TT CLUB

WindStorm II

Practical risk management guidance for marine & inland terminals

transport insurance plus

TT CLUB IS MANAGED BY **THOMAS MILLER**

WINDSTORM II

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COVER IMAGE
Hurricane Katrina – Approaching the Gulf Coast on 29 August 2005 8:20am EDT, 64.8 m/s winds/GOES Satellite/MODIS Land Rapid Response Team

About the TT Club & ICHCA International

TT CLUB

The TT Club is the international transport and logistics industry's leading provider of insurance and related risk management services. Established in 1968, the Club's membership comprises ship operators, ports and terminals, road, rail and airfreight operators, logistics companies and container lessors.

As a mutual insurer, the Club exists to provide its policyholders with benefits that include specialist underwriting expertise, a world-wide office network providing claims management services, and first class risk management and loss prevention advice. This is one of a number of publications that seek to disseminate good practice advice through the supply chain.

For more information about TT Club and its services please visit www.ttclub.com.

ICHCA International Ltd

ICHCA International is dedicated to the promotion of safety and efficiency in the handling and movement of goods by all modes and during all phases of both the national and international transport chains. Originally established in 1952 and incorporated in 2002, it operates through a series of Local, National and Regional Chapters, Panels, Working Groups and Correspondence Groups and represents the cargo handling world at various international organisations, including the International Maritime Organization (IMO), United Nations Conference on Trade and Development (UNCTAD), International Labour Organization (ILO) and the International Standards Organization (ISO).

ICHCA members include ports, terminals, transport companies and other groups associated with cargo handling and coordination. Members of ICHCA Panels represent a substantial cross-section of senior experts and professionals from all sectors of the cargo transport industry globally. Members benefit from consulting services and informative publications dealing with technical matters, "best practice" advice, and cargo handling news.

For more information on ICHCA and its services please visit www.ichca.com.

Acknowledgments

This booklet is inevitably the product of a large number of contributions, as well as experience gathered in responding in the aftermath of storms and analysing the procedures in place that have affected the degree of damage and disruption – either positively or negatively – in locations suffering storm events. It would be impossible to identify all contributors, but the following people and organisations have provided specific advice and support in the preparation of this second edition of the WindStorm booklet.

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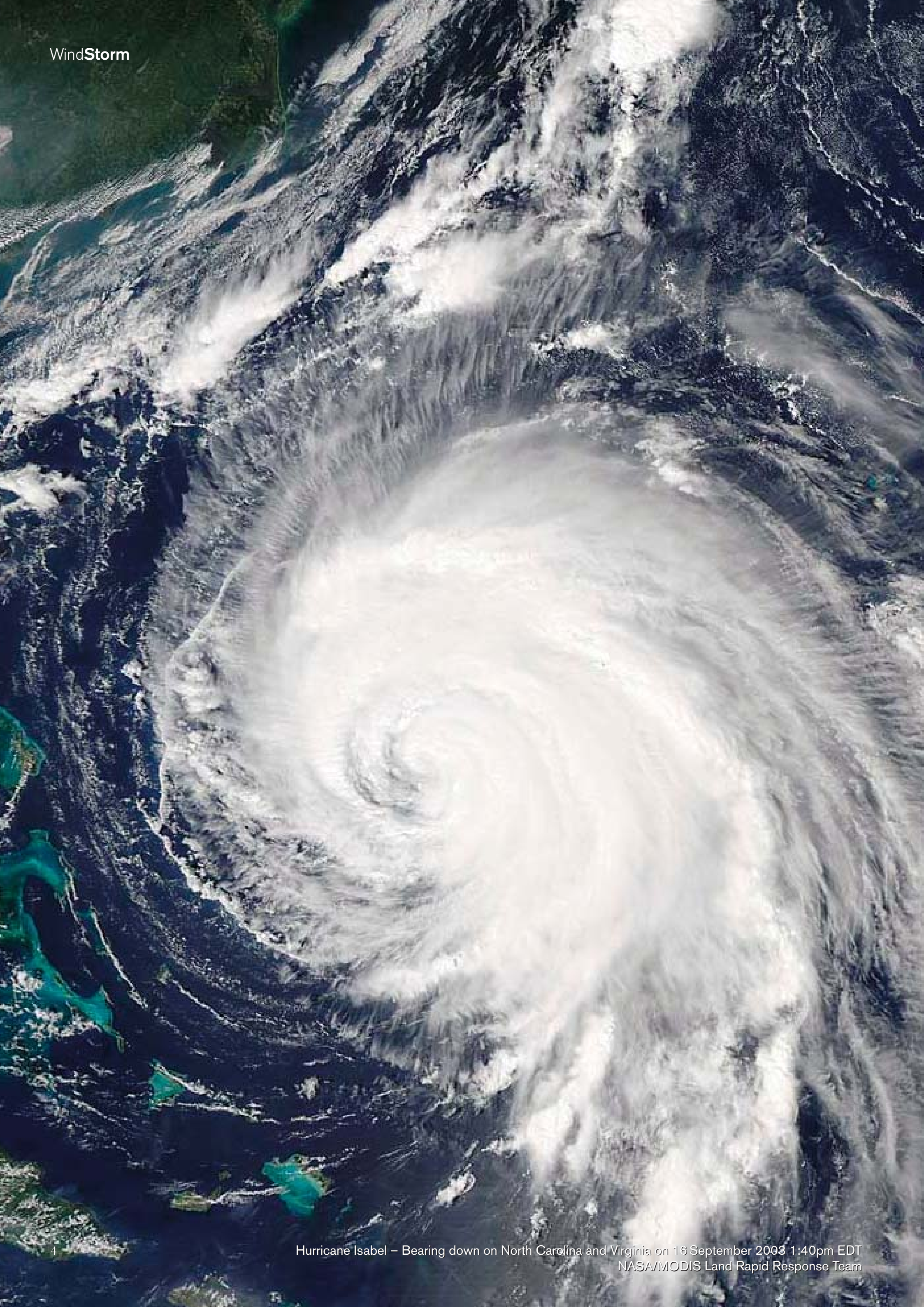
This 'StopLoss' booklet has been prepared in collaboration with the International Safety Panel of ICHCA International, who publish this text as General Series GS#3. ICHCA International has also published a companion document reporting on the findings of a survey conducted amongst ports and terminals globally during 2007, as Research Paper RP15.

Note
In this publication wind velocities are expressed in metres per second (m/s). A table is included at Annexe 1 (p. 94) showing the conversion to the other measurement standards, ie. kilometres per hour, miles per hour and knots.



Hurricane Isabel – Bearing down on North Carolina and Virginia on 16 September 2003 1:40pm EDT
NASA/MODIS Land Rapid Response Team

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Foreword

Severe windstorms are terrifying in the amount of devastation they can wreak, and the area over which they extend. Even more worrying is evidence that storms are increasing both in their frequency and intensity. While the causes of this increase are a matter of debate among scientists and climatologists, the effects of these increasingly violent storms are only too apparent.

By virtue of their coastal location, ports and terminals are particularly vulnerable with all kinds of harbour installations at risk from the enormous forces of nature unleashed in a storm. Some of the Club's biggest losses have been caused by storms hitting major ports, with several instances of multi-million dollar gantry cranes being reduced in minutes to little more than piles of scrap metal. Operators also face many other unquantifiable losses, such as a reduction in throughput or even loss of customers, which may take years to reverse.

Storms are also unique in another way: unlike almost all other natural catastrophes, their arrival is usually predicted by meteorologists several days in advance, thus giving operators valuable time to take action to prevent the worst damage.

In this booklet, the Club has brought together the expertise of operators and technical advisors to identify the actions that need to be taken, based on real experience. We are particularly pleased to have worked with the International Safety Panel of ICHCA International in producing this second edition.

By providing valuable guidance on a range of subjects, from formulating a disaster plan to getting assistance with clear-up and recovery operations once the storm has passed, we hope that this booklet will help operators weather any storm. This booklet is not just aimed at operators in well-known hurricane or typhoon areas: storms can hit almost any coast and also inland at almost any time. This booklet should therefore be read and acted upon by anyone who operates a cargo handling terminal or facility. Preparation is key!

J A Dorto, *Board Member, TT Club - CEO,*
Virginia International Terminals Inc

Hurricane Wilma – Approaching Florida on 23 October 2005
NASA/MODIS Land Rapid Response Team

Introduction

Destructive windstorms have always wreaked havoc in many parts of the world. Whether attributed to climate change or better global communications, there is far greater awareness of damage to the environment, property and loss of life due to severe windstorms, not just in the tropical cyclone areas. Although the empirical evidence may not support it, there is certainly the perception that the number and severity of storms is progressively increasing. Moreover, there is concern that places previously largely unaffected by severe storms – or only irregularly – may suffer in future. Further, it is sobering that in the period 1980-2005 windstorms made up 42% of all natural catastrophes.

The economic cost attached to windstorms is enormous. Munich Re figures for 2008 attribute a total cost of US$72 billion worldwide to such events. Added to this there was a further US$18 billion attributed to floods. In the period 1950-2008 the total economic cost attributed to US tropical cyclones is stated as US$453 billion. In any perception, these are significant figures; it is critical for any operation to recognise that only a portion of these amounts will have been insured. By way of example in the extreme year of 2005, of the windstorm economic loss of US$185 billion, less than 50% (US$90 billion) was insured.

Because of their coastal location, ports, harbours and terminal installations are all heavily exposed to the risk of damage caused by high winds. This booklet considers the ways operators can make preparations that reduce these risks and thus protect their businesses. These recommendations are, however, equally valid for terminals located inland; perhaps more so, since there may be a lower expectation of a severe occurrence.

This booklet is not just about hurricanes, cyclones and typhoons. While many people may associate severe windstorms with these devastating occurrences in sub-tropical areas, gales, severe storms and sudden winds called squalls or microbursts with winds gusting up to hurricane strength (Beaufort force 12 or 32.7 m/s) also occur and cause damage in more northerly or southerly latitudes, particularly during winter months. Please therefore do not think that, because you are not operating in an area of tropical storms, this booklet is not for you: the advice it contains is as much valid if your facility is located at 55° N as if it is at 10° N.

A fundamental business consideration, applicable to all threats to the company, whether from fire, flooding, hazardous materials spillage or loss of power, is the creation of an emergency plan. The emergency plan should be based on a careful review of the threats to your business and include specific steps to minimise them. By looking at the risks encountered at any major terminal, this booklet gives guidance on the creation and operation of such plans. While an emergency plan will help reduce the risk of damage to your operations, windstorms are often unpredictable in their speed, strength and track. What might appear to be a storm that will safely pass a hundred kilometres or so away, may change course during the night and devastate your facility. It could even result in the storm's eye passing across the port – a case study on 'Hugo' is included of such an occurrence and the outcome. While hopefully none of this will happen, an entire chapter is devoted to the formulation of disaster recovery plans.

An emergency plan is also just that: something to be kept in reserve (but up-to-date) to be used when an emergency threatens. However there is often very little time to implement the plan in full. Simple good housekeeping practices round the clock and throughout the year can do much to reduce the volume of work that has to be done in that short period. Keeping container stacks no more than four high means that you do not have to devote personnel and equipment to an emergency program to remove high tiers as the wind increases in strength. Maintaining service and park brake systems and always locking down cranes when they are not being used guards against them being blown along the track in the event of sudden and unexpected squalls. Even keeping storm pin sockets clear and free of debris can help. Having a back-up computer facility off-site can protect the company's vital records. This booklet highlights many of these issues.

Each facility's situation will be individual and specific. Because you have not yet suffered a storm does not mean that you never will; nor should the fact that they have happened in the past necessarily mean that you are properly prepared for a future storm.

The main recommendations in this booklet are based on the general experience gained in storms affecting terminals and other facilities, but no publication of this kind can be comprehensive in the advice it offers. Every storm presents its own unique risk profile and therefore no hazard can be entirely eliminated. Hopefully this guide will play some part in helping you to be prepared.

This booklet is not intended to be a technical manual relating to windstorm preparation. Every port and every terminal has its own characteristics. The risk profile of any facility depends on factors such as design, construction, layout, location, the type and amount of equipment, the prevalence of windstorms and the wind speeds normally encountered. You should therefore consider consulting engineers with specialist knowledge of your handling equipment and possibly also the civil engineers responsible for constructing your facility to ensure that you have the best possible advice relating to your own particular circumstances.

Windstorm

What is a windstorm?

At its simplest, a storm is a disturbance of the atmosphere resulting in severe weather. It may be marked by strong wind, thunder and lightning, heavy precipitation, or wind transporting objects (such as dust or debris). Storms are created when a centre of low pressure develops, with a system of high pressure surrounding it. The opposing forces create winds. The Beaufort scale recognises that winds of force 8 (17.2 m/s) or more can cause damage; this booklet therefore takes this level as the starting point.

A windstorm can refer to any type of storm where winds can cause damage and different terms are used around the globe – hurricane, cyclone, typhoon, tornado, microburst, winter gales by way of example. There are also regional variations for the classifications or scales to measure and describe the level of storm. Whatever the name or whatever the region, windstorms can cause severe damage. Annexe 1 sets out a number of the commonly used scales, together with correlations and common damage patterns, as well as a conversion chart for the different speed measurements (kilometres per hour, miles per hour, metres per second and knots). Throughout this booklet, speed is given in metres per second (m/s).

The generic name for a low pressure system giving rise to winds is 'cyclone'. In meteorology, a cyclone refers to well defined wind circulations that rotate anti-clockwise in the northern hemisphere and clockwise in the southern hemisphere. There are different types of cyclones, most of which are latitudinally based (ie. relative position to the Equator). For the purposes of this booklet, we review the material sub-divisions, followed by related storm risks. Additional information relating to development of particular types of storm can be found in Annexe 2.

(a) Key cyclone types

Tropical cyclone (also called hurricane or typhoon)

A tropical cyclone is a storm system characterised by a low pressure centre that has well-defined wind circulations (anti-clockwise in the northern hemisphere, clockwise in the southern) with a region surrounding the centre with gale force winds (sustained winds of 17.5 m/s or greater with gusts in excess of 25 m/s). The gale force winds can extend hundreds of kilometres from the cyclone centre. If the sustained winds around the centre reach 30.1 m/s with gusts in excess of 47.2 m/s, then the system is called a severe tropical cyclone.

The circular eye or centre of a tropical cyclone is an area characterised by light winds and often by clear skies. Eye diameters are typically 40 kilometres (25 miles) but can range from under 10 kilometres (6 miles) to over 100 kilometres (62 miles). The eye is surrounded by a dense ring of cloud about 16 kilometres (10 miles) high known as the eye wall which marks the belt of strongest winds and heaviest rainfall.

Moving out from the centre the wind velocity lessens but it can gust erratically and produce peak speeds of more than twice the sustained velocity almost anywhere throughout the system. Such gusts are not only violent, but also unpredictable.

The size of a tropical cyclone can vary considerably. However a typically mature typhoon may have an estimated radius of 400 kilometres (250 miles) with light winds at the outer edges but intensifying as they move towards the centre. Typical wind speeds may be 20.3 m/s at 200 kilometres (125 miles) and 33.3 m/s at 120 kilometres (75 miles) from the centre. Cyclones typically move with a linear speed of up to 13.9 m/s at their most intense.

Diagram of a typical cyclone in the southern hemisphere
(Source: Commonwealth of Australia, Bureau of Meteorology)

Such storms form almost exclusively in tropical regions of the globe, and over large bodies of warm water; they lose strength when they move over land. While tropical cyclones are most associated with extremely powerful winds and torrential rain, they are also likely to result in high waves and damaging storm surge. Equally, while storm surge can cause extensive damage many miles from the coastline, the heavy rains are likely to result in significant flooding inland.

Tropical cyclones are only able to develop or gain increasing momentum if the surface temperature of the ocean is at least 26.5° C, although, once formed, they will persist for some time even if the sea temperature is cooler. Because of their surface temperature, large parts of the world's oceans remain completely free from tropical cyclones; for instance the south Atlantic and the eastern part of the south Pacific are both cooled by currents from the Antarctic. All oceanic regions above 40° N or 40° S also remain normally free of cyclones because the ocean surface temperature is below 26.5° C.

The earth's rotational pull is weakest at the Equator and therefore the area between 5° N and 5° S is normally free of tropical cyclones, despite the warm surface temperature of the oceans. In this area the rotational pull is unable to divert air currents from a straight path so avoiding the eddying found in other latitudes. The area of storm activity is, therefore, in the warmest ocean regions between 5° and 40° N and 5° and 40° S.

When crossing land, a tropical cyclone is weakened in two ways: first it is not able to take up as much energy as there is less water evaporating over land than there is at sea. Secondly, the airflow in the cyclone meets greater friction over land: therefore more air is able to flow into the centre of the cyclone, so the barometric pressure increases and the rotation is slowed down. The most dangerous cyclones are those that hit the coast at right angles, as they have not incurred the gradual weakening effect of traversing a land mass and therefore retain all of their original force.

Depending on their location and strength, tropical cyclones are referred to by other names, such as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression, or simply as a cyclone. It is significant that 80% of the costliest windstorm losses worldwide in the period 1970–2008 occurred in the tropical zone.

Extra-tropical cyclone

This is the term given to a storm that occurs between the tropics and the polar regions (between approximately 30° and 60° N or S). Extra-tropical cyclones (also known as mid-latitude or baroclinic storms) are often referred to as 'depressions' or 'lows' by weather forecasters, and the formation is typically along the cold and warm frontal boundaries, rather than having a defined 'eye'. The cyclone primarily gets its energy from the horizontal temperature contrasts that exist in the atmosphere.

Often, a tropical cyclone will transform into an extra-tropical cyclone as it moves away from the tropics. Occasionally, an extra-tropical cyclone will lose its frontal features, particularly over warm waters, and develop convection near the centre of the storm, transforming into a full-fledged tropical cyclone. Such a process is most common in the North Atlantic and Northwest Pacific basins. The transformation between tropical and extra-tropical cyclones is a particular challenge to forecasters.

Deep depression

This refers to areas of intense low pressure usually accompanied by heavy rain or snow and winds in excess of Force 8. They are generally associated with higher northern or southern latitudes in the winter.

While their winds are usually less than hurricane velocity, depressions may create as much or more damage. While hurricanes move fairly rapidly, slow-moving winter storms may bring winds of 22.2 – 27.7 m/s for several days.

Another form of very strong winds is known as 'downslope winds'. One is the wind that develops along the eastern slope of the Rocky Mountains where it is known as a 'Chinook'. These winds are not only strong, but are also warm and dry. They can raise the local temperatures, causing a high rate of snowmelt, resulting in flooding.

In Alaska, 'Williwaws' have gusts of up to 30.5 m/s in almost every month, along exposed portions of the southeast, south and southwest coasts.

European windstorms

A European windstorm is a severe extra-tropical cyclone that causes significant windstorm insured loss when it impacts Europe. These extra-tropical cyclones form typically in the North Atlantic during the winter months (peak incidence in January) and track eastwards towards northwest Europe. They impact the United Kingdom, Ireland, Scandinavia, the Netherlands, Belgium, France and Germany, and occasionally the countries in central Europe. Wind damage occurs in swathes 50-500km across. These swathes are oriented typically west-east, parallel to and to the right of the storm-centre track.

The Beaufort Wind Scale (Annex 1) is used to classify European windstorms based on their peak 10-minute mean wind. To cause significant windstorm insured loss – and thus qualify as a 'European windstorm' – an extra-tropical cyclone would need to have 10-minute mean winds of at least Beaufort Scale 9 (>20.8 m/s).

Historically European windstorms have caused substantial damage and disruption. Between 1970 and January 2005 these events are thought to be responsible for 75-80% of all European insured losses, 10 of the 14 most costly European insured loss events, and an annual insured loss of at least US$1 billion. Windstorm 'Emma' in Mar 2008 caused economic damage across Northern Europe estimated at US$2 billion and storm series Hilal in May/June 2008 US$1.5 billion in Germany.

Subtropical cyclone

A subtropical cyclone is a weather system that has some characteristics of a tropical cyclone and some characteristics of an extratropical cyclone. Such storms can form between the equator and 50° N or S, although mainly in the northern hemisphere. These storms can have maximum winds extending further from the centre than in a purely tropical cyclone and have no weather fronts linking directly to the centre of circulation.

Subtropical cyclones are also more likely than tropical cyclones to form outside of a region's designated hurricane season, since the sea surface temperatures required for their formation are lower than the tropical cyclone threshold by about 3°C, lying around 23°C. Although subtropical storms rarely have hurricane-force winds, they may become tropical in nature as their cores warm. The maximum recorded wind speed for a subtropical storm is 33 m/s, which equates to hurricane force, Beaufort scale 12.

Monsoon

This word comes from the Arabic word for 'season'. The monsoon winds, which have various other names such as 'Crachin' on the south China coast, come about as a result of the thermal effect of the entire Asian land mass. This acts as a large battery for the weather systems from the Indian Ocean to the China Sea and on to Japan. The intense cooling that occurs in the interior of this land mass in winter and the extreme heating in summer has the effect of causing a great anti-cyclone centred around Mongolia in winter and an intense depression centred around the Himalayas in the summer. These two pressure systems dominate the entire Asian weather pattern as far south as the Equator. The monsoons are winds from the north-northeast in the seas between south Japan and the Philippines in the winter and, conversely, from the south-southwest in the summer. In addition, the wind in South East Asia, especially in the Indian Ocean, blows from the southwest in the summer (wet monsoon) and from the northeast in the winter (dry monsoon).

Mesocyclone

A mesocyclone is a vortex of air, most often associated with a localised low-pressure region within a severe thunderstorm. Air rises and rotates around a vertical axis, usually in the same direction as low pressure systems in a given hemisphere. Such storms can feature strong surface winds and severe hail. Mesocyclones often occur together with updrafts in 'supercells' (a type of thunderstorm), where tornadoes may form.

Thunderstorms

These are usually small but intense local storms. They may form as a series of squalls along a frontal system and can produce winds in excess of 29.2 m/s.

Thunderstorms can spawn tornadoes and produce heavy rains, hail and lightning, which may cause property damage. Thunderstorms occur worldwide and tend to occur in warm weather. They tend not to seriously damage well-designed buildings or structures but can damage roofs, signs, cranes, buildings under construction and unprotected property. The heavy rain often associated with such storms can overload rivers, streams and other watercourses and cause flash floods.

Tornado

A tornado is a very violent storm which can cause extreme damage where its vortex touches the ground. Tornadoes travel along a narrow track, typically no more than 200 metres across and at a forward speed of around 13.8 m/s; they are often accompanied by a twisting funnel-shaped cloud. Although they often only touch ground over short distances (up to 5 kilometres/3 miles), wind speeds in the vortex can reach 83.3 m/s and tornadoes will devastate anything in their path. At sea, tornadoes are called waterspouts.

(b) Related storm risks

Microbursts and squalls

Microbursts are sudden extreme windstorms that are difficult to detect and predict. They are intense downdrafts of air affecting an area of less than 4 kilometres/2.5 miles wide and are capable of producing winds of more than 44.7 m/s causing significant damage on the ground. The downward motion of the air hits ground level and then spreads outward in all directions which are opposite to that of a tornado. They are generally associated with thunderstorms, often taking place during a region's wet season, but can occur suddenly and at any time. The scale and suddenness of a microburst makes it a great danger to aircraft due to the low-level wind shear caused by its gust front, with several fatal crashes attributed to the phenomenon over the past several decades. It has also been attributable to many quay cranes below blown along the rails resulting in collisions and collapses. The sketch below shows the air flow of a microburst.

Like microbursts, squalls often 'appear out of nowhere', with very little warning. Sometimes they can be part of an established, but lesser, storm pattern – and be manifested as a localised 'micro-burst'.

In view of the unpredictability of these two weather patterns, all equipment should be placed in 'storm-safe' mode if at all possible. Obviously, when a squall appears, all lifting operations should cease; 'swinging' containers should be placed on the ground and spreaders taken to the highest position, while buckets, grabs and other similar equipment lowered to the ground. Doors and windows in warehouses etc. should be shut and all personnel moved to safe areas. If time permits, quay cranes should be tied down and pinned.

If the driver has to take appropriate emergency action to position the crane in a safe position, careful consideration must be given to driver safety.

A terminal in northern Europe was hit by a sudden and unexpected squall, with extreme gusts of wind. There was no time to secure equipment. One track-mounted crane was blown more than 500 metres/ 0.3 miles along the quayside before colliding with another crane, damaging both of them.

Storm surges & flood

Although storm surges are not actually winds, they are the consequence of winds and flooding is one of the major causes of damage in storms. In insurance terms, of course, 'flood' is generally defined and covered on terms that are separate to 'wind'. The low pressure at the 'eye' of the storm can create a tidal surge of several metres, sufficient to swamp many harbour installations and continue inland for some considerable distance. In coastal regions, most storms are accompanied by fierce wave activity: the power of the water alone can cause substantial damage to modern steel-clad buildings, containers and equipment.

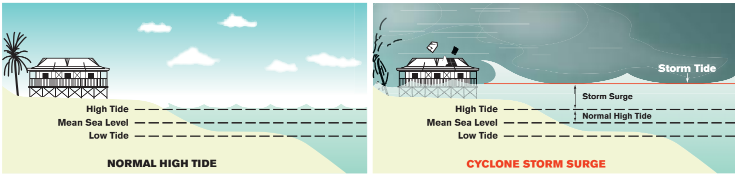
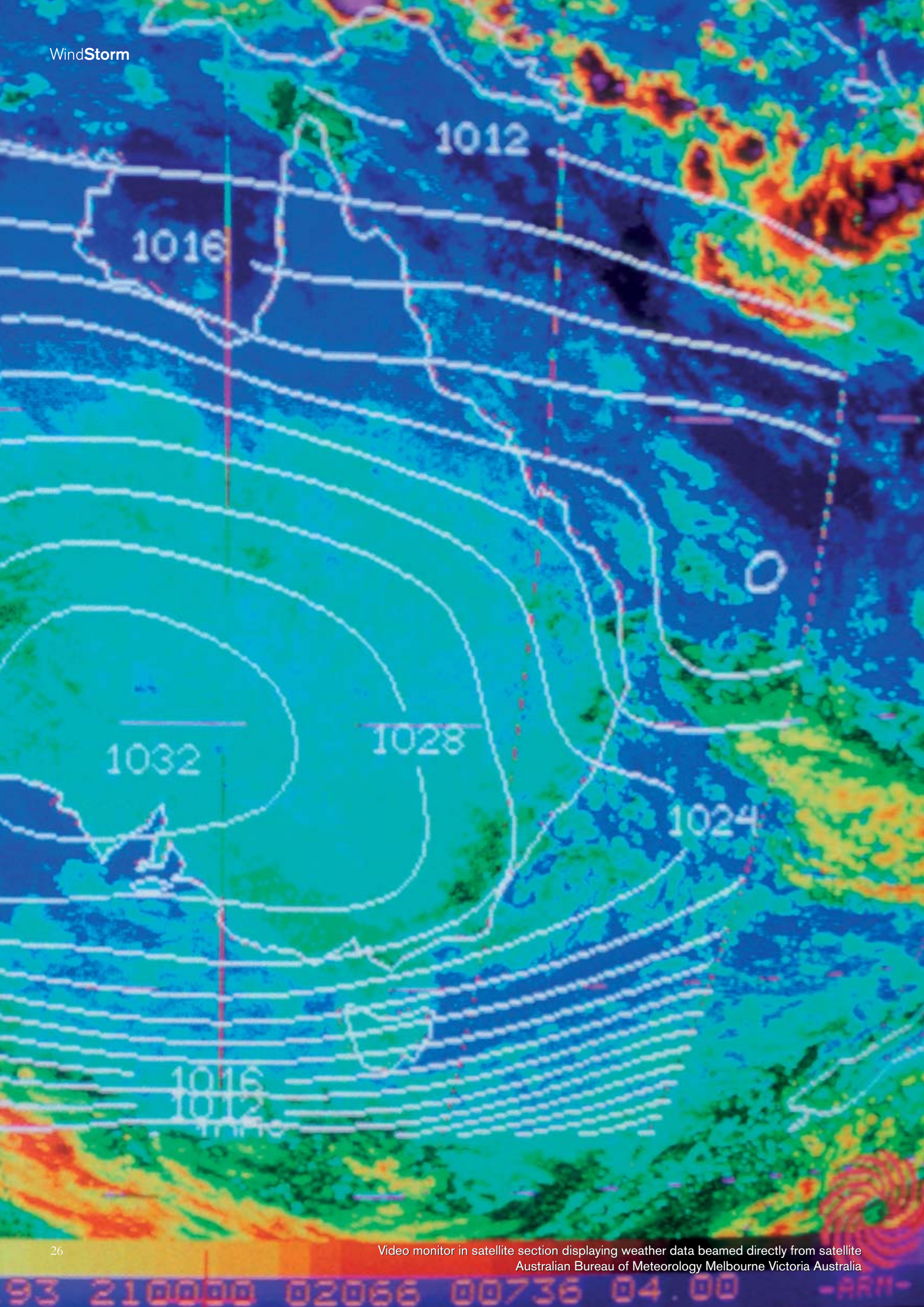


Diagram showing the impact of storm surge
(Source: Commonwealth of Australia, Bureau of Meteorology)

Flash floods can also occur following violent thunderstorms. The likelihood of such an occurrence depends very much on the topography of the area behind the port, and where streams and rivers run.

A warehouse facility was severely damaged when an unforecast storm broke on a Sunday morning. Although the area was sheltered by harbour breakwaters, breaking waves still had sufficient force to cross a service road and the perimeter wall. Containers and motor vehicles parked on the area between the wall and the warehouse were swept along by the water and smashed into the warehouse walls. One container was later retrieved from inside the warehouse building, while another had been carried through the building and out of the opposite door. Much of the cargo stored in the building was ruined.



Video monitor in satellite section displaying weather data beamed directly from satellite
Australian Bureau of Meteorology Melbourne Victoria Australia

Forecasting

Modern weather forecasting employs very complex computer models to simulate how the weather will evolve over days and weeks. Enormous numbers of weather measurements – at sea, on land, in the air and from space – are collated and used to give the best picture of the present weather conditions. With an accurate idea of the present weather, supercomputer simulations can evolve weather patterns through time to provide forecasts.

Weather forecasters use these computer simulations, combined with their many years of experience and access to satellite tracking and the latest weather observations, to deliver weather forecasts tailored for the end user. Unlike other emergencies which can occur without warning (fire, earthquake and so on), there is generally time before the arrival of a storm to take precautionary measures (the exception is microbursts). As a rule of thumb, enhanced forecasting techniques now deliver three day forecasts which are as accurate as the two day forecasts being made 10 years ago. However forecasts are still far from perfect; for example tropical storms are notoriously unpredictable as to their strength and track, and localised effects, such as funnelling of winds by the local terrain will not be captured.

Forecasting the probability of windstorm events *(probabilistic forecasts)*

The atmosphere is a chaotic system, so making forecasts with absolute certainty is an almost impossible task. Modern forecasting techniques can suggest a windstorm event will occur many days and even a week ahead. However these longer range forecasts must be taken as only indicative, and forecasters may offer an associated probability of the windstorm event occurring (rather than saying you will have a damaging storm in 3 days time, the forecast may be that there is a 50% chance winds will exceed a crucial threshold in 3 days time). Medium range weather forecasting, such as carried out by the European Centre for Medium Range Weather Forecasting (ECMWF), deals almost exclusively in such probabilistic forecasts.

Longer range forecasts of windstorm events may be of great use in preventing associated losses. However the probabilistic nature of longer term forecasts needs to be handled appropriately. The emergency plan needs to be flexible to enable it to be upgraded or downgraded as the forecasts change, without unduly disrupting the operation of the facility. An early warning of a windstorm event, even if it has a low probability of occurring, can be used to trigger preparatory action, for example:

- Triggering more comprehensive monitoring of the weather situation
- Allow timely inspection of safety equipment and briefing of staff
- Ensuring key staff are available in the run up to any possible windstorm event

Accessing relevant weather information

If a storm threatens your facility, you should consider appointing someone to monitor its development, using all available and reliable sources of information. This person should be part of the emergency operations team and should report directly to the incident controller.

Radio and TV stations will often be the main source of information about impending storms, but there are many specialised websites available offering weather information and giving specific warning about threats to your area. A selection of these is noted in Annexe 3 but there may be others serving your local area. It is worthwhile checking these sites for accuracy during a quiet period and making a short list of the best and most reliable ones. Local emergency services may also have (or activate) websites with information on threats, precautions to be taken, and any instructions on evacuation.

If your vulnerability to storm events is particularly severe, you should consider procuring specialised local weather information, or expert weather forecasting support. Any procurement decision should obviously be based on the cost against benefit of such a service. Analysis of past storm events, their handling and their impact should indicate whether a specialist service will be effective in preventing losses and hence be cost effective. Forecasts based on local knowledge and observation can also provide weather parameters more applicable to the operations under threat, such as wind speed at 30m height, instead of the standard 10m height, more appropriate to the particular port infrastructure vulnerability.

Tropical Storm Risk

Tropical Storm Risk (TSR) offers a leading resource for forecasting the risk from tropical storms worldwide. The venture provides information and innovative forecast products to benefit risk awareness and decision making in (re)insurance, other business sectors, government and society. The venture developed from the UK government-supported TSUNAMI initiative project on seasonal tropical cyclone prediction which ran from October 1998 to June 2000. TSR has won two major insurance industry awards in the past three years - the British Insurance Awards for Risk Management (2006) and for London Market Innovation (2004). Recent innovations include a breakthrough in the seasonal prediction of hurricane activity reaching the coast of the US, the first demonstration of the business relevance of seasonal US hurricane forecasts, and the introduction of forecast wind speed probabilities for tropical cyclones worldwide. http://www.tropicalstormrisk.com

Daily forecasts from the TSR Business web site are published on the TT Club website in a section entitled 'Hurricane Watch'. This information is also used for risk aggregation and catastrophe response planning purposes. See Annexe 2 (p. 96) for 'basins' monitored by TSR.
http://www.tropicalstormrisk.com/business http://www.ttclub.com

Monitoring the weather situation

If your organisation is located in a part of the world where windstorms are either prevalent or common, you may wish to undertake continuous monitoring of general weather conditions for yourself rather than solely rely on the meteorological service for early warning of windstorm build-up. The table 'Windstorm 'Basins' & Occurrence' in Annexe 2 lists the months of the year during which each type of windstorm may be expected in which areas of the world.

The objective of weather monitoring is to make a detailed and timely appraisal of threats in order to have the maximum possible lead time for a controlled closedown of your facility. Information needs to be collected on a systematic basis, according to an established procedure, to determine the effects of the weather on the facility's operation and to provide a record of circumstances when incidents occur.

In the early build up to a windstorm event, external sources of weather information will be most valuable. They can, in theory, give information on the progress of a storm, its likely track and its severity. Local measurements will have little to offer in the early stages, other than perhaps showing a change in barometric pressure. As the storm approaches, local weather measurements will become increasingly valuable. They may corroborate the external forecasts, or indicate that a storm is perhaps arriving earlier than forecast, has an increased severity, or is actually taking a different track.

The cost of continuous weather monitoring is often small by comparison to the disturbance caused by windstorm. Setting up a monitoring unit requires some basic equipment housed within, or adjacent to, the main office (see the section on emergency planning) so that the appropriate manager, or staff normally engaged in other duties, is able to devote some of their time to weather monitoring on a regular basis. If a storm threatens, the monitoring unit should automatically become part of the emergency operations team and report to the incident controller.

The monitoring unit should have available the following items in good working order:

- Plans of the facility and charts of the local area – preferably laminated;
- Telephone and fax connections for obtaining weather information;
- Local electronic information (email/web feeds);
- Radio with the appropriate bandwidth to receive weather forecasts – in some areas you may need short wave radio to listen to shipping forecasts;
- Access to weather information on the internet – some useful addresses can be found in Annexe 3;
- Barometer and barograph to record changes in atmospheric pressure;
- Printed record sheets (on clipboards) to ensure that time and action records are maintained.

In addition a wind speed indicator (anemometer), a wind direction vane should be fitted to the roof of the building or some convenient high structure bearing in mind the table in Annexe 1 with regard to heights, with the readings relayed to the monitoring office. This anemometer should be separate from any installed on cranes. Automatic logging of weather measurements can be very useful for any post event analysis of a windstorm event.

The monitoring unit should also consider what other weather information is available locally. Meteorological services may provide – free or for a fee – regular updates on weather conditions. Port authorities, the coastguard service or other maritime safety agencies may also have their own forecasting and monitoring services which can provide information and early warnings. You may find that you can exchange information with these services.

It would be wise to ensure that at least three people are familiar with the equipment, the local weather systems and their effects on the locality. Local weather knowledge can be extremely valuable, as local weather effects will likely not be captured by large scale forecasts. Local terrain may enhance winds, or may shelter a facility. Heavy rain may cause regular localised flooding, or waves may be known to breach sea defences. If there is not continuity of staff providing such local knowledge, a written record of such factors may be appropriate as a training aid.

The influence of climate change

Scientists are suggesting that climate change is significantly increasing vulnerability to weather extremes. The effects – rising sea levels, warming waters and atmospheric disturbances – should be considered when planning ahead. For example, it is important to take into account future weather vulnerability when considering the potential site for a new terminal or expansion. At the operational level, weather can disrupt cargo handling operations and emergency plans should consider the impact of untoward events.

In forecasting individual windstorm events, forecasters will have considered climate change factors, such as the seas being warmer than expected. On a day to day basis, forecasts can be used in a standard fashion without the need for considering climate change influences. Also it is impossible to link any one severe windstorm to climate change. Only after a series of events over a significant elapsed time (ie. many years or decades) can it be statistically determined whether vulnerability to weather extremes is changing at a given location.

Creating an emergency plan

The key to business survival is to have an effective set of flexible plans capable of dealing with all foreseeable threats. Although this booklet deals specifically with planning for the eventuality of storms, an emergency plan should deal with all other possible threats to the business, such as fire or explosion, flood, hazardous materials escape and so on. This chapter is not intended to be prescriptive; as the plan itself needs to be flexible, so the process followed should be appropriate to the circumstances you face.

Good emergency planning can help ensure that an incident does not turn into a disaster, but when dealing with natural forces, such as high winds, not even the best plan can prevent unforeseen and disastrous damage occurring. A good plan will therefore also include measures to be taken to recover from a disaster.

The overall objectives of emergency planning are:

- to contain and control emergency incidents;
- to safeguard people in the operational and neighbouring areas;
- to mitigate the effects and minimise damage to property and the environment;
- to enable business to be resumed at the earliest opportunity

Plans will be concerned with three factors:

- the hazard, nature and extent of the threat;
- the risk and probability of occurrence;
- the consequences and the possible effect on people, the environment and the business

The preparation of an emergency plan cannot normally be carried out in isolation. Local authorities and emergency services may well have their own developed plans; your facility may be very close to another industrial plant, or it may fall within the jurisdiction of a port authority. There may be other organisations working in, or with involvement in your facility, for instance stevedores, warehouse operators, engineers and repairers, other terminal operators, customs, railway operators, forwarders, ship's agents and so on; each should, in turn, have its own detailed plan.

Alternatively, employees of such organisations should be included in your own plan. If you regularly use workers from outside agencies (for instance, a port labour pool) you should involve that agency in your plans. Further, to avoid confusion, the terminology used in the plan should be agreed and standardised with the other organisations.

The key to success lies in the harmonisation of all these plans, and in drawing clear lines of responsibility for control according to the nature and severity of the particular emergency. Once developed and agreed, emergency plans should be published, tested and revised at regular intervals.

Appointing an incident controller

Within the business, an emergency coordinator should be appointed at board or senior management level, with instructions to create an emergency plan in coordination with other colleagues. He or she should have a broad knowledge of all the company's operations and be able to call on other senior officials and experts, such as:

- Chief Operating Officer
- Chief Engineer
- Site Manager (with responsibility for buildings and other infrastructure)
- Head of security
- Safety officer
- Human Resources/ Personnel
- Public relations
- IT and communications

to help formulate an emergency plan, and to implement it when necessary. Each manager should be given the task of reviewing his or her area of operation and producing plans to meet the overall objectives of the emergency plan.

Elements of the emergency plan

This booklet identifies some of the threats arising from windstorms, to help members of the group assess the risks and draw up the appropriate action plan.

The coordinator should ensure that these plans fit together smoothly and also comply with the emergency plans of other interested parties.

Timing

The plan should be realistic about the time needed to undertake some of the tasks.

The co-ordinator should monitor how long it takes to complete the tie-down of a crane (including moving it from its operational position to an anchor point), and then factor in an increase of at least 25% to allow for the difficulties of undertaking the manoeuvre in high winds, to work out how much time will be required to tie-down all the cranes in the facility.

In making these calculations, you should remember that personnel may understandably be concerned or preoccupied with the safety of their own homes and families and may therefore want to leave early or may simply stay away from work at times of storm threat. The local authority or police may also order people to evacuate danger areas, or may stop people travelling into coastal areas under threat. You may therefore need to calculate that you will have a reduced workforce available for some of the shutdown tasks.

Decision-making

The plan should include a hierarchy of decision-making. For instance, it is probably inappropriate for a single crane driver to decide that the whole facility should be closed because the conditions on his/ her crane are too dangerous to work in. Whether you would wish to allow the shift manager to make the decision to cease work on that particular berth is a matter for your organisation. It would probably be better for the decision to be made by the incident controller, who should be guided by the experience of the operating personnel concerned.

Communications

In the event of an emergency it is important to manage media and other communications effectively. The emergency plan should document precisely how this should be done, including the activities and responsibilities of management, staff and external agencies, such as appointed public relations staff.

The following are some suggestions concerning the action steps that need to be tightly coordinated in the event of an emergency:

- Inform all staff of the event (by email/ telephone/ fax) and that media communication must be centralised;
- Management of the 'message' is key and no comment should be made without agreement of the appointed person/ team;
- Inform the key corporate stakeholders;
- Inform public relations & draft news releases as relevant.

For more on communications procedures during a storm, see the case study of Hurricane 'Hugo' in September 1989 below (p. 43).

With customers

You will want your customers to know the latest situation regarding operations on your terminal. While the tight coordination of information is of paramount importance, regular and open briefings to customers will assist greatly in maintaining a future relationship.

Obviously, where you have public relations professionals, they can advise appropriately on the content, regularity and media for passing information to customers. In many circumstances, posting information on the corporate website will provide a useful 'buffer' to reduce interruptions to implementation of key elements of your emergency plan. It is also possible to create email mailing lists to which standard statements can be sent quickly and easily.

With employees

You will want your employees to return to work as soon as possible after the emergency. Communicating the latest situation and the expected restart date is of prime importance. All personnel should know in advance what to do to find out latest information about returning to work.

The emergency management team must have a full and up-to-date list of the mobile phone numbers of all key employees. A 'telephone tree' can usefully be organised (one person calls ten people on his list; each of those calls another ten, and so on...), but bear in mind that phone links (both mobile and fixed) may be disrupted by the storm. Text (SMS) messages can sometimes be sent and received in conditions where ordinary phone calls fail.

The company website also can be used to pass on information to employees. Local radio or TV stations may be prepared to carry short messages from companies to their employees.

Computers

Computers are key to many aspects of your operation. Apart from secure back-up procedures, you should ensure that emergency power supplies maintain core functions and that the procedures include controlled shutdown.

Emergency operations room

The incident controller and his/ her team must have access to an operations room housed in a substantial building that is storm-proof and unlikely to be affected by the emergency itself, including flooding or the effects of the storm on cranes, box stacks or any other equipment. It should be located, designed and equipped to remain operational throughout an emergency.

Testing the plan

Once agreed, the overall plan should be published and copies made available to all personnel. It should be tested regularly by drills or practices, and any lessons learned should be incorporated in the plan. Everybody involved should be made aware of any revision and appropriately revised instructions and plans made available.

Emergency plans need to be tested when first devised and rehearsed at suitable intervals thereafter. Rehearsals or exercises are important because they:

- familiarise personnel with their roles, equipment and the details of the emergency plan;
- allow for professional emergency services to test their parts of the plan, the co-ordination of their activities and the compatibility of communication equipment;
- familiarise the professional emergency services with the special hazards;
- prove the current accuracy of details of the plan, e.g. telephone numbers, the availability of special equipment such as fire and rescue equipment, etc.;
- give experience to and build confidence in team members. In the initial shock and confusion of a real incident the ability to fall back on well-rehearsed actions will be invaluable;
- can identify any unforeseen weaknesses of the plan.

Operators, in conjunction with the appropriate authorities, should regularly test their emergency plans and ensure that all employees receive refresher training. Such exercises should test each part of the emergency plan in each part of the area, or each berth, stage by stage starting with the first immediate action. Emergency shutdown, securing of equipment and evacuation should be rehearsed. Where appropriate this may be by simulation. Familiarisation visits by the emergency services should be encouraged.

Emergency control room

You should check that all systems in the emergency room are working. The room should have:

- An up-to-date copy of the emergency plan;
- Working phones and computer terminal(s) with email and internet access;
- Details of all personnel remaining on the facility, together with their (internal) phone numbers and locations. This includes people not directly employed by you but who are legitimately working in the facility, such as customs officers, security guards, ship's agents etc.;
- Means of communication with such personnel (short-wave radio, 'walkie-talkie', internal or mobile phone);
- Spare batteries and chargers for mobile phones, computers etc.;
- Access to the details of all containers on the facility;
- Details of all vulnerable consignments (temperature-controlled, tank containers and dangerous commodities);
- An up-to-date list of employees' addresses, email addresses and contact phone numbers, both mobile and fixed;
- Radio to listen to weather bulletins etc.;
- Contact numbers for local emergency services and coastguard etc.;
- Contact number for security company;
- Contact details for surveyors and hazardous goods specialists;
- Contact details for your insurers' local office;
- A copy (either in book or electronic form) of the current IMDG manual;
- Torches (flashlamps) etc. and batteries;
- First aid manual and first aid supplies;
- Supplies of water and food.

While this is applicable to all other emergency plans, your windstorm plan should be tested on at least an annual basis, so that all personnel are familiar with their roles and duties. Regular exercises will also help identify weaknesses and areas for improvements: employees should be encouraged to give feedback on the effectiveness of the plan.

Implementing the plan

If an emergency is declared, the emergency coordinator will automatically become the incident controller, with responsibility for implementing the plan. He or she should be vested by the board of directors with full authority to take whatever decisions that may be necessary to protect the business. The coordinator/ controller should have at least one deputy with the same level of authority, to cover for absences. The controller should be supported by an emergency operations team, with people drawn from a number of different departments and specialisms. The incident controller, or his deputy, together with an emergency team and nominated key personnel should always be available to carry out immediate response. As they may be called out at any time, ideally none of the team should live too far away from the facility.

Other personnel on site

Other important personnel, such as those representing shipping interests, will be required to report to the incident controller and implement his/ her decisions. Relationships with some other groups of workers, for instance those from the customs or immigration services, may need to be handled tactfully, but they should recognise that complying with the plan is in the interests of their own safety. All such organisations should report to the incident room if they are closing down their own operations, or – if not – which of their personnel will remain on site.

A further group of essential workers will be required to undertake emergency work such as:

- stopping all cargo handling operations and making them safe (if possible);
- moving equipment and lashing it down;
- checking vulnerable cargo;
- acting as marshals or runners, or staffing assembly or communication centres.

Arrangements should be made to ensure that all staff not required as part of the emergency plan is safely away from the danger area.

When typhoon 'Maemi' hit the coast of South Korea with winds gusting at up to 58.3 m/s, it blew one crane along its track until it collided with its neighbour. The collision triggered a 'domino' collapse of five cranes. In another facility in the same port, three more ship-to-shore cranes were written off and three others derailed. In addition, hundreds of containers, many loaded with cargo, were inundated with seawater. The total cost of repairs and other expenses exceeded US$30 million. The initial impact lifted the leading edge of the first crane and brought the storm pins out of their sockets.

When to implement the plan?

This is a question of crucial importance. If the plan is implemented too early and the storm fails to materialise, it could disrupt normal operations to no good purpose. Leave implementation too late, and there will be insufficient time to put the plan fully into operation, with consequent risk to the business. The plan should therefore be sufficiently flexible to reflect this dilemma. A multi-stage implementation allows the plan to be upgraded or downgraded as the threat assessment changes.

You should, in general, err on the side of safety. It takes some time to shutdown the facility (your emergency planning will have shown how long), and you have to ensure the safe evacuation of personnel from exposed positions. Also remember that wind speed increases dramatically with height above ground: the strong breeze blowing at 11.1 m/s which you encounter on the quayside is probably blowing at gale force 19.4 m/s round the driver's cab 30 metres or so above. And he still has work to do up there before he can safely leave his post! It may be helpful to use professional risk management techniques in striking a balance between being over cautious against being too cavalier.

The following sections identify potential dangers that may threaten your business and offer some suggestions on how to mitigate them.

Further help

An Emergency Plan Checklist can be found in Annexe 5 (p. 115).

Further guidance on the creation of effective emergency plans may be found in Safety Briefing Pamphlet No. 6 available from ICHCA International:

http://www.ichca.com

Case study

The Storm whose Eye went across an entire Port

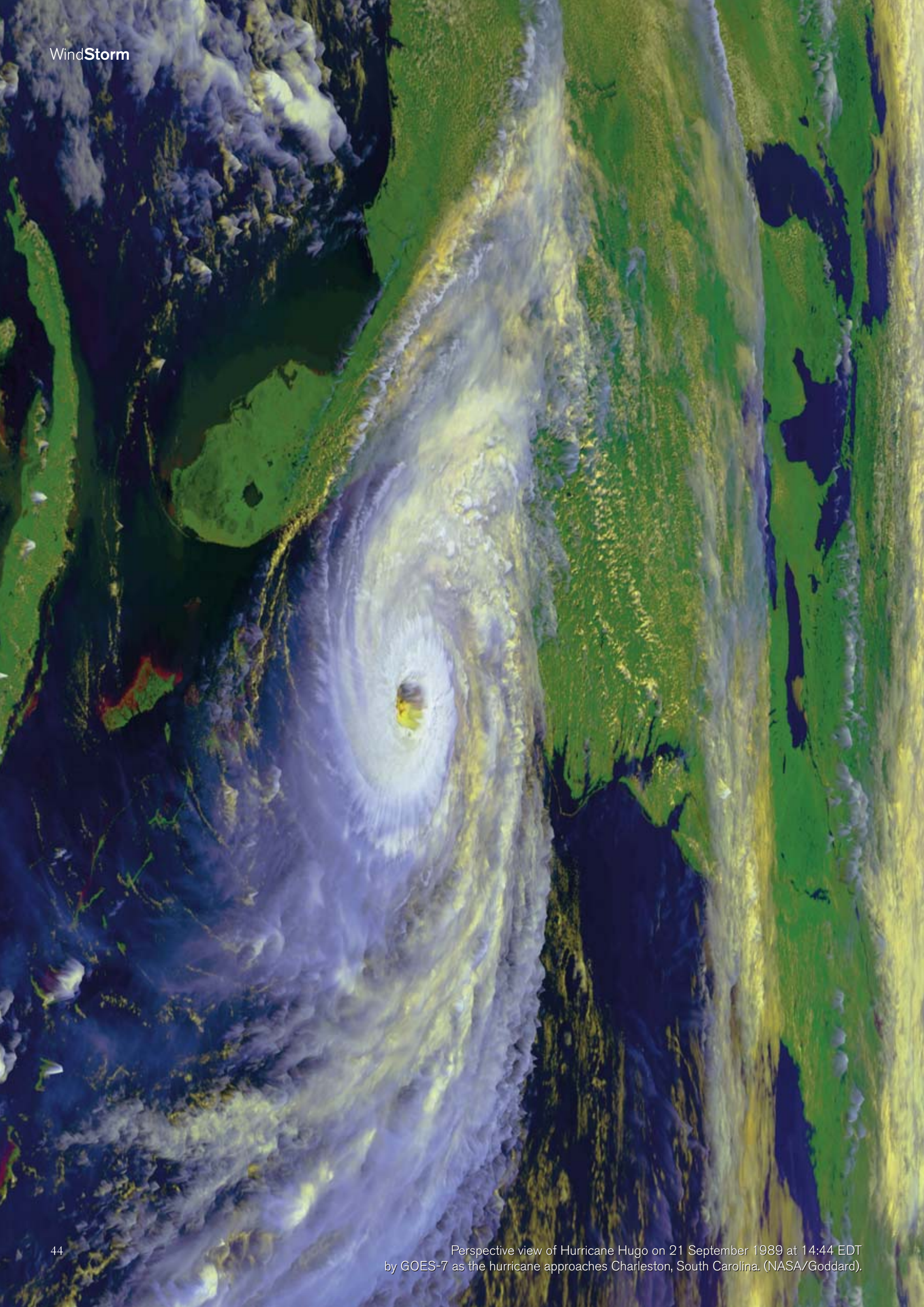
Hurricane Hugo and the Port of Charleston 1989

In September 1989, a storm that had started out as a tropical depression hundreds of miles away off the west coast of Africa, came ashore on the east coast of USA as a full blown hurricane. With gusts touching 89.4 m/s and a storm surge of 20' which came on top of a high tide, hurricane Hugo severely tested the Port of Charleston in South Carolina. A rather more unusual feature of the storm was that the eye actually passed directly over the harbour and that, combined with the general effects, resulted in an experience and lessons from which others could learn.

This entire coast from Florida up to the Chesapeake Bay area is annually vulnerable to these storms and Charleston was well prepared. Thanks to being linked with a reliable weather forecasting service, every ship had left the port and everything that could be was secured. Mobile equipment was placed inside warehouses and container stacks were broken down with full boxes stowed against sheds and warehouses where they were more secure and could protect windows. Potential objects that the wind could turn into missiles were identified and moved.

As Hugo had dumped 10-15" rain on the Caribbean on the way to Charleston, waterproof protection was wrapped around essential electrical and electronic equipment such as crane controllers to keep them dry. Two days before the storm hit, groups at all levels in the port talked about the impending situation and the roles to be followed, with communications, decisions and decision makers crucial and interlinked. Based on previous storm experience, trigger points were set and action levels decided. Heavy equipment was positioned in strategic places in the coast area and generators had been purchased beforehand as part of the preparations. Once the preparations were complete, the port's employees were told to secure their own homes and not come back until called.

The storm actually struck during the night with widespread flooding and damage to buildings and other structures. With large numbers of trees down, movements on the roads became difficult and with telephone lines down immediate communication was cut off. Power was also cut for up to 19 days in some areas. In the port, warehouse roofs were blown off, one container crane was totally destroyed as it hit the buffer stops and fell onto an adjacent pier. It was noticeable that the crane moved in the opposite direction to



Perspective view of Hurricane Hugo on 21 September 1989 at 14:44 EDT
by GOES-7 as the hurricane approaches Charleston, South Carolina. (NASA/Goddard).

that of the storm. A 400t capacity crane was severely damaged as it fell backwards, in effect across the line of the storm.

Because of the preparations made and due to the dedication of all those who worked in the Port, the main clean up was completed and cargo handling activities were possible within three days.

There were a number of lessons that might be of relevance to others.

- *One of the major consequences of the storm was that all navigational aids were swept away and the navigable channel that led into the port was altered. This meant that the channel had to be resurveyed and re-marked and it is notable that the first ship to come into the port did so five days later and experienced no further delays*
- *The Port was properly insured and the long term result was that many warehouses acquired new roofs and the port got a new container crane.*
- *The reason the container crane moved held another lesson. It was secured via chains at each corner bolted onto the crane and shackled to pad eyes set into the quay. The chains were vertical when properly deployed and the pad eyes were set across the line of movement. The subsequent investigation concluded that the extreme vibration set up by the storm caused the shackle pins to work loose and finally to fall out. As a result, the pad eyes have been reset so as to be aligned with the line of movement and the pins would be welded into place. The chain angles were also to be altered so as to provide variously angled securing over the four corners. As was acknowledged, an alternative would be to install a second, separate securing system.*
- *At a point in time, all communications failed, even mobile phones as the repeaters were down. The only means of communication was by word of mouth. Anything that relied upon batteries did not last very long and, without plentiful battery reserves, such equipment soon became useless.*
- *Other essential items for storage beforehand were sheets of plywood, chainsaws and generators.*

Hugo was the worst storm that the coast had experienced at that time and the Port was hard hit. However, it recovered remarkably quickly and tourists could buy postcards showing a satellite view of the eye of the storm centred on the Port very soon afterwards.

Before the storm

Operational housekeeping

The importance of good housekeeping practices cannot be emphasised enough. While much of this booklet focuses on containerised operations, the principles apply equally to bulk and other port operations.

- Cranes and other equipment should always be parked safely and locked down when not required.
- The heights of container stacks (particularly of empties) should be kept under review. Stacks over 4 units high pose a serious risk in high winds.
- Keeping your facility tidy will avoid day-to-day (and ultimately expensive) accidents to people and will avoid the need for an emergency clear-up, as a storm builds, to stop debris being blown around.
- Proper routine maintenance of equipment can avoid making the disturbing discovery at the last minute that emergency equipment is not working properly (especially quay and terminal crane service and park brakes, and storm pins and tie-downs).
- The prevalence of storms should also be taken into account when designing buildings and terminal layouts, and in the construction of other infrastructure.
- All routine maintenance should be scheduled for completion before the expected start of a recognised 'windstorm season'.
- Emergency plans should be tested regularly so that all personnel are familiar with their implementation.

Cranes and major handling equipment

Where there is public reporting of high wind conditions, pictures of large cranes are often shown, as they tend to cause the most physical damage and if they collapse they are particularly spectacular and are therefore regarded as more newsworthy.

This booklet relates to all terminal cargo handling equipment, not just cranes. Also, 'quay cranes' refers to all cranes on the quay (container cranes and bulk loaders and unloaders).

The recommendations in this booklet are intended to supplement, not supersede, those of the manufacturer and the requirements of international and national standards on equipment design, construction, operation, maintenance, inspection, and testing.

In establishing safe procedures consideration should be given to the following:

- during high winds it may not be safe to boom up or boom down;
- personnel may have to walk up and down exposed ladders to boom up or boom down;
- personnel may not always be readily available at short notice to assist in making equipment safe;
- in some conditions it may be impossible to long travel move a crane into the wind;
- during high winds travelling downwind may lead to the crane going out of control and not being able to stop
- steady wind speeds are easier to work with than gusting conditions;
- winds can be very localised on large terminals, with over-the-limit wind speeds being recorded in one area, while others are still experiencing speeds below the danger level;
- one of the other main problems in working during high winds is the danger arising from falling debris and containers in terminal storage;
- safe operation of other terminal equipment can be affected.

Preventative maintenance

The regular planned preventative maintenance of electrical and mechanical components based on manufacturers' recommendations is essential to ensure safe operation and reduce the incidence of breakdowns or accidents. In many countries operators are legally obliged to maintain cranes and other items of heavy machinery properly. Local regulations (or your lease contract) may also require you to undertake various tests and thorough examinations on a regular basis to ensure that cranes can be used safely.

A regular, thorough examination of a crane, at intervals of at least once in every 12 months, is a very important complementary step to planned maintenance. Parts of cranes vulnerable to corrosion should be regularly inspected with special attention given to walkways, staircases and securing bolts. All areas should be regularly inspected and if proper access is not possible via the crane's structure, suitable alternative provisions should be made.

Maintenance of all terminal cranes (including container and bulk cranes) and regular checks for corrosion are essential – particular care should be given in the inspection of weather resistant coatings.

Maintenance of all safety devices including limit switches, actuators and their electrical controls should receive special attention as part of the planned maintenance program. For terminal cranes, braking systems, storm pins and tie-downs are especially important.

All parts of the crane used for access, including emergency exits, should be lit to a minimum level of 10 lux. Lighting should be so arranged as to minimise glare to persons either working on or with the crane or those navigating ships or working on the water. Escape systems should also get regular and careful examination. Escape harness equipment and the harness material itself must be part of the inspection and maintenance regime.

A record or logbook should be kept of all aspects of maintenance work including repairs, breakdowns, hours worked and any items that have been replaced or renewed. It is important that the correct lubricants are used and that the optimum frequency of application and inspection is maintained. You may also be required by law to keep certain records. In any event it is a sensible business practice to keep full records of testing and maintenance for at least six years or preferably the life of the equipment.

What is often overlooked in preventative maintenance schedules is the structural integrity examinations of cranes. This is extremely important and is discussed in more detail in its own section below.

Structural integrity examination of cranes

Structural examinations of cranes at ports and terminals should be carried out regularly during manufacture and throughout their working life.

Major structural failures can result in serious injuries to workers and be very costly in repairs and operational downtime. These failures can occur at any time, but during windstorms any structural defects can result in sudden catastrophic failure.

Testing and thorough examination is basic to crane safety. Provisions for such examinations are specified in ILO Convention 152 and its accompanying Code of Practice, and represent the international standard for the port industry. The purpose of thorough examination is to make sure a crane can continue working effectively, and a crucial element of this is the safety of its structure.

It is recommended that independent examinations are always performed when procuring any type of crane. It is also recommended that appropriate mechanical and electrical inspections are carried out during installation and commissioning to check for quality and conformance to standards and specification.

Crucially, however good its manufacture, a crane should also be examined regularly whilst in operation. Damage resulting from relatively minor impacts or simply regular heavy lifts close to or equal to the safe working load can result in sudden failure or early fatigue failure. Often these operational issues occur without anybody being aware, so regular inspections need to be carried out in any case. Any known incident should clearly result in a check on the structural integrity of the crane.

The international standard calls for thorough examinations to be carried out at least once in every 12 months, and this should be reflected in national regulatory requirements. Generally as the crane gets older the examination frequency should increase. But some countries have less than stringent or no regulatory requirements. All regulatory requirements must be adhered to, but for those with no regulatory requirements a minimum examination period should be implemented based on international standards. Furthermore, the regularity of examinations should increase based on use, particularly where this is at or close to the crane's safe working load and the crane's age. Obviously, regular mechanical, electrical and painting maintenance should also be implemented to ensure safe and reliable operation.

Crane owners need to ensure compliance with the standard to ensure safe and reliable operations. Regular crane examinations will in the long term save downtime and money. It will also help the crane better weather windstorms.

Crane braking systems

There are normally two different braking systems used for rail mounted cranes, service brakes and park brakes.

The service braking system forms the normal operating brake. These brakes are normally part of the gantry (long travel) motor and gearbox of the crane, which slows and ultimately stops the crane during daily working. The electrical motor control system of the crane normally slows the crane speed down and when it reaches below about 20% speed then the service brakes are applied to stop the crane. At least 50% of the wheels of the crane should be driven and braked, however with the increased occurrence of cranes being blown along the quay a larger percentage and even all the wheels may be braked. Some crane designs use wheel brakes instead of or as well as motor/ gearbox brakes. These are generally disc brakes mounted on the crane wheels. The more wheels with brakes the more chance of stopping the crane when being blown along by the wind.

Park brakes or, as they are sometimes called, storm brakes include rail clamps and railhead brakes. However, these are static brakes, ie. in normal operations they are only applied when the crane has stopped moving and in some crane control systems they are delayed applying for several minutes to minimise their usage and wear during normal crane operations. They should only operate immediately, while the crane is still moving, when the emergency stop is activated, and unless severely damaged may help prevent a stationary crane from being pushed along by the wind. Their main purpose and benefit is to park and secure the crane between normal operations without the need to apply the storm pins or tie-downs. If rail clamp and railhead brakes are applied when the crane is moving, both the brakes themselves and the crane rail can be damaged. For this reason, many crane designs include wheel brakes to work as service brakes but they also provide increased park braking capability.

With some crane controls the emergency stop may be activated automatically when the wind is above a certain speed. This can prevent the crane moving to the storm pin and tie-down point. The crane controls should be checked and if this automatic stop above a certain wind speed is installed it should be disabled.

Both maintenance and training are crucial to the braking systems stopping a crane. Investigations of incidents where a crane has been unable to stop during operations due to high winds have shown that most were due to, or made worse by, many of the service brakes and park brakes being inoperative due to poor maintenance. Driving procedures and training are covered in a later section.

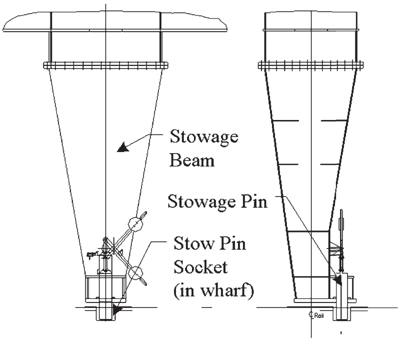
Service brakes and park brakes are normally designed to hold the crane against a certain wind speed, typically 35 m/s. Above this wind speed the crane should have storm pins and tie-downs in place. If storm conditions are forecast or operations are ceasing for an extended period, all cranes should be secured additionally by the use of storm pins and tie-downs. For more information on storm pins and tie-downs see the following sections.

Several gale force winds in Northern Europe caused a rail mounted container gantry crane which was not secured to collide with and collapse onto a neighbouring crane. As a result of the accident, the first crane was a constructive total loss and the second was badly damaged. The terminal was insured for physical loss and damage, but with an insurance limit based on the value of one crane only. This was decided on the basis of a risk assessment that considered the loss of more than one crane – and the consequent operational disruption – as extremely remote. As a result of the incident, the entire business went bankrupt.

Quay crane storm pins

Storm pins are vertical sliding pins mounted at suitable positions under each leg of the crane. These pins are dropped into sockets set into the surface of the berth to help prevent the crane from being blown along the quay by horizontal forces. The pins must be interlocked with the travel motion so that the crane can only be moved when the pins are disengaged.

The pins and the mounting on the crane and also the pin sockets in the quay structure must both be designed to withstand the maximum forecast forces exerted. Hardware often fails due to improper design and/ or construction by either or both the quay civil constructor and the crane manufacturer. Poor design/ manufacture may result in storm pins breaking away from the crane structure, pin sockets pulling out of the quay deck, and/ or pins not far enough into the socket due to flexing of the crane structure. The effectiveness of the storm pinning system is directly related to the depth and width of the pins. An example of good practice is illustrated below.



(Courtesy of Liftech Consultants, California, USA)

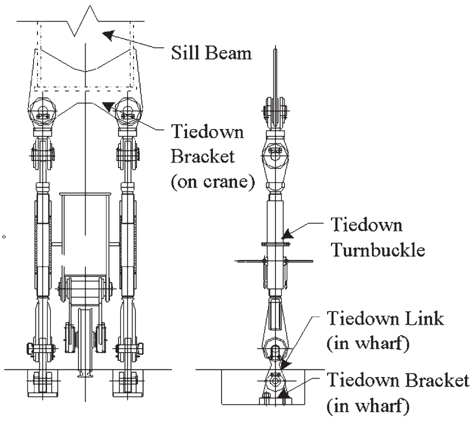
As part of good housekeeping routines, it is essential that the storm pin sockets in the quay are kept clear of debris. Sockets blocked in this way can become ignored as a means of locking down. If they are covered with rubbish, available sockets may be missed by the driver or engineer trying to find a suitable position in an emergency. Marking the position of sockets by a symbol painted on the ground is a cheap and effective way of highlighting these areas. Filled or partially filled storm pin sockets result in less of the storm pin in the hole and less uplift needed to dislodge the pin during a windstorm.

Storm pin systems should be part of the maintenance program. Any items that are seriously corroded or damaged should be discarded and replaced as a matter of priority.

All storm pins equipment on the crane should be of the same size and breaking strain: ideally all such equipment should be interchangeable for cranes located in the same facility.

Quay crane storm tie-downs

Storm tie-downs are to prevent the crane from any uplift wind forces which could move or topple the crane. It is particularly important to recognize the need for design parameters to withstand substantial and sudden vertical forces as well as horizontal forces. Storm tie-downs are connections on the crane, normally at the four corners, where suitable slings, chains or bars of appropriate size and number are fitted to connect to anchor points in the terminal pavement. These anchors must be able to hold the loadings of the crane under potential wind conditions. When engaged, the storm tie-downs must be interlocked with the travel motion so that the crane can only be moved when the tie-downs are disengaged. An example of good practice is illustrated below.



(Courtesy of Liftech Consultants, California, USA)

Many crane manufacturers claim their crane can withstand a certain wind force, without uplift, which is above the maximum expected wind for the location that the crane will be installed. For this reason there are many quay cranes that do not have tie-downs. However the manufacturers' calculations may be inadequate and inaccurate, and it is important to review the crane and terminal hardware together ensuring that the same design considerations are used. A third party design company should be used to review the crane and terminal hardware design and calculations. It is important to prepare for windstorms regardless of location, in view of the apparently increasing severity and random distribution. Some cranes have additional ballast or weights to limit uplift. Although ballast can help, in most situations it is recommended to ensure both storm pins and tie-downs are provided for all quay cranes. In seismic zones however, tie-downs may need special evaluation, and an alternative is extra ballast on the crane. There are many factors to be considered when designing the crane. If you specify storm pins and tie-downs you need to ensure the crane manufacturer does not design stability assuming the tie-downs are always in place. Due to the time it takes to pin and tie-down a crane, and in the case of sudden windstorms like microbursts, you still need adequate stability and security with just brakes and ballast or the weight of the crane. Reducing uplift by adding ballast will help make a more secure crane however there are limits to the amount of ballast due to maximum crane rail wheel loads and extra capital and running costs for larger gantry motors. Therefore it is important that all crane owners and operators review the ballast, tie-down and also storm pin requirements and arrangements that they have for existing and new cranes. They should discuss this with the crane manufacturer and also a third party design reviewer.

Incident investigations have shown where a crane has been blown along or breaks away, even though it was tied-down and pinned, many failures were due to the tie-down or storm pin securing system in the quay deck and not hardware on the crane. The weak point is often the securing systems embedded in the quay infrastructure. Many civil installations bury the tie-down anchors deep into the concrete deck, held by friction only, to afford protection by sheer strength. However a parked crane hit by a big storm is first subjected to uplift forces which tend to pull the anchors out of the ground, so not only should the anchors be appropriate for the size of the crane and the expected shear forces, they should also be sufficiently embedded and properly tied to the quay to guard against uplift. Once all tie-downs on one crane have failed, the crane can be blown along the quay and impact with other cranes and cause major damage and collapses. Therefore it is highly recommended, for all new and also existing quay cranes, that the storm pin and tie-downs systems on the crane and the quay hardware are checked. It is important to involve the civil engineers and the crane manufacturer as well as a third party in checking the requirements, design, installation and condition of the crane hardware and the civil hardware in the quay structure.

A situation where the crane hardware has created major problems is cranes with a 'cradle' type bogie design. With the uplift forces on the crane, gusts of high wind can lift cranes from their mountings. The substantial difference in wind speeds at different heights has already been noted: the wind striking the top of an upright boom, perhaps 60 or 70 metres up in the air, will be significantly stronger than it is at quay level. This effect causes an unrestrained crane to tilt slightly, lifting the upwind wheels (bogies) off their track. While the bogie wheels may drop back into their correct position on the track, experience shows that bogies may be derailed or even lifted by as much as 2.5 metres (about 8 feet). If the bogie is of the 'cradle' type, the crane's structure is simply sitting in the 'trough' on the bogies, held there by its own weight. If the top part of the crane is struck by wind gusts and tilts as described above, the lower part will lift out of this 'trough'. However, when it falls back it is highly unlikely to relocate properly into the correct position. This is much more difficult to correct than a simple derailment. It is therefore far better to ensure that your cranes are all fitted with 'pin through' type bogies, where the bogie is firmly attached to the superstructure by pins. If this is not the case, ensure the tie-down connections on the crane are on the superstructure (sill beam) and not the bogie structure.

Tie-down systems, including the linkage on the crane and the quay hardware, should be part of the maintenance program. Any items that are seriously corroded or damaged should be discarded and replaced as a matter of priority.

Where practical, all tie-down equipment on a crane should be of the same size and breaking strain and with cranes of a similar size in the same facility, all such equipment should be interchangeable. This provides advantages of standardised operational and maintenance procedures, and reduced spare parts.

Other equipment tie-downs

While most rail mounted quay cranes should have storm pins and tie-downs, all other cranes and other tall mobile structures such as mobile harbour cranes, rubber tyred gantries, rail mounted gantries and straddle carriers should be assessed to determine the need for tie-downs. This need will depend on their location, design, normal braking system and maximum expected wind speed. If in doubt, tie-downs should be installed. On some handling equipment this means fixing wire hawsers or chains between the shoulder points and securing points on the ground. Wherever possible these tie-downs should be from all four corners of the crane and should be at an angle of about 45°. It may not be possible to tie-down quay cranes in this way because the front legs of the crane are too close to the edge of the quay.

It is important to note that effective tie-down requires each leg to be secured, preferably in identical fashion since damage can be exacerbated due to racking forces exerted in high wind conditions.

Crane buffers

On the four corners of each quay crane and at each end of each crane rail should be installed gantry buffers. The buffers are used for shock absorption in the event of the cranes colliding or a crane hitting the rail end buffers. If a crane was being blown along the rails, depending on the speed, these buffers may help prevent a total crane collapse.

All buffers should be the same height. This statement may seem obvious but it is often overlooked when adding new cranes to the quay.

Anemometers

Cranes should be fitted with anemometers (wind speed gauges) at the topmost part of the rigid structure where readings will not be affected by other parts of the structure. The anemometer should be connected to an effective warning system that alerts the driver to dangerous wind conditions and this information can usefully also be transmitted back to terminal control. A siren should also sound to alert any personnel on the crane structure. Each crane driver should be guided only by the warning system on the crane he or she is using. No reliance should be placed upon the anemometers or warning systems on other, adjacent cranes.

The anemometer should not be interlinked with other parts of the crane's system. If, for instance, it is linked to the drive system and automatically cuts out the motors at a pre-set wind speed, it can be difficult – if not impossible – to move the crane under power to a storm pin and tie-down point.

Second-hand equipment

Equipment that has been bought from another company, or maybe transferred from one facility to another within the same organisation, must be brought up to the same standard as existing equipment. Engineering specifications – set for the needs of the original location – need to be reviewed for more than pure operational performance criteria. Care should be taken where the unit has been purchased from another part of the world, since wind speed designs for cranes are based on expectations in the region of the world where they are to be sited.

In addition, you must check that the storm pins on these cranes will fit existing sockets on the quayside, and that your facility's standard tie-down equipment will also be usable. If not, appropriate modifications should be made to the crane, so that it can be properly secured in an emergency.

Everyday routine operations

It is a fact that the majority of crane losses are the result of people not doing what they should have done, or forgetting to do what they know is needed, even when there is a procedure in place. The best storm protection is an enforced philosophy of correct parking and securing procedures every time the cranes are out of use. Make sure that cranes are positioned correctly, secured by all the brakes and with booms stowed every time work stops. When operations stop for an extended period or for a period when terminal manning is reduced, the cranes should also be pinned and tied-down.

Driver's cabin

One common effect of high winds is that the driver's cabin window is blown out. Generally the window is not blown inwards (into the cabin) but outwards. The usual reason for this is that the driver's cabin door has been left open: the resulting difference in air pressure between the inside and outside of the cabin causes the window to burst from its frame. Drivers should be instructed to close the door at all times and also lock the door whenever they leave the crane.

Emergency electrical power

Electricity supplies may be disrupted if power lines are blown down. You should have a supply of generators of your own available for emergency use both for lighting and power. It is inadvisable to rely on hiring generators as they may not be available in an emergency (everyone else will want them, and they may even be requisitioned by the authorities).

Make sure that the generators are included in the maintenance program, that they are tested regularly, kept fully fuelled and that personnel know how to use them. You should consider carefully how many generators you are likely to need in the event of prolonged or widespread disruption to power supplies, and make sure that you have adequate reserves of fuel available on site.

Ideally, generators and some fuel supplies should be kept above ground level to ensure that they can be used even after flooding.

Cargo

You should identify particular risks to cargo when planning storage locations.

- Tank containers may be ruptured by flying debris.
- Temperature-controlled units will be affected if power supplies fail.
- You may need to check that sheeted loads and tarpaulins on open-top containers are properly secured: they therefore need to be easily accessible.
- Some out of gauge cargo may need special protection, for instance by being surrounded with standard general purpose containers.
- Motor vehicles are easily damaged by debris carried in the wind.

Cars were stored in an open compound in the port awaiting shipment. Due to increasing trade volumes, an extension to the storage area was being built and the contractors had placed piles of sand there ready for use. A violent windstorm occurred, which blew the sand with great velocity over the cars, effectively sand-blasting them. The paintwork and windshields of the cars were seriously damaged. The refurbishing work involved on each car was considerable and exceeded the limits allowed under rules governing the international trade in new vehicles. This meant that they could no longer be sold as 'new', resulting in a considerable loss in value for the manufacturer. Total losses were in excess of US$5 million.

The emergency operations room should have details available of all hazardous and vulnerable cargo on site. It should also have access to the current version of the IMDG code and the medical first aid guide for use in accidents involving dangerous goods (MFAG).

Container stack heights

High stacks of containers, particularly of empties, are particularly vulnerable in high winds. As noted elsewhere in this booklet, the combination of a large surface area and low weight means that empty containers can be blown down. The risk increases with height above the ground and, of course, the greater the drop the greater is the likelihood that a container will be a total loss after it hits the ground – as well as the potential injury to personnel and damage to other assets. Containers have been known to come off of two high stacks and part loaded boxes have also been moved.

When a container depot was hit by an unexpected gust of wind, a container was blown off the stack of empty units, killing one employee, injuring others and damaging a container stacker.

Hazardous materials and cargo

The emergency plan should also include measures to deal with spills and escapes of hazardous materials and other liquids. Personnel remaining on site during a storm should know how to deploy and use equipment to contain spills. Remember to include any supplies of your own on site (eg. stocks of vehicle fuel) in your risk assessment.

Buildings and other infrastructure

Buildings should be properly maintained. Any loose structural parts should be re-secured as a matter of routine priority.

Windows and other openings should be equipped with clips to permit storm-boards or screens to be fitted quickly. Boards or screens should be checked for damage after each use, and replaced if necessary.

Three warehouses, another building and two gates were seriously damaged when a storm, with winds gusting up to force 12 hit southern Sweden. Repair costs were estimated at US$200,000.

Storms are, of course, usually accompanied by heavy rainfall and flooding is a major cause of damage. Gutters and drains should be adequate to cope with severe conditions and must be kept clear and checked from time to time. Do not allow storm drains to be used for other purposes.

Other structures, such as lighting and communications masts, are also likely to be damaged: ideally they should be constructed to withstand the highest likely wind speeds experienced in your area.

Accommodation for personnel

Any personnel who have to remain on site during a storm must have access to storm-proof accommodation. Ideally this should be close to the emergency operations room and should comprise at least bunks, cooking, washing and toilet facilities, a supply of food and bottled water, a first aid kit, TV and radio, internet/ email access, secure heating and lighting. Copies of the latest version of the emergency operations manual and the list of contact numbers for other key personnel should be kept permanently in this room. Ensure that supplies of provisions are regularly checked and renewed: remember that as a storm approaches there may be panic buying as local residents seek to get their own supplies and supermarket shelves will empty rapidly.

Other supplies

Consider having emergency supplies available of timber, plastic sheeting, canvas, plastic pipes, wire and tools for use by an emergency crew. Keep these stocks under review, if possible in their own locked area and preferably adjacent to the storm-proof accommodation. It is an unfortunate fact of life that items intended for emergency use are sometimes 'borrowed' for some other task and never returned. All stocks should therefore be reviewed and renewed on a regular basis.

Shelters

If your facility is prone to sudden and unpredictable squalls or tornadoes, you should have substantial and clearly marked shelters constructed in or near operational areas where personnel can take refuge.

Communications

Communications with your personnel once the storm has passed can be difficult. Consider setting up a website to be used in such an emergency, hosted away from your own servers, which can carry news about the facility and instructions on returning to work etc. This could be linked with alternative email addresses, made available through one of the public email service providers. Planning should include the possibility that all usual means of electric and electronic communications might be impossible – see case study of 'Hugo'. (p. 43).

Issue all personnel with a credit-card sized card giving the address of the website, email facilities and emergency contact phone numbers. Review the information and reissue the cards at least annually. Consider equipping key personnel with satellite phones for use in case the fixed and mobile phone networks are not functioning.

Computer back-up

You should have a storm-proof computer back-up facility off-site. These can often be provided by specialist companies under contractual arrangements: in an emergency your staff can work from that facility until your on-site computer systems are functioning again. The off-site arrangements should be regularly monitored both in spot checks and in disaster-recovery exercises. Your IT and other key staff should know how to get to the facility, and the access codes to get inside.

Traffic management

Effective and appropriate traffic management is necessary at all times. Clarity of procedures and signage is all the more important when your emergency plan has been invoked. Personnel may be less familiar with any modified procedures; there will be pressure to complete tasks and ensure that equipment is parked/ secured appropriately.

Responsibility of the landlord/ site owner & tenant/operator

The precise way in which the premises are owned or leased will differ vastly. It will generally be true that the occupier/ tenant will need to ensure that the premises are suitable for the operations being conducted there. Thus, for example, while the civil engineering infrastructure for a port operation may be in place, the operator should be satisfied that the storm tie-down points are adequate in every respect.

Following from this, it is unlikely that the landlord or site owner will have any contractual responsibility for the consequences of a storm, even if evidence indicates that aspects of the infrastructure were inadequate. Equipment will generally be insured by the operator and there will be no possibility of recourse.

Security

Security of your terminal is part of your obligation under ISPS; meteorological conditions are no excuse for failing to maintain proper control of your premises. Understandably, security personnel will not wish to venture outside in dangerous conditions: you should make arrangements for them to be accommodated safely in a storm-proof location from where they can monitor the terminal and its perimeter (perhaps by CCTV or similar remote devices). If you rely on an outside company to provide security, your contract should also include an agreement on the arrangements for maintaining security during violent storms.

Your ISPS regulatory authority will probably want to know what measures you have in place to ensure continuous security, and what contingency plans you have in the event of any breach in physical barriers (for instance, if a perimeter fence or wall is blown down); conversely it may also be able to help you by supporting your requests to the authorities for help in ensuring security during a storm.

You should involve local law-enforcement and fire-fighting agencies in the formulation of your emergency plans. As part of this you may wish to explore with the law-enforcement agency what assistance or support it would be able to give to help protect your facility during and after a storm. You may also need to protect your premises against looting after the storm.

Make sure that your fire alarm system is storm-proofed and ensure that you have adequate hand-operated fire extinguishers available.

Port of Rotterdam the automated stormvloedkering or locks in the nieuwe waterweg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970
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Storm forecast imminent

The main threats

The main threats from windstorms are:

- Risks to human life
- Damage to cranes and other equipment
- Damage to buildings
- Containers being blown over
- Storm surges and flood
- Damage to cargo by wind-borne debris, rain or flood
- Ship impact with berth and/ or quay cranes
- Loss of power
- Breaches of security (fences blown down)
- Removal of navigation aids and changes in navigational channel

Personnel

The highest priority must be accorded to the safety of human life, and plans should be created to ensure that all necessary work is completed before the period of greatest danger is expected to begin.

Quay crane drivers

The significant difference in wind speeds between the quay level and the cab height on a quay crane has already been noted. While conditions may seem safe to you on the ground, the workers in the cranes may take an entirely different view. Attention has to be paid to the needs of these personnel working in high or exposed positions and their ability to move about the crane and descend to the ground.

Container cranes are normally at their safest in high winds when the boom is upright (although this depends on the design – please refer to the manufacturer of your equipment for guidance). To raise the boom, the driver may have to leave the cab and make his/ her way to the control station (which may be some way above the cab height) and then lock the boom into position, before returning to the cab to assist in manoeuvring the crane to its nearest storm pin and tie-down point. The difficulties of doing this in a high wind will be readily appreciated. Some modern cranes allow the driver to manoeuvre the boom from the cab or from the ground: it may be worthwhile to consider including this facility when existing cranes are upgraded or new ones ordered. It is recommended to have automatic boom latching; if the boom requires manual locking in the raised position with a storm pin or latch then it is normally too dangerous to climb to the top of the 'A' frame to do this in high winds.

Getting out of the cab and down to the ground may be difficult because access lifts tend to be exposed and intolerant of wind buffeting. The only way down may therefore be either by a vertical ladder or a sloping stairway open to the elements. The access lifts on many modern quay cranes are fitted with a high wind shut down system. If the wind is allowed to increase beyond the safe operating wind speed of the lift, the access lift will not work and the crane driver will either have to use the stairway or wait until the lift is operational again. This should also be considered in the decision making process.

Many container cranes can now be driven from duplicate controls at their base. This may be a preferable option, once the boom has been secured in an upright position and the driver has safely left the crane.

Crane maintenance personnel

Personnel who find themselves in the open on a crane in high winds will find difficulty making their way about the crane. No new maintenance work on cranes should be started when high winds are threatening, and any work in progress should be halted as rapidly and as safely as possible.

Lashers

The emergency plan should include a wind threshold at which container-top-workers or lashers should cease work. This may well be different to the threshold for the cranes. However, some sites use the high wind pre-alarm siren of the crane for the threshold, which indicates that the wind is approaching the maximum operating wind speed of the crane. When the wind speed reaches the maximum operating wind speed (shut down condition) of the crane, all ship-working personnel, such as lashers, deckmen and supervisors should be brought ashore.

Pool or casual labour, contractors and other irregular workers

If your facility uses workers who are not your regular employees (for instance if they come from a labour pool) you should be aware that they may not be familiar with the details of your emergency plans. Provision must be made to ensure their safety, particularly if they are asked to perform unfamiliar tasks.

Closedown

The closedown should always be done in an orderly manner and, where possible, the process should be documented and issued to relevant staff.

The safe closedown of the facility may involve a number of people in different areas of the facility. Each will have a specific task to carry out and should have had both training and practice in doing that task. It is unwise to allow persons that have not had training and practice to assist in these tasks on a casual basis.

A list of all employees known to be at work should be available and supervisors must be required to ensure that everyone is accounted for.

The emergency controller and other members of the emergency team should each have a full and up-to-date list of contact phone numbers (both mobile and fixed) for key personnel.

Access for key personnel

You may also need to discuss with your emergency planning authority arrangements for your key personnel to get to your facility when everyone else is moving away from the coast. For instance, the administration or police may issue special passes or badges to be displayed on vehicles. The emergency plan should document the procedure to be followed and the people to contact to obtain such passes.

Quay cranes

When not in use, quay cranes should always be secured. The main problems arise from the high 'sail area' of their superstructure and boom. Although bulk crane loaders and unloaders generally have a lower profile than the larger modern container cranes, these too must be secured.

Cargo operations

High wind conditions will affect the stability of a crane in various ways and these dangers should be borne in mind at all times. Maximum wind speeds for normal operations vary between 18 and 22 m/s. Containers, particularly empties or lightly-loaded ones, are likely to sway uncontrollably in high winds.

If wind is coming on-shore roughly at right angles to the quayside, operations will take place in the relative shelter of the vessel and stability may therefore be less of an issue: container sway control is often acceptable. It should also be noted that in these circumstances, wind-speed monitoring equipment on the crane will give high readings because of wind acceleration over the obstruction caused by the vessel.

When working in borderline conditions with no indications of imminent increase in wind speed, the decision on appropriate action is not easy. The emergency plan should determine the levels of authority for such decisions. If the decision rests with the incident controller, he or she should take note of the experience and guidance of the berth supervisor and crane driver. Once it becomes clear that safe working wind speeds will be exceeded, shutdown procedures must be initiated.

Remember that the drivers may find themselves in a very difficult position in high winds. Firstly they will need to position the load off the crane, then move the boom to the stow position and lock into position. Many boom control stations are separate from the normal driver's cab and mean that the driver must clamber even higher to see the boom latching mechanism. He may then have to return to the cab to drive the crane to its lockdown position and secure it. Escape from the cab may become progressively more difficult and dangerous as the wind increases:

the emergency plan should take full account of the time needed to reach the emergency position and still permit the safe evacuation of the cab. If the driver has to remove sensitive electronic items from the cab and bring them down with him, you must ensure that this can be done safely and without hampering the driver's descent.

Danger time: the crane gets carried away

The most difficult and dangerous time is as the storm is building. A driver, preoccupied with completing the loading or discharge of the ship, may not notice the way the wind is increasing, particularly if the crane is working downwind.

If the driver then tries to move the crane he/ she will find it difficult, if not impossible to manoeuvre against the wind. If the driver is moving downwind and then tries to stop he/ she may find the crane continues to move, as it is being carried by the wind, rather than being restrained by the motors and brakes. When a driver is faced with a crane being blown along the quay, the natural tendency in many cases has been for him/ her to try to move the crane back into the wind. However, by doing this the crane service brakes are lifted and become ineffective. The driver must immediately hit the emergency stop, which applies the service brakes as well as the storm or parking brakes. With some crane controls the emergency stop may be activated automatically when the wind is above a certain speed. This further complicates the business of moving the crane to a safe anchoring point. The crane controls should be checked before the storm and if this automatic stop above a certain wind speed is installed it should be disabled.

The difficulty in stopping the crane is made worse if rain has already started to fall. Water is an extremely efficient lubricant between the steel wheels and the steel rail, so even with the emergency stop applying the park brakes, the crane may continue to slide.

This possibility must be taken into account when making a decision on closing down operations. Clear instructions must be given to drivers and those controlling operations – and written into the emergency plan – to ensure that equipment is taken out of service before such a dangerous wind condition arises.

Securing quay cranes

In any windstorm safety of large quay cranes must be accorded high priority. All cranes have applicable safety guidelines for operation in high wind conditions. The relative wind speeds at which each stage is carried out will vary according to these recommendations, the terminal location and the assessment of safety officers or site engineers. It is crucial that the manufacturer's recommendations and guidance be made available to the operating and maintenance staff. These criteria should be recorded in the emergency plan.

Most quay cranes are designed to be at their most stable with the boom raised. However, some quay cranes are designed to be stowed around 45 degrees. The important point is that the boom should be stowed at the designed position. Boom latches should be secured if the boom is stowed for wind in the fully raised position, so the boom does not bounce between a buffer and the rope support. The spreader or grab should be lifted to its highest possible position before the boom is raised: this stops it being blown around and causing damage. If the crane can be driven from a control panel at ground level, this should be activated once the boom has been locked upright and the regular driver has safely made his way to the ground.

Rail mounted cranes have a high sail area coupled with a substantial weight and are working on rails which, when wet, become very slippery. If a crane is not secured, it can quite easily be blown along the track by high winds, until it collides either with the buffer stops or – significantly more expensive – its neighbouring crane. Even if wheels are braked, the wind force can be sufficient to push the crane along, sliding or skidding on the tracks. Most rail mounted quay cranes should therefore be secured by storm pins and tie-downs at pre-determined anchoring positions. They should, whenever possible, be parked away from ships so that, if they do collapse, they are unlikely to create more damage.

In a port on the coast of east Africa, two rail-mounted container cranes were positioned at either end of the quayside track, but were not locked down. A storm arose which blew one of the cranes the entire length of the track, to collide with the other, putting both out of action. These were the only two large cranes in the port and their loss severely hampered operations for several months, while repairs took place.

A problem associated with moving a crane in windstorms is that the action of energising the long travel motors automatically releases the parking and service brakes: this means that the only braking available is regenerative from the motor. If insufficient horsepower is available to drive the crane into the wind, it will start to roll backwards. If this occurs and the tie-down position upwind cannot be reached it may be possible to move the crane to an alternative anchor point downwind. If moving the crane downwind care must be taken to ensure the crane does not "run away". The crane should be travelled slowly and "inched" by starting and stopping the travel so that the service brakes are applied before too much speed is reached. If the speed starts to increase too much the park brakes should also be applied by hitting the emergency stop. It may be prudent to allow maintenance staff to assist the driver when 'locking down' so that safe positioning of the crane can be achieved quickly.

Once at their anchor points, the cranes should be secured by storm pins correctly and fully inserted into the appropriate sockets, by applying the park brakes, by wooden chocks (scotches) under the wheels and by tie-downs.

Remember, securing a quay crane takes time. Refrain from the pressure to continue operations to the last possible moment. The safety of personnel and then equipment is more important than a few extra boxes on or off a ship. As part of the Emergency Plan, practice securing the quay crane, identify the time needed and ensure that in the event of an imminent windstorm sufficient time is made available to secure the crane fully.

These are not alternative methods of securing cranes: they are cumulative.

In high wind conditions reliance should not be placed on the storm pins or the park braking system alone to hold cranes in position. When positioning a crane for expected high winds, all applicable systems should be used: the crane should have the storm pins dropped, the park brakes (rail clamps, railhead brakes or wheel brakes) applied and the tie-downs connected. It is also important to ensure that all the service brakes which include the motor/ gearbox brakes and/ or wheel brakes are all operating correctly and applied.

All cranes should be properly secured before the facility is closed and sufficient personnel should be retained on site to ensure that this work can be completed.

Obviously when a windstorm is forecast the quay cranes should be fully secured. However many terminals consider it operationally impractical to tie-down and storm pin quay cranes when not in use unless a windstorm is forecast. Those terminals that have experienced windstorm incidents now realise the need always to secure fully the quay cranes when not in use. As stated on p. 55, additional ballast may assist in mitigating the risk from microbursts or from improper or damaged tie-down installation.

A practical quay crane securing procedure adopted by many terminals is as follows:

- If the quay crane is unmanned for short periods during shift changes or lunch breaks then it is not practical that the quay crane be fully secured. The parking and service brakes should all be on and working.
- If the quay crane is not planned to operate for eight hours or more, or there is, or will be limited personnel on the terminal to help secure all the quay cranes if a windstorm develops, the quay crane should be fully secured with park brakes, tie-downs and storm pins.

A terminal operator in Northern Europe was stopping operations because wind speeds were increasing. One crane had already been locked down, using its on-board systems, and workers were engaged in locking down a second one. A sudden very strong gust of wind blew the cranes into each other, with the first one suffering serious structural damage. Loading operations had to be suspended for seven days while the second crane underwent temporary repairs. A mobile crane was brought in from another part of the facility to replace the first crane, but handling rates were reduced by 40%, so some ships had to be diverted to other facilities.


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Other terminal equipment

Introduction

The comments above concerning quay cranes apply generally for cranes of most types in terms of brakes, clamps, storm pins and tie-downs. Smaller cranes may not require such onerous windstorm preparations, but nevertheless procedures need to be adequate.

Mobile harbour cranes should always be moved to a location away from the berth where it is possible to lower the jib (and also, if possible, the mast) to the ground (according to manufacturer's guidance). If space permits, off quay parking of mobile harbour cranes is recommended at all times when not in operation. Generally this will locate it in a less windy location and away from other dangers.

An incident occurred in Europe where a quay crane was blown along the quay and hit and wrote-off a brand new mobile harbour crane which was parked at the end of the quay.

Rubber tyred gantries

Rubber tyred gantries (RTGs), being smaller than quay cranes and generally operating in the inner terminal, may not be the first to stop operations. Despite the fact that they are not as tall as cranes, they still operate with container configurations of 1 over 5 (or higher with some designs). They are normally wide enough to pass over containers stacked five or more wide. Because of this width to height stability, they are less likely to be affected by low speed gusts but will be affected by high speed gusts and also continuous high winds.

RTGs should be positioned, where possible, in a sheltered area and secured in accordance with manufacturers' recommendations. A sensible policy for parking rubber tyred gantries is to turn the wheels, on two opposing corners, to 90° to the normal direction of travel. This limits the freedom of the wheels to roll. This should be done whether the gantry is tied down or not. Block parking the RTGs within in a stack row will also help.

Rail mounted gantries

These units are designed to spend a major part of their operating lives in long travel and drives are accordingly more powerful, in relation to mass, than those fitted to quay cranes. RMGs also have less sail area to catch the wind, and operate within the relative shelter of the container stacks. Nonetheless, long travel is as much an issue with this equipment as it is with quay cranes. Skidding or sliding along the tracks is a common feature necessitating the provision of 'lockdown' points (storm pins). With manned RMGs there is the added danger of containers becoming dislodged from the stacks. Driver escape is an issue that must be addressed with non-automated cranes.

If you have only a single rail mounted gantry on a track, it is a sensible precaution to park it up against the buffer stops at one end of the track and then to use storm pins to hold it there. Where there are two units on a track, park them in this way at either end of the track. Alternatively you can consider parking both units hard against each other and securing them with storm pins.

In one terminal, a rail-mounted gantry was blown along the track where it collided with two other gantries. The repair costs for the three gantries amounted to US$750,000.

Straddle carriers

With ample power and braking available to most straddle carriers, this equipment is unlikely to be the first to stop in stormy conditions. However, container stability within the storage areas will be a problem and suitable safe parking should be provided where neither machine nor driver will come to harm.

Straddle carriers can be parked together as a block, so that they can afford each other some mutual support during a storm. If possible, two wheels, on opposing corners, should be turned 90° to the normal direction of travel (as for rubber tyred gantries).

Alternatively or additionally, straddle carriers should be tied down by cables or chains from the shoulders to anchor points set in the ground.

Reach stackers and lift trucks

Windstorm guidance for this equipment will be much the same as for straddle carriers with the added element of caution regarding stability with an elevated load. Manufacturers' recommendations should be followed.

Internal movement vehicles (chassis etc)

In the normal course of events, these vehicles should be the last to be affected by storm conditions. Remember that load stability when cornering – often a problem in normal conditions – can be made worse by strong winds. Danger from falling containers may also be a consideration and suitable safe parking facilities should be provided.

Once the cranes have stopped working, there may be very little work for these vehicles to do, so drivers can possibly be released for other tasks.

When the decision is taken to cease container operations, there will be trucks driving or waiting to be served by cranes. The emergency plan needs to ensure that an effective message system is in place. An example is notifying the internal truck drivers to evacuate storage areas by sending a message to the Radio Data Telemetry (RDT) displays which are normally fitted in the cabins of the internal trucks or chassis. The message could be sent by personnel in the Control Tower once the decision to cease operations in the container storage areas is taken.

Smaller equipment

Where possible, smaller equipment such as fork-lift trucks, container stackers, mobile conveyor belts etc. should be placed inside a warehouse or other structure. Battery-powered equipment should be left on charge so that it is available for immediate use when operations re-start, even if there have been power cuts in the meantime.

Debris

Loose materials on the roof or on the ground can quickly become flying missiles capable of penetrating buildings or containers or striking people. All such items, including things such as used pallets, discarded lashing material and so on should be collected up and secured in a building or an empty container.

Rubbish bins should be emptied and, if possible, put inside buildings.

Road vehicles

These are almost invariably driven by non-employees of the operator. It is vital that road vehicles be kept out of the container terminal during windstorm conditions. Any that may already be on the terminal should be conducted promptly to a place of safety or evacuated. Loaded vehicles should be parked as close as possible together to minimise the risk of containers becoming dislodged. The safest place for the driver is likely to be in an appropriate terminal building. As for your own personnel, humanitarian provision will have to be made for such drivers in the event of a protracted storm.

Other assets at the terminal

Containers

Containers, particularly empty ones, are easily blown over in high winds. Their high 'sail area' and relatively low weight makes them easy prey for high winds. An empty container weighing 2 – 3 tonnes being blown around a terminal can create an enormous amount of damage.

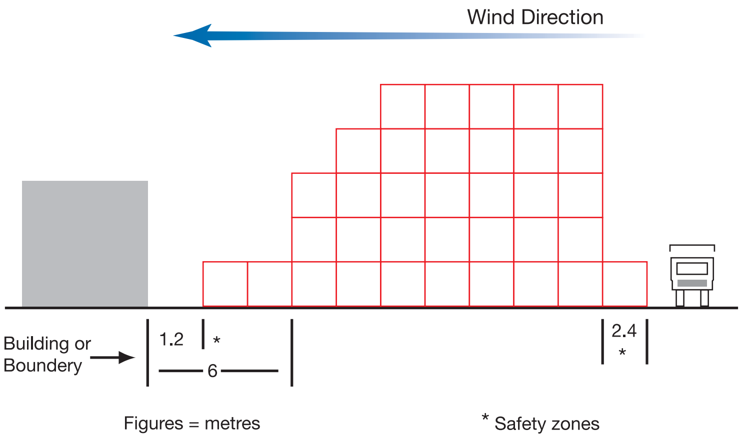
As part of general good housekeeping, port side terminals and even inland facilities should have a properly thought-out policy for container stacking. High stacks, particularly of empty containers, are vulnerable to high winds. In general it is therefore better to stack containers routinely lower and wider, to avoid the need for emergency re-stacking as a storm approaches.

Container stacks should, wherever possible, be aligned so that the units' longitudinal axes are in line with the predominant wind direction.

Additional measures that may be considered include:

- Stacks should be interlinked with locking cones, straps, webbing or other temporary lashing material to create a heavier and more stable mass.
- Stacking loaded containers on top of empties also helps (it also keeps the cargo from being damaged if the terminal is affected by flooding!)

If empty containers have to be stacked more than four units high, then "pyramiding" should be given serious consideration. The inner rows of containers are stacked higher than the outer rows on a stepped basis. The end shape would then look something like the diagram below, in which the arrow shows the wind direction. The containers are stacked in a way that reduces the risk of being dislodged and also to provide a protective barrier for the adjacent building (indicated as the 'safety zone' in the diagram on p. 82).



If there is a serious risk of flooding, and there is sufficient time, it may be possible to put loaded containers on the top of empties. This keeps the empties from being blown about, and keeps the cargo out of the floodwater.

Cargo

While loaded containers are less likely to be blown over than empty ones, they can suffer damage from units being blown along in the wind or from other wind-borne debris.

If there is sufficient warning of a storm, it may be appropriate to try to persuade importers to take their cargo away quickly, and to get exporters or truckers to delay deliveries to the terminal.

Open top containers, flatracks and out-of-gauge items

The sheets or tarpaulins and all the lashings should be checked before the storm arrives, and tightened where necessary. It may be useful to position other standard (dry van) containers around such units, or to move them close to buildings to protect the loads from damage.

Tank containers

These units may be punctured by flying debris and should be similarly protected. The emergency team should have details of all such containers with hazardous cargoes, as well as access to the current edition of the IMDG code, details of the shipper's emergency response line and contact numbers for other specialists.

Temperature-controlled containers

Reefer units and their cargo may be affected if there is a prolonged power failure: measures should be taken to ensure continuity of power supply, for instance through purchasing emergency generators.

Rail wagons

Railway wagons (railroad freight cars) have a very low centre of gravity but the low friction coefficient between steel wheels and steel rails, combined with the sail effect of containers loaded on them means that, like cranes, they can be blown along tracks. A derailed train can cause more disruption in a terminal than most other pieces of equipment. If rail access is blocked, cargo on other trains will have to be removed and brought in by road or delayed beyond a reasonable time.

Wagons should be secured by applying brakes and wheel chocks (scotches). Points (switches) should be set so that any runaway units cannot get on to other sidings or the railway's main operational lines. You should try to protect any level (grade) crossings within your facility to ensure that they cannot become blocked by runaway wagons.

You may wish to suggest to the railway company that it delays delivering trains to your facility (and collects trains early) when a storm is forecast.

Ships

You should maintain close contact with the representatives of the shipping lines that regularly use your terminal to find out what their plans are. Many masters prefer to ride out storms at sea, rather than come close inshore or remain in port. Ships on berths may therefore want to accelerate their departure in advance of the worsening conditions, while those expected may delay their arrival until the storm has passed. Some re-scheduling of berth allocations may be necessary, for periods both before and after the storm.

You may also need to talk to masters about the safety of seafarers on shore leave. Ideally they should either return to the ship and stay there, or stay somewhere safe ashore. If you are going to lock the gates of the facility for the duration of the storm, they will not be able to get back to the ship.

If a ship remains in port at the berth, winds and swell can cause the ship to impact with the berth and/ or quay cranes. The ship and/ or those responsible for mooring lines should ensure they are all in place and if required additional lines installed. Adequate spare mooring ropes should be available in case of rope breakages. Depending on tie-down locations of the quay cranes, where possible the ship should be berthed as far away as possible from any quay cranes or other structures.

At a terminal in Europe, a ship at the berth broke from its mooring lines and moved along the quay. This ship was carrying quay cranes with the booms protruding sideways from the ship and over the berth and they impacted two existing quay cranes installed on the terminal and caused their total collapse. The cost of this incident was in excess of US$20 million.

Recovery

If disaster strikes

If, in spite of all your precautions, your facility has been damaged by the storm you will clearly need to get assistance fast, although your priority may well be to ensure that all staff are safe. Clearly, you need to make an assessment of the damage that has been incurred and ensure that protection systems (eg. security or fire) are operational or that appropriate measures can be taken to protect your facility.

Additional resources may be required to achieve this mitigation both during and after the windstorm event – resources to clear a backlog, temporary structures, equipment, etc. – and should be considered in assessing the incident's cost. In your assessment, it is worth noting that the damage of a storm is not only the physical impact, but also operational disruption. Such disruption can affect a terminal during precautionary downtime, during the windstorm event itself, and during post-event recovery.

See the Recovery Checklist in Annexe 5 (p. 115) or your emergency plan for actions that may be appropriate following a storm.

Mitigation

You must take whatever steps you can to mitigate (reduce) your potential losses. For instance, if machinery has been affected by water, you should do whatever is necessary to dry out the electrical systems and protect all parts against the development of rust or corrosion, as well as securing your property against further weather damage (eg. sheeting where roofing has been damaged).

Wet cargo should be separated from that which is still dry (subject to customs agreement, if necessary). Any spillages of liquid must either be soaked up with sawdust or similar absorbent material or contained by plastic booms to stop it running into watercourses or the sea. Any hazardous material spillages should be contained (with personnel appropriately protected) but strictly subject to guidance from experts or the emergency services.

Insurance

If you are insured, you will need to make contact with your broker or insurer to report the claim and seek assistance in assessing the extent of damage. While waiting for a surveyor or loss adjuster to arrive, start making an inventory of the damage. If you have to move debris or damaged items, take pictures of them before you do so, so that there is a record.

It is probably best to use telephone, rather than fax or email, to contact your broker or insurer in the first instance so that you are sure that your message has been received. Their power system may also have been disrupted! Make sure that you provide a phone number where you can be contacted.

In some circumstances, the windstorm may have been sufficiently predicted to allow you to agree in advance to the appointment of a loss adjuster, who may then be able to reach your site more quickly.

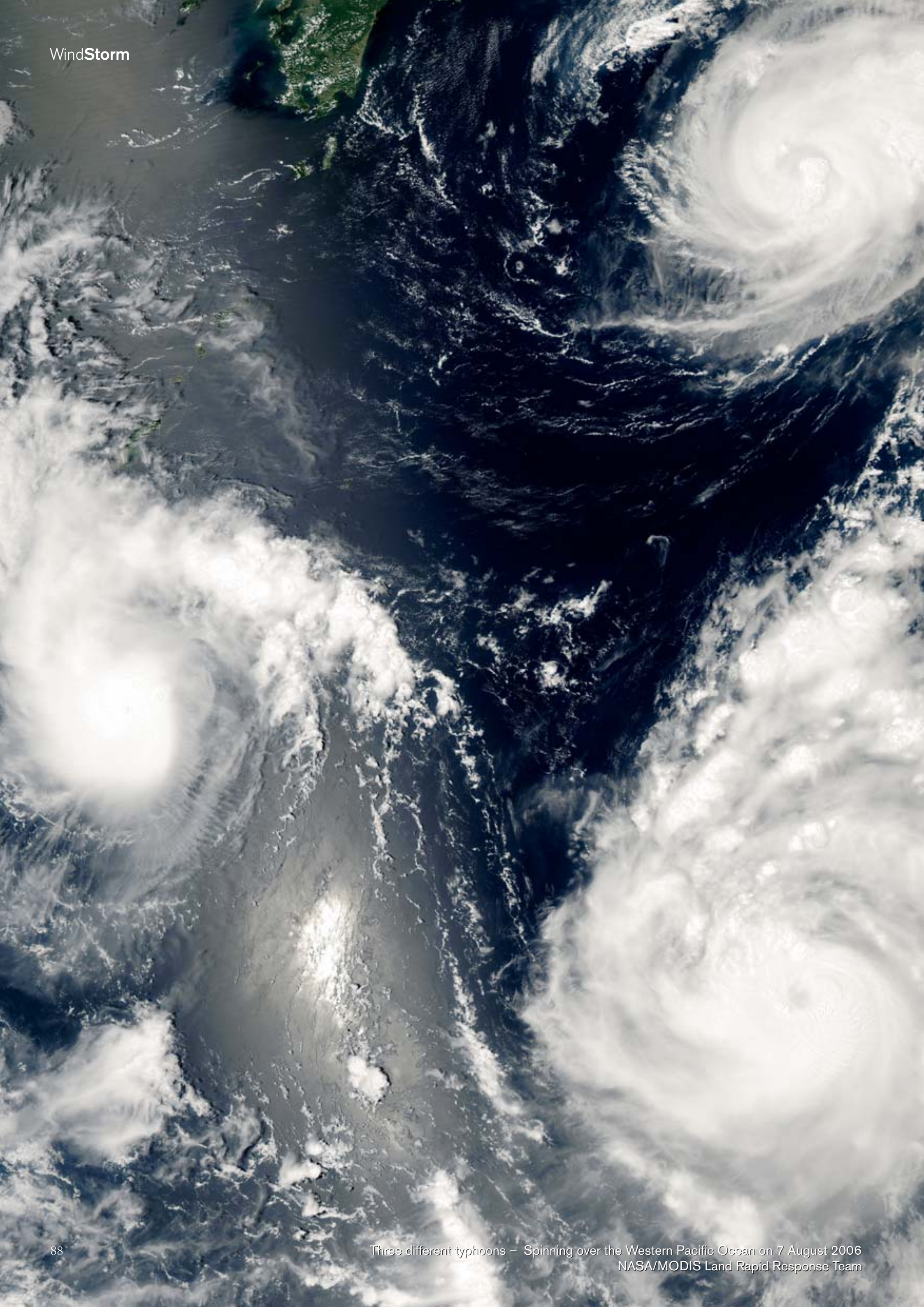
If you are a member of the TT Club, call your local Club contact as soon as possible. If the office has been forced to close because of the same storm, phone calls will usually be automatically transferred to another office from where assistance can be provided. In some locations you may receive a recorded message giving you alternative phone numbers to call.

Post-event analysis

In responding appropriately to windstorm events, it is likely that lessons have been learned from past events ie. how they were forecast and handled. It may be valuable to suggest an explicit action of identifying and learning lessons following a windstorm event. Even if the event did not cause losses, there may still be value in identifying what went well in the planning and handling of the event, and what could be improved in the future. A facility may have just been fortunate in not suffering losses, or on the other hand it may have been prepared for any eventuality. Some questions to consider around weather aspects may be:

- How far ahead was the windstorm identified as likely to hit the facility?
- Did this allow enough time for implementing the emergency plan?

- Would more time for preparation have prevented losses?
- Was forecasting the event further ahead feasible?
- Was best use made of the available weather information?
- Did local weather measurements corroborate the forecasts? If not were local weather effects at work, or were forecasts poor quality?
- Was a lack of overall weather knowledge, or knowledge of localised weather effects, a factor in degrading the emergency response?
- Would additional sources of weather information be beneficial, eg. preventing future losses?
- Does the windstorm event add to a body of evidence of changing storminess?



Three different typhoons – Spinning over the Western Pacific Ocean on 7 August 2006
NASA/MODIS Land Rapid Response Team

Annexe 1 – Windstorm Classifications, Wind Scales & Damage Indications

Tropical Cyclone Classifications and Damage

Sustained Wind speed (m/s)	**N Indian Ocean** IMD (3)	**SW Indian Ocean** MF (1)	**Australia** BOM (1)	**SW Pacific** FMS (1)	**NW Pacific** JMA (1)	**NW Pacific** JTWC (2)	**NE Pacific & N Atlantic** NHC & CPHC (2)	**Likely Damage**
<13.9	*Depression*	*Tropical Disturbance*	*Tropical Low*	*Tropical Depression*	*Tropical Depression*	*Tropical Depression*	*Tropical Depression*	*Negligible house damage. Damage to some crops, trees and caravans. Craft may drag moorings*
13.9 – 14.9	*Deep Depression*	*Depression*						
15.0 – 17.1						*Tropical Storm*	*Tropical Storm*	
17.2 – 24.4	*Cyclonic Storm*	*Moderate Tropical Storm*	*Tropical Cyclone (1)*	*Tropical Cyclone (1)*	*Tropical Storm*			
24.5 – 28.4	*Severe Cyclonic Storm*	*Severe Tropical Storm*	*Tropical Cyclone (2)*	*Tropical Cyclone (2)*	*Severe Tropical Storm*			*Minor house damage. Significant damage to signs, trees and caravans. Heavy damage to some crops. Risk of power failure. Small craft may break moorings.*
28.5 – 32.6						*Typhoon*	*Hurricane (1)*	
32.7 – 37.1	*Very Severe Cyclonic Storm*	*Tropical Cyclone*	*Severe Tropical Cyclone (3)*	*Severe Tropical Cyclone (3)*	*Typhoon*			*Some roof and structural damage. Some caravans destroyed. Power failure likely.*
37.2 – 43.7							*Hurricane (2)*	
43.8 – 45.8			*Severe Tropical Cyclone (4)*	*Severe Tropical Cyclone (4)*			*Major Hurricane (3)*	*Significant roofing loss and structural damage. Many caravans destroyed and blown away. Dangerous airborne debris. Widespread power failure.*
45.9 – 51.0		*Intense Tropical Cyclone*						
51.1 – 54.6							*Major Hurricane (4)*	
54.7 – 58.7			*Severe Tropical Cyclone (5)*	*Severe Tropical Cyclone (5)*				*Extremely dangerous with widespread destruction.*
58.8 – 61.2		*Very Intense Tropical Cyclone*				*Super Typhoon*		
>61.2	*Super Cyclonic Storm*						*Major Hurricane (5)*	

(1) Sustained wind speed based on 10-minute average. (2) Sustained wind speed based on 1-minute average. (3) Sustained wind speed based on 3-minute average.

The Beaufort Scale and Damage

The following table shows wind speeds for 10-minute average winds only. Differing 'Descriptions' are used around the world; those used here indicate the relative dangers of the different wind speed levels.

No.	Description	Wind speed				Typical conditions	
		m/s	Kph	Mph	Knots	At sea	On land
0	*Calm*	*0 – 0.2*	*0 – 1*	*0 – 1*	*0 – 1*	*Mirror-like*	*Smoke rises vertically*
1	*Light Air*	*0.3 – 1.5*	*1 – 5*	*1 – 3*	*1 – 3*	*Ripples, no crests*	*Smoke drifts*
2	*Light Breeze*	*1.6 – 3.3*	*6 – 11*	*4 – 7*	*4 – 6*	*Small wavelets, crests do not break*	*Feel wind on face, flags flap, wind vanes move*
3	*Gentle Breeze*	*3.4 – 5.4*	*12 – 19*	*8 – 12*	*7 – 10*	*Large wavelets, crests start to break*	*Flags fly fully extended, light rubbish moves*
4	*Moderate Breeze*	*5.5 – 7.9*	*20 – 28*	*13 – 18*	*11 – 15*	*Small waves, some white horses*	*Dust is raised, branches sway*
5	*Fresh Breeze*	*8.0 – 10.7*	*29 – 38*	*19 – 24*	*16 – 21*	*Larger and longer waves, many white horses*	*Small trees sway, waves on ponds*
6	*Strong Breeze*	*10.8 – 13.8*	*39 – 49*	*25 – 31*	*22 – 27*	*Large waves forming white foam crests*	*Umbrella hard to hold, phone cables whistle*
7	*Near Gale*	*13.9 – 17.1*	*50 – 61*	*32 – 38*	*28 – 33*	*Sea heaps up, waves break, foam streaks*	*Hard to walk against wind, big trees sway*
8	*Gale*	*17.2 – 20.7*	*62 – 74*	*39 – 46*	*34 – 40*	*Higher, longer waves, crests break into spindrift*	*Walking against wind is a battle, twigs break off trees*
9	*Strong Gale*	*20.8 – 24.4*	*75 – 88*	*47 – 54*	*41 – 47*	*High waves, crests roll over, spray*	*Light objects fly, car steering pulls*
10	*Storm*	*24.5 – 28.4*	*89 – 102*	*55 – 63*	*48 – 55*	*Very high waves, sea surfaces white*	*Tree branches break, empty drums tumble*
11	*Violent Storm*	*28.5 – 32.6*	*103 – 117*	*64 – 72*	*56 – 63*	*Giant waves, crests froth, visibility bad*	*Loose iron sheets fly, canvas tears*
12	*Hurricane*	*Over 32.7*	*Over 118*	*Over 73*	*Over 64*	*Turbulent white seas, visibility nil*	*Wooden huts collapse, timber balks fly*

The Saffir-Simpson Hurricane Wind Scale

This is an extension to the Beaufort scale to accommodate wind velocities for 1-minute average winds only.

Category	Description	Wind speed m/s	Kph	Mph	Knots	Likely Damage
1	Damaging Winds	32.7 – 42.6	118 – 153	73 – 95	64 – 82	No real damage to building structures; damage mainly to unanchored mobile homes, shrubbery, trees; some coastal flooding, minor pier damage
2	Widespread Damage	42.7 – 49.5	154 – 177	96 – 110	83 – 96	Some roofing material, door, window damage; considerable damage to vegetation, mobile homes, etc.; flooding damages piers, small craft in unprotected moorings may break their moorings
3	Extensive Damage	49.6 – 58.5	178 – 209	111 – 130	97 – 113	Some structural damage to small residences, utility buildings, with a minor amount of curtainwall failures; mobile homes destroyed; flooding near coast destroys smaller structures, large structures damaged by floating debris; terrain may be flooded well inland
4	Devastating Damage	58.6 – 69.4	210 – 249	131 – 155	114 – 134	More extensive curtainwall failures, some complete roof structure failure on small residences; major erosion of beach areas; terrain may be flooded well inland
5	Catastrophic Damage	Over 69.5	Over 250	Over 156	Over 135	Complete roof failure on many residences, industrial buildings; some complete building failures with small utility buildings blown over or away; flooding causes major damage to lower floors of all structures near shoreline; massive evacuation of residential areas may be required

Australian Bureau of Meteorology - Tropical cyclone severity categories

The severity of a tropical cyclone is described in terms of categories ranging from 1 to 5 related to the zone of maximum winds. As such, any warning is not designed as an exact statement of conditions at any given location, rather a general idea of the expected worst conditions. Actual damage will vary depending on multiple factors, including distance from the zone of maximum winds, how exposed the location is and local topography.

Category	**Strongest Gust** m/s	**Typical effects**
1. Tropical Cyclone	*Less than 34.7 m/s* *Gales*	*Minimal house damage. Damage to some crops, trees and caravans. Boats may drag moorings.*
2. Tropical Cyclone	*34.7 – 45.5 m/s* *Destructive winds*	*Minor house damage. Significant damage to signs, trees and caravans. Heavy damage to some crops. Risk of power failure. Small boats may break moorings.*
3. Severe Tropical Cyclone	*45.8 – 62.2 m/s* *Very destructive winds*	*Some roof and structural damage. Some caravans destroyed. Power failure likely.*
4. Severe Tropical Cyclone	*62.5 – 77.5 m/s* *Very destructive winds*	*Significant roofing and structural damage. Many caravans destroyed and blown away. Dangerous airborne debris. Widespread power failures.*
5. Severe Tropical Cyclone	*More than 77.8 m/s* *Extremely destructive winds*	*Extremely dangerous with widespread destruction*

Fujita Tornado Scale and Damage

Category	Description	Wind speed m/s	Kph	Mph	Knots	Typical conditions
F0	Gale Tornado	17.7 – 32.2	64 – 116	40 – 72	34 – 62	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	Moderate Tornado	32.5 – 50	117 – 180	73 – 112	63 – 97	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant Tornado	51 – 70	181 – 252	113 – 157	98 – 136	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	Severe Tornado	71 – 92.2	253 – 332	158 – 206	137 – 178	Roof and some walls torn off well constructed houses; trains overturned; most trees in forests uprooted.
F4	Devastating Tornado	92.5 – 116.1	333 – 418	207 – 260	179 – 225	Well-constructed houses levelled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible Tornado	116.4 – 142.2	419 – 512	261 – 318	226 – 276	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged.
F6	Inconceivable Tornado	142.5 – 169.5	513 – 610	319 – 379	277 – 329	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies.

Wind Speed Conversions

The World Meteorological Organization (WMO) has set the recommended standards for meteorological measurements, but common practice differs around the world.

Depending on the standard adopted, it may be necessary to make conversions for both the meteorological height of the observation as well as the period of sustained wind. Indeed, some information is given on the basis of maximum wind gusts rather than average sustained velocity. While in any given location it is likely that the information given will be consistent and therefore understood, care needs to be taken when comparing information from different sources or across different basins.

Where it is necessary to make conversions, the following tables may assist.

Wind Speed Conversions by Unit

m/s	Kph	Mph	Knots
1	3.6	2.237	1.943
19.4	70	43.4	37.7
27.8	100	62.2	54
41.7	150	93.3	81
55.6	200	124.4	108
69.4	250	155.2	134.8

Wind Speed Conversions by Period

10 minute sustained	0.89
3 second gust	1.3

Wind Speed Conversions by Height

2 m height	0.7
3 m height	0.8
6 m height	0.9
15 m height	1.1
25 m height	1.2
40 m height	1.3

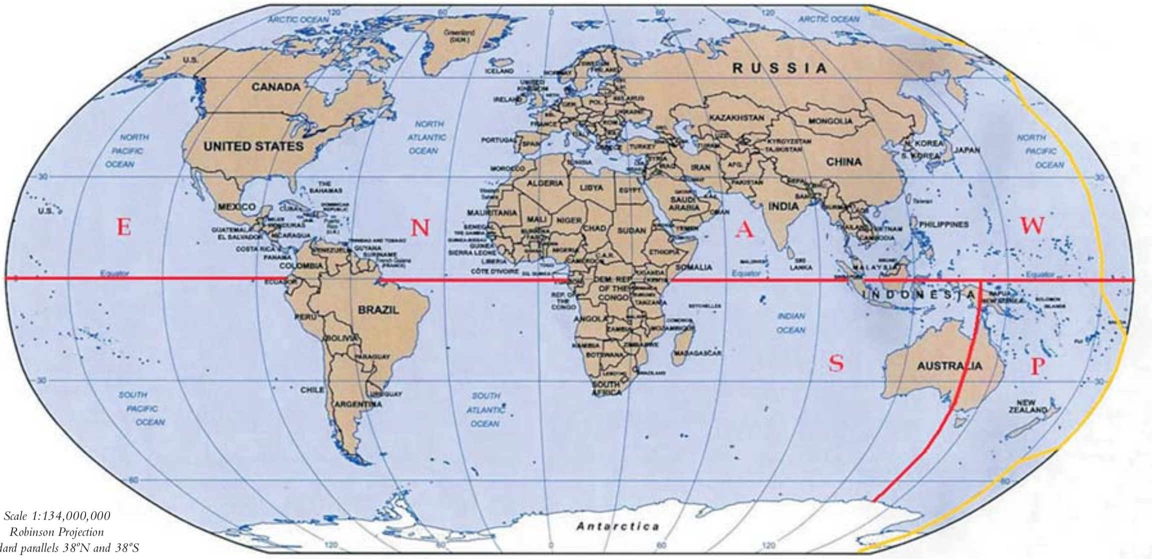
Annexe 2 – Windstorm 'Basins', Occurrence & Development

(a) Windstorm 'Basins' & Occurrence

The following table lists the months of the year during which each type of windstorm may be expected:

Windstorm Type	Months of Occurrence	Peak Month(s) of Occurrence
North Atlantic and NE Pacific Hurricanes	*May – November*	*September*
NW Pacific Typhoons	*All year round*	*August – September*
Southern Hemisphere Tropical Cyclones	*November – May*	*January – March*
North Indian Ocean Cyclones	*April – December*	*May, November*
European Windstorms	*October – March*	*January*
Tornadoes	*All year round*	*May (US), July (Europe)*

Tropical Cyclone Basins monitored by Tropical Storm Risk (TSR)



Scale 1:134,000,000
Robinson Projection
Standard parallels 38°N and 38°S

TSR Windstorm Basins

Letter	Description
N	*North Atlantic – America/Mexico East coast to Africa/Europe, equator northwards*
E	*North East Pacific – Dateline Eastwards to the US/Mexico West coast - equator northwards*
W	*North West Pacific – Dateline westwards to Asia/Sumatra - equator northwards*
A	*North Indian – North Indian Ocean & Bay of Bengal from African coast across to Malay Peninsula*
S	*South Indian – African coast up to 140E, equator southwards*
P	*South West Pacific – 140E Eastwards, equator southwards*

(b) Development of storms

(i) Tropical storms

A tropical cyclone is a warm-centred low pressure system which is non-frontal, occurs in tropical and sometimes subtropical waters, and has a closed low level wind circulation. During its life a tropical cyclone may grow from a tropical depression to a tropical storm and, if it strengthens enough, to a hurricane. It is wind speed alone which determines a tropical cyclone's category. Hurricane (or typhoon) status is achieved once the surface wind has reached a sustained level of 33 m/s (74 mph). About 80 tropical storms form globally each year, with about 50 of these reaching hurricane strength. The northern hemisphere sees twice as many tropical storms (and hurricanes) as the southern hemisphere.

There are six main preconditions for tropical cyclone formation. The relative importance of these factors varies with ocean basin (tropical cyclones occur in six ocean basins worldwide). These preconditions are:

- A pre-existing atmospheric circulation (such as an easterly wave).
- Ocean waters warmer than ~27°C to a depth of ~50m. This is necessary to provide sufficient heat energy to fuel the storm's growth.
- Sufficient cooling of the air through the height of the troposphere so that the air column is unstable to the formation of thunderstorms.
- Moist air through most of the troposphere height (without this thunderstorms would not form).
- A location at least 5-10° away from the Equator so that the Coriolis Force will cause air to circulate.
- Low vertical wind shear (ie. difference between upper level and low level winds should be <10 m/s). This allows a coherent vortex to be sustained vertically without being torn apart.

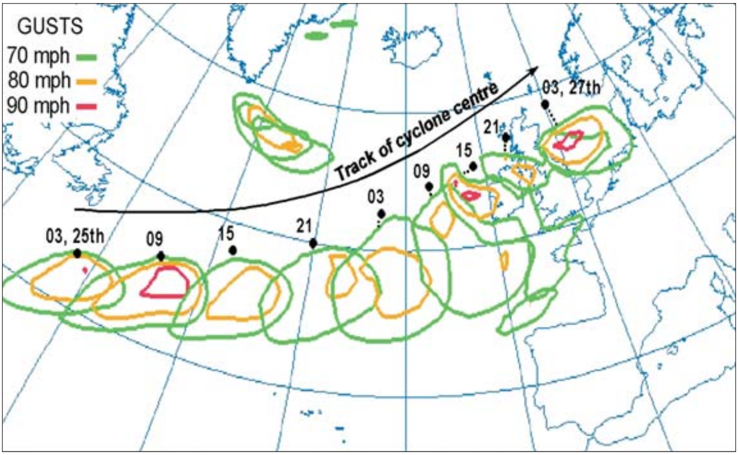
The life cycle of a typical North Atlantic hurricane begins with thunderstorms moving off the west coast of Africa merging into a group to form a large storm. This 'large storm' is blown westward by the prevailing trade winds. If the sea surface temperatures are warm enough, the troposphere moist enough, and vertical wind shear low enough, the 'large storm' may intensify to form a hurricane. Depending upon the location and strength of large-scale high and low pressure systems over North America and the North Atlantic, the tropical storm or hurricane will be ‘steered’ either towards US landfall or recurve to stay out at sea in the North Atlantic. Once the storm/hurricane makes landfall its source of energy and moisture is gone so the storm dissipates quickly. It takes 7-10 days for a developing tropical storm/hurricane to move from the west coast of Africa to US landfall.

(ii) European windstorms

Most European windstorms originate from North Atlantic extra-tropical low pressure systems. These systems develop and gain their energy from horizontal temperature contrasts between cold polar air masses and warm subtropical air masses. The horizontal temperature gradient gives rise to and is co-located with the polar jet stream. The deepening of extra-tropical cyclones occurs typically near a maximum in the upper level jet stream known as a jet streak where divergence occurs. The divergence causes upward motion and convergence in the near-surface wind field. If the upper level divergence exceeds the low level convergence the surface pressure will fall and the storm will strengthen. If upper level divergence is particularly favourable the storm can deepen explosively (also known as a bomb). Such a storm can have gust wind speeds reaching Beaufort Scale 12 (hurricane force) with central pressures of 950 mb or lower. Explosive deepenings are difficult to predict.

Some of the most damaging winds in European windstorms are believed to be associated with a phenomenon known as the sting jet. This is a zone of strong winds originating from within the mid-troposphere which descends to the surface. Gust wind speeds in excess of 90 mph can be associated with the sting jet.

The motion of a developing European windstorm is driven typically by upper level westerly winds. These move the storm in a general west to east (or zonal) motion across the North Atlantic. Occasionally this general flow pattern may buckle to a more north-south (or meridional) motion. Interactions with other low and high pressure systems may also influence a storm’s motion. The motion, size and gust wind speeds of a typical European windstorm are shown in the diagram below.



Track and Size of the 'Boxing Day' European windstorm of 26 December 1998
(Figure courtesy of Tim Hewson, Met Office).

(iii) Tornadoes

A tornado is an intense rotating column of air extending from the base of a thundercloud to the ground. When a tornado occurs over water it is called a waterspout. A tornado is nature's most violent wind with wind speeds ranging up to 300 mph. Fortunately only 2% of tornadoes have winds exceeding 200 mph. Tornadoes can last from several seconds to more than an hour. However, most last less than 10 minutes.

Although much has still to be understood about the formation of tornadoes, it is well known that they form below severe thunderstorms and that unstable air is essential for their development. Each year around 1,000 tornadoes are reported in the US (this is more than any other country in the world). Conditions favourable for tornado development occur most often in spring and early summer over the Great Plains (central Texas to Nebraska), a region known as 'tornado alley'. The conditions which cause tornadoes here are triggered by warm moist air moving northwards at low levels from the Gulf of Mexico meeting cold dry air moving eastwards at high levels from the Rocky Mountains. This air combination is unstable to the formation of thunderstorms. The presence of vertical wind shear would help to give any updraft a twisting motion, turning a normal thunderstorm into a potential tornado-spawning supercell.

Around 50 tornadoes occur in the UK each year. This is the highest frequency of any European country. Most UK tornadoes are fairly weak, although high F1 to low F2 tornadoes occurred in King's Heath, Birmingham (2005) and Kensal Rise, London (2006). The UK's maritime position where advancing cold fronts overrun warm air masses create good conditions for tornado formation.

Annexe 3 – Information sources

(a) Weather and climate generally

World Meteorological Organisation
http://www.wmo.int/pages/index_en.html

Australian Bureau of Meteorology
http://www.bom.gov.au/

UK Meteorological Office
Includes current forecasts for UK and Europe, maritime weather forecasts for surrounding sea areas, and world weather forecasts
http://www.metoffice.gov.uk/

US National Oceanic and Atmospheric Administration
US and international weather forecasts
http://weather.gov/

All India Weather Forecast
http://www.imd.gov.in/section/nhac/wch/todaywch.htm

(b) Cyclone, hurricane, typhoon and tornado predictions

Tropical Storm Risk
University College, London
Tropical Storm Risk (TSR) offers a leading resource for forecasting the risk from tropical storms worldwide
http://www.tropicalstormrisk.com

US National Oceanic and Atmospheric Administration
Climate prediction center:

Atlantic hurricane outlook
http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml

East Pacific hurricane outlook
http://www.cpc.ncep.noaa.gov/products/Epac_hurr/Epac_hurricane.html

Central Pacific hurricane outlook
http://www.weather.gov/pa/fstories/2005/0505/fs16may2005b.php

Hong Kong Observatory
Typhoon tracking and warning
http://www.hko.gov.hk/wxinfo/currwx/tc_pos.htm

Philippines Atmospheric, Geophysical and Astronomical Services Administration
Weather warnings for the Philippines and surrounding sea areas
http://www.pagasa.dost.gov.ph/

(c) Storm warnings

US National Oceanic and Atmospheric Administration
US national hurricane warnings
http://www.hurrwarn.com/

Joint typhoon warning system
Located at the naval base at Pearl Harbor in Hawaii, the Joint Typhoon Warning Center (JTWC) is the agency of the US Department of Defense responsible for issuing tropical cyclone warnings for the Pacific and Indian Oceans.
http://metocph.nmci.navy.mil/jtwc.php

The Weather Channel
For locations in the USA
http://www.weather.com/ready/tropical/risk.html

Caribbean Islands Hurricane Network
http://stormcarib.com/

(d) Storm survival guides

US Federal Emergency Management Agency (FEMA)
http://www.fema.gov/hazard/hurricane/index.shtm
http://www.fema.gov/areyouready/

The Australian Bureau of Meteorology
http://www.bom.gov.au/weather/cyclone/about/tc-checklist.shtml

Hong Kong Observatory
Typhoon signal system and advice on precautions to be taken
http://www.hko.gov.hk/informtc/tcsignal.htm

Many local police or civil defence organisations, particularly in areas prone to storm activity, maintain their own websites with information about current threats and advice on what to do. Please check the web for your own local organisation.

(e) Ship captain's medical guide

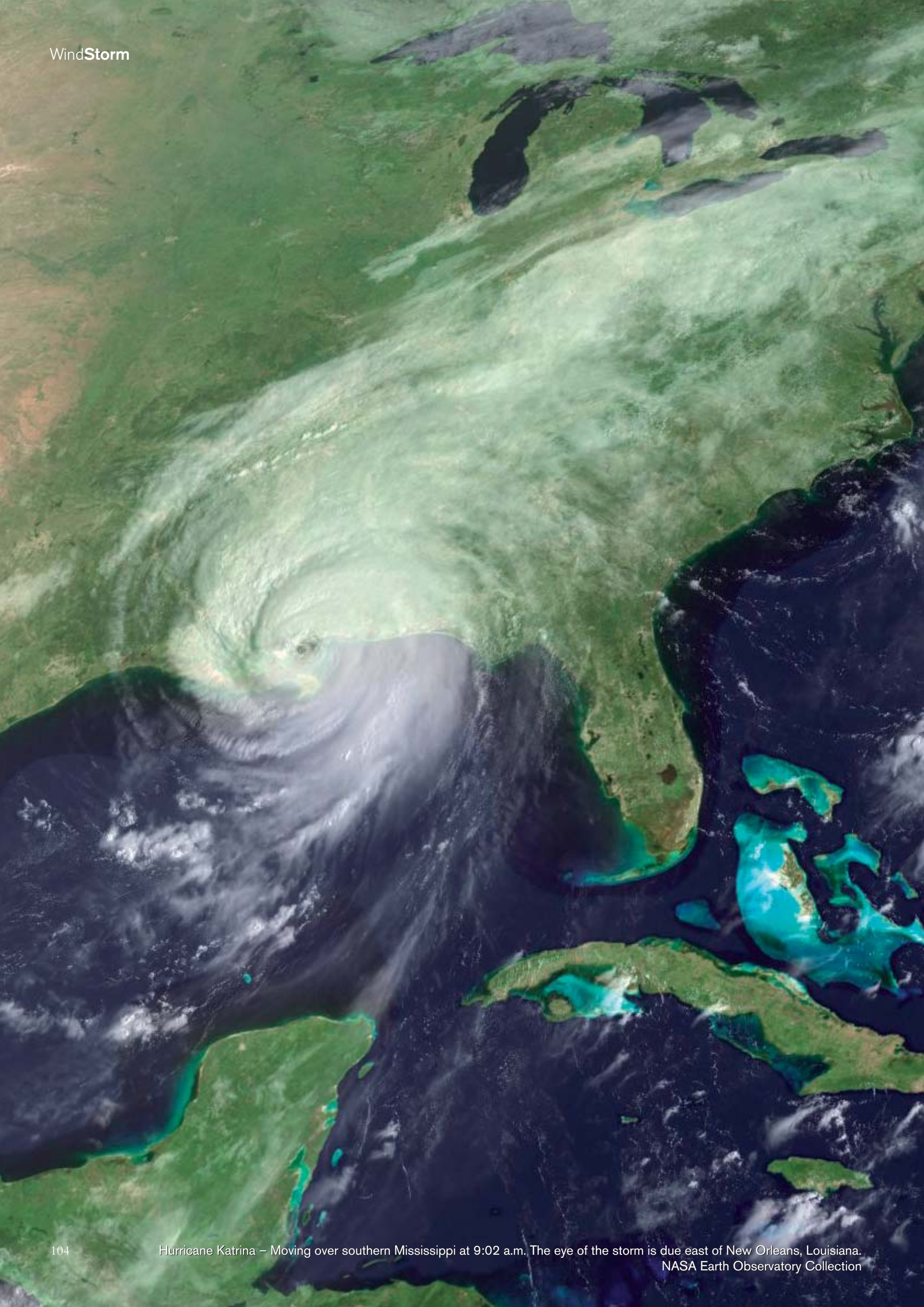
First aid advice on dealing with emergencies
http://www.mcga.gov.uk/c4mca/mcga07-home/workingatsea/mcga-medicalcertandadvice/mcga-dqs_st_shs_ships_capt_medical_guide.htm

(f) Economic analysis of WindStorm risks

Munich Re
http://www.munichre.com/en/publications/default.aspx

Swiss Re
http://www.swissre.com/pws/research%20publications/research%20and%20publications.html

The TT Club accepts no responsibility for the accuracy of information on any of these websites, or their continued availability. All the links were valid at the time this booklet was published.



Hurricane Katrina – Moving over southern Mississippi at 9:02 a.m. The eye of the storm is due east of New Orleans, Louisiana.
NASA Earth Observatory Collection

Annexe 4 – Storm miscellany

(a) Naming of storms

The naming of tropical cyclones is a method with specific guidelines used throughout the world. In the past, storms were identified by their longitude and latitude points—an impractical system. It was found that using shorter, familiar names was a much easier way of discussing the storms, whether between a ship and a coastal station or on a news broadcast. Today, the names are determined by the Tropical Cyclone Regional Body which is responsible for each specific ocean basin (see Annexe 1 for list of ocean basins). The lists are alphabetical, and often rotate on a six-year basis. For instance, in the Atlantic Basin there are six lists of names, which alternate men's and women's names, and after six years the rotation restarts.

A storm name will be retired if it is used for a particularly deadly or costly event due to sensitivity issues. This decision will be made by the World Meteorological Organization Tropical Cyclone Committees, and is the only reason the storm lists will change. If, for Atlantic basin storms, more occur in a season than there are names to assign them (21, in this case), the additional names will come from the Greek alphabet. There are different name lists for various oceanic regions in the world: the central North Pacific, Australian region, Southwest Indian Ocean etc. The names are chosen because they are familiar to the native people of that region, as the goal is to be easily understood and remembered by all. In general, each region has its own rotating schedule and specific naming rules.

(b) Commonly used wind names

Abroholos	A squall frequent from May through August between Cabo de Sao Tome and Cabo Frio on the coast of Brazil.
Auster	Same as OSTRIA
Austru	A east or southeast wind in Rumania. They are cold in winter and may be a local name for a foehn wind.
Bali wind	A strong east wind at the eastern end of Java.
Barat	A heavy northwest squall in Manado Bay on the north coast of the island of Celebes, prevalent from December to February.
Barber	A strong wind carrying damp snow or sleet and spray that freezes upon contact with objects, especially the beard and hair.
Bayamo	A violent wind blowing from the land on the south coast of Cuba, especially near the Bight of Bayamo.
Bentu de Soli	An east wind on the coast of Sardinia.
Bora	A cold, northerly wind blowing from the Hungarian basin into the Adriatic Sea. See also FALL WIND.
Borasco	A thunderstorm or violent squall, especially in the Mediterranean.
Boreas	An ancient Greek name for north winds (also borras) The term may originally have meant "wind from the mountains" and thus the present term BORA.
Brickfielder	A wind from the desert in Southern Australia. Precedes the passage of a frontal zone of a low passing by. Has the same dusty character as the Harmattan.

Brisa	A northeast wind which blows on the coast of South America or an east wind which blows on Puerto Rico during the trade wind season.
Brisote	The northeast trade wind when it is blowing stronger than usual on Cuba.
Briza	The northeast monsoon in the Philippines.
Brubu	A name for a squall in the East Indies.
Bull's Eye Squall	A squall forming in fair weather, characteristic of the ocean off the coast of South Africa. It is named for the peculiar appearance of the small isolated cloud marking the top of the invisible vortex of the storm.
Cape Doctor	The strong southeast wind which blows on the South African coast. Also called the DOCTOR.
Caver, Kaver	A gentle breeze in the Hebrides.
Chinook	A type of foehn wind. Refers to the warm downslope wind in the Rocky Mountains that may occur after an intense cold spell when the temperature could rise by 20 to 40 degrees Fahrenheit in a matter of minutes. Also known as the Snow Eater.
Chubasco	A violent squall with thunder and lightning, encountered during the rainy season along the west coast of Central America.
Churada	A severe rain squall in the Mariana Islands during the northeast monsoon. They occur from November to April or May, especially from January through March.
Cierzo	See MISTRAL.
Contrastes	Winds a short distance apart blowing from opposite quadrants, frequent in the spring and fall in the western Mediterranean.

Cordonazo The "Lash of St. Francis." Name applied locally to southerly hurricane winds along the west coast of Mexico. It is associated with tropical cyclones in the southeastern North Pacific Ocean. These storms may occur from May to November, but ordinarily affect the coastal areas most severely near or after the Feast of St. Francis, October 4.

Coromell A night land breeze prevailing from November to May at La Paz, near the southern extremity of the Gulf of California.

Cyclone A severe tropical storm (ie. winds >33m/s) in the Indian Ocean and Bay of Bengal. See also Hurricane and Typhoon. The term is also applied to closed circulations in the mid latitudes and also popularly to small scale circulations such as tornadoes.

Diablo Northern California version of Santa Ana winds. These winds occur below canyons in the East Bay hills (Diablo range) and in extreme cases can exceed 60 mph. They develop due to high pressure over Nevada and lower pressure along the central California coast.

Doctor

1. A cooling sea breeze in the Tropics.
2. See HARMATTAN.
3. The strong SE wind which blows on the south African coast. Usually called CAPE DOCTOR.

Elephanta A strong southerly or southeasterly wind which blows on the Malabar coast of India during the months of September and October and marks the end of the southwest monsoon.

Etesian A refreshing northerly summer wind of the Mediterranean, especially over the Aegean Sea.

Euros The Greek name for the rainy, stormy southeast wind.

Foehn	A warm dry wind on the lee side of a mountain range, whose temperature is increased as the wind descends down the slope. It is created when air flows downhill from a high elevation, raising the temperature by adiabatic compression. Examples include the Chinook wind and the Santa Ana wind. Classified as a katabatic wind.
Fremantle Doctor	A cooling seabreeze in Western Australia,often made note of during hot summertime cricket matches.
Gregale	A strong northeast wind of the central Mediterranean.
Haboob	A strong wind and sandstorm (or duststorm) in the northern and central Sudan, especially around Khartum, where the average number is about 24 per year. The name come from the Arabic word, "habb", meaning wind.
Harmattan	The dry, dusty trade wind blowing off the Sahara Desert across the Gulf of Guinea and the Cape Verde Islands. Sometimes called the DOCTOR, because of its supposed healthful properties.
Hurricane	A severe tropical storm (ie. winds >33m/s) in the Atlantic, Caribbean, Gulf of Mexico and Eastern Pacific. The word is believed to originate from the Caribbean Indian storm god "Huracan". See also TYPHOON and CYCLONE.
Knik	A strong southeast wind in the vicinity of Palmer, Alaska, most frequent in the winter.
Kona	A storm over the Hawaiian Islands, characterized by strong southerly or southwesterly winds and heavy rains.
Leste	A hot, dry, easterly wind of the Madeira and Canary Islands.

Levanter	A strong easterly wind of the Mediterranean, especially in the Strait of Gibraltar, attended by cloudy, foggy, and sometimes rainy weather especially in winter.
Levantera	A persistent east wind of the Adriatic, usually accompanied by cloudy weather.
Levanto	A hot southeasterly wind which blows over the Canary Islands.
Leveche	A warm wind in Spain, either a foehn or a hot southerly wind in advance of a low pressure area moving from the Sahara Desert. Called a SIROCCO in other parts of the Mediterranean area.
Maestro	A northwesterly wind with fine weather which blows, especially in summer, in the Adriatic. It is most frequent on the western shore. This wind is also found on the coasts of Corsica and Sardinia.
Maria	A fictional wind popularised in "Paint Your Wagon" (Lerner and Lowe, 1951) and by the Kingston Trio (1959), whose name may have originated with the 1941 book "Storm" by George R. Stewart.
Matanuska	A strong, gusty, northeast wind which occasionally occurs during the winter in the vicinity of Palmer, Alaska.
Mistral	A cold, dry wind blowing from the north over the northwest coast of the Mediterranean Sea, particularly over the Gulf of Lions. Also called CIERZO. See also FALL WIND.
Nashi, N'aschi	A northeast wind which occurs in winter on the Iranian coast of the Persian Gulf, especially near the entrance to the gulf, and also on the Makran coast. It is probably associated with an outflow from the central Asiatic anticyclone which extends over the high land of Iran. It is similar in character but less severe than the BORA.

Norte	A strong cold northeasterly wind which blows in Mexico and on the shores of the Gulf of Mexico. It results from an outbreak of cold air from the north. It is the Mexican extension of a norther.
Nor'easter	A northeast wind, particularly a strong wind or gale; an unusually strong storm preceded by northeast winds off the coast of New England. Also called Northeaster.
Nor'wester	This is a very warm wind which can blow for days on end in the province of Canterbury, New Zealand. The effect is especially felt in the city of Christchurch. The wind comes in from the Tasman Sea, drys as it rises over the Southern Alps, heats as it decends, crosses the Canterbury Plains, then blows through Christchurch.
Norther	A cold strong northerly wind in the Southern Plains of the United States, especially in Texas, which results in a drastic drop in air temperatures. Also called a Blue Norther.
Ostria	A warm southerly wind on the Bulgarian coast; considered a precursor of bad weather.
Pali	A local name for strong winds which blow through the Pali Pass above Honolulu.
Pampero	A west or southwest wind in Southern Argentina. This wind (often violently) picks up during the passage of a cold front of an active low passing by.
Papagayo	A violent northeasterly fall wind on the Pacific coast of Nicaragua and Guatemala. It consists of the cold air mass of a norte which has overridden the mountains of Central America. See also TEHUANTEPECER.
Santa Ana	A strong, hot, dry wind blowing out into San Pedro Channel from the southern California desert through Santa Ana Pass.

Shamal	A summer northwesterly wind blowing over Iraq and the Persian Gulf, often strong during the day, but decreasing at night.
Sharki	A southeasterly wind which sometimes blows in the Persian Gulf.
Sirocco	A warm wind of the Mediterranean area, either a foehn or a hot southerly wind in advance of a low pressure area moving from the Sahara or Arabian deserts. Called LEVECHE in Spain.
Squamish	A strong and often violent wind occurring in many of the fjords of British Columbia. Squamishes occur in those fjords oriented in a northeast-southwest or east-west direction where cold polar air can be funneled westward. They are notable in Jervis, Toba, and Bute inlets and in Dean Channel and Portland Canal. Squamishes lose their strength when free of the confining fjords and are not noticeable 15 to 20 miles offshore.
Suestado	A storm with southeast gales, caused by intense cyclonic activity off the coasts of Argentina and Uruguay, which affects the southern part of the coast of Brazil in the winter.
Sumatra	A squall with violent thunder, lightning, and rain, which blows at night in the Malacca Straits, especially during the southwest monsoon. It is intensified by strong mountain breezes.
Sundowner	Warm downslope winds that periodically occur along a short segment of the Southern California coast in the vicinity of Santa Barbara. The name refers to their typical onset (on the populated coastal plain) in the late afternoon or early evening, though they can occur at any time of the day. In extreme cases, wind speeds can be of gale force or

higher, and temperatures over the coastal plain and even at the coast itself can rise significantly above 37.8 degrees C (100 degrees F).

Taku Wind A strong, gusty, east-northeast wind, occurring in the vicinity of Juneau, Alaska, between October and March. At the mouth of the Taku River, after which it is named, it sometimes attains hurricane force.

Tehuantepecer A violent squally wind from north or north-northeast in the Gulf of Tehuantepec (south of southern Mexico) in winter. It originates in the Gulf of Mexico as a norther which crosses the isthmus and blows through the gap between the Mexican and Guatamalan mountains. It may be felt up to 100 miles out to sea. See also PAPAGAYO.

Tramontana A northeasterly or northerly winter wind off the west coast of Italy. It is a fresh wind of the fine weather mistral type.

Typhoon A severe tropical storm (ie. winds >33m/s) in the Western Pacific. The word is believed to originate from the Chinese word "ty-fung". See also Hurricane and Cyclone.

Vardar A cold fall wind blowing from the northwest down the Vardar valley in Greece to the Gulf of Salonica. It occurs when atmospheric pressure over eastern Europe is higher than over the Aegean Sea, as is often the case in winter. Also called VARDARAC.

Warm Braw A foehn wind in the Schouten Islands north of New Guinea.

White Squall A sudden, strong gust of wind coming up without warning, noted by whitecaps or white, broken water; usually seen in whirlwind form in clear weather in the tropics.

Williwaw	A sudden blast of wind descending from a mountainous coast to the sea, in the Strait of Magellan or the Aleutian Islands.
Willy-willy	A tropical cyclone (with winds 33 knots or greater) in Australia, especially in the southwest. More recent common usage is for dust-devils.
Zephyros	The ancient Greek name for the west wind, which is generally light and beneficial. It has evolved into "zephyr" which denotes a soft gentle breeze.

Annexe 5 – WindStorm checklist

Routine operations checklist

- ☐ Crane tie-down equipment checked and fully operational
- ☐ All crane storm pin points kept clear of debris
- ☐ Emergency stop systems checked and fully operational
- ☐ All service and park brakes checked and fully operational
- ☐ Emergency control room checked and equipment fully operational
- ☐ All necessary documents available and up to date

Emergency equipment, tools and supplies checked and fully operational:

- ☐ Emergency lighting equipment
- ☐ Timber and nails
- ☐ Sand bags
- ☐ Roofing paper
- ☐ Tape for windows
- ☐ Caulking compound
- ☐ Power and hand tools
- ☐ Shovels and axes
- ☐ Chain saws
- ☐ Tarpaulins

Emergency supplies of the following in a secure location:

- ☐ Emergency medical equipment
- ☐ Emergency lighting equipment
- ☐ Non-perishable food
- ☐ Bottled drinking water
- ☐ Emergency communications equipment
- ☐ Generators checked, fully operational and fuelled

Buildings checked: any loose items repaired or replaced.
Inspect and repair if necessary:

- ☐ roofs
- ☐ flashings
- ☐ coverings
- ☐ drains and gutters
- ☐ edge strips
- ☐ sign and stack supports, guy wires and anchors
- ☐ weak door or window latches or hardware and insecure wall panel fastenings
- ☐ Clear debris and unrestrained materials from roofs
- ☐ Check computer back-up functioning. Ensure that vital records are held or duplicated off-site
- ☐ Check container stack heights and ensure they conform to site rules

Recovery checklist

- ☐ Initiate search and rescue procedures
- ☐ Assess the damage from wind, fire, flooding, and impairments to fire protection equipment immediately
- ☐ Be alert for downed or damaged power lines – notify the electric utility company of needed repairs
- ☐ Inform insurers
- ☐ Check cargo, containers etc. for obvious damage and initiate property conservation procedures
- ☐ Inform personnel when facility due to reopen
- ☐ Protect building contents from rain damage
- ☐ Temporarily repair openings in roofs and walls
- ☐ Cover building contents with tarpaulins to minimise rain damage
- ☐ If roofs are safe to stand on, clear debris from roof drains to prevent 'ponding' of water
- ☐ Prohibit the use of any flame or heat-producing equipment in any area where the presence of any flammable liquids or gases is suspected
- ☐ Check that navigational channels have not been altered for ships coming to and departing from the terminal
- ☐ Ensure navigational aids have not been swept away
- ☐ Make sure both internal and external communications are still in full use

Emergency plan checklist

- ☐ Incident controller to set up incident room
- ☐ Set up a weather monitoring team
- ☐ Determine whether a complete or partial shutdown of the facility is required
- ☐ Determine the order in which processes are to be shutdown and the facility secured
- ☐ Initiate process emergency shutdown procedures

Operations on the facility

- ☐ Communicate the procedures and timetable to operational crews
- ☐ Inform clients, suppliers, neighbouring facilities, landlord and local authority, as appropriate, of your planned closedown
- ☐ Cease crane operations as soon as practical. Lift booms to vertical and then move cranes to pre-determined lockdown points. Secure with on-board brakes, storm pins and tie-downs
- ☐ Move rail mounted gantries to end of track(s) and secure
- ☐ Move rubber tyred gantries to securing points and secure
- ☐ Move straddle carriers to pre-determined safe zone, block-park all together
- ☐ Move all small machinery to protected positions
- ☐ Check lashings for all open-top containers and other sheeted loads
- ☐ Move vulnerable cargo to sheltered positions (or create shelter for vulnerable cargo by moving other containers around it)
- ☐ Reduce stack heights of empty containers to four units or less
- ☐ Consider putting loaded containers on top of empties
- ☐ Consider pyramid stacking of containers
- ☐ Anchor structures in the yard that can be moved by high winds, such as tarpaulins, timber or any loose yard storage
- ☐ Remove all debris and place all rubbish receptacles inside a warehouse

Buildings and other fixed structures

- ☐ Protect windows from flying debris
- ☐ Brace unsupported structural members at construction sites
- ☐ Fill all above ground tanks to capacity with product or water
- ☐ Ensure that all fire protection equipment is in service
- ☐ Check who is on site and who will be remaining there for the duration of the storm

The following two copies of the WindStorm checklist are designed to be torm out and completed as and when required.

TT CLUB

ROUTINE OPERATIONS CHECKLIST

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- ☐ Emergency control room checked and equipment fully operational
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RECOVERY CHECKLIST

- ☐ Initiate search and rescue procedures
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- ☐ Protect building contents from rain damage
- ☐ Temporarily repair openings in roofs and walls
- ☐ Cover building contents with tarpaulins to minimise rain damage
- ☐ If roofs are safe to stand on, clear debris from roof drains to prevent ‘ponding’ of water
- ☐ Prohibit the use of any flame or heat-producing equipment in any area where the presence of any flammable liquids or gases is suspected
- ☐ Check that navigational channels have not been altered for ships coming to and departing from the terminal
- ☐ Ensure navigational aids have not been swept away
- ☐ Make sure both internal and external communications are still in full use

EMERGENCY PLAN CHECKLIST

- ☐ Incident controller to set up incident room
- ☐ Set up a weather monitoring team
- ☐ Determine whether a complete or partial shutdown of the facility is required
- ☐ Determine the order in which processes are to be shutdown and the facility secured
- ☐ Initiate process emergency shutdown procedures

Operations on the facility

- ☐ Communicate the procedures and timetable to operational crews
- ☐ Inform clients, suppliers, neighbouring facilities, landlord and local authority, as appropriate, of your planned closedown
- ☐ Cease crane operations as soon as practical. Lift booms to vertical and then move cranes to pre-determined lockdown points. Secure with on-board brakes, storm pins and tie-downs
- ☐ Move rail mounted gantries to end of track(s) and secure
- ☐ Move rubber tyred gantries to securing points and secure
- ☐ Move straddle carriers to pre-determined safe zone, block-park all together
- ☐ Move all small machinery to protected positions
- ☐ Check lashings for all open-top containers and other sheeted loads
- ☐ Move vulnerable cargo to sheltered positions (or create shelter for vulnerable cargo by moving other containers around it)
- ☐ Reduce stack heights of empty containers to four units or less
- ☐ Consider putting loaded containers on top of empties
- ☐ Consider pyramid stacking of containers
- ☐ Anchor structures in the yard that can be moved by high winds, such as tarpaulins, timber or any loose yard storage
- ☐ Remove all debris and place all rubbish receptacles inside a warehouse

Buildings and other fixed structures

- ☐ Protect windows from flying debris
- ☐ Brace unsupported structural members at construction sites
- ☐ Fill all above ground tanks to capacity with product or water
- ☐ Ensure that all fire protection equipment is in service
- ☐ Check who is on site and who will be remaining there for the duration of the storm

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