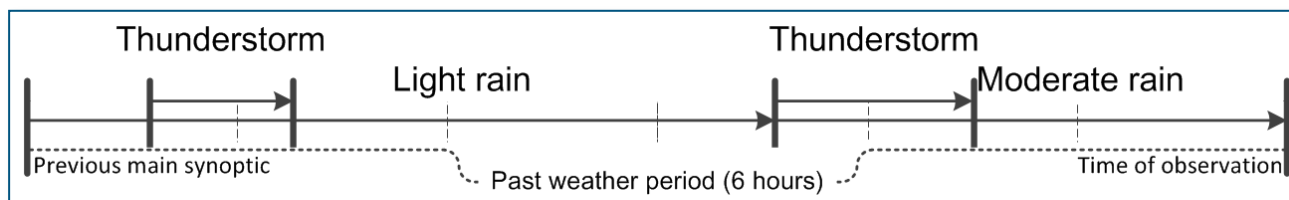
The rain reported by ww and W_1 are separate occurrences.

Example (7): $ww = 95$; $W_1 = 9$; $W_2 = 8$



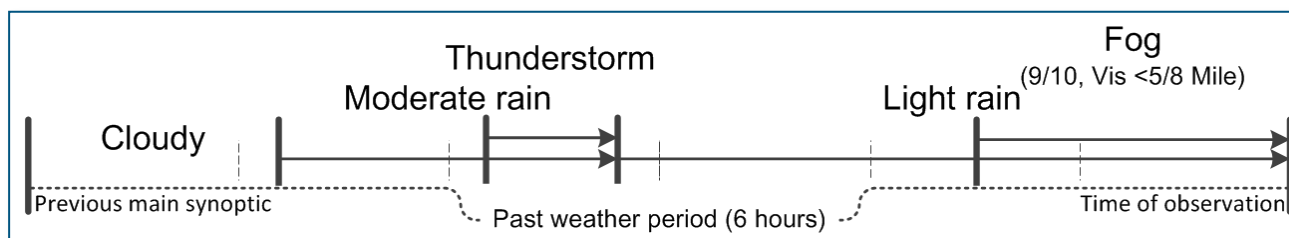
If only one type of past weather was encoded, it would be code 8. In selecting past weather in addition to the code 8, the earlier thunderstorm is the most significant event, and because of its priority in the code table it is encoded as W_1 .

Example (8): $ww = 63$; $W_1 = 9$; $W_2 = 6$



The past weather consists of continuous rain and occasional thunderstorms. W_1 is coded 9 because the highest past weather code figure is assigned to thunderstorms, and W_2 is coded 6.

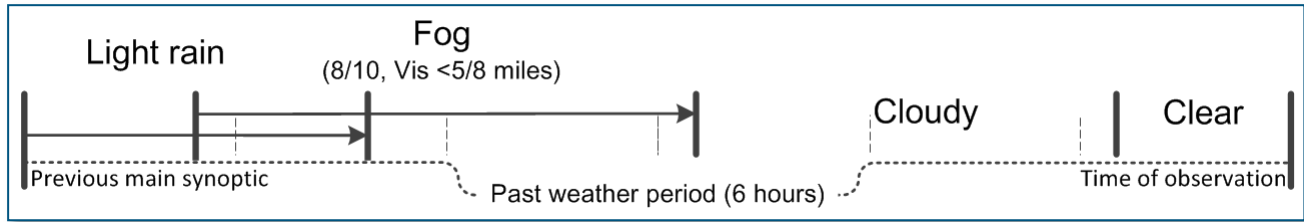
Example (9): $ww = 61$; $W_1 = 9$; $W_2 = 4$



Example (10): $ww = 61$; $W_1 = 8$; $W_2 = 1$

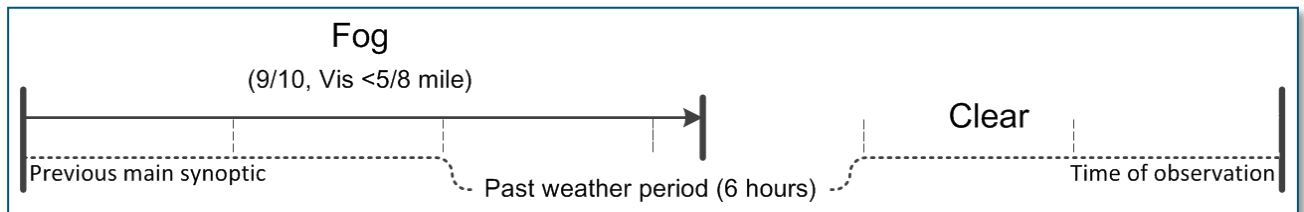


Example (11): $ww = 01$; $W_1 = 6$; $W_2 = 4$



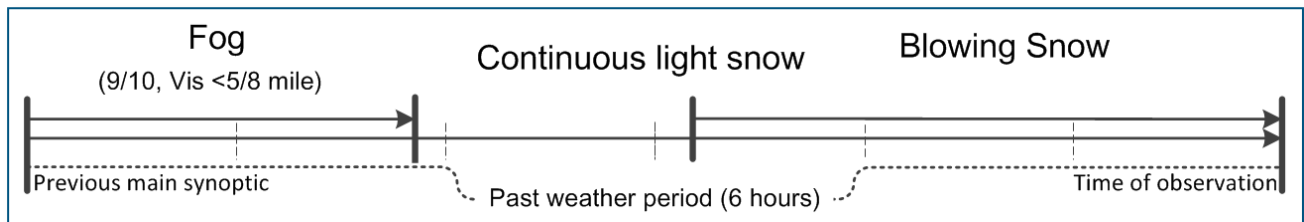
The clouds have generally dissolved in the past hour so ww is coded 01 . In the past weather code, rain has a higher code figure than fog, therefore W_1 is coded 6 and W_2 is coded 4 .

Example (12): $ww = 02$; $W_1 = 4$; $W_2 = 4$



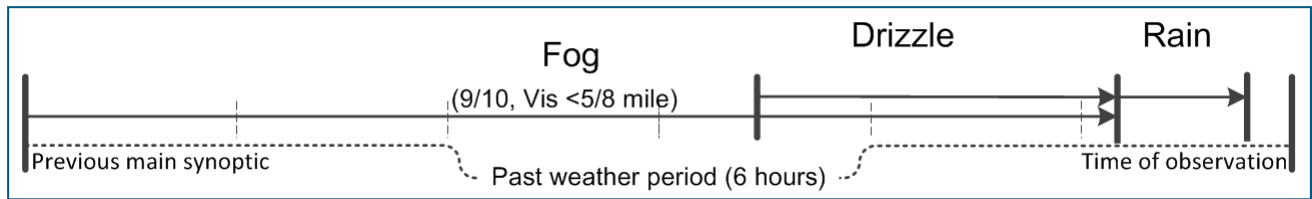
The clear skies during the hour preceding the time of observation are reported by $ww = 02$. The significant weather which necessitates the encoding of the 7-group is the fog in the past weather. Since fog was the only weather type prevailing before the weather reported by ww , both W_1 and W_2 are encoded 4 .

Example (13): $ww = 71$; $W_1 = 4$; $W_2 = 3$



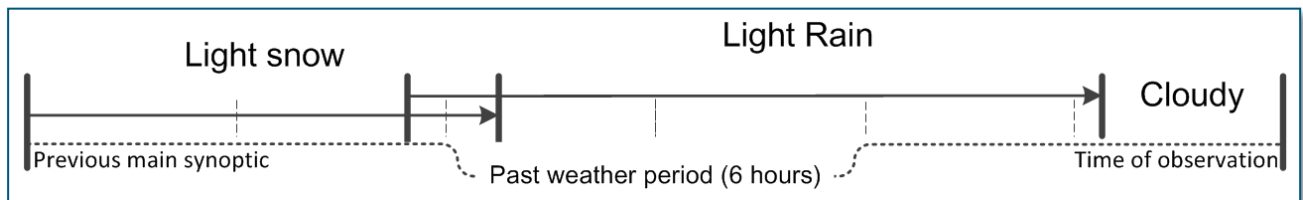
Although the light snow has been falling continuously throughout the period, it is not repeated in W_1 and W_2 because of the occurrence of two other weather types which are coded.

Example (14): $ww = 28$; $W_1 = 6$; $W_2 = 5$



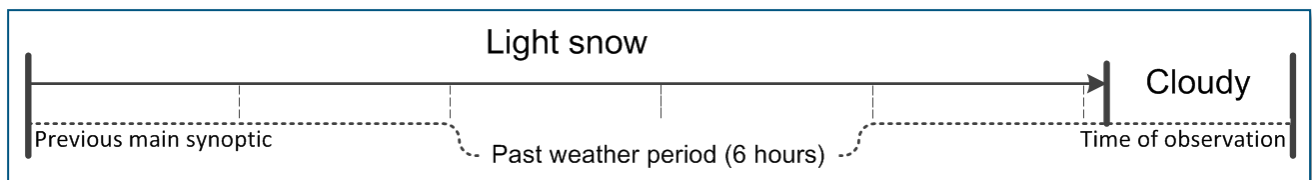
Fog ending in the past hour is the highest code figure that can be used for present weather, hence $ww = 28$. Although the fog has been continuous up to its description by ww , two other past weather types are coded for W_1 and W_2 .

Example (15): $ww = 21$; $W_1 = 7$; $W_2 = 2$



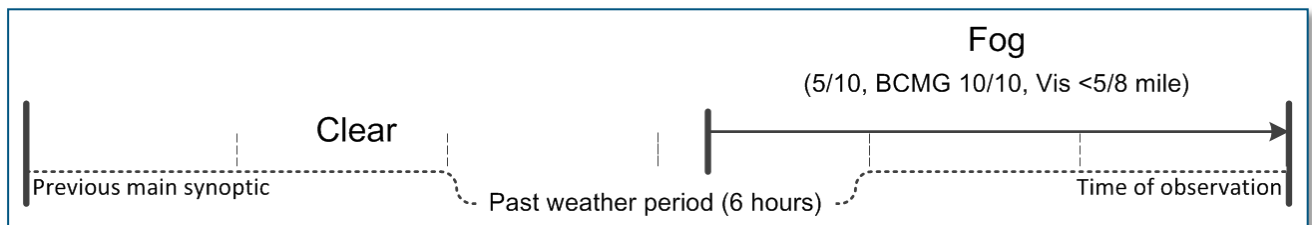
The light rain which ended in the past hour is the highest code figure applicable to present weather, so $ww = 21$. Other reportable weather consisted of snow and the cloudy skies which prevailed since the rain ended; therefore W_1 and W_2 are coded 7 and 2 respectively.

Example (16): $ww = 22$; $W_1 = 7$; $W_2 = 2$



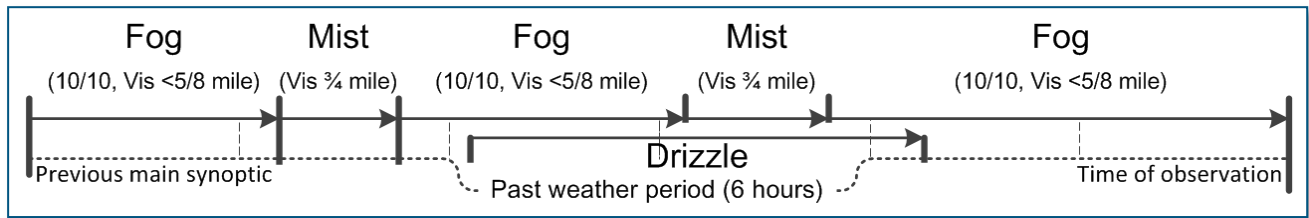
The light snow was continuous for more than six hours.

Example (17): $ww = 47$; $W_1 = 0$; $W_2 = 0$



By the time of observation, the sky had become totally obscured by thickening fog, preceded only by clear skies.

Example (18): $ww = 45$; $W_1 = 5$; $W_2 = 4$



Reportable past weather consisted of drizzle and fog; therefore W_1 and W_2 are coded 5 and 4, respectively.

Note: In the case of a six-hour period of mist, in which visibilities vary upward from 5/8 mi. and during which there has been no significant past weather, encode the 7-group as follows: $ww = 10$; W_1 and $W_2 = 0, 1$, or 2 . Select the most appropriate code figure even if the sky has been obscured.

8.3 Definitions of terms and descriptions of phenomena

At the time of observation: The code figures for [ww](#) should describe the weather that is occurring at the scheduled time of observation (0000, 0600 UTC, etc.), or in the case of code figures [20](#) to [29](#), during the 60 min prior to the scheduled time. Hence *at the time of observation* generally means at the *scheduled* time of observation. If it is necessary to make an observation an hour earlier than the scheduled time, say at 1100 UTC instead of 1200 UTC, then *at the time of observation* means 1100 UTC.

Note: For the purpose of reporting a thunderstorm, *at the time of observation* includes the 15 min prior to the scheduled time of observation.

Continuous: is applied to the precipitation other than showers, and means that the precipitation that is occurring at the time of observation has continued without a break through the past hour, or has commenced during the past hour and continued without a break.

Drizzle: is defined as fairly uniform precipitation composed exclusively of fine drops of water of diameter less than 0.5 mm (1/50 in.) and very close to one another. Drizzle drops are too small to cause appreciable ripples on the surface of still water. The drops appear almost to float, thus making even slight movements of the air visible.

During the past hour: means during the period starting 60 min before the scheduled time of observation.

Note: For the purposes of reporting code figure [29](#), the *past hour* is from 1 h and 15 min ago to 15 min ago.

Fog: is a suspension of very small water droplets in the air reducing the visibility at the earth's surface. The term fog is restricted to cases in which the horizontal visibility at the earth's surface is less than 0.5 SM.

Freezing drizzle: is drizzle, the drops of which freeze on impact with the ground or with objects on the earth's surface.

Freezing rain: is rain, the drops of which freeze on impact with the ground or with objects on the earth's surface

Hail: is precipitation of small balls or pieces of ice (hailstones) with a diameter ranging from 5 to 50 mm (0.5 to 2 in.) or sometimes more, falling either separately or fused into irregular lumps. Hailstones are composed, almost exclusively of transparent ice, or a series of transparent ice at least 1 mm (1/25 in.) in thickness, alternating with translucent layers. Hail is generally observed during heavy thunderstorms.

Haze: is a suspension in the air of extremely small dry particles invisible to the naked eye and sufficiently numerous to give the air an opalescent (milky or pearly) appearance. The visibility may be reduced but is always better than 0.5 SM. Haze is sometimes confused with mist. If the relative humidity of the air is very high (90–100%), the phenomenon is mist; but if the relative humidity is lower (60–80%), the phenomenon may be classified as haze.

Ice crystals: is a fall of unbranched ice crystals in the form of needles, columns, or plates, often so tiny that they seem to be suspended in the air. These crystals may fall from cloud or from a cloudless sky. They are not classified according to intensity.

Ice pellets: are precipitation in the form of transparent or translucent pellets of ice, which are spherical or irregular, rarely conical, and which have a diameter of 5 mm (1/5 in.) or less. The pellets usually bounce when hitting a hard surface and make a sound on impact. They are subdivided into two main types:

- Frozen raindrops, or snowflakes which have largely melted and refrozen. The freezing process usually takes place near the earth's surface.
- Pellets of snow encased in a thin layer of ice that has formed from the freezing either of droplets intercepted by the pellets or of water resulting from the partial melting of the pellets. This type always occurs in showers. The intensity of ice pellets is determined by the rate of accumulation on the ground in the same manner as for hail.

Intensity of drizzle: Drizzle must be classified with regard to the intensity as either slight, moderate, or heavy. The visibility criterion applies only when the drizzle is occurring alone. Its intensity is more difficult to estimate than that of rain, but the following descriptions will serve as a guide:

- **Slight drizzle:** Rate of fall is 0.3 mm (0.01 in.) per hour or less. Visibility is 0.5 NM or more. It can be detected on the face, but produces very little run-off from deck, roofs, etc..
- **Moderate drizzle:** Rate of fall is approximately 0.5 mm (0.02 in.) per hour. Visibility is between 0.25 and 0.5 NM. It causes windows and flat surfaces to stream with moisture.
- **Heavy drizzle:** Rate of fall is 0.8 mm (0.03 in.) per hour or more. Visibility is 0.25 NM or less.

Intensity of hail: Hail must be classified as either slight, moderate or heavy. The intensity is determined by the rate of accumulation of stones on flat surfaces as follows:

- **Slight hail:** Few stones falling, no appreciable accumulation on the ground
- **Moderate hail:** Slow accumulation of stones
- **Heavy hail:** Rapid accumulation of stones

Intensity of rain: Rain and showers of rain must be classified with regard to intensity as either slight, moderate, or heavy. The following descriptions will serve as a guide:

- **Slight rain:** Rate of fall is 2.5 mm (0.10 in.) per hour or less. Individual drops are easily identifiable. Spray observed on roofs, decks, etc. is slight. Puddles form very slowly. Over two minutes may be required to completely wet dry surfaces. Sound on roofs ranges from slow pattering to gentle swishing.
- **Moderate rain:** Rate of fall is 2.6–7.5 mm (0.11–0.30 in.) per hour. Individual drops are not clearly identifiable. Spray is observable. Puddles form rapidly. Sound on roofs ranges from swishing to gentle roar.
- **Heavy rain:** Rate of fall is 7.6 mm (0.31 in.) per hour or more. Rain seemingly falls in sheets. Individual drops are not identifiable. Heavy spray to a height of several centimetres is formed over hard surfaces. Puddles form very rapidly. Sound on roofs resembles the roll of drums or a distant roar.

Intensity of snow: Snow or showers of snow must be classified with regard to intensity as either slight, moderate, or heavy. The visibility in the snow is used as a criterion for intensity as follows:

- **Slight snow:** Visibility 0.5 NM or more ($VV = 94$ or higher)
- **Moderate snow:** Visibility 0.25 NM to 0.5 NM ($VV = 93$)
- **Heavy snow:** Visibility less than 0.25 NM ($VV = 90, 91, \text{ or } 92$)

Intermittent: is applied to precipitation other than showers and means that the precipitation must have stopped and recommenced at least once during the 60 min preceding the scheduled time of observation.

Mist: is a suspension in the air of microscopic water droplets or wet hygroscopic particles, reducing the visibility at the earth's surface. The term mist is used when the visibility is reduced to not less than 0.5 SM.

Precipitation: is any product of the condensation of atmospheric water vapour that is deposited on the earth's surface. The most common types of precipitation are liquid (rain and drizzle) and frozen (snow, hail, ice pellets, snow pellets, snow grains, and diamond dust).

Rain: is defined as precipitation of liquid droplets, either in the form of drops more than 0.5 mm (1/50 in.) in diameter, or of smaller widely scattered drops. Rain drops are normally larger than drops of drizzle. Nevertheless drops falling on the edge of a rain zone may be as small as drizzle drops, owing to partial evaporation.

Rime: is caused by the solidification into ice of super-cooled water droplets in a fog after coming in contact with solid objects at a temperature below the freezing point. With persistent fog and below-freezing temperatures, rime may grow to a considerable thickness that is an inch or more. The growth is in the direction from which the water droplets are being carried by the wind. The deposit is white and feathery.

Scheduled time of observation: is the time at which the observation should be completed and ready for transmission. These times are the four main synoptic hours of 0000, 0600, 1200, 1800 UTC, or the intermediate synoptic hours of 0300, 0900, 1500, 2100 UTC.

Showers: Precipitation in the form of showers begins and ends abruptly and lasts for short periods ranging from less than a minute up to a half hour or more. Usually there are rapid fluctuations in the intensity of the precipitation, and there is a noticeable brightening of the sky after or between showers. Snow pellets and hail always occur in the form of showers, but rain, snow, and ice pellets can occur with either showery or non-showery characteristics.

Snow grains: is precipitation of very small white and opaque grains of ice. The grains are fairly flat and elongated; their diameter is generally less than 1 mm (1/25 in.). When the grains hit a hard surface they do not bounce or shatter. They usually fall in very small quantities, mostly from stratus cloud and never in the form of a shower. As there is only one code specification that refers to snow grains ([ww = 77](#)), it is not necessary to classify their intensity.

Snow pellets: is precipitation in the form of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2 to 5 mm (1/10 to 1/5 in.). Snow pellets are brittle and easily crushed. When they fall on a hard surface they bounce and often break up. They generally occur in showers together with snowflakes or raindrops, when the temperature is around 0 °C. The intensity of snow pellets, when occurring alone is determined by the visibility in the same manner as for snow.

Snow: is precipitation, in the form of ice crystals, most of which are branched (sometimes star-shaped). The branched crystals are sometimes mixed with unbranched crystals. At temperatures warmer than about -5 °C, the crystals are generally clustered to form snowflakes.

Squalls: A squall is defined as a sudden increase of wind speed by at least three stages of the Beaufort scale (by 16 kt if facilities are available for measuring the wind speed), the speed rising to Force 6 (22 kt) or more and lasting for at least one minute, then diminishing. Squalls frequently occur along the line of a cold front and are accompanied in a typical case by a sudden drop in temperature, a veer of the wind, and a roll-shaped cloud with a horizontal axis. These are known as line squalls. Squalls may or may not be accompanied by precipitation. If precipitation has occurred then this fact is reported in the [ww](#) code (usually some form of shower), and the squall is disregarded as far as Present Weather is concerned. If no precipitation has occurred with the squall, then the squall is reported by [ww](#) = 18.

Thunderstorms: A thunderstorm is considered to be occurring at the ship when thunder is heard. A thunderstorm is regarded as being heavy when sharp and pronounced thunder and lightning occur almost continuously, accompanied by heavy rain or snow and often by hail, and the peak wind preceding or accompanying the storm is usually in excess of 40 kt.

Within sight or at a distance: means that although precipitation, etc., is not occurring at the ship, it is seen to be occurring in the near neighborhood.

Chapter 9 Clouds

9.1 Introduction

The World Meteorological Organization's *International Cloud Atlas* defines a cloud as a hydrometeor consisting of minute particles of liquid water or ice, or both, suspended in the free air and usually not touching the ground. It may also include larger particles of liquid water or ice as well as non-aqueous liquid or solid particles such as those present in fumes, smoke, or dust. Fog and mist conform to the above definition of a cloud, but they are not classified or reported as such. Fog may be thought of as a cloud which touches the surface of the earth.

9.2 Cloud types

Clouds may assume almost an infinite variety of forms, and it is very unlikely that two clouds of exactly the same form will ever be seen. However even a casual observer will notice that there are many clouds which are similar in appearance or other characteristics. At the beginning of the nineteenth century four types of clouds were recognized and named. These were Cirrus, the thin wispy thread-like cloud; Cumulus the white cauliflower-like cloud; Stratus, the flat featureless layer of cloud giving no rain; and Nimbus, the darker layer-type rain giving cloud. These original names, or variations of these names, are still in use.

9.2.1 Basic cloud types

Today, ten distinctive types (genera) of cloud are recognized. The ten basic types, together with their official abbreviations are as follows:

- Altocumulus (AC)
- Altostratus (AS)
- Cirrocumulus (CC)
- Cirrostratus (CS)
- Cirrus (CI)
- Cumulonimbus (CB)
- Cumulus (CU)
- Nimbostratus (NS)
- Stratocumulus (SC)
- Stratus (ST)

The above types are mutually exclusive, that is to say a given cloud can belong to one type only. See section 0 for descriptions of the ten types.

9.2.2 Ranges of altitudes

Clouds can be encountered at all levels in the atmosphere ranging from sea level to as high as 18,300 m (60,000 ft) in the tropics, 13,700 m (45,000 ft) in temperate latitudes, and 7,600 m (25,000 ft) in the polar regions. By convention that part of the atmosphere in which clouds are usually found has been divided vertically into three ranges of altitude — high, middle, and low. Each range is defined by the levels at which clouds of certain types occur most frequently. The ranges overlap, and their limits vary with latitude. The approximate heights of the limits of each range, depending on region, are shown in Table 9—1.

Table 9—1: Approximate height of clouds in different regions by range type

Range	Polar Regions	Temperate Regions	Tropical Regions
High	3000–7600 m (10 000–25 000 ft)	5000–13 700 m (16 500–45 000 ft)	6100–18 300 m (20 000–60 000 ft)
Middle	2000–4000 m (650–13 000 ft)	2000–7000 m (650–23 000 ft)	2000–7600 m (650–25 000 ft)
Low	Surface–2000 m (Surface–6500 ft)	Surface–2000 m (Surface–6500 ft)	Surface–2000 m (Surface–6500 ft)

The cloud types that occur in the three ranges are as follows:

High

- Cirrocumulus
- Cirrostratus
- Cirrus

Middle

- Altcumulus
- Altostratus (often extends into high range)
- Nimbostratus (base is in low range, and top usually extends into the high range)

Low

- Cumulonimbus (bases are in low range, but tops may reach into middle and high range)
- Cumulus (bases are in low range, but tops may reach into middle and high range)
- Stratocumulus
- Stratus

9.2.3 Identifying the cloud types

9.2.3.1 The international cloud atlas

As an aid in identifying the ten basic cloud types the observer will have available a copy of the World Meteorological Organization's *International Cloud Atlas* (abridged). This atlas contains 72 photographs (plates) in color and black and white, of all the cloud types, as well as various weather phenomena such as showers, fog, waterspouts, etc.. Also included in the atlas is an extensive text on the observation of clouds.

In beginning a study of the identification of cloud types the observer should first study the descriptions given below in conjunction with the corresponding photographs in the *International Cloud Atlas*. The main distinguishing feature of each type may be learned in this way, but there is no substitute for practical experience. Consequently the observer should take every opportunity to observe the clouds and identify them, referring to the descriptions and photographs frequently for confirmation until skill has been obtained.

Note: In the following descriptions (and elsewhere in this chapter) plate numbers refer to those appearing in the *International Cloud Atlas*.

9.2.3.2 Description of the cloud types

9.2.3.2.1 Altocumulus (AC)

Altocumulus occurs most commonly in the form of an extensive sheet composed of elements which are fairly regularly arranged. Sometimes the elements take the form of elongated parallel rolls (Plate 30 and 31), which may be separated by definite clear lanes. Altocumulus sheets often occur simultaneously at two or more levels.

Altocumulus is also observed in lens or almond-shaped patches, often very elongated and with well-defined outlines. These patches are either composed of small elements closely grouped together, or consist of one more or less smooth unit (Plates 28 and 29). In the latter case there are pronounced shadings.

More rarely Altocumulus appears in the form of small isolated tufts, the lower parts of which are somewhat ragged; these clouds are often accompanied by fibrous trails (Plate 39). Another equally rare form of Altocumulus has the appearance of row of turrets rising from a common horizontal base (Plate 38).

Altocumulus clouds vary considerably in transparency. In some cases the greater part of the cloud allows the position of the sun to be determined (Plates 26 and 27). In other cases the cloud is sufficiently opaque to mask the sun completely. Some shading is nearly always visible in Altocumulus clouds. A corona around the sun is frequently observed through Altocumulus.

Summary: White or gray, or both white and gray patch, sheet or layer of cloud, generally with shading; composed of laminae, rounded masses, rolls, which are sometimes partly fibrous or diffuse and which may or may not be merged. Most of the regularly arranged small elements usually have an apparent width between one and five degrees, when observed at an angle of more than 30° above the horizon (five degrees is approximately the width of three fingers held at arm's length). If the elements appear larger than five degrees, the cloud is not *Alto cumulus*, but *Strato cumulus*.

9.2.3.2.2 *Altostratus* (AS)

Altostratus is nearly always of great horizontal extent (up to hundreds of kilometres) and of fairly considerable vertical extent (up to thousands of metres). It may be composed of two or more superimposed layers at slightly different levels, sometimes partly merged. Undulations or broad parallel bands are occasionally in evidence.

Altostratus is generally so dense that even through its thinner parts, the sun is only vaguely seen as through ground glass (Plates 21 and 22); the thicker parts may be dense enough to mask the sun completely (Plates 23 and 37).

Altostratus is a precipitating cloud. The precipitation may or may not reach the ground (or sea surface) If it does reach the ground, it is usually of the continuous type and in the form of rain, snow or ice pellets.

Clouds in ragged shreds (*Pannus*, *Cumulus* or *Stratus* of bad weather) may form under the *Altostratus* in the lower turbulent layers when these are moistened by evaporation from precipitation. In the initial stage of their formation, the *Pannus* clouds are small, sparse and well separated. They usually occur at a considerable distance below the under-surface of the *Altostratus* (Plate 21). Later with thickening of the *Altostratus* and a lowering of its base, the distance is greatly reduced. At the same time the ragged clouds increase in size and number and may merge into almost a continuous layer.

Summary: Grayish or bluish cloud sheet, or layer of striated, fibrous or uniform appearance, totally or partly covering the sky, and having parts thin enough to reveal the sun at least vaguely, as through ground glass. *Altostratus* does not show halo phenomena.

9.2.3.2.3 *Cirrocumulus* (CC)

True *Cirrocumulus* is comparatively rare, and is one of the clouds that give the beautiful “mackerel sky” appearance.

Cirrocumulus generally occurs in more or less extensive sheets, consisting of very small elements in the form of grains, ripples, etc. (Plate 56). These sheets often show one or two systems of undulations. They may have fibrous margins (Plate 57).

Cirrocumulus also occurs in patches in the shape of lenses or almonds, often very elongated and usually with well-defined outlines.

Cirrocumulus is always associated with Cirrus or Cirrostratus, or results from the change in Cirrus or Cirrostratus. If this is not the case the cloud is almost certainly Altocumulus.

Summary: Thin white patch, sheet or layer of cloud without shading, composed of very small elements in the form of grains, ripples, etc., merged or separate, and more or less regularly arranged. Most of the elements have an apparent width of less than one degree (one degree is less than the apparent width of the little finger held at arm's length).

9.2.3.2.4 Cirrostratus (CS)

Cirrostratus may occur in the form of a fibrous veil in which thin striations can be seen (Plates 51, 52, and 54), or it may resemble a nebulous veil (Plates 53 and 55). The edge of the Cirrostratus veil is sometimes sharply defined, but it is more often frayed with Cirrus (Plates 51 and 52).

Cirrostratus is never thick enough to prevent objects on the ground from casting shadows, except when the sun is low.

The remarks about the color of Cirrus are, to a great extent also true for Cirrostratus.

Halo phenomena are also observed in thin Cirrostratus (Plate 53). Sometimes the veil of Cirrostratus is so thin that the halo provides the only indication of its presence.

Summary: Transparent, whitish cloud veil of fibrous (hair-like) or smooth appearance, totally or partly covering the sky, and generally producing halo phenomena.

9.2.3.2.5 Cirrus (CI)

Cirrus is one of the easiest clouds to identify because of its thin wispy or feathery appearance.

Cirrus may occur in the form of thin fibers or filaments. These may be nearly straight or irregularly curved or seemingly entangled in a capricious manner (Plates 42 and 43). The fibers or filaments are sometimes shaped like a comma, terminating at the top in a hook or in a tuft which is not rounded (Plates 48–50).

Cirrus also occurs in patches that are sufficiently dense to appear grayish when viewed towards the sun. This species of cirrus may also veil the sun, obscure its outline or even hide it (Plates 44–47). This species is known as dense Cirrus.

Cirrus occurs more rarely in the form of small isolated rounded tufts, often with trails, or in the form of small rounded turrets or battlements rising from a common base.

The elements of Cirrus are sometimes arranged in broad parallel bands converging towards the horizon (Plate 54).

Cirrus which is not too close to the horizon is white at all times of the day (whiter than any other cloud in the same part of the sky). With the sun on the horizon it is whitish, while lower clouds may be tinted yellow or orange. When the sun sinks below the horizon Cirrus high in the sky is yellow, then pink, red, and finally gray. The color sequence is reversed at dawn.

Cirrus near the horizon often takes a yellowish or orange tint (Plate 50). These tints are less conspicuous in lower cloud types.

Halo phenomena may occur; circular halos almost never appear as a complete ring, owing to the narrowness of the Cirrus clouds.

Summary: Detached clouds in the form of white, delicate filaments or white or mostly white patches or narrow bands. These clouds have a fibrous (hair-like) appearance, or a silky sheen or both.

9.2.3.2.6 Cumulonimbus (CB)

Cumulonimbus is the familiar thunder cloud. The horizontal and vertical dimensions of Cumulonimbus are so great that the characteristic shape of the clouds as a whole can only be seen when the cloud is observed from a considerable distance. During the initial stages of the development from Cumulus, Cumulonimbus clouds often show rounded protuberances at the summit in spite of the fact that their upper portion is losing its sharp outlines (Plates 6 and 7). Later the upper portion is completely transformed into a fibrous or striated mass, often shaped like an anvil (Plates 17, 18 and 64).

Cumulonimbus clouds may appear either as isolated clouds or in the form of a continuous line of clouds which resembles a very extensive wall. When the cloud is nearly or directly above the observer (Plates 19, 20, 63 and 68), the upper parts are hidden by the extended cloud base or by low ragged cloud (pannus). Sometimes the upper portions of the Cumulonimbus are merged with Altostratus or Nimbostratus. Occasionally Cumulonimbus may develop within the general mass of Altostratus or Nimbostratus.

The dark menacing or even terrifying aspect of Cumulonimbus is usually enhanced by thunder and lightning and may be accentuated by intense showers of rain, snow or hail, by squalls and by such accessory features as mamma (hanging protuberances, Plate 20) or more rarely by tuba (waterspouts, Plate 68).

Summary: Heavy and dense cloud, with a considerable vertical extent, in the form of a mountain or huge towers. At least part of its upper portion is usually smooth, or fibrous or striated, and nearly always flattened. This upper part often spreads out in the shape of an anvil or vast plume.

9.2.3.2.7 Cumulus (CU)

Cumulus is one of the most commonly observed clouds, and probably one of the easiest clouds to identify.

Cumulus clouds may occur simultaneously in various stages of development (Plate 3). They may have a small vertical extent and appear as if flattened (Plate 2). They may be of moderate vertical extent with small protuberances and sprouting, or they may have a great vertical extent with bulging upper parts frequently resembling a cauliflower (Plates 4 and 5) and with outlines undergoing continuous and often very rapid changes.

Cumulus of very great vertical extent may produce precipitation (Plate 4). In the tropics these clouds often release abundant rain in the form of showers.

Summary: Detached clouds, generally dense and with sharp outlines, developing vertically in the form of rising mounds, domes or towers, of which the bulging upper part often resembles a cauliflower. The sunlit parts of these clouds are mostly brilliant white; the base is relatively dark and nearly horizontal. Sometimes Cumulus is ragged.

9.2.3.2.8 Nimbostratus (NS)

Nimbostratus usually appears as an extensive, low, dark gray layer, with a very diffuse base from which rain, snow or ice pellets fall continuously, without necessarily reaching the ground (Plates 24 and 25). In the tropics particularly during short lulls in the rainfall, Nimbostratus can be seen breaking up into several different layers which rapidly merge again.

The under surface of Nimbostratus is often partially or totally hidden by low ragged clouds (Pannus or Stratus of bad weather) which forms at or below the base of the Nimbostratus and change shape rapidly (Plate 14). At first these Pannus clouds consist of separate units; later on they merge into a continuous layer. When the Pannus covers a large expanse of the sky, care should be taken in order not to confuse it with the under surface of the Nimbostratus.

Summary: Gray cloud layer, often dark, the appearance of which is rendered diffuse by more or less continuously falling rain or snow, which in most cases reaches the surface. It is thick enough throughout to blot out the sun. Low ragged clouds frequently occur below the layer, with which they may or may not merge.

9.2.3.2.9 Stratocumulus (SC)

Stratocumulus most often occurs as a sheet or layer composed of elements similar to those of Altocumulus but at a lower level and therefore apparently larger. The size, thickness and shape of the cloud elements vary over a wide range (Plates 8–11, 15 and 16). Sometimes the elements are in the form of parallel rolls, which may be separated by clear lanes (Plate 11). Occasionally, notably in the tropics, Stratocumulus occurs in the form of a large single roll (roll cloud). Stratocumulus sheets often occur simultaneously at two or more levels.

Stratocumulus clouds vary considerably in transparency. Sometimes the greater part of the cloud is thin enough to allow the position of the sun to be determined (Plates 10 and 16). In other cases the cloud is sufficiently opaque to blot out the sun (Plates 11 and 15).

Stratocumulus is sometimes accompanied by precipitation of weak intensity in the form of rain, snow, or ice pellets. When Stratocumulus is not very thick a corona around the sun is sometimes seen.

Summary: Gray or whitish patch, sheet or layer of cloud that almost always has dark parts, composed of rounded masses, rolls, etc., which are non-fibrous and which may or may not be merged. Most of the regularly arranged small elements have an apparent width of more than five degrees when observed at an angle of more than 30° above the horizon (five degrees is approximately the width of three fingers at arm's length). If most of the elements are smaller than five degrees, the cloud should be classed as Altocumulus.

9.2.3.2.10 Stratus (ST)

Stratus most commonly occurs as a nebulous, gray, and fairly uniform layer, with its base often low enough to obscure the tops of low hills or high buildings (Plate 12). It may be so thin that the outline of the sun or moon can be seen clearly through it. More often however it is opaque enough to mask the sun or moon. Occasionally it has a dark or even menacing appearance.

Stratus is sometimes observed in the form of fragments of varying size and luminance, which are more or less joined (Plate 13) or in the form of ragged shreds (Plate 14) which change rapidly.

When very thin Stratus produces a corona around the sun or moon at very cold temperatures it may under exceptional circumstances produce a halo.

Any precipitation from Stratus that reaches the surface is in the form of drizzle, snow or snow grains.

Summary: Generally gray cloud layer with a fairly uniform base, which may give drizzle, snow or snow grains. When the sun is visible through the clouds its outline is clearly discernible. Stratus sometimes appears in the form of ragged patches.

9.2.3.3 Hints on observing cloud types

The identification of the types is based primarily on their appearance as viewed from the earth's surface. If the cloud has a uniform featureless, sheet-like appearance it is probably Cirrostratus, Altostratus, Stratus or Nimbostratus. If the cloud layer consists of elements either detached or merged together, it is probably Cirrocumulus, Altocumulus, Stratocumulus or Cumulus of small or moderate vertical extent. The apparent size of the elements determine whether it is CC, AC, or SC. If the cloud layer is in the form of more or less parallel rolls, it is either Altocumulus or Stratocumulus, the apparent width of the rolls determining which type. Ragged, tattered shreds of low cloud occurring alone are Cumulus or ragged Stratus, but if these tattered clouds are seen below a higher diffuse layer when precipitation is occurring or imminent, they are called Stratus of bad weather or Cumulus of bad weather, or more familiarly *scud*. Cumulus of moderate or great vertical extent is unmistakable due to its boiling, cauliflower-like appearance. Cirrus is also unmistakable because of feathery, thread-like appearance. If thunder, lightning, hail, or heavy showers are occurring, the cloud is almost certainly Cumulonimbus.

The height of the base of a cloud, if known can also be a clue to its type. As noted earlier clouds occur in three ranges of altitude in the atmosphere. CI, CC, and CS occur in the high range and are known as high clouds. AC and AS occur in the middle range and are known as middle clouds. The bases of NS, SC, ST, CU, and CB are in the low range and are called low clouds except that NS is treated as a middle cloud for reporting purposes. Very frequently it will be obvious to the observer that different clouds at more than one level are present. For example, if clouds are present at three different levels, the highest clouds will most likely be CI, CC, or CS (these are easy to identify in any case); the intermediate layer will probably be either AC or AS, and the lowest layer will likely be SC, ST, CU, or CB. NS when present usually covers the sky completely so higher clouds even if present could not be seen. The apparent speed of movement of clouds is an indication of their relative height and provides a clue to their type. Low clouds appear to move more rapidly across the sky than middle or high clouds simply because they are closer to the observer. High clouds, although their actual speed may be much greater than lower clouds appear to move slowly because of their great distance from the observer.

The type of precipitation that may be occurring also provides a clue to the type of cloud. The following is a list the type of precipitation that may be expected from the ten types of clouds:

- AC — If any, light rain or snow, usually of the intermittent type.
- AS — If any, rain, snow, or ice pellets, usually of the continuous type.
- CB — Showers of rain, snow, or hail, sometimes very intense, and usually accompanied by thunder and lightning.
- CC — None
- CI — None
- CS — None
- CU — Rain showers from CU of great vertical extent only
- NS — Continuous fall of rain, snow, or ice pellets
- SC — If any, rain, snow, or ice pellets, of weak intensity and usually intermittent.
- ST — If any drizzle, snow, or snow grains.

9.2.3.4 Night observations

At night the observer must first allow sufficient time for the eyes to become adapted to the darkness before any cloud observing is attempted. On nights when the moon is more than one quarter full, it is usually possible to identify the clouds present and their respective amounts. On moonless nights at sea identifying the types is very difficult and unless there is some evidence to the contrary about the best that can be done is to report the type or types which were present when darkness set in. On dark nights occurrences of precipitation will also furnish a clue to the type as indicated in the list in Section 9.2.3.3. For example if continuous rain is falling the cloud might be AS or NS.

9.3 Observing cloud amounts

In making the observation it is necessary to stand in a location which affords an uninterrupted view of the whole sky. All cloud amounts are determined by estimation. To make an estimate for the whole sky at once requires practice and is rather difficult at first. It may be more convenient to imagine the sky divided into quadrants by two arcs drawn at right angles through the zenith. Each quadrant represents two oktas of the sky. By estimating the number of oktas of cloud in each quadrant then the amount of cloud for the whole sky is obtained simply by adding the amounts estimated for the separate quadrants.

9.3.1 Cloud amounts at night

When the moon is more than one quarter full, cloud amounts can be estimated almost as well as in daylight. On moonless nights however, cloud amounts can be estimated roughly by noting the portions of the sky where stars are plainly visible. These portions can be considered to be clear. It should be kept in mind however that the brighter planets and first magnitude stars are visible through thin veils of Cirrus and Cirrostratus, and that stars near the horizon may be blotted out by haze alone.

9.3.2 Obscured sky condition

The sky is said to be obscured when clouds or blue sky cannot be seen due to some obscuring medium which touches the surface of the earth. The obscuring medium is usually fog (visibility less than 0.5 NM) or moderate or heavy snow. Sometimes a layer of fog is shallow and a portion of the sky overhead can be seen through it. If this condition is observed, treat the portion of the sky which can be seen as the whole sky (disregard the fog, etc. altogether) and code the cloud amount, types and heights in the usual way.

9.4 Recording information on cloud observations

9.4.1 Group $8N_h C_L C_M C_H$

9.4.1.1 8 — Numerical indicator figure

The figure 8 indicates that figure group $N_h C_L C_M C_H$ is being included in the report. This figure is always recorded in Column 40.

9.4.1.2 N_h — Amount of cloud

The symbol N_h indicates the fraction of the sky covered by all the C_L cloud(s) present, or if no C_L cloud is present then the fraction covered by all the C_M cloud(s) present. Code figures for N_h are given in Table 9—2 followed by the corresponding fraction of the celestial dome covered by clouds, given in tenths and oktas. The appropriate code figure for N_h is to be entered in Column 41 on the meteorological log.

Note: Selected Ships record the code figures for N_h .

The fraction of the sky covered by C_L (or C_M) clouds can never be greater than the fraction covered by all the clouds. Therefore, N_h will always be equal to, or less than, N . If C_L clouds are the only ones present, then N_h will be equal to N . However, if C_M or C_H clouds or both are also observed, then N will usually be greater than N_h .

Note: Fractions correspond to the celestial dome covered by all the C_L cloud(s) present and if no C_L cloud is present, that fraction is covered by all the C_M cloud(s) present.

Table 9—2: WMO code table 2700 — Specification of code figure N_h

Code figure	Tenths	Oktas (eighths)
0	0/10	0/8
1	1/10 or less, but not 0/10	1/8 less, but not 0/8
2	2/10 - 3/10	2/8
3	4/10	3/8
4	5/10	4/8
5	6/10	5/8
6	7/10 - 8/10	6/8
7	9/10 or more, but not 10/10	7/8 or more, but not 8/8
8	10/10	8/8
9	Sky obscured by fog and/or other meteorological phenomena.	Sky obscured by fog and/or other meteorological phenomena.
/	Cloud cover is indiscernible for reasons other than fog or other meteorological phenomena, or observation is not made.	Cloud cover is indiscernible for reasons other than fog or other meteorological phenomena, or observation is not made.

9.4.1.3 C_L — Low cloud types

The symbol C_L indicates the type of low cloud present of the genera stratocumulus, stratus, cumulus and cumulonimbus. Code figures for C_L are given in Table 9—3 followed by the corresponding specification. Selected Ships will enter the appropriate code figure for C_L in Column 42.

Table 9—3: WMO code table 0513 — Specification of code figure C_L

Code Figure	Specification
0	No Stratocumulus, Stratus, Cumulus, or Cumulonimbus
1	Cumulus with little vertical extent and seemingly flattened or ragged Cumulus other than of bad weather or both (see plates 1, 2, 23, and 52).
2	Cumulus of moderate or strong vertical extent, generally with protuberances in form of domes or towers, either accompanied or not by other Cumulus or by Stratocumulus, all having their bases at the same level (see plates 3, 4, 5, and 41).
3	Cumulonimbus the summits of which, at least partially, lack sharp outlines, but are clearly fibrous (cirriform) nor in the form of an anvil. Cumulus, Stratocumulus or Stratus may also be present (see plates 6 and 7).
4	Stratocumulus formed by the spreading out of Cumulus. Cumulus may also be present (see plates 8, 9, and 35).
5	Stratocumulus not formed from the spreading out of Cumulus (see plates 10 and 11).
6	Stratus in a more or less continuous sheet or layer, or in ragged shreds, or both; but no ragged Stratus of bad weather ¹ (see plates 12 and 13).
7	Ragged Stratus of bad weather or ragged Cumulus of bad weather ¹ , or both; usually occur below Altostratus or Nimbostratus (see plates 14 and 21).
8	Cumulus and Stratocumulus other than formed by the spreading out of Cumulus; the base of the Cumulus is at a different level from that of the Stratocumulus (see plates 15 and 16).
9	Cumulonimbus, the upper part of which is clearly fibrous (cirriform), often in the form of an anvil, either accompanied or not by Cumulonimbus without anvil or fibrous upper part, by Cumulus, Stratocumulus or Stratus (see plates 17–20).
/	Stratocumulus, Stratus, Cumulus, or Cumulonimbus are invisible owing to darkness, or cannot be seen (e.g. on an oil drilling rig at night due to glare of lights).

Note (1): *Bad weather* denotes the conditions which generally exist during precipitation and a short time before and after.

9.4.1.3.1 Priority of reporting for C_L clouds

It frequently happens that two or more types of low cloud are present in the sky at the same time. To assist the observer in this decision the following order of priority of code figures for C_L has been developed. If it is seen that two or more code figures are applicable, go down the following list and report the first figure which is applicable no matter how small the amount of this type may be, and regardless of the presence of other types having a lower priority.

C_L code figure followed by coding criteria:

- 1) Cumulonimbus present, with or without other C_L -clouds:
 - a) $C_L = 9$ — If the upper part of at least one of the Cumulonimbus clouds present is clearly fibrous or striated¹.
 - b) $C_L = 3$ — If the upperpart of none of the Cumulonimbus clouds present is clearly fibrous or striated.
- 2) No cumulonimbus present:
 - a) $C_L = 4$ — If Stratocumulus formed by the spreading out of Cumulus is present.
 - b) $C_L = 8$ — If the C_L code figure 4 is not applicable and if Cumulus and Stratocumulus clouds with bases at different levels are present.
 - c) $C_L = 2$ — If the C_L code figures 4 and 8 are not applicable and if Cumulus clouds of moderate or strong vertical extent are present.
 - d) If the C_L code figures 4, 8 and 2 are not applicable:
 - i. $C_L = 1$ — If the C_L clouds present are predominantly² Cumulus with little vertical extent and seemingly flattened or ragged Cumulus other than of bad weather, or both;
 - ii. $C_L = 5$ — If among the C_L clouds present Stratocumulus other than that formed by the spreading out of cumulus is predominant¹;
 - iii. $C_L = 6$ — If the C_L clouds present are predominantly² Stratus in a more or less continuous sheet or layer, or in ragged shreds (other than ragged Stratus of bad weather), or both;
 - iv. $C_L = 7$ — If the C_L clouds present are predominantly² pannus (ragged shreds of Stratus of bad weather³ or ragged Cumulus of bad weather, or both).
- 3) $C_L = 0$ — If no Stratocumulus, Stratus, Cumulus or Cumulonimbus.
- 4) $C_L = /$ — Use “ / ” only under conditions outlined in Table 9—3.

Note (1): Consult WMO Cloud Atlas on the specification $C_L = 9$.

Note (2): In the present case, consideration of the predominance is restricted to the clouds corresponding to C_L code figures 1, 5, 6 and 7 which have the same priority. Clouds of any one of these four specifications are said to be predominant when their sky cover is greater than that of the clouds of any of the three other specifications.

Note (3): “Bad weather” denotes the conditions which generally exist during precipitation and a short time before and after.

PICTORIAL GUIDE FOR C_L -CLOUDS

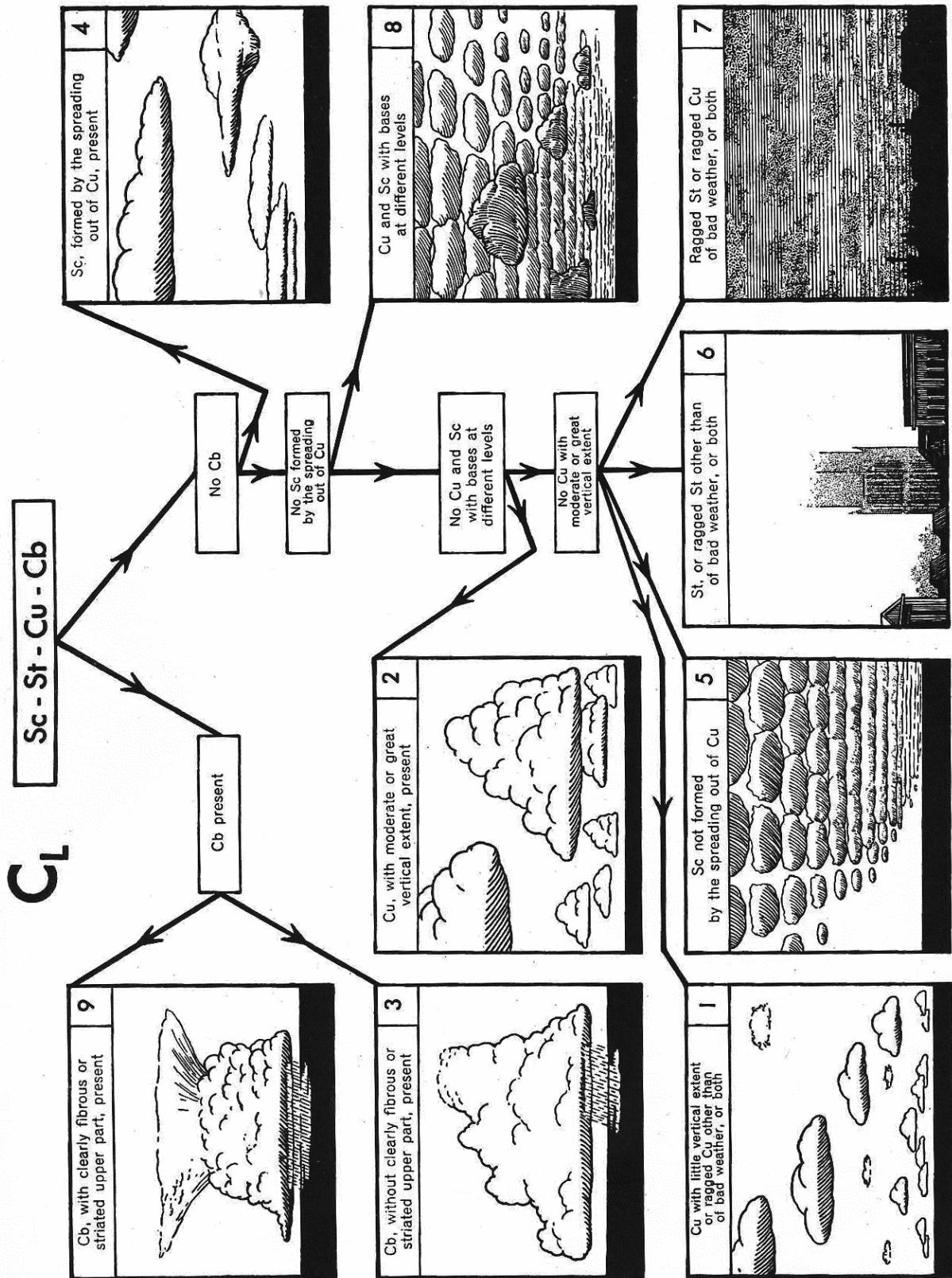


Figure 9—1: Pictorial guide for coding C_L clouds

9.4.1.3.2 Hints on estimating heights of C_L clouds

9.4.1.3.2.1 Cumulus and cumulonimbus

The probable height of the base of these clouds can be determined from the difference between the dry bulb temperature and the dew point. Multiply the difference by 123 to obtain the height in metres or by 400 to obtain the height in feet.

Example: if the dry bulb temperature is 25 °C and the dew point is 14 °C, the height of Cumulus or Cumulonimbus is about:

$$(25 - 14) \times 123 = 1353 \text{ m}$$

or

$$(25 - 14) \times 400 = 4400 \text{ ft}$$

Note: This rule is not valid for other cloud types, nor does it apply to ragged cumulus of bad weather.

9.4.1.3.2.2 Stratocumulus

If the cloud elements appear large and few rolls are visible, the height is likely 150–350 m (500–1200 ft). With the cloud elements appearing smaller and quite a few rolls visible, the height is likely 350–1200 m (1200–4000 ft). If the cloud elements are small, but are not smaller than 5° in width (about the width of three fingers at arm's length) the height is probably 1200–2000 m (4000–6500 ft).

9.4.1.3.2.3 Stratus

The height of a continuous layer of Stratus is difficult to estimate due to its lack of features; however, it is always low — usually never higher than 450 m (1500 ft). It may be as low as 30 m (100 ft) at times.

9.4.1.3.2.4 Ragged stratus and ragged cumulus (of bad weather)

When these clouds occur below the base of Nimbostratus and Cumulonimbus are always quite low — usually in the range 100–350 m (300–1200 ft). When it is windy these clouds appear to move across the sky at great speed due to their very low height.

9.4.1.3.2.5 Nimbostratus

The base of this cloud may occur at any height between 100–2000 m (300–6500 ft), but its usual range is 150–600 m (500–2000 ft). The featureless aspect of this cloud makes its height difficult to estimate, but usually the darker the cloud the lower the base.

9.4.1.4 C_M — Middle cloud types

The symbol C_M indicates the type of middle cloud present of the genera Altostratus, Altostratus, and Nimbostratus. Code figures for C_M are given in Table 9—4 followed by the corresponding specification. The appropriate code figure for C_M is to be entered in Column 42 on the meteorological log.

Note: Selected Ships will record code figures for C_M .

Table 9—4: WMO code table 0515 — Specification of code figure C_M

Code Figure	Specification
0	No Altostratus, Altostratus, or Nimbostratus present
1	Altostratus, the greater part of which is semi-transparent; through this part the sun or moon may be weakly visible as through ground glass (see plates 21 and 22).
2	Altostratus the greater part of which is sufficiently dense to hide the sun or moon (see plate 23); or Nimbostratus (see plates 24 and 25).
3	Altostratus the greater part of which is semi-transparent; the various elements of the cloud change only slowly and are all at a single level (see plates 26 and 27).
4	Patches (often in the form of almonds or fishes) of Altostratus, the greater part of which are semi-transparent; the clouds appear at one or more levels and the elements are constantly changing in appearance (see plates 28 and 29; also appears in plates 7 and 9).
5	Semi-transparent Altostratus in bands; or Altostratus in one or more fairly continuous layers (semi-transparent or opaque), progressively invading the sky; these Altostratus clouds generally thicken as a whole (see plates 30 and 31).
6	Altostratus resulting from the spreading out of Cumulus or Cumulonimbus (see plates 32 and 33).
7	Altostratus in two or more layers, usually opaque in places, and not progressively invading the sky (see plate 34); or opaque layer of Altostratus not progressively invading the sky (see plate 35); or Altostratus together with Altostratus, or Nimbostratus (see plates 36 and 37).
8	Altostratus with the sproutings of small towers or battlements, or Altostratus having the appearance of cumulus-shaped tufts (see plates 38 and 39).
9	Altostratus of a chaotic sky, generally at several levels (see plates 40 and 41).

Code Figure	Specification
/	Alto cumulus, Altostratus or Nimbostratus are invisible owing to darkness, or cannot be seen (e.g. on an oil drilling rig at night, due to glare of lights), or more often because of the presence of an overcast layer of C_L cloud (this last condition is shown in plates 10,11,12,19 and 20).

9.4.1.4.1 Priority of reporting for C_M clouds

It frequently happens that two or more types of middle cloud are present in the sky at the same time. To assist the observer in this decision the following order of priority of code figures for C_M has been developed. If it is seen that two or more code figures are applicable, go down the following list and report the first figure which is applicable no matter how small the amount of this type may be, and regardless of the presence of other types having a lower priority.

C_M Code figure followed by coding criteria:

- 1) Alto cumulus present (Altostratus or Nimbostratus may be present):
 - a) $C_M = 9$ — If the sky is chaotic.
 - b) $C_M = 8$ — If the C_M code figure 9 is not applicable and if Alto cumulus with sproutings in the form of turrets or battlements or Alto cumulus having the appearance of small cumuliform tufts is present.
 - c) $C_M = 7$ — If the C_M code figures 9 and 8 are not applicable and if Altostratus or Nimbostratus is present together with Alto cumulus.
- 2) Alto cumulus present (No Altostratus or Nimbostratus present):
 - a) $C_M = 6$ — If the C_M code figures 9, 8 and 7 are not applicable and if Alto cumulus formed by the spreading out of Cumulus or Cumulonimbus is present.
 - b) $C_M = 5$ — If the C_M code figures 9, 8, 7 and 6 are not applicable, and if the Alto cumulus present is progressively invading the sky.
 - c) $C_M = 4$ — If the C_M code figures 9, 8, 7, 6 and 5 are not applicable and if the Alto cumulus present is continually changing in appearance.
 - d) $C_M = 7$ — If the C_M code figures 9, 8, 6, 5 and 4 are not applicable and if the Alto cumulus present occurs at two or more levels.
 - e) $C_M = 7$ or 3 — If the C_M code figures 9, 8, 6, 5 and 4 are not applicable and if the Alto cumulus present occurs at one level, use $C_M = 7$ or 3 depending on whether the greater part of the Alto cumulus is respectively opaque or semi-transparent.

-
- 3) No Altocumulus Present:
- a) $C_M = 2$ — If Nimbostratus is present or if the greater part of the Altostratus present is opaque.
 - b) $C_M = 1$ — If there is no Nimbostratus and if the greater part of the Altostratus present is semi-transparent.
- 4) $C_M = /$ — If C_M clouds invisible owing to continuous layer of lower clouds or because of fog, blowing dust or other similar phenomena. Use only under the conditions given in Table 9—4.
- 5) $C_M = 0$ — If no Altocumulus, Altostratus or Nimbostratus.

PICTORIAL GUIDE FOR C_M -CLOUDS

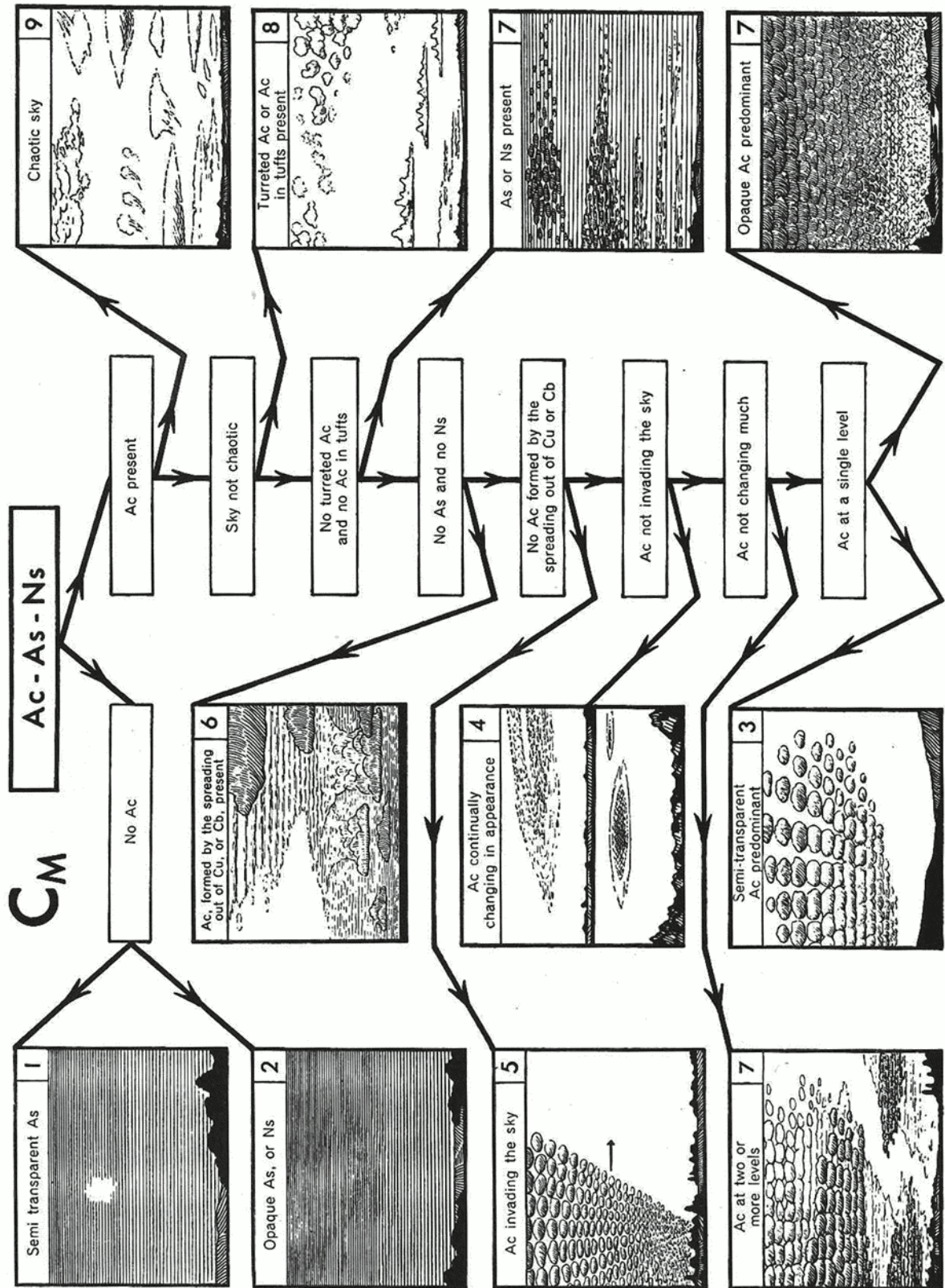


Figure 9—2: Pictorial guide for coding C_M clouds

9.4.1.5 C_H — High cloud types

The symbol C_H indicates the type of high cloud present of genera Cirrus, Cirrocumulus and Cirrostratus. Code figures for C_H are given in Table 9—5 followed by the corresponding specification. The appropriate code figure for C_H is to be entered in Column 44 on the meteorological log.

Note: Only Selected Ships record code figures for C_H .

Table 9—5: WMO code table 0509 — Specification of code figure C_H

Code Figure	Specification
0	No Cirrus, Cirrocumulus or Cirrostratus present
1	Cirrus in the form of filaments, strands or hooks; not progressively invading the sky (see plates 42 and 43).
2	Dense cirrus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a Cumulonimbus (see plate 44); or Cirrus with sproutings in the form of small turrets or battlements, or Cirrus having the appearance of cumulus-shaped tufts (see plate 45).
3	Dense Cirrus, often in the form of an anvil, being the remains of the upper part of Cumulonimbus (see plates 46 and 47).
4	Cirrus in the form of hooks or filaments, or both, progressively invading the sky; they generally become denser as a whole (see plates 48,49, and 50).
5	Cirrus (often in bands converging towards one point or two opposite points of the horizon) and Cirrostratus; or Cirrostratus alone. In either case they are progressively invading the sky, and generally grow denser as a whole, but the continuous veil does not reach 45° above the horizon (see plate 51).
6	Cirrus and Cirrostratus; or Cirrostratus alone as in 5 above, except that the continuous veil extends more than 45° above the horizon without the sky being totally covered (see plates 28 and 52).
7	Veil of Cirrostratus covering the celestial dome completely (see plate 52)
8	Cirrostratus not progressively invading the sky and not completely covering the celestial dome (see plates 54 and 55)
9	Cirrocumulus alone; or Cirrocumulus accompanied by Cirrus or Cirrostratus or both, but Cirrocumulus is predominant (see plates 56 and 57).
/	Cirrus, Cirrocumulus, and Cirrostratus are invisible owing to darkness or cannot be seen (e.g. on an oil drilling rig at night, due to glare of lights) or more often because of the presence of a continuous layer of lower cloud (see plates 10, 11, 12, 19–25, and 37).

9.4.1.5.1 Priority of reporting for C_H clouds

It frequently happens that two or more types of middle cloud are present in the sky at the same time. To assist the observer in this decision the following order of priority of code figures for C_H has been developed. If it is seen that two or more code figures are applicable, go down the following list and report the first figure which is applicable no matter how small the amount of this type may be, and regardless of the presence of other types having a lower priority.

C_H code figure followed by coding criteria:

- 1) $C_H = 9$ — Cirrocumulus is present alone or if the amount of the Cirrocumulus is more than the combined sky cover of any Cirrus and Cirrostratus present.
 - a) If $C_H = 9$ is not applicable and Cirrostratus present with or without Cirrus or Cirrocumulus:
 - i. $C_H = 7$ — If the Cirrostratus covers the whole sky.
 - ii. $C_H = 8$ — If the Cirrostratus does not cover the whole sky and is not invading the celestial dome.
 - iii. $C_H = 6$ — If the Cirrostratus is progressively invading the sky and if the continuous veil extends more than 45° above the horizon but does not cover the whole sky.
 - iv. $C_H = 5$ — If the Cirrostratus is progressively invading the sky but the continuous veil does not reach 45° above the horizon.
 - b) If $C_H = 9$ is not applicable and no Cirrostratus present:
 - i. $C_H = 4$ — If the Cirrus clouds are invading the sky.
 - ii. $C_H = 3$ — If the C_H code figure 4 is not applicable and if dense Cirrus which originated from Cumulonimbus is present in the sky.
 - iii. If $C_H = 4$ or 3 are not applicable:
 1. $C_H = 2$ — If the combined sky cover of dense Cirrus, of Cirrus with sproutings in the form of small turrets or battlements and of Cirrus in tufts is greater than the combined sky cover of Cirrus in the form of filaments, strands or hooks.
 2. $C_H = 1$ — If the combined sky cover of Cirrus in the form of filaments, strands or hooks is greater than the combined sky cover of dense Cirrus, of Cirrus with sproutings in the form of small turrets or battlements and of cirrus in tufts.

- 2) $C_H = /$ — If C_H clouds invisible owing to continuous layer of lower clouds or because of fog, blowing dust or other similar phenomena. Code $/$ only under the conditions given in Table 9—5.
- 3) $C_H = 0$ — If no Cirrus, Cirrostratus or Cirrocumulus.

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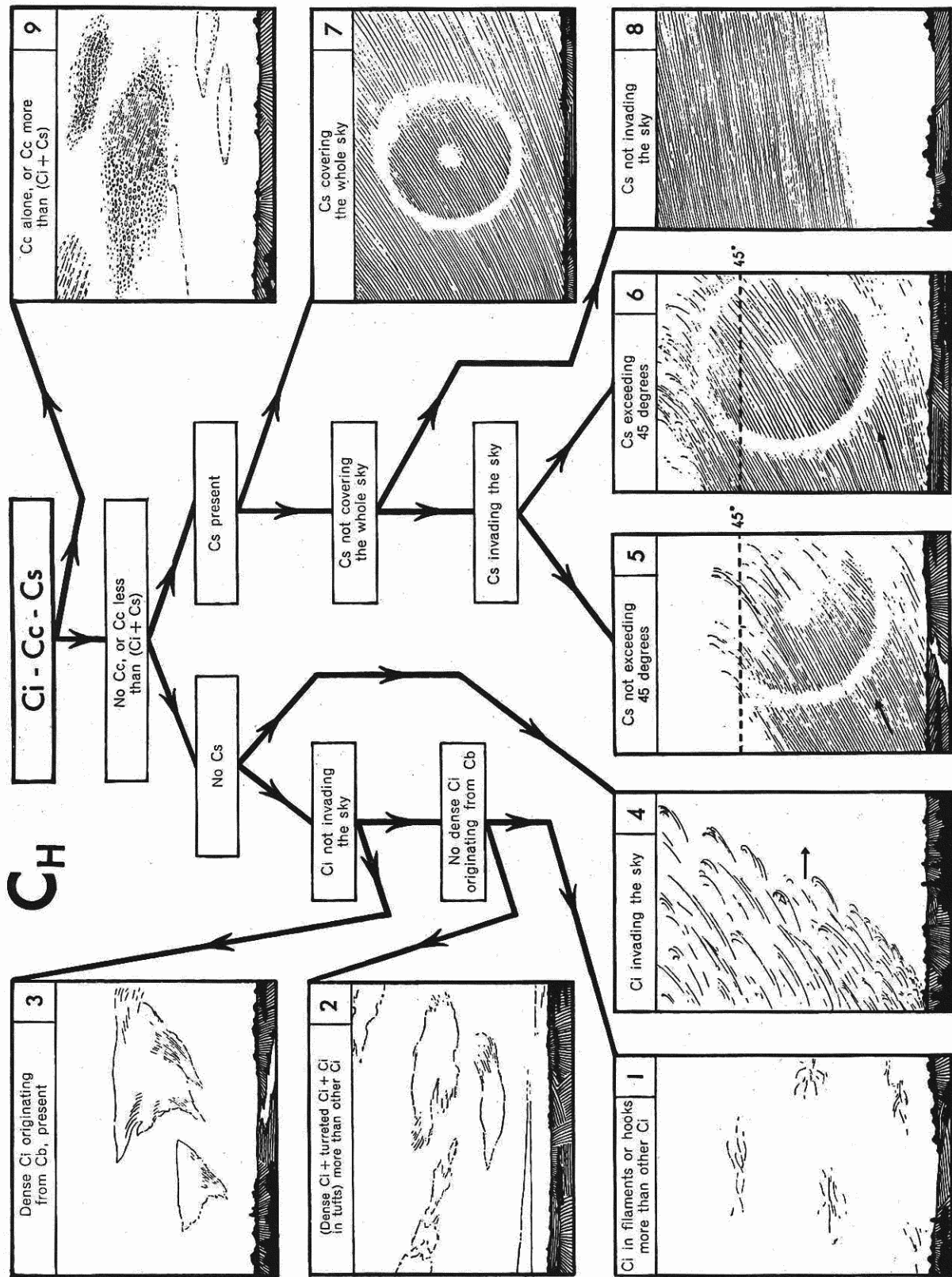


Figure 9—3: Pictorial guide for coding C_H clouds

9.4.2 Examples of cloud coding

To further assist the observer in learning to code cloud data, a number of typical cloud situations are described below with the corresponding correct coding for h , N , and the cloud group $8N_h C_L C_M C_H$.

Example (1): Sky clear, no clouds of any type

$$h = 9; N = 0; 8N_h C_L C_M C_H = 80000$$

Example (2): Sky 7/8 covered with $C_L = 5$, at 900 m (3000 ft)

$$h = 5; N = 7; 8N_h C_L C_M C_H = 87500$$

Example (3): Sky overcast with $C_L = 6$ at 250 m (800 ft)

$$h = 3; N = 8; 8N_h C_L C_M C_H = 886//$$

Example (4): Sky overcast with Nimbostratus $C_M = 2$ at 300 m (1000 ft)

$$h = 4; N = 8; 8N_h C_L C_M C_H = 8802/$$

Example (5): Sky 2/8 covered with $C_M = 3$ at 3000 m (10000 ft)

$$h = 9; N = 2; 8N_h C_L C_M C_H = 82030$$

Example (6): Sky overcast with $C_M = 1$ at 3700 m (12000 ft)

$$h = 9; N = 8; 8N_h C_L C_M C_H = 8801/$$

Example (7): Sky 4/8 covered with $C_H = 5$

$$h = 9; N = 4; ; 8N_h C_L C_M C_H = 80005$$

Example (8): 2/8 of $C_L = 1$ at 1200 m (4000 ft); 4/8 $C_M = 3$

$$h = 6; N = 6; 8N_h C_L C_M C_H = 82130$$

Example (9): 2/8 of $C_L = 7$ at 150 m (500 ft); 6/8 of $C_M = 2$ (NS)

$$h = 2; N = 8; 8N_h C_L C_M C_H = 8272/$$

Example (10): 4/8 of $C_M = 4$ at 2400 m (8000 ft); 2/8 $C_H = 1$

$$h = 8; N = 6; 8N_h C_L C_M C_H = 84041$$

Example (11): 3/8 of $C_L = 2$ at 750 m (2500 ft); 2/8 of $C_H = 4$

$$h = 5; N = 5; 8N_h C_L C_M C_H = 83204$$

Example (12): 1/8 of $C_L = 1$ at 900 m (3000 ft); 7/8 of $C_H = 7$

$h = 5; N = 8; 8N_h C_L C_M C_H = 81107$

Example (13): 3/8 of $C_L = 5$ at 600 m (2000 ft); 2/8 of $C_M = 3$; and 1/8 of $C_H = 1$

$h = 5; N = 6; 8N_h C_L C_M C_H = 83531$

Example (14): 6/8 of $C_L = 4$ at 1200 m (4000 ft); 1/8 of $C_M = 3$; and 1/8 of $C_H = 4$

$h = 6; N = 8; 8N_h C_L C_M C_H = 86434$

Example (15): 5/8 of $C_L = 1$ at 600 m (2000 ft); with traces of $C_M = 4$ and $C_H = 4$

$h = 5; N = 5; 8N_h C_L C_M C_H = 85141$

Example (16): Sky completely obscured by dense fog

$h = /; N = 9; 8N_h C_L C_M C_H = 89///$

Example (17): Sky partially obscured by fog to 30° above horizon, sky clear above 30°

$h = 9; N = 0; 8N_h C_L C_M C_H = 80000$

Example (18): Sky partially obscured by fog to 30° above horizon, portion of sky visible 4/8 covered by $C_M = 7$ at 3000 m (10 000 ft)

$h = 9; N = 4; 8N_h C_L C_M C_H = 84070$

Example (19): Clouds cannot be seen due to glare of lights

$h = /; N = /; 8N_h C_L C_M C_H = 8////$

Chapter 10 Ship's course and speed

10.1 Introduction

Section 2 of the SHIP weather message begins with this chapter. As well as ship's course and speed, this group contains information on sea surface temperature, waves, ice accretion, and sea ice.

10.2 Recording information on the ship's course and speed

10.2.1 Group 222D_sv_s

10.2.1.1 222 — Numerical indicator figure

The three-figure indicator group 222 identifies Section 2 of the weather message. The code figures 222 are preprinted in Column 45 on the meteorological log.

10.2.1.2 D_s — Ship's true course

If the ship's course was held constant during the three hours then the course in this period will be the actual course at the time of observation. If the ship has altered course at some time in the previous three hours, then the course made good will differ from the actual course at the time of observation. Figure 10—1 presents an example of this second possibility.

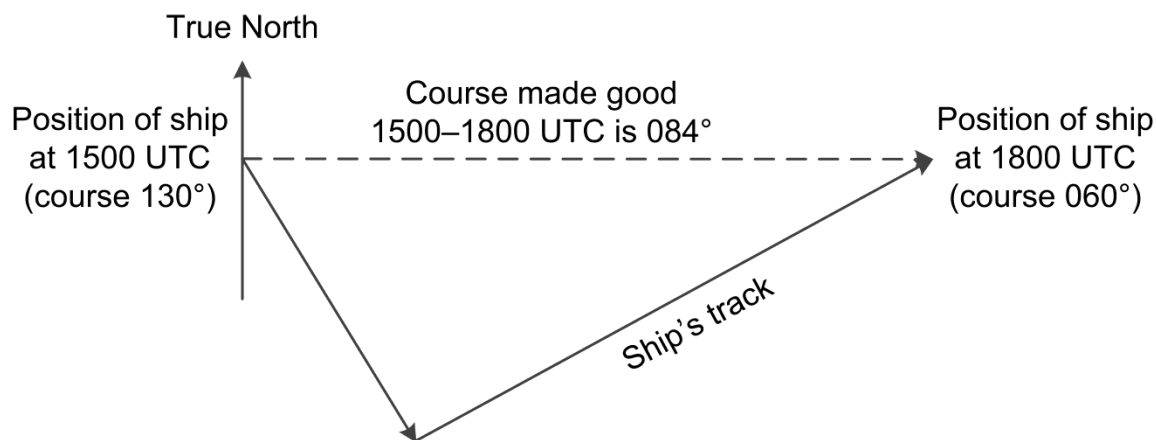


Figure 10—1: Determination of ship's course made good

In the example presented in Figure 10—1 the ship's course at 1800 UTC, the time of observation, is 060° true; but due to an alteration in course sometime after 1500 UTC, the course made good since 1500 UTC is 084° true, which will be the course represented by D_s (entered as 2).

The symbol D_s indicates the ship's true course during the three hours preceding the observation. Code figures for D_s are given in Table 10—1 followed by the corresponding specification of true course. The appropriate code figure for D_s is to be entered in Column 46 on the meteorological log.

Note (1): Selected Ships will record code figures for D_s .

Note (2): Auxiliary Ships are not required to report the Ship's Course so D_s is coded as a /.

Table 10—1: WMO code table 0700 — Specification of code figure D_s

Code Figure	Specification
0	Stationary
1	NE
2	E
3	SE
4	S
5	SW
6	W
7	NW
8	N
9	Unknown

10.2.1.3 v_s — Average speed of the ship

If the course and speed have been held constant over the three hours then the average speed will be the actual speed at the time of observation. However if the ship's course, or speed or both have changed during the previous three hours, then the average speed made good will have to be determined. In these circumstances the simplest method of determining the average speed made good is to find the distance, in nautical miles, between the ship's position at the time of observation, and its position three hours previously. This distance is then divided by three to obtain the average speed in knots.

In Figure 10—1, if the distance between the ship's positions at 1800 UTC and 1500 UTC is 24 NM, the average speed made good (in the direction 084°) is 8 kt. However in the three-hour period, the ship actually traversed a total distance of about 30 NM so the value computed for v_s is less than the average speed computed by taking into account the total distance travelled; v_s would be coded as 2.

The symbol \bar{v}_s indicates the average speed of the ship made good during the three hours preceding the time of observation. Code figures for \bar{v}_s are given in Table 10—2 followed by the corresponding specification of average speed. The appropriate code figure for \bar{v}_s is to be entered in Column 47 on the meteorological log.

Note (1): Selected Ships are required to record the appropriate code figure for \bar{v}_s .

Note (2): Auxiliary Ships are not required to record the ship's speed so \bar{v}_s will be coded as /.

Table 10—2: WMO code table 4451 — Specification of code figure \bar{v}_s

Code Figure	Specification of average speed in knots
0	0
1	1–5
2	6–10
3	11–15
4	16–20
5	21–25
6	26–30
7	31–45
8	36–40
9	Over 40

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Chapter 11 Waves

11.1 Introduction

Although wave observations have been made by observers on moving ships for many years, our knowledge of sea and swell waves is far from complete even on the most frequented shipping lanes. Much remains to be learned regarding the production, travel, and decay of ocean waves; information which is vital before accurate forecasts of wave conditions can be made available to mariners. A knowledge of the height and other characteristics of waves is of considerable practical value for a variety of purposes, including: the design and behavior of ships at sea, the design and orientation of harbours and the construction of breakwaters; problems of coast erosion and silting; discharging of ships into open anchorage's; landing operations on exposed beaches; and the landing and take-off of civil and military aircraft, either with reference to the sea itself or to aircraft carriers. In tropical waters the arrival of a gentle swell may be the first warning that is given of the approach of a dangerous hurricane or typhoon. Hence observers should include wave information in their weather messages at every opportunity. By doing so they are making a contribution to the safety and efficient operation of all shipping at sea (from which each contributing ship will in turn derive benefits).

11.2 Waves and swell

11.2.1 Simple waves

The following definitions are used to describe a simple wave:

Length (L) — expressed in metres, is the horizontal distance between two successive crests, or two successive troughs.

Height (H) — expressed in metres, is the vertical distance between the top of a crest and the bottom of the trough on either side.

Speed (C) — expressed in knots, is the speed at which individual waves travel.

Period (T) — expressed in seconds, is the time interval required for the passage of successive crests (or successive troughs) past a fixed point.

Some useful theoretical relationships, which have been checked by observation, exist among the length, speed, and period of simple waves. If one of these characteristics is known, approximate values for the other two can be calculated. The relationships are:

$$\text{Length (metres)} = 1.56 \times \text{Period} = 0.17 \times \text{Speed}$$

$$\text{Speed (knots)} = 3 \times \text{Period} = 2.43 \times \text{Length}$$

$$\text{Period (seconds)} = 0.76 \times \text{Length} = 0.33 \times \text{Speed}$$

These relationships hold true only for simple waves, which are never observed at sea. However they can be used to obtain rough estimates for ocean waves.

Unlike the length and speed, the wave height bears no definite relationship to the wave period. However it is found that the height of a wave seldom exceeds $\frac{1}{13}$ of its length, otherwise the wave will break at the crest, forming white horses. The ratio H / L is called the *steepness* of the wave, and cannot exceed about $\frac{1}{13}$. The limiting value of the steepness explains why the mean maximum height of the sea waves is roughly in proportion to their length. For example, wind driven waves of length 120 m (period of eight seconds) would not be expected to have a mean maximum height greater than 9 m. If the wave length were about 150 m (period of nine seconds) this limiting value of the mean maximum height would be increased to about 12 m. On the other hand, long swells, perhaps 300–500 m in length may have heights of less than 0.3 m.

11.2.2 Freak waves

A freak wave may be defined as a wave of very considerable height ahead of which there is a deep trough. Thus, it is the unusual steepness of the wave that is its outstanding feature, and which makes it dangerous to shipping. Reports available so far suggest that such waves have usually occurred where a strong current flows in the opposite direction to a heavy sea.

If freak waves are encountered anywhere, please record the following information in the *Supplementary Notes* portion of the meteorological log:

- Date, time, and ship's position
- Full description of freak wave, including height and horizontal distance between crest and trough.
- Weather conditions
- State of sea
- Any other factors that may have influenced the state of the sea.
- Any damage sustained by the ship.

All such reports will be forwarded to the British Meteorological Office which has agreed to serve as a collection agency for the data.

11.2.3 Sea waves and swell

11.2.3.1 Sea waves

Sea waves are the wave disturbance raised by the wind blowing at the ship at the time of observation. Sea waves run in a direction within 10° or so of the wind blowing in the vicinity of the ship. The height of the sea waves is determined by the distance over which the wind has acted on the water in the same direction (called *fetch*), the average wind speed over the fetch, and the length of time the wind has been blowing. The height of sea waves varies from $\frac{1}{13}$ to about $\frac{1}{35}$ of their length.

11.2.3.2 Swell

A swell is a wave system not raised by the local wind blowing at the time of observation, but raised at some distance away due to winds blowing there, and which has moved to the vicinity of the ship, or to waves raised nearby by winds that have since died away. Swell waves travel out of a stormy or windy area and continue on in the direction of the winds that originally formed them as sea waves. The swell may travel for thousands of miles before dying away. As the swell wave advances, its crest becomes rounded and its surface smooth. Its length increases until it is approximately 35 to 200 or more times its height.

Swell waves normally come from a direction different from the direction of the prevailing wind and sea waves at the time of observation. However, sea and swell waves may occasionally be seen coming from essentially the same direction, thus making it more difficult to distinguish the two systems, especially if the sea waves are high.

Sea waves and one or more systems of swell waves are frequently present at the same time, forming *cross seas*. Sea waves may also be absent (as would occur under conditions of very light winds) while one or more systems of swell waves may still be present.

11.2.4 Wave motion at sea

The waves observed on the ocean are not simple waves such as those described earlier in this chapter, but are highly complex and irregular in form. From the records obtained from mechanical wave recorders, it has been shown that complicated ocean waves may be regarded as the result of the superposition of a large number of simple wave trains having different heights, periods, and directions.

Suppose for example that we superimpose two simple wave trains having the same height, but slightly different periods. Where the crests of the two individual wave trains collide, the heights of the resultant wave will be twice that of each individual wave. To each side of this point however, owing to the difference in period, the additive effect becomes less until a point is reached where the crests of one component wave coincide with the troughs of the other component wave. Here the two components cancel each other, and the result is an area of relatively dead water. Beyond this point the heights again become additive until the crests once more coincide. For example: the simple wave train illustrated in Figure 11—1 combines with the simple wave train illustrated in Figure 11—2 to form the wave pattern illustrated in Figure 11—3.

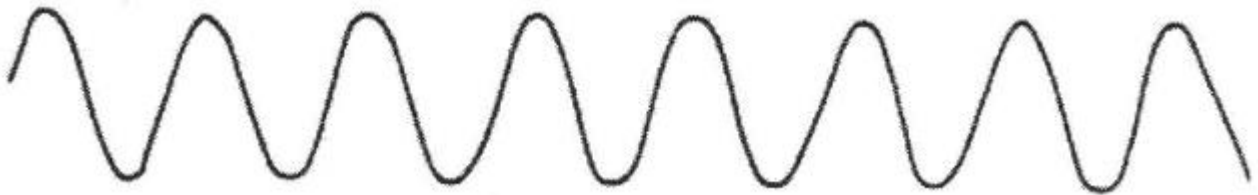


Figure 11—1: Simple wave train of a shorter period

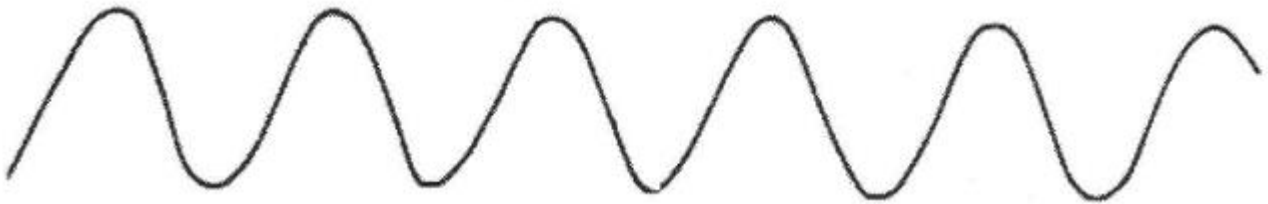


Figure 11—2: Simple wave train of a longer period

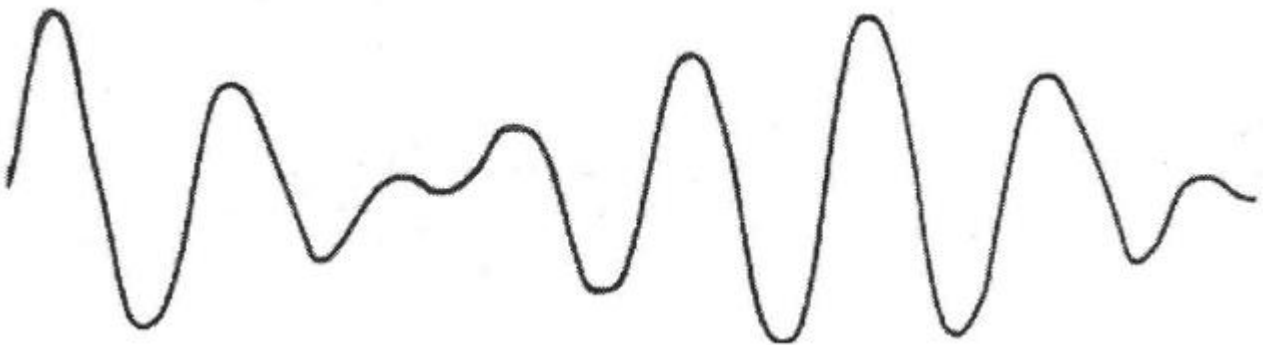


Figure 11—3: Wave pattern resulting from the superposition of two simple wave trains of different periods

11.2.5 Wave groups

It can be seen therefore that waves generally travel in groups with large well-formed waves at the center of each group, and patches of relatively dead water between the groups. It can also be shown that wave trains moving in slightly different directions give a resultant pattern composed of *short-crested* waves as distinct from the *long-crested* waves when a single train is present.

11.3 Observing ocean waves

11.3.1 Wave characteristics to be observed

The wave characteristics that are reported in the weather message are:

- Wave period
- Wave height
- Direction from which the waves are coming from (for swell only)

If more than one system of waves is present at the same time (e.g. a sea and a swell, or no sea and two swells), and can be distinguished, then the characteristics of each wave system should be reported.

To the experienced mariner ocean waves are part of their life, and they have learned to judge accurately their characteristics through acquaintanceship. However because of the complex nature of ocean waves, a new observer may regard the sea surface as being in a state of great confusion. For example, are all waves to be considered on an equal footing, or are only the big waves to be counted? Since the wave characteristics vary so much, what average values should be taken? It is obvious that if comparable results are to be obtained the observer must follow a definite procedure. The flat and badly formed waves between the wave groups cannot be observed accurately by eye and different observers would undoubtedly obtain different results if an attempt were made to include them. The best method therefore is to observe only the well-formed waves near the center of the wave groups.

Reliable values of period and height can only be obtained by observing at least 15–20 well-formed wave groups. Of course these waves cannot be consecutive. A few must be selected from each succeeding group until the required number has been observed. Measurements or quite good estimates are required; rough guesses have little value and should not be recorded.

11.3.2 Observing the direction of waves

Wave direction, like wind direction is the direction from which the waves are coming. The wave direction is determined with reference to True North (not magnetic), and is recorded to the nearest 10° (e.g., 010°, 020°, 030°, right around to 360°).

The direction of the sea waves is not required, as their direction is normally within 10° of the wind direction. Only the direction of the swell waves is required.

The direction is most easily found by sighting along the wave crests, then turning through 90° to face the advancing waves. The direction you are then facing will be the direction from which the waves are coming.

11.3.3 Observing the wave period

For measurements of period a stop watch is invaluable. If this is not available, an ordinary watch with a second hand may be used, or a practiced observer may count seconds.

The average value of the periods of the larger well-formed waves near the center of the wave groups are reported. To measure the period, an object floating on the water at some distance from the ship must be available. This can be a piece of wood thrown overboard from the bow by a crew member while you observe from the bridge. A piece of seaweed or a bird floating on the sea will also serve, or if nothing better is available a distinct patch of foam that remains identifiable for a minute or so will do. When the object reaches the crest of the first well-formed wave start the stop watch and count the number of crests which passed under the object. Note the time elapsed and the number of crests that passed under the object (do not count the first crest). Repeat the procedure until at least 15 well-formed waves have been timed. A new floating object will usually be necessary for each wave group, as the original object will probably have passed out of sight by the time the next wave group arrives. Finally add the elapsed time for the various wave groups together and divide the total by the number of crests counted to obtain the average period.

Example: An observer might make the observations shown in Table 11—1 while determining the wave period.

Table 11—1: Example of observations made to determine the average wave period

Wave group number	Crests counted	Time elapsed (seconds)
1	3	36
2	4	34
3	3	25
4	4	48
5	2	19
Totals	16	162

$$\text{Average period} = 162/16 = 10.1 \text{ seconds}$$

The wave period would be recorded to the nearest second; in this case 10 seconds.

11.3.4 Observing the wave height

There is no inexpensive device yet available for measuring the height of waves on a moving ship, so the height must be estimated by the observer.

When estimating wave height, consider only the larger well-formed waves near the center of the wave group. Estimate the average height of these larger waves, and disregard the lesser waves between the groups.

11.3.5 Waves of shorter length than the ship

If the length of the waves is short in comparison to the ship's length (i.e., if the ship spans two or more wave crests), then the observer should take up a position on the deck amidships where the effect of pitching is least, and on the side of the ship towards which the waves are coming. Look over the side of the ship and watch the waves as they travel the length of the ship at times when the rolling is least. Estimate the height (vertical distance between trough and crest) using as a yardstick the relative heights of two known points along the side, for example, the sea ladder fittings, the loading ports, or the rubbing strake. Try to estimate the height to the nearest half metre (or one foot).

11.3.6 Waves of greater length than the ship

The recommended method of estimating height in this situation is that the observer takes up a position in the ship so that their eyes are just in line with the advancing wave crest and the horizon, when the ship is vertical in the trough. The height of the eye above the waterline is then the height of the wave. If the ship is rolling heavily it is particularly important to make the observation at the instant when it is upright in the trough, otherwise the estimate of the height will be too large.

11.3.7 Wave observation at night or in low visibility

On very dark nights or in dense fog, the most that the observer can hope for is an estimate of the height of the sea waves, which would be based on the last clear sighting of the waves, and whether in the observer's judgment the waves have since increased or decreased, as might be indicated by the ship's motion, or by a change in wind speed. Swell waves are difficult to observe at any time, but at night it becomes almost impossible. It is only on very bright moonlit nights that the height, and perhaps the period, could be observed.

11.4 Recording wave information

In the weather message provision is made for reporting wave data in up to four groups as follows:

$2P_w P_w H_w H_w$ — Period and height of sea waves

$3d_{w1} d_{w1} d_{w2} d_{w2}$ — Direction(s) of the swell system

$4P_{w1} P_{w1} H_{w1} H_{w1}$ — Period and height of the predominant swell system

$5P_{w2} P_{w2} H_{w2} H_{w2}$ — Period and height of the secondary swell system

If there is no swell or if the swell cannot be distinguished then only the sea wave group $2P_w P_w H_w H_w$ is reported. Under calm conditions (no sea waves or swell) $2P_w P_w H_w H_w$ is coded as 20000.

If a swell is present but no sea waves, then $2P_w P_w H_w H_w$ is omitted, and the swell is reported by the appropriate swell group.

If sea waves and one swell system are observed, then the first three groups are reported.

The second group (direction of swell) is coded as $3d_{w1} d_{w1} //$; the $//$ indicates that a secondary swell system was not observed.

If sea waves and two swell systems can be observed, then all four groups are reported. The predominant swell system is the one having the higher waves.

11.4.1 Group $2P_w P_w H_w H_w$ — Period and height of sea waves

Group $2P_w P_w H_w H_w$ is reported by Selected and Auxiliary Ships.

11.4.1.1 2 — Numerical indicator figure

The figure 2 indicates that figure group $P_w P_w H_w H_w$ is being included in the report. This figure is always recorded in Column 51 on the meteorological log.

11.4.1.2 $P_w P_w$ — Period of sea waves

The symbol $P_w P_w$ indicates the period of sea waves, in seconds, and is to be entered in Column 52 on the meteorological log.

11.4.1.3 $H_w H_w$ — Height of sea waves

The symbol $H_w H_w$ indicates the height of the sea waves in units of half metres (as per Table 11—2) and is to be entered in Column 53 on the meteorological log.

Note (1): Under calm conditions (no sea waves or swell) $P_w P_w$ is coded as 00.

Note (2): When the period of the waves (sea or swell) cannot be determined because of a confused sea $P_w P_w$ is coded as 99.

Note (3): When the period of the waves (sea or swell) cannot be determined for any other reason $P_w P_w$ is coded as //.

11.4.2 Group $3d_{w1}d_{w1}d_{w2}d_{w2}$ — Directions of the swell system

Note: Group $3d_{w1}d_{w1}d_{w2}d_{w2}$ is reported by Selected ships.

11.4.2.1 3 — Numerical indicator figure

The figure 3 indicates that figure group $d_{w1}d_{w1}d_{w2}d_{w2}$ is being included in the report. This figure is recorded in Column 54 on the meteorological log.

11.4.2.2 $d_{w1}d_{w1}$ — Direction of the predominant swell waves

The symbol $d_{w1}d_{w1}$ indicates the direction from which the predominant swell waves are coming. The swell direction is reported in tens of degrees referred to true north, in the same way as the wind direction, in a scale from 01 to 36. The appropriate code figure for $d_{w1}d_{w1}$ is to be entered in Column 55 on the meteorological log.

11.4.2.3 $d_{w2}d_{w2}$ — Direction of the secondary swell waves

The symbol $d_{w2}d_{w2}$ indicates the direction from which the secondary swell waves are coming. It is reported in tens of degrees similar to $d_{w1}d_{w1}$. The appropriate code figure for $d_{w2}d_{w2}$ is to be entered in Column 56 on the meteorological log.

Note: If only one system of swell waves is observed, then $d_{w2}d_{w2}$ is coded as //.

11.4.3 Group $4P_{w1}P_{w1}H_{w1}H_{w1}$ — Period and height of the predominant swell system

Note: Group $4P_{w1}P_{w1}H_{w1}H_{w1}$ is reported by Selected ships.

11.4.3.1 4 — Numerical indicator figure

The figure 4 indicates that figure group $P_{w1}P_{w1}H_{w1}H_{w1}$ is being included in the report. This figure is recorded in Column 57 on the meteorological log.

11.4.3.2 $P_{w1}P_{w1}$ — Period of the predominant swell wave

The symbol $P_{w1}P_{w1}$ indicates the period of the predominant swell wave, in seconds. The appropriate code figure for $P_{w1}P_{w1}$ is to be entered in Column 58 on the meteorological log.

11.4.3.3 $H_{w1}H_{w1}$ — Height of waves in the predominant swell system

The symbol $H_{w1}H_{w1}$ indicates the height of the waves (half metres) in the predominant swell system. The appropriate code figure for $H_{w1}H_{w1}$ (as per Table 11—2) is to be entered in Column 59 on the meteorological log.

Note (1): When the period of the swell cannot be determined because of a confused sea $P_{w1}P_{w1}$ is coded as 99.

Note (2): When the period of the swell cannot be determined for any other reason $P_{w1}P_{w1}$ is coded as //.

11.4.4 Group $5P_{w2}P_{w2}H_{w2}H_{w2}$ — Period and height of the secondary swell system

Note: Group $5P_{w2}P_{w2}H_{w2}H_{w2}$ is reported by Selected ships.

11.4.4.1 5 — Numerical indicator figure

The figure 5 indicates that figure group $P_{w2}P_{w2}H_{w2}H_{w2}$ is being included in the report. This figure is recorded in Column 60 on the meteorological log.

11.4.4.2 $P_{w2}P_{w2}$ — Period of the secondary swell wave

The symbol $P_{w2}P_{w2}$ indicates the period of the secondary swell wave, in seconds. The appropriate code figure for $P_{w2}P_{w2}$ is to be entered in Column 61 on the meteorological log.

11.4.4.3 $H_{w2}H_{w2}$ — Height of waves in secondary swell system

The symbol $H_{w2}H_{w2}$ indicates the height of the waves (half metres) in the secondary swell system. Table 11—2 specifies the code figures for waves of different heights. The appropriate code figure for $H_{w2}H_{w2}$ is to be entered in Column 62 on the meteorological log.

Note (1): When the period of the swell cannot be determined because of a confused sea $P_{w2}P_{w2}$ is coded as 99.

Note (2): When the period of the swell cannot be determined for any other reason $P_{w2}P_{w2}$ is coded as //.

Table 11—2: Height of waves — Specification of code figures H_w , H_{w1} , and H_{w2}

Code Figure	Height (Metres)	Height (Feet)
00	Less than 0.25	Less than 1
01	0.5	1 or 2
02	1.0	3 or 4
03	1.5	5
04	2.0	6 or 7
05	2.5	8 or 9
06	3.0	10
07	3.5	11 or 12
08	4.0	13
09	4.5	14 or 15
10	5.0	16 or 17
11	5.5	18
12	6.0	19 or 20
13	6.5	21 or 22
14	7.0	23
15	7.5	24 or 25
16	8.0	26 or 27
17	8.5	28
18	9.0	29 or 30
19	9.5	31
20	10.0	32 or 33
21	10.5	34 or 35
22	11.0	36
23	11.5	37 or 38
24	12.0	39 or 40
25	12.5	41
26	13.0	42 or 43
27	13.5	44 or 45
28	14.0	46 ¹
//	Not determined due to confused sea	Not determined due to confused sea

Note (1): To obtain the code figures for heights over 46 feet, multiply the height in feet by 0.6 and round off to the nearest whole number.

11.4.5 Special weather report — SPREP

11.4.5.1 Selected ships

A Special Weather Report (SPREP) should be sent whenever combined seas (wind, waves, and swell) become hazardous or increase to 2–3 m (7–10 ft) or more in excess of those forecast.

11.4.5.2 Auxiliary ships (Great Lakes)

A Special Weather Report (SPREP) should be sent whenever the significant wave height has increased by 1.5 m (5 ft) over the wave height reported at the previous synoptic hour.

Chapter 12 Ice accretion on ships

12.1 Introduction

In higher latitudes, during stormy weather in the winter season, the deposition of a coating of ice on the ship's superstructure due to the freezing of spray, rain, or drizzle, is a common and sometimes dangerous occurrence. In recent years in fact, several smaller ships have foundered in the seas north of Great Britain because of an intolerable load of ice. Icing may also occur even in relatively calm weather, due to the formation of a coating of rime ice when the ship is passing through fog. This is caused by the freezing of fog droplets on the superstructure.

Because of the risks and inconveniences brought about by ice accretion, it benefits mariners to have offices ashore issue warnings when the weather and sea conditions are conducive to ice accretion. At present our knowledge of all the conditions that produce icing is incomplete, and since forecasts of all parameters are based on observed data, provision has been made to report occurrences of ice accretion in the weather message. Thus the meteorological and sea conditions which produce icing can be observed and studied so that reliable warnings can be broadcast when a danger is foreseen. Mariners are therefore urged to report occurrences of ice accretion on their ships whenever they are observed.

12.2 Recording ice accretion information

12.2.1 Group $6I_sE_sE_sR_s$

Note: Group $6I_sE_sE_sR_s$ is to be reported by Selected ships and Auxiliary ships.

12.2.1.1 6 — Numerical indicator figure

The figure 6 indicates that figure group $I_sE_sE_sR_s$ is being included in the report. This figure is recorded in Column 63 on the meteorological log.

12.2.1.2 I_s — Cause of ice accretion

The symbol I_s indicates the cause of ice accretion on ships. There are various causes of ice accretion on ships, including ocean spray, fog, spray and fog, precipitation, as well as spray and precipitation. Code figures for I_s are given in Table 12—1 followed by the corresponding specification. The appropriate code figure for I_s is to be entered in Column 64 on the meteorological log.

Table 12—1: WMO code table 1751 — Specification of code figure I_s

Code Figure	Specification
1	Icing from ocean spray
2	Icing from fog
3	Icing from spray and fog
4	Icing from precipitation
5	Icing from spray and precipitation

12.2.1.3 E_sE_s — Thickness of ice accretion

The symbol E_sE_s indicates the thickness of ice accretion. The thickness of the ice accretion reported should be the maximum thickness observed at the time of observation, measured and recorded in centimetres. If the thickness is being measured in inches determine the maximum thickness of ice accretion to the nearest quarter of an inch, then find the code figure (centimetres) which has the inch equivalent closest to the measured value. Code figures for E_sE_s are given in Table 12—2 followed by the corresponding specification of different thicknesses of ice. The appropriate code figure for E_sE_s is to be entered in Column 65 on the meteorological log.

Table 12—2: $E_s E_s$ — Thickness of ice accretion on ships in centimetres and inches

Code figure	Thickness of ice (centimetres)	Thickness of ice (inches)
00	0	$< \frac{1}{4}$
01	1	$\frac{1}{4}$ or $\frac{1}{2}$
02	2	$\frac{3}{4}$
03	3	1 or $1 \frac{1}{4}$
04	4	$1 \frac{1}{2}$ or $1 \frac{3}{4}$
05	5	2
06	6	$2 \frac{1}{4}$ or $2 \frac{1}{2}$
07	7	$2 \frac{3}{4}$
08	8	3 or $3 \frac{1}{4}$
09	9	$3 \frac{1}{2}$
10	10	$3 \frac{3}{4}$ or 4
11	11	$4 \frac{1}{4}$ or $4 \frac{1}{2}$
12	12	$4 \frac{3}{4}$
13	13	5 or $5 \frac{1}{4}$
14	14	$5 \frac{1}{2}$
15	15	$5 \frac{3}{4}$ or 6
16	16	$6 \frac{1}{4}$
17	17	$6 \frac{1}{2}$ or $6 \frac{3}{4}$
18	18	7 or $7 \frac{1}{4}$
19	19	$7 \frac{1}{2}$
20	20	$7 \frac{3}{4}$ or 8
21	21	$8 \frac{1}{4}$
22	22	$8 \frac{1}{2}$ or $8 \frac{3}{4}$
23	23	9 or $9 \frac{1}{4}$
24	24	$9 \frac{1}{2}$
25	25	$9 \frac{3}{4}$ or 10
26	26	$10 \frac{1}{4}$
27	27	$10 \frac{1}{2}$ or $10 \frac{3}{4}$
28	28	11
29	29	$11 \frac{1}{4}$ or $11 \frac{1}{2}$

12.2.1.4 R_s — Rate of ice accretion on ships

The symbol R_s indicates the rate of ice accretion on ships. Code figures for R_s are given in Table 12—3 followed by the corresponding specification. The appropriate code figure for R_s is to be entered in Column 66 on the meteorological log.

Table 12—3: WMO code table 3551 — Specification of code figure R_s

Code figure	Specification of rate of accretion
0	Ice not building up
1	Ice building up slowly
2	Ice building up rapidly
3	Ice melting or breaking up slowly
4	Ice melting or breaking up rapidly

12.2.2 Special weather report — **SPREP**

A special weather report (**SPREP**) should be sent whenever ice forms on the ship's superstructure.

Chapter 13 Ice

13.1 Introduction

Ice information is included in weather messages from Selected and Auxiliary ships whenever sea ice and/or ice of land origin are observed from the ship's position at the time of observation.

The reporting of ice in the weather message is not to supersede the reporting of sea ice or icebergs in accordance with the International Convention for the Safety of Life at Sea.

13.2 Recording ice information

13.2.1 Group **ICE** $c_i S_i b_i D_i z_i$

13.2.1.1 **ICE** — Code word indicator

The code word **ICE** indicates that figure group $c_i S_i b_i D_i z_i$ is being included in the report. This code word is recorded in Column 70 on the meteorological log.

13.2.1.2 c_i — Concentration or arrangement of sea ice

The symbol c_i indicates the concentration or arrangement of sea ice. Code figures for c_i are given in Table 13—1 followed by the corresponding specification. The appropriate code figure for c_i is to be entered in Column 71 on the meteorological log.

Table 13—1: WMO code table 0639 — Specification of code figure C_i

Code figure	Concentration or arrangement of sea ice	Uniformity of sea ice concentration	Ship's position relative to ice
0	No sea ice in sight	—	—
1	Ship in open lead more than 1 NM wide, or ship in fast ice with boundary beyond limit of visibility	—	—
2	Sea ice present in concentrations less than 3/10 (3/8 open water or very open pack ice)	Sea ice concentration is uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
3	4/10 to 6/10 (3/8 to less than 6/8) open pack ice	Sea ice concentration is uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
4	7/10 to 8/10 (6/8 to less than 7/8) close pack ice	Sea ice concentration is uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
5	9/10 or more but not 10/10 (7/8 to less than 8/8) very close pack ice	Sea ice concentration is uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
6	Strips and patches of pack ice with open water between	Sea ice concentration is not uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
7	Strips and patches of close, or very close pack ice with area of lesser concentrations between	Sea ice concentration is not uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
8	Fast ice with open water very open, or open pack ice to seaward of the ice boundary	Sea ice concentration is not uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
9	Fast ice with close or very close pack ice to seaward of the ice boundary	Sea ice concentration is not uniform in the observation area	Ship in ice or within 0.5 NM of the ice edge
/	Unable to report because of darkness lack of visibility, or because the ship is more than 0.5 NM away from the ice edge.	—	—

Note (1): The coding chosen for C_i should describe the condition that is of the most navigational significance.

Note (2): If the ship is in an open lead more than 1 NM wide, code $C_i = 1$. If the ship is in fast ice with the ice boundary beyond the limit of visibility, code $C_i = 1$.

13.2.1.3 S_i — Stage of development of sea ice

The symbol S_i indicates the stage of development of sea ice. Code figures for S_i are given in Table 13—2 followed by the corresponding specification. The appropriate code figure for S_i is to be entered in Column 72 on the meteorological log.

Table 13—2: WMO code table 3739 — Specification of code figure S_i

Code Figure	Specification of stage of development
0	New ice only (frazil ice, grease ice, slush, shuga)
1	Nilas or ice rind, less than 10 cm thick
2	Young ice (gray ice, gray-white ice, 10–30 cm thick)
3	Predominately new and/or young ice with some first-year ice
4	Predominately thin first-year ice with some new and/or young ice
5	All thin first-year ice (30–70 cm thick)
6	Predominately medium first-year ice (70–120 cm thick) and thick-first year ice (more than 120 cm thick) with some thinner (younger) first-year ice
7	All medium and thick first-year ice
8	Predominately medium and thick first-year ice with some old ice (usually more than 2 m thick)
9	Predominately old ice
/	Unable to report because of darkness, lack of visibility, or because only ice of land origin is visible, or because ship is more than 0.5 NM away from ice edge

13.2.1.4 b_i — Ice of land origin

The symbol b_i indicates the ice of land origin. Code figures for b_i are given in Table 13—3 followed by the corresponding specification. The appropriate code figure for b_i is to be entered in Column 73 on the meteorological log.

Table 13—3: WMO code table 0439 — Specification of code figure b_i

Code Figure	Specification
0	No ice of land origin
1	1–5 icebergs, no growlers or bergy bits
2	6–10 icebergs, no growlers or bergy bits
3	11–20 icebergs, no growlers or bergy bits
4	Up to and including 10 growlers and bergy bits — no icebergs
5	More than 10 growlers and bergy bits — no icebergs
6	1–5 icebergs with growlers and bergy bits
7	6–10 icebergs with growlers and bergy bits
8	11–20 icebergs with growlers and bergy bits
9	More than 20 icebergs with growlers and bergy bits — a major hazard to navigation
/	Unable to report because of darkness, lack of visibility, or because only sea ice is visible

Note: If only ice of land origin is present, the ice group is coded as $0/b_i/0$ (e.g. $0/2/0$ would mean 6–10 icebergs in sight, but no sea ice).

13.2.1.5 D_i — True bearing of principal ice edge

The symbol D_i indicates the true bearing of principal ice edge. Code figures for D_i are given in Table 13—4 followed by the corresponding specification. The appropriate code figure for D_i is to be entered in Column 74 on the meteorological log.

Table 13—4: WMO code table 0739 — Specification of code figure D_i

Code Figure	Specification
0	Ship inshore of flaw lead
1	Principal ice edge towards NE
2	Principal ice edge towards E
3	Principal ice edge towards SE
4	Principal ice edge towards S
5	Principal ice edge towards SW
6	Principal ice edge towards W
7	Principal ice edge towards NW
8	Principal ice edge towards N
9	Not determined (ship in ice)
/	Unable to report because of darkness, lack of visibility, or because only ice of land origin is visible

Note (1): The bearing of the principal ice edge reported should be to the closest part of the edge.

Note (2): If the ship is in an open lead more than 1 NM wide code $D_i = 0$. If the ship is in fast ice with the ice boundary beyond the limit of visibility, code $D_i = 9$

13.2.1.6 z_i — Present ice situation and trend of conditions

The symbol z_i indicates the present ice situation and trend of conditions over preceding three hours. Code figures for z_i are given in Table 13—5 followed by the corresponding specification. The appropriate code figure for z_i is to be entered in Column 75 on the meteorological log.

Table 13—5: WMO code table 5239 — Specification of code figure z_i

Code figure	Specification	Ship in difficult to penetrate ice	Ship in ice
0	Ship in open water with floating ice in sight	—	—
1	Ship in easily penetrable ice, conditions improving	—	Ship in ice
2	Ship in easily penetrable ice, conditions not changing	—	Ship in ice
3	Ship in easily penetrable ice, conditions worsening	—	Ship in ice
4	Ship in ice difficult to penetrate, conditions improving	—	Ship in ice
5	Ship in ice difficult to penetrate, conditions not changing	—	Ship in ice
6	Ice forming and floes freezing together	Ship in ice that is difficult to penetrate and conditions are worsening	Ship in ice
7	Ice under slight pressure	Ship in ice that is difficult to penetrate and conditions are worsening	Ship in ice
8	Ice under moderate or severe pressure	Ship in ice that is difficult to penetrate and conditions are worsening	Ship in ice
9	Ship beset	Ship in ice that is difficult to penetrate and conditions are worsening	Ship in ice
/	Unable to report because of darkness or lack of visibility	—	—

13.3 Ice terms and definitions

Anchor ice: Submerged ice attached or anchored to the bottom, irrespective of the nature of its formation.

Bergy bit: A large piece of floating glacier ice, generally showing more than 1 m but less than 5 m above sea level and normally 100–300 m² in area.

Beset: Situation of a vessel surrounded by ice and unable to move.

Brash ice: Accumulations of floating ice made up of fragments not more than 2 m across, formed by the wreckage of other ice.

Calving: The breaking away of a mass of ice from an ice wall, ice front or iceberg.

Close pack ice: Pack ice in which the concentration is 7/10 to 8/10 (6/8 to less than 7/8) composed of floes mostly in contact.

Compacted ice edge: Close, clear-cut ice edge compacted by wind or current (usually on the windward side of an area of pack ice).

Compact pack ice: Pack ice in which the concentration is 10/10 (8/8) and no water is visible.

Concentration: The ratio expressed in tenths or oktas describing the mean areal density of ice in a given area.

Consolidated pack ice: Pack ice in which the concentration is 10/10 (8/8) and the floes are frozen together.

Dark nilas: Nilas that is under 5 cm in thickness and is very dark in colour.

Diffuse ice edge: Poorly defined ice edge limiting an area of dispersed ice (usually on the leeward side of an area of pack ice).

Fast ice: Sea ice which forms and remains fast along the coast, where it is attached to the shore, to an ice wall, to an ice front, between shoals or grounded icebergs. Vertical fluctuations may be observed during changes of sea level. Fast ice may be formed in situ from sea water or by freezing of pack ice of any age to the shore, and it may extend a few metres or several hundred kilometres from the coast. Fast ice may be more than one year old and may then be prefixed with the appropriate age category — old, second-year, or multi-year. If it is thicker than about 2 m above sea level it is called an ice shelf.

Finger rafting: Type of rafting whereby interlocking thrusts are formed, each floe thrusting *fingers* alternately over and under the other (common in nilas and gray ice).

First-year ice: Sea ice of not more than one winter's growth, developing from young ice: thickness 30 cm–2 m. May be sub-divided into thin first-year ice/white ice, medium first-year ice and thick first year ice.

Flaw lead: A passage-way between pack ice and fast ice that is navigable by surface vessels.

Floating ice: Any form of ice found floating in the water. The principal kinds of floating ice are lake ice, river ice, and sea ice which form by the freezing of water at the surface, and glacier ice (ice of land origin) formed on land or in an ice shelf. The concept includes ice that is stranded or grounded.

Floe: Any relatively flat piece of sea ice 20 m or more across. Floes are sub-divided according to horizontal extent as follows:

- **Giant:** Over 5.4 NM across
- **Vast:** 1.1–5.4 NM across
- **Big:** 500–2000 m across
- **Medium:** 100–500 m across
- **Small:** 20–100 m across

Floeberg: A massive piece of sea ice composed of a hummock or a group of hummocks frozen together and separated from any ice surroundings. It may float up to 5 m above sea level.

Fracture: Any break or rupture through very close pack ice, compact pack ice, consolidated pack ice, fast ice, or a single floe resulting from deformation processes. Fractures may contain brash ice and/or be covered with nilas and/or young ice. Length may vary from a few metres to many nautical miles.

Frazil ice: Fine spicules or plates of ice suspended in water.

Glacier: A mass of snow and ice continuously moving from higher to lower ground or, continuously spreading if afloat. The principal forms of glacier are: inland ice sheets, ice shelves, ice streams, ice caps, ice piedmonts, cirque glaciers and various types of mountain (valley) glaciers.

Glacier-berg: An irregularly shaped iceberg.

Glacier ice: Ice in or originating from a glacier, whether on land or floating on the sea as icebergs, bergy bits or growlers.

Grease ice: A later stage of freezing than frazil ice when the crystals have coagulated to form a soupy layer on the surface. Grease ice reflects little light giving the sea a matt appearance.

Gray ice: Young ice 10–15 cm thick; less elastic than nilas and breaks on swell. Usually rafts under pressure.

Gray-white ice: Young ice 15–30 cm thick. Under pressure more likely to ridge than to raft.

Growler: Smaller piece of ice than a bergy bit or floeberg, often transparent but appearing green or almost black in colour, extending less than 1 m above the sea surface and normally occupying an area of about 20 m².

Hummock: A hillock of broken ice that has been forced upwards by pressure (may be fresh or weathered). The submerged volume of broken ice under the hummock, forced downwards by pressure, is termed a bummock.

Iceberg: A massive piece of ice greatly varying in shape, more than 5 m above sea level, which has broken away from a glacier, and which may be afloat or aground. Icebergs may be described as tabular, dome-shaped, sloping, pinnaced, weathered or glacier-bergs.

Ice boundary: The demarcation at any given time between fast ice and pack ice or between areas of pack ice of different concentrations.

Ice edge: The demarcation of any given time between the open sea and sea ice of any kind whether fast or drifting. It may be termed compacted or diffuse.

Ice front: The vertical cliff forming the seaward face of an ice shelf or other floating glacier varying in height from 2–50 m or more above sea level.

Ice of land origin: Ice formed on land or in an ice shelf, found floating in water. The concept includes ice that is stranded or grounded.

Ice patch: An area of pack ice that is less than 5.4 NM across.

Ice rind: A brittle shiny crust of ice formed on a quiet surface by direct freezing or from grease ice usually in water of low salinity. Thickness to about 5 cm. Easily broken by wind or swell, commonly breaking in rectangular pieces.

Ice shelf: A floating ice sheet of considerable thickness showing 2–50 m or more above sea level, attached to the coast. Usually of great horizontal extent and with a level or gently undulating surface. Nourished by annual snow accumulation and often also by the seaward extension of land glaciers. Limited areas may be aground. The seaward edge is termed an ice front.

Ice stream: Part of an island ice sheet in which the ice floes move rapidly and not necessarily in the same direction as the surrounding ice. The margins are sometimes clearly marked by a change in direction of the surface slope but may be indistinct.

Ice under pressure: Ice in which deformation processes are actively occurring and hence a potential impediment or danger to shipping.

Ice wall: An ice cliff forming the seaward margin of a glacier that is not afloat. An ice wall is aground, the rock basement being at or below sea level.

Lake ice: Ice formed on a lake, regardless of observed location.

Lead: Any fracture or passage-way through sea ice that is navigable by surface vessels.

Light nilas: Nilas that is more than 5 cm in thickness and rather lighter in colour than dark nilas.

Medium first-year ice: First year ice 70–120 cm thick.

Multi-year ice: Old ice up to 3 m or more thick that has survived at least two summers' melt. Hummocks even smoother than in second year ice, and the ice is almost salt free. Colour where bare is usually blue. Melt pattern consists of large inter-connecting irregular puddles and a well-developed drainage system.

New ice: A general term for recently formed ice that includes frazil ice, grease ice, slush, and shuga. These types of ice are composed of ice crystals which are only weakly frozen together (if at all) and have a definite form only when they are afloat.

Nilas: A thin elastic crust of ice easily bending on waves and swell and under pressure thrusting in a pattern of interlocking *fingers* (finger rafting). Has a matt surface and is up to 10 cm in thickness. May be divided into dark nilas and light nilas.

Old ice: Sea ice that has survived at least one summer's melt. Most topographic figures are smoother than on first year ice. May be subdivided into second-year and multi-year ice.

Open pack ice: Pack ice in which the ice concentration is $\frac{4}{10}$ to $\frac{6}{10}$ ($\frac{3}{8}$ to less than $\frac{6}{8}$), with many leads and polynyas and the floes are generally not in contact with one another.

Open water: A large area of freely navigable water in which sea ice is present in concentrations less than $\frac{1}{10}$ ($\frac{1}{8}$). There may be ice of land origin present, although the total concentration of all ice shall not exceed $\frac{1}{10}$ ($\frac{1}{8}$).

Pack ice: Term used in a wide sense to include any area of sea ice, other than fast ice, no matter what form it takes or how it is disposed.

Polynya: Any non-linear shaped opening enclosed in ice. Polynyas may contain brash ice and/or be covered with new ice, nilas, or young ice; submariners refer to these as skylights. Sometimes the polynya is limited on one side by the coast and is called shore polynya or by fast ice and is called a flaw polynya. If it recurs in the same position every year it is called a recurring polynya.

Puddle: An accumulation on ice of melt-water, mainly due to melting snow, but in the more advanced stages also to the melting of ice. Initial stage consists of patches of melted snow.

Rafting: Pressure processes whereby one piece of ice overrides another. Most common in new or young ice.

Ridging: The pressure process by which sea ice is forced into ridges, i.e. a line or wall of broken ice forced up by pressure.

River ice: Ice formed on a river, regardless of observed location.

Sea ice: Any form of ice found at sea that has originated from the freezing of sea water.

Second-year ice: Old ice that has survived only one summer's melt. Because it is thicker and less dense than first year ice it stands higher out of the water. In contrast to multi-year ice, summer melting produces a regular pattern of numerous small puddles. Bare patches and puddles are usually greenish-blue.

Shuga: An accumulation of spongy white ice lumps, a few centimetres across; they are formed from grease ice or slush and sometimes from anchor-ice rising to the surface.

Slush: Snow that is saturated and mixed with water on land or ice surfaces, or as a viscous floating mass in water after a heavy snowfall.

Strip: Long narrow area of pack ice about 0.5 NM or less in width, usually composed of small fragments detached from the main mass of ice, and run together under the influence of wind, swell, or current.

Tabular berg: A flat-topped iceberg. Most tabular bergs form by calving from an ice shelf and show horizontal banding.

Thick first-year ice: First year ice over 120 cm thick.

Thin first-year ice/white ice: First-year ice 30–70 cm thick.

Very close pack ice: Pack ice in which the concentration is 9/10 to less than 10/10 (7/8 to less than 8/8).

Very open pack ice: Pack ice in which the concentration is 1/10 to 3/10 (1/8 to less than 3/8) and water preponderates over ice.

Young ice: Ice in the transition stage between nilas and first-year ice, 10–30 cm in thickness. May be divided into gray ice and gray-white ice.

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Chapter 14 Remarks column

14.1 Introduction

Column 76 on the meteorological log is reserved for plain language remarks which give additional information about the weather not contained in the coded report, or other notes which are useful or interesting.

14.2 Recording remarks concerning weather

The most important considerations are that the remarks be brief and specific. The information that is especially important to record is:

- Time (UTC) of beginning and ending of precipitation of any kind.
- Time of change in the type of precipitation (rain to snow, drizzle to rain etc.)
- Time of beginning and ending of fog (visibility less than 0.5 NM)
- Time at which first and last thunder was heard.
- Time of wind shifts (with direction before and after shift)

Note: Generalized remarks without detail are of little value (e.g. frequent showers; continuous rain; wind variable; Low sea and swell).

If remarks concerning the above list are entered it will assist greatly in the coding of Present Weather (^{ww}) and Past Weather (^{W₁}^{W₂}). If the observer enters the remarks in the log book before they go off watch the officers taking over will have a record of the past weather which will be of assistance to them in making the report which occurs during their watch. Remarks as suggested above are also of great value in editing the records before they are transferred to archives at Environment and Climate Change Canada headquarters.

Remarks should not be lengthy. The following are typical entries:

- Light rain began 0810. Rain ended 1135.
- Rainshowers 2015–2025, 2110–2135.
- Rain to snow 1345. Snow ended 1550
- Fog began 0015, ended 1630.
- First thunder heard 1020, last thunder 1105
- Windshift SSW to NNW 2120.

Note: Enter all times in UTC

14.3 Recording other remarks

When a new Principal Observing Officer takes over the weather program on the ship, it is important that this fact be recorded in the Remarks column, giving the name of the new officer, so that the work may be credited to the proper person.

Notes should be made regarding instruments, such as malfunctioning of the barograph, wind equipment, psychrometer.

In addition to the basic remarks on weather already mentioned, observers are invited to note other interesting or unusual phenomena relating to the fields of meteorology, oceanography, astronomy, natural history, etc., observed at sea. Observations of such phenomena such as waterspouts, St. Elmo's Fire, abnormal refractions, haloes, rainbows, meteors, and other astronomical phenomena, aurora, ocean currents, birds or unusual marine life are welcome and the observer will be making a valuable contribution to our knowledge of these subjects.

14.4 The supplementary notes section

Notes concerning the phenomena mentioned in the previous paragraph are best made in the Supplementary Notes section which will be found on the back of each log sheet.

Sketches and if possible photographs enhance the value of an observation greatly.

Chapter 15 Message transmission

15.1 Introduction

It is of the utmost importance that meteorological forecast centers receive ships' weather messages as soon as possible after the scheduled times of observation of 0000, 0600, 1200, 1800 UTC. Therefore as soon as the observation has been completed in coded form it should be copied on to the Form 63–9452 *Selected Ships' Coded Weather Report* or Form 63–9454 *Auxiliary Ships' Coded Weather Report* and handed to the Radio Officer for transmission.

15.2 Inclusion of service indicator — OBS

When transmitting the weather message to a coastal station, it should be noted that the paid service indicator **OBS** must be included in the message before the telegraphic address to which the message is being sent.

The reasons for the use of the abbreviation **OBS** as a service indicator before the address in ships' weather messages are:

- To obtain for the transmitting ship station the priority Number 6 contemplated by Article 37 of the *Radio Regulations* for communications relating to weather observation messages.
- To obtain for the recipient meteorological centre the reduction in the transmission charges provided for in Article 4, Additional Radio Regulations No. 2056.

It should be emphasized that weather messages are transmitted free of charge to the ship. The meteorological service to which the message is addressed bears all coastal receiving station and forwarding charges.

Coastal receiving stations designated to accept ship's weather messages have been established in all parts of the world. The radio officer should make every effort to clear the message through one of these designated stations. If unable to contact a coastal station for any reason the message may be relayed to the appropriate address through an Ocean Weather Ship, or other ships in the general area. It is especially important to do this in those ocean areas where shipping, and hence ships' weather reports, are sparse.

When navigating in areas for which no weather bulletins are available, all ships are requested when convenient to broadcast their routine weather messages for the benefit of all ships. The message should be addressed ALL STATIONS and be broadcast on medium frequency immediately after the first silent period following the time of observation. Such exchange of weather information among ships in less frequented waters may be of great value in providing advance warning of impending bad weather in the area.

Note: Ships are not required to send the same weather message to more than one address.

15.3 Procedures for transmitting weather messages to coastal radio stations

For the purpose of collecting and disseminating ships' weather reports, oceanic and sea areas have been divided into WMO Regions and the Antarctic, and in some areas sub-divided into zones. The following is a list of these regions:

- Region 1 — Africa (divided into six zones)
- Region 2 — Asia (divided into three zones)
- Region 3 — South America
- Region 4 — North and Central America
- Region 5 — South—West Pacific
- Region 6 — Europe (divided into four zones)

The position and name of coastal radio stations accepting ships' weather reports free of charge to ships within each region and/or zone can be found in the booklet *Ship to Shore Transmission of Weather Reports*.

Weather reports from a mobile ship station should be transmitted without special request as soon as possible after the time of observation, to the nearest coastal radio station that is situated in the zone where the ship is navigating.

If it is difficult because of poor radio propagation conditions, or other circumstances, to promptly contact the nearest coastal radio station that is situated in the zone where the ship is navigating, the weather reports should be transmitted in the following sequence until the reports have been cleared or accepted:

- 1) Transmit to any other coastal radio station in the zone.
- 2) Transmit to any coastal radio station in an adjacent zone within the same region.
- 3) Transmit to any coastal radio station in any other zone in the same region.
- 4) Transmit to a coastal radio station in an adjacent zone in a neighbouring region, or failing that to any other station in a neighbouring region.
- 5) Transmit to another ship or an ocean weather station that is willing to act as a relay station.

The radio address in a ship's weather report, appropriate to the designated coastal radio station is to be entered in Column 77 on the meteorological log. The time the report was sent should be entered as well.

15.4 Additional Procedures for Single-Operator Ships

Owing to the difficulties resulting from fixed radio watch hours, single-operator ships in making weather observations and in transmitting messages, should be guided by the procedures in the sequence given as follows:

- 1) When operational difficulties on board ship make it impracticable to take and/or transmit a surface synoptic observation at a main standard synoptic time (0000, 0600, 1200, 1800 UTC), the actual time of the observation should be as near as possible to the main standard synoptic time to ensure transmission of a report to a coastal radio station before the radio officer goes off duty. Alternatively in special cases, observations may be taken one full hour earlier than the main standard synoptic time and be indicated accordingly. However it is emphasized that such departures should be regarded only as exceptions.
- 2) When it is impractical to follow the above instructions the observation should be taken and transmitted at 0300, 0900, 1500, 2100 UTC respectively. For example if the radio officer is scheduled to complete their watch by 2200 UTC the observation should be taken and the report transmitted at 2100 UTC.
- 3) When the observation is taken at 0300, 0900, 1500, 2100 UTC in order to ensure its transmission to a coastal radio station, the observation at the next main standard synoptic time should be made for climatological purposes and if possible transmitted at a later time.

An observation taken at any of the standard synoptic times 0000, 0600, 1200, 1800 UTC should be transmitted as follows even if a period of delay occurs after the time of observation:

- In most parts of the world the observation should be transmitted 12 h after the time of observation if it is not possible to do so earlier.
- In the Southern Hemisphere and other areas where few ships' weather reports are available the observation should be transmitted up to 24 h after the time of observation.

It is important that this procedure be followed even if the observation for a more recent time is also being transmitted.

15.5 Cellular telephones

This procedure is identical to that used by radio. The message would begin with **BBXX** that is the same requirement as the radio transmission.

15.6 Shipboard Environmental Data Acquisition System

The *Shipboard Environmental Data Acquisition System* (SEAS III) is an automated system developed by The National Oceanic and Atmospheric Administration (NOAA) to improve global weather forecasting. SEAS III eliminates the errors associated with manual radio transmission of ships' weather observations and oceanographic data. It will improve the data availability from ships at sea and ultimately provide a basis for more accurate weather forecasts. SEAS III will allow the operator to collect, analyze, store, and transmit meteorological and oceanographic data in an accurate and efficient manner. This will greatly improve the real-time marine weather and oceanographic data reporting capabilities of vessels. Refer to Appendix D for a more detailed description of this system.

Note: The U.S. Coast Guard has discontinued all Morse Code services.

Appendices

Appendix A Safety of navigation at sea

Introduction

The *International Convention on Safety of Life at Sea* (SOLAS), 1974, is published by the International Maritime Organisation (IMO). The revised Chapter V, Safety of Navigation, of the Annex to the International Convention came into force on July 1st, 2002. Chapter V of SOLAS identifies certain navigation safety services which should be provided by Contracting Governments and sets forth provisions of an operational nature applicable in general to all ships on all voyages. Regulations 1, 5, 6, 31, and 32 — of the 35 total regulations found in Chapter V — have been reproduced as Appendix A of MANMAR for reference purposes (retrieved from the United Kingdom's Maritime & Coastguard Agency [website](#)). For a copy of the complete publication of *Convention on Safety of Life at Sea*, 1974, please contact IMO at www.imo.org.

Regulation 1 — Application

Summary

- Outlines the application of Chapter V (i.e. all ships on all voyages unless expressly provided otherwise)
- States which ships may be exempted from certain Regulations by Administrations

Regulation 1

1. Unless expressly provided otherwise, this chapter shall apply to all ships on all voyages, except:
 - 1.1 warships, naval auxiliaries and other ships owned or operated by a Contracting Government and used only on government non-commercial service; and
 - 1.2 ships solely navigating the Great Lakes of North America and their connecting and tributary waters as far east as the lower exit of the St. Lambert Lock at Montreal in the Province of Quebec, Canada.

However, warships, naval auxiliaries or other ships owned or operated by a Contracting Government and used only on government non-commercial service are encouraged to act in a manner consistent, so far as reasonable and practicable, with this chapter.

2. The Administration may decide to what extent this chapter shall apply to ships operating solely in waters landward of the baselines which are established in accordance with international law.

3. A rigidly connected composite unit of a pushing vessel and associated pushed vessel, when designed as a dedicated and integrated tug and barge combination, shall be regarded as a single ship for the purpose of this chapter.
4. The Administration shall determine to what extent the provisions of regulations 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 and 28 do not apply to the following categories of ships:
 - 4.1 ships below 150 gross tonnage engaged on any voyage;
 - 4.2 ships below 500 gross tonnage not engaged on international voyages; and
 - 4.3 fishing vessels

Regulation 5 — Meteorological services and warnings

Summary

- Contracting Governments are obliged to provide and promulgate meteorological information and warnings to shipping.
- Provisions for recording and reporting observations from ships (5.2)
- Transmission of ship reports (5.3)

Regulation 5

1. 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.¹ 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.
2. 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 radio communications services.

- 2.2 to issue, at least twice daily, by terrestrial and space radio communication services², 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 radio communications 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 radio communications 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).

Note (1): Refer to the Recommendation on weather routeing adopted by the Organization by resolution A.528(13).

Note (2): Refer to regulations IV/7.1.4 and IV/7.1.5.

Regulation 6 — Ice patrol service

Summary

- Contracting Governments to provide the North Atlantic Ice Patrol Service
- Ships transiting the North Atlantic iceberg region during the ice season to make use of the Service
- Requirements for maintaining the service
- The Appendix to the Regulations contains the Rules covering the service

Regulation 6

1. The Ice Patrol contributes to safety of life at sea, safety and efficiency of navigation and protection of the marine environment in the North Atlantic. Ships transiting the region of icebergs guarded by the Ice Patrol during the ice season are required to make use of the services provided by the Ice Patrol.

2. The Contracting Governments undertake to continue an ice patrol and a service for study and observation of ice conditions in the North Atlantic. During the whole of the ice season, i.e. for the period from February 15th through July 1st of each year, the south-eastern, southern and south-western limits of the region of icebergs in the vicinity of the Grand Banks of Newfoundland shall be guarded for the purpose of informing passing ships of the extent of this dangerous region; for the study of ice conditions in general; and for the purpose of affording assistance to ships and crews requiring aid within the limits of operation of the patrol ships and aircraft. During the rest of the year the study and observation of ice conditions shall be maintained as advisable.
3. Ships and aircraft used for the ice patrol service and the study and observation of ice conditions may be assigned other duties provided that such other duties do not interfere with the primary purpose or increase the cost of this service.
4. The Government of the United States of America agrees to continue the overall management of the ice patrol service and the study and observation of ice conditions, including the dissemination of information therefrom.
5. The terms and conditions governing the management, operation and financing of the Ice Patrol are set forth in the Rules for the management, operation and financing of the North Atlantic Ice Patrol appended to this chapter which shall form an integral part of this chapter.
6. If, at any time, the United States and/or Canadian Governments should desire, to discontinue providing these services, it may do so and the Contracting Governments shall settle the question of continuing these services in accordance with their mutual interests. The United States and/or Canadian Governments shall provide 18 months written notice to all Contracting Governments whose ships entitled to fly their flag and whose ships are registered in territories to which those Contracting Governments have extended this regulation benefit from these services before discontinuing providing these services.

Regulation 31 — Danger messages

Summary

- Masters to communicate information on navigational dangers
- Contracting Governments to promulgate danger information
- Messages free of charge to ships

Regulation 31

1. The master of every ship which meets with dangerous ice, a dangerous derelict, or any other direct danger to navigation, or a tropical storm, or encounters sub-freezing air temperatures associated with gale force winds causing severe ice accretion on superstructures, or winds of force 10 or above on the Beaufort scale for which no storm warning has been received, is bound to communicate the information by all means at his disposal to ships in the vicinity, and also to the competent authorities. The form in which the information is sent is not obligatory. It may be transmitted either in plain language (preferably English) or by means of the International Code of Signals.
2. Each Contracting Government will take all steps necessary to ensure that when intelligence of any of the dangers specified in paragraph 1 is received, it will be promptly brought to the knowledge of those concerned and communicated to other interested Governments.
3. The transmission of messages respecting the dangers specified is free of cost to the ships concerned.
4. All radio messages issued under paragraph 1 shall be preceded by the safety signal, using the procedure as prescribed by the Radio Regulations as defined in regulation IV/2.

Regulation 32 — Information required in danger messages

Summary

- Details of information to include in danger messages
- Examples of typical danger messages

Regulation 32

The following information is required in danger messages:

1. Ice, derelicts and other direct dangers to navigation:
 - 1.1 The kind of ice, derelict or danger observed.
 - 1.2 The position of the ice, derelict or danger when last observed.
 - 1.3 The time and date (Universal Co-ordinated Time) when the danger was last observed.
2. Tropical cyclones (storms)¹
 - 2.1 A statement that a tropical cyclone has been encountered. This obligation should be interpreted in a broad spirit, and information transmitted whenever the master has good reason to believe that a tropical cyclone is developing or exists in the neighbourhood.
 - 2.2 Time, date (Universal Co-ordinated Time) and position of ship when the observation was taken.
 - 2.3 As much of the following information as is practicable should be included in the message:
 - barometric pressure,² preferably corrected (stating millibars, millimetres, or inches, and whether corrected or uncorrected);
 - barometric tendency (the change in barometric pressure during the past three hours);
 - true wind direction;
 - wind force (Beaufort scale);
 - state of the sea (smooth, moderate, rough, high);
 - swell (slight, moderate, heavy) and the true direction from which it comes. Period or length of swell (short, average, long) would also be of value;
 - true course and speed of ship.

Note (1): The term tropical cyclone is the generic term used by national meteorological services of the World Meteorological Organization. The term hurricane, typhoon, cyclone, severe tropical storm, etc., may also be used, depending on the geographical location.

Note (2): The standard international unit for barometric pressure is the hectopascal (hPa) which is numerically equivalent to the millibar (mbar).

Subsequent observations

3. When a master has reported a tropical cyclone or other dangerous storm, it is desirable but not obligatory, that further observations be made and transmitted hourly, if practicable, but in any case at intervals of not more than 3 hours, so long as the ship remains under the influence of the storm.
4. Winds of force 10 or above on the Beaufort scale for which no storm warning has been received. This is intended to deal with storms other than the tropical cyclones referred to in paragraph 2; when such a storm is encountered, the message should contain similar information to that listed under the paragraph but excluding the details concerning sea and swell
5. Sub-freezing air temperatures associated with gale force winds causing severe ice accretion on superstructures:
 - 5.1 Time and date (Universal Co-ordinated Time).
 - 5.2 Air temperature.
 - 5.3 Sea temperature (if practicable).
 - 5.4 Wind force and direction.

Examples of danger messages

Ice

TTT ICE. LARGE BERG SIGHTED IN 4506 N, 4410W, AT 0800 UTC. MAY 15.

Derelicts

TTT DERELICT. OBSERVED DERELICT ALMOST SUBMERGED IN 4006 N, 1243W, AT 1630 UTC. APRIL 21.

Danger to navigation

TTT NAVIGATION. ALPHA LIGHTSHIP NOT ON STATION. 1800 UTC. JANUARY 3.

Tropical cyclone

TTT STORM. 0030 UTC. AUGUST 18. 2004 N, 11354 E. BAROMETER CORRECTED 994 MILLIBARS, TENDENCY DOWN 6 MILLIBARS. WIND NW, FORCE 9, HEAVY SQUALLS. HEAVY EASTERLY SWELL. COURSE 067, 5 KNOTS.

TTT STORM. APPEARANCES INDICATE APPROACH OF HURRICANE. 1300 UTC. SEPTEMBER 14. 2200 N, 7236 W. BAROMETER CORRECTED 29.64 INCHES, TENDENCY DOWN .015 INCHES. WIND NE, FORCE 8, FREQUENT RAIN SQUALLS. COURSE 035, 9 KNOTS.

TTT STORM. CONDITIONS INDICATE INTENSE CYCLONE HAS FORMED. 0200 UTC. MAY 4. 1620 N, 9203 E. BAROMETER UNCORRECTED 753 MILLIMETRES, TENDENCY DOWN 5 MILLIMETRES. WIND S BY W, FORCE 5. COURSE 300, 8 KNOTS.

TTT STORM. TYPHOON TO SOUTHEAST. 0300 UTC. JUNE 12. 1812 N, 12605 E. BAROMETER FALLING RAPIDLY. WIND INCREASING FROM N.

TTT STORM. WIND FORCE 11, NO STORM WARNING RECEIVED. 0300 UTC. MAY 4. 4830 N, 30 W. BAROMETER CORRECTED 983 MILLIBARS, TENDENCY DOWN 4 MILLIBARS. WIND SW, FORCE 11 VEERING. COURSE 260, 6 KNOTS.

Icing

TTT EXPERIENCING SEVERE ICING. 1400 UTC. MARCH 2. 69 N, 10 W. AIR TEMPERATURE 18°F (-7.8°C). SEA TEMPERATURE 29°F (-1.7°C). WIND NE, FORCE 8.

Appendix B Port Meteorological Officers (PMO)

Canada

Canadian port meteorological officers are listed in geographical order from East to West.

Atlantic ports — Newfoundland

Andre Dwyer, PMO
 Meteorological Service of Canada, ECCC
 6 Bruce Street
 Mount Pearl, NL A1N 4T3
 Tel: (709) 772-4798
 Cell: (709) 689-5787
 Fax: (709) 772-5097
 Email: andre.dwyer@canada.ca

Atlantic ports — Maritimes

Derek Cain, PMO
 Meteorological Service of Canada, ECCC
 275 Rocky Lake Drive
 Bedford, NS B4A 2T3
 Tel: (902) 426-6616
 Cell: (902) 222-6325
 Fax: (902) 426-6404
 Email: derek.cain@canada.ca

St-Lawrence ports — Québec

Erich Gola, PMO
 Meteorological Service of Canada, ECCC
 Place Bonaventure, Portail Nord-Est
 800 de la Gauchetière ouest, Suite 7810
 Montréal QC H5A 1L9
 Tel: (514) 283-1644
 Fax: (514) 496-1867
 Email: erich.gola@canada.ca

Great Lakes ports

Shawn Rickard, PMO
 Meteorological Service of Canada, ECCC
 867 Lakeshore Road,
 Burlington, Ontario L7S 1A1
 Tel: (905) 336-4672
 Email: shawn.rickard@canada.ca

Manitoba Lakes ports

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 Meteorological Service of Canada, ECCC
 123 Main Street, Suite 150
 Winnipeg, MB R3C 4W2
 Tel: (204) 983-6155
 Email: greg.stansfield@canada.ca

Great Slave Lake ports; Lake Athabasca ports; Western Arctic ports

Mark Pyper, PMO
 Meteorological Service of Canada, ECCC
 M.J. Greenwood Centre
 9345 49th Street
 Edmonton, AB T6B 2L8
 Telephone: (780) 495-5472
 Cell: (780) 991-1709
 Fax: (780) 495-7739
 Email: mark.pyper@canada.ca

Pacific ports

Dragan Radovic, PMO

Meteorological Service of Canada, ECCC

13160 Vanier Place, Suite 140

Richmond, BC V6V 2J2

Cell: (604) 340-2153

Fax: (604) 664-4094

Email (2): dragan.radovic@canada.ca

United States of America

The following link provides a list of current port meteorological officers from the United States' National Weather Service, National Oceanic and Atmospheric Administration (NOAA): http://www.vos.noaa.gov/met_officers.shtml

Headquarters Office

Paula Rychtar, VOS Operations Manager
National Weather Service, NOAA
National Data Buoy Center, Building 3203
Stennis Space Center MS 39529-6000
Tel: (228) 688-1457
Fax: (228) 688-3923
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Louis Quinones, VOS Program Manager
National Weather Service, NOAA
Office of Observations
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Silver Spring, MD 20910
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Atlantic ports

David Dellinger, PMO
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Jacksonville, FL 32218-7933
Tel: (904) 741-5186, ext.117
Fax: (904) 741-0078
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Peter Gibino, PMO, Norfolk
National Weather Service, NOAA
104 Hemlock Court
Yorktown, VA 23693-4544
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Frederick, MD 21702
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Flemington, NJ 08822
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National Weather Service, NOAA
2234 South Hobson Avenue
Charleston SC 29405-2413
Tel: (843) 709-0102
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Gulf of Mexico ports

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Slidell, LA 70460-5243
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Chris Fakes, PMO
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1353 FM 646, Suite 202
Dickinson, TX 77539
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Fax: (281) 534-4308
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Great Lakes ports

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Email: pmoglakes@noaa.gov

Pacific ports

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Long Beach, CA 90802-4213
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Matt Thompson, PMO
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Fax: (206) 526-6094

Hawaii/Alaska ports

Derek Lee Loy, PMO
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Honolulu, HI 96818
Tel: (808) 725-6016
Fax: (808) 725-6005
email: derek.leeloy@noaa.gov
Alternate PMO: David Meek
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Larry Hubble
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Appendix C The Marine Forecast code — MAFOR

Introduction

The code used in the transmission of marine weather forecasts is known as the MARine FORecast (MAFOR) code. Environment and Climate Change Canada issues MAFOR coded forecasts as part of their marine weather products for the Great Lakes and the St. Lawrence and Saguenay Rivers. MAFOR forecasts are coded according to the World Meteorological Organization's (WMO) *FM 61–IV Forecast for shipping* code form.

MAFOR Groups and decode tables

The code name MAFOR appears as a prefix for all MAFOR forecast messages. The code begins with a date/time group, followed by the name of the lake to which the forecast applies, followed by one or more five figure groups. Each of the five figure groups may in turn be followed by an optional group. Refer to Table C—1 for the MAFOR code form.

Table C—1: MAFOR code form

Group 1	Group 2	Group 3	Group 4	Group 5
YYG ₁ G ₁ /	0AAAa _m	1GDF _m W _m	[2VST _x T _n]	[3DkP _w H _w H _w]

Note: Groups enclosed in square brackets are not included in the Canadian MAFOR bulletins issued by the Meteorological Service of Canada and are being provided for reference purposes only. This is consistent with the World Meteorological Organization's coding regulations for the MAFOR bulletins.

Group 1 — YYG₁G₁/

YY — Day of the month

G₁G₁ — Time of commencement of forecast (UTC). Midnight is encoded as 00.

/ — The last digit of this group is not used.

Group 2 — 0AAAa_m

The group 0AAAa_m indicates the maritime area to which the whole forecast or set of forecasts refers. If the geographical name for the forecast region is used instead of the indicator AAAa_m, it shall be inserted at the place of this group. Table C—2 specifies code figures for decoding the portion of the maritime area.

Table C—2: Portion of the maritime area — Specification of code figure a_m

Code figure	Specification
0	Whole of the area AAA
1	Northeast quadrant of the area AAA
2	Eastern half of the area AAA
3	Southeast quadrant of the area
4	Southern half of the area AAA
5	Southwest quadrant of the area AAA
6	Western half of the area AAA
7	Northwest quadrant of the area AAA
8	Northern half of the area AAA
9	Rest of the area AAA

Group 3 — 1GDF_mW_m

This group shall indicate the period of time covered by the forecast, the direction and the force of the forecast wind and the forecast weather.

G — Forecast period. Table C—3 specifies code figures for decoding the forecast period.

Table C—3: Forecast period — Specification of code figure **G**

Code figure	Specification
0	Beginning of period
1	Valid for 3 hrs
2	Valid for 6 hrs
3	Valid for 9 hrs
4	Valid for 12 hrs
5	Valid for 18 hrs
6	Valid for 24 hrs
7	Valid for 48 hrs
8	Valid for 72 hrs
9	Occasionally

D — Direction from which the wind is blowing. Table C—4 specifies code figures for decoding forecast wind direction.

Table C—4: Wind direction — Specification of code figure **D**

Code figure	Specification
0	Calm
1	Northeast
2	East
3	Southeast
4	South
5	Southwest
6	West
7	Northwest
8	North
9	Variable

F_m — Wind speed. Table C—5 specifies code figures decoding forecast wind speed.

Table C—5: Wind speed — Specification of code figure F_m

Code figure	Specification
0	0–10 kt
1	11–16 kt
2	17–21 kt
3	22–27 kt
4	28–33 kt
5	34–40 kt
6	41–47 kt
7	48–55 kt
8	56–63 kt
9	64 kt or more

W_m — Forecast weather. Table C—6 specifies code figures for decoding forecast weather.

Table C—6: Forecast weather — Specification of code figure W_m

Code figure	Specification
0	Visibility greater than 3 NM
1	Risk of accumulation of ice on superstructures
2	Strong risk of accumulation of ice on superstructure
3	Visibility is greater of equal to 1 NM and less than or equal to 3 NM
4	Visibility is greater than 1 NM, including fog
5	Drizzle
6	Rain
7	Snow, or rain and snow
8	Squally weather with or without showers
9	Thunderstorms

Group 4 — [2VST_xT_n]

This optional group shall indicate the forecasts of visibility, state of sea and extreme air temperatures.

V — Visibility. Table C—7 specifies code figures for decoding forecast visibility.

Table C—7: Visibility — Specification of code figure V

Code figure	Specification
0	Less than 50 m
1	50–200 m
2	200–500 m
3	500–1000 m
4	1–2 km
5	2–4 km
6	4–10 km
7	10–20 km
8	20–50 km
9	More than 50 km

S — State of the sea. Table C—8 specifies code figures for decoding the forecasted state of the sea.

Table C—8: State of the sea — Specification of code figure S

Code figure	State of the sea	Wave height
0	Calm	0 m
1	Calm	0–0.1 m
2	Smooth	0.1–0.5 m
3	Slight	0.5–1.25 m
4	Moderate	1.25–2.5 m
5	Rough	2.5–4.5 m
6	Very rough	4–6 m
7	High	6–9 m
8	Very high	9–14 m
9	Phenomenal	More than 14 m

T_x — Maximum air temperature. Table C—9 specifies code figures for decoding forecast maximum air temperature.

T_n — Minimum air temperature. Table C—9 specifies code figures for decoding forecast minimum air temperature.

Table C—9: Maximum and minimum air temperatures — Specification of code figures T_x and T_n

Code figure	Specification
0	Less than -10 °C
1	-10 to -5 °C
2	-5 to -1 °C
3	About 0 °C
4	1 to 5 °C
5	5 to 10 °C
6	10 to 20 °C
7	20 to 30 °C
8	Greater than 30 °C
9	Not forecast

Group 5 — [3D_kP_wH_wH_w]

This group shall indicate, as an optional feature, the direction, the period and the height of the forecast waves. The direction from which the wave of longest period is travelling shall be given when waves from several directions are forecast.

D_k — Direction from which swell is moving. Table C—10 specifies code figures for decoding forecast swell direction.

Table C—10: Direction from which swell is moving — Specification of code figure D_k

Code figure	Specification
0	Calm
1	Northeast
2	East
3	Southeast
4	South
5	Southwest
6	West
7	Northwest
8	North
9	Variable

P_w — Period of waves. Table C—11 specifies code figures for decoding forecast period of waves.

Table C—11: Period of waves — Specification of code figure P_w

Code figure	Specification
0	10 seconds
1	11 seconds
2	12 seconds
3	13 seconds
4	14 seconds or more
5	5 seconds or less
6	6 seconds
7	7 seconds
8	8 seconds
9	9 seconds
/	Calm or not determined

H_w — Height of forecast waves, in units of 0.5 m.

Example of a marine forecast

MAFOR 0403/ Superior 12646 14755 245// 12720 Ontario
15820 12804

Referring to the code tables this may be decoded as follows:

MAFOR 0403/: Marine forecast valid from 03 Coordinated Universal Time of the fourth day of the current month

(Lake) Superior: First 6 hours of the forecast period — wind west at 28–33 knots, with rain. Next 12 hours of forecast period — wind northwest 34–40 knots, with drizzle. During the same period — visibility 0.5–1 NM, with rough seas, wave heights of 2.5–4 m. Final 6 hours of the forecast period — wind northwest at 17–21 kt, visibility greater than 3 NM.

(Lake) Ontario: First 18 hours of forecast period — wind north 17–21 kt, visibility greater than 3 NM. Final 6 hours of forecast period — wind north at 10 kt or less, with fog reducing visibility to less than 0.5 NM.

MAFOR Synopsis

Each MAFOR broadcast is followed by a brief technical synopsis of the current weather map in plain language. The synopsis gives the location of the centers of significant high and low pressure areas, and their forecast motion (direction and speed). Reference is occasionally made to marked windshift lines, giving the anticipated time at which the wind shift will occur at key points.

The following is an example of the type of synopsis that is issued:

Low Chicago moving ENE 35
High New York City moving E 15
Wind shift SW to NW Detroit early morning
Kingston late evening

Appendix D Shipboard Environmental Acquisition System — SEAS III

System description

The Shipboard Environmental Acquisition System, SEAS III provides automatic transmission of properly formatted oceanographic and weather messages through the Geostationary Operational Environmental Satellite (GOES). It ensures the reception of environmental observations for use in real-time forecasts.

Meteorological data is entered into the microcomputer by the operator via a digital computer keyboard. The computer is programmed to automatically perform error checks on the data and allow the operator to correct errors made during data entry. Barometric pressure readings are entered automatically by a pressure sensor if the system is so equipped. The system provides sub-surface measurements of water temperature versus depth. An optional global positioning system (GPS) automatically provides the SEAS III computer with pertinent navigational information, which is used to derive ship's position, speed, heading, set, drift, way point locations and estimated time of arrival. When this system is not installed the operator provides position information manually.

After the data is entered the computer automatically compiles the data into a properly formatted NWS Weather Message (World Meteorological Organization Ship Code FM 13–XIV). These messages are then automatically sent on schedule by the GOES transmitter for NWS weather forecasts.

Appendix E State of the sea — Beaufort scale

Introduction

This appendix displays 11 photos depicting the effects at sea of Beaufort Forces 0–11.

Beaufort Force 0

Wind speed: Less than 1 kt (calm)

Sea criterion: Sea like a mirror

Probable wave height: none



Figure E—1: Photo depicting Beaufort Force 0

Beaufort Force 1

Wind speed: 1 to 3 kt (light air)

Sea criterion: Ripples with the appearance of scales are formed, but without foam crest.

Probable wave height: 0.1 m ($\frac{1}{4}$ ft)



Figure E—2: Photo depicting Beaufort Force 1

Beaufort Force 2

Wind speed: 4 to 6 kt (light breeze)

Sea criterion: Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break.

Probable wave height: 0.2 to 0.3 m (0.5 to 1 ft)

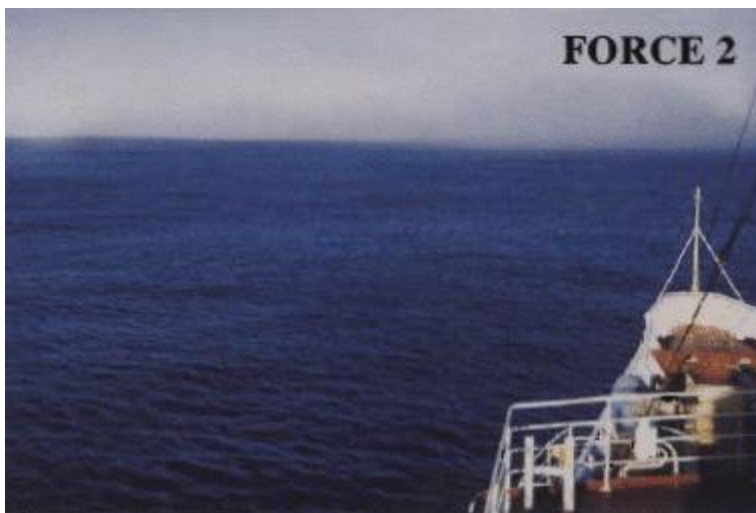


Figure E—3: Photo depicting Beaufort Force 2

Beaufort Force 3

Wind speed: 7 to 10 kt (gentle breeze)

Sea criterion: Large wavelets; crests begin to break; have foam of glassy appearance: perhaps, scattered white horses.

Probable wave height: 0.6 to 1 m (2 to 3 ft)



Figure E—4: Photo depicting Beaufort Force 3

Beaufort Force 4

Wind speed: 11 to 16 kt (moderate breeze)

Sea criterion: Small wave becoming longer; fairly frequent white horses.

Probable wave height: 1 to 1.5 m (3.5 to 5 ft)

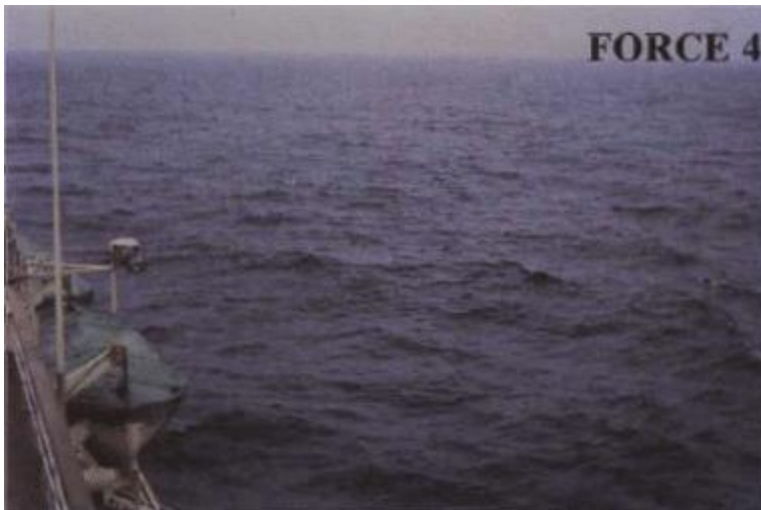


Figure E—5: Photo depicting Beaufort Force 4

Beaufort Force 5

Wind speed: 17 to 21 kt (fresh breeze)

Sea criterion: Moderate waves taking a more pronounced long form; many white horses are formed (chance of some spray).

Probable wave height: 2 to 2.5 m (6 to 8.5 ft)



Figure E—6: Photo depicting Beaufort Force 5

Beaufort Force 6

Wind speed: 22 to 27 kt (strong breeze)

Sea criterion: Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray).

Probable wave height: 3 to 4 m (9.5 to 13 ft)

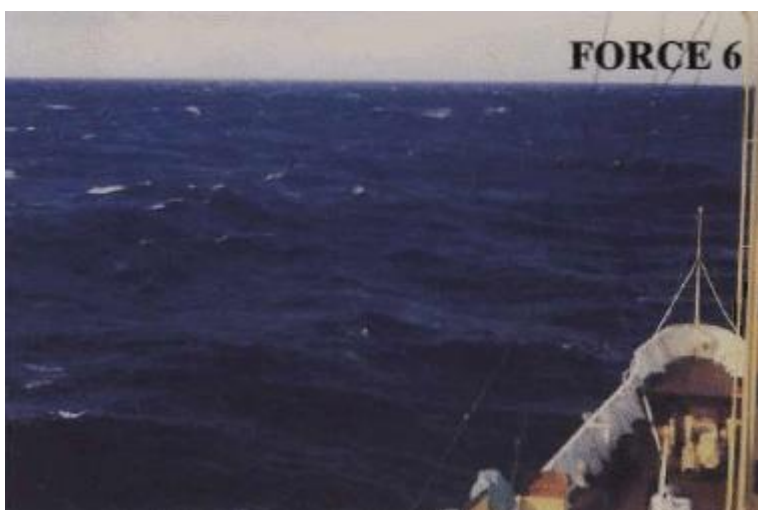


Figure E—7: Photo depicting Beaufort Force 6

Beaufort Force 7

Wind speed: 28 to 33 kt (near gale)

Sea criterion: Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.

Probable wave height: 4 to 5.5 m (13.5 to 19 ft)



Figure E—8: Photo depicting Beaufort Force 7

Beaufort Force 8

Wind speed: 34 to 40 kt (gale)

Sea Criterion: Moderately high waves of greater length; edges of crests begin to break into the spindrift; the foam is blown in well-marked streaks along the direction of the wind.

Probable wave height: 5.5 to 7.5 m (18 to 25 ft)



Figure E—9: Photo depicting Beaufort Force 8

Beaufort Force 9

Wind speed: 41 to 47 kt (strong gale)

Sea criterion: 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 visibility.

Probable wave height: 7 to 10 m (23 to 32 ft)



Figure E—10: Photo depicting Beaufort Force 9

Beaufort Force 10

Wind speed: 48 to 55 kt (storm)

Sea Criterion: 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 a white appearance, the tumbling of the sea becomes heavy and shock-like; visibility affected.

Probable Wave Height: 9 to 12.5 m (29 to 41 ft)



Figure E—11: Photo depicting Beaufort Force 10

Beaufort Force 11

Wind speed: 55 to 63 kt (violent storm)

Sea criterion: Exceptionally high waves (small and medium size ships might be for a time lost to view behind the 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.

Probable wave height: 11.5 to 16 m (37 to 52 ft)



Figure E—12: Photo depicting Beaufort Force 11

Appendix F Cloud chart

Introduction

This appendix displays photographic depictions of clouds for reference when identifying clouds.

Alto cumulus

Patterned, white or grayish cloud deck consisting of rounded elements. Frequently in layers, with a roll or honeycomb appearance. Occurs in patches or long bands and sometimes covers the entire sky.



Figure F—1: Photo depicting Alto cumulus clouds

Alto cumulus (lenticular)

Alto cumulus can occur in large lens or almond-shaped elongated patches with well-defined outlines as shown in the foreground of Figure F—2. Alto cumulus lenticular occurs most frequently near mountainous or hilly areas.



Figure F—2: Photo depicting Alto cumulus (lenticular) clouds

Alto cumulus and Altostratus

Layers of altostratus and alto cumulus frequently occur together as separate patches or mixed into a chaotic looking sky. The altostratus is grayish and featureless; the alto cumulus is textured.



Figure F—3: Photo depicting Alto cumulus and Altostratus clouds

Altostratus

Grayish or bluish uniform sheet of cloud with very little texture. Usually thicker and grayer and lower in altitude than cirrostratus. Altostratus does not exhibit halos.



Figure F—4: Photo depicting Altostratus clouds

Cirrocumulus

Sheets of organized bands of high clouds having a grainy or tufted appearance (upper part of the photo). A lower deck of altocumulus clouds with larger cloud elements is visible in the middle of Figure F—5.



Figure F—5: Photo depicting Cirrocumulus clouds

Cirrostratus

Small or extensive sheets of transparent whitish cloud either fibrous or smooth textured which sometimes produce halos around the sun. A cirrocumulus patch is also visible in the upper part of Figure F—6.



Figure F—6: Photo depicting Cirrostratus clouds

Cirrus

High, white, distant looking patches, filaments or long bands of ice crystals stretching across the sky. Their shape and texture are often described as looking like horses' tails.



Figure F—7: Photo depicting Cirrus clouds

Cirrus streamers are frequently blown into a chaotic pattern by strong winds that change direction and speed with altitude. At dawn and dusk the white clouds take on tints of yellow and red.



Figure F—8: Photo depicting Cirrus clouds at dawn or dusk

Cumulonimbus

Large (25 km or more) well organized cloud often exhibiting an anvil shaped top. Produces heavy rain showers, lightning, thunder and sometimes hail or tornadoes. Entire cloud can only be seen from a distance.



Figure F—9: Photo depicting Cumulonimbus clouds

Cumulonimbus (thunderstorm)

A cumulonimbus (thunderstorm) cloud viewed from below has a dark ominous base with curtains or heavy rain and/or hail visible. The sky brightens as the cloud passes.



Figure F—10: Photo depicting Cumulonimbus (thunderstorm) clouds

Cumulus

Fair weather clouds having well defined bases, little vertical extent, producing no precipitation and rarely covering more than one-half the sky (may eventually grow much larger).



Figure F—11: Photo depicting Cumulus clouds

Cumulus (towering)

Vigorously growing, shower producing, cumulus clouds with rounded well defined tops. They appear to be tall (towering) or tall and broad and can be isolated or grow from lower lines or decks of clouds.



Figure F—12: Photo depicting Cumulus (towering) clouds

Fog

A thin layer of cloud resting on the ground. Normally composed of water droplets but can consist of ice crystals at very cold temperatures. Generally forms in calm or low wind conditions.



Figure F—13: Photo depicting fog

Nimbostratus

Dark gray clouds with little visible structure. Usually covers entire sky and completely hides the sun. Continuous rain is produced in the summer and snow in the winter.



Figure F—14: Photo depicting Nimbostratus clouds

Stratocumulus

Low, distinct, gray or whitish cloud elements with a well-defined rounded appearance often merged or organized into rolls or streets. The flat even bases have darker patches.



Figure F—15: Photo depicting Stratocumulus clouds

Stratus

Low, uniform, featureless layer of cloud found above a land or water surface. Sometimes produces light drizzle. Where it intersects a headland (as in this picture), stratus become fog.



Figure F—16: Photo depicting Stratus clouds