MARSH

Energy Practice

THE 100 LARGEST LOSSES
1974-2013

LARGE PROPERTY DAMAGE LOSSES IN THE HYDROCARBON INDUSTRY

23RD EDITION

SOLUTIONS...DEFINED, DESIGNED, AND DELIVERED.

MARSH & McLENNAN COMPANIES

CONTENTS

ACKNOWLEDGEMENT

Marsh's Energy Practice acknowledges the significant input in the preparation of this document from those working in the insurance industry, and elsewhere, interested in the prevention and mitigation of large property damage losses. We would like to thank the contributors from the energy insurance market who have continued to provide key information to aid in the development of this valuable publication. We continue to rely on information kindly supplied by interested professionals to supplement the information available in the public domain, and encourage all readers to bring to our attention any errors, omissions, or additional information.

FOREWORD

I was delighted to accept the opportunity to write this foreword for the 23rd edition of Marsh's *The 100 Largest Losses*. This publication is essential reading for managers and practitioners alike in the energy industry and beyond as we try to learn lessons from the past and integrate those lessons in design, operations, and maintenance of the process facilities. This unique compendium of the 100 largest losses represents major incidents in various sectors that provide a treasure trove of information that is no doubt of great use for academia, government regulators and industry.

The Mary Kay O'Connor Process Safety Center continues to conduct a great deal of work to study and understand the causation of incidents. This is rooted in the fact that the formation of the Center itself followed a tragic incident at a petrochemical facility resulting in the death of Mary Kay O'Connor and 22 others. *The 100 Largest Losses* is confirmation of the value one can take from drawing on past experiences to prevent recurrence of these incidents and improve safety performance.

As standards of living generally improve across the globe, there is a corresponding change in people's perception of risk and how willing one is to tolerate it. When we have major incidents, examples of which are given in this book as well as previous editions, the whole industry gets painted with the same brush. So what are our options? Naturally, NIMBY (Not In My Back Yard), is not an option because our 'backyards' are getting so small that an incident anywhere in the world can have global ramifications. On the other hand, BANANA (Build Absolutely Nothing Anywhere Near Anyone) is also not an option either and that is because of the continuous needs and demands of a growing and affluent world population.

A major issue for organizations is being able to learn from incidents and capture those lessons into design, procedures, training, maintenance, and other programs. There is no excuse when "lessons learned" from incidents are ignored or not implemented, particularly "lessons learned" from incidents that have occurred in one's own organization or that are widely publicized. But one factor that is often overlooked is the types of incidents that are tracked or investigated. Quite often incidents are defined narrowly and include only the ones that cause serious or catastrophic consequences. While this may be the politically expedient thing to do, it leads to some problems and pitfalls.

The underlying causes for incidents are usually the same regardless of which part of the incident pyramid the incident falls within. In other words, an incident that causes no injury and is classified in the lower part of the pyramid could easily have been classified in the top part. Thus, the broader the incident definition, the more statistically sound the lessons from the incident analysis. In fact, it would seem that as safety programs mature, the incident definition should be expanded to include not only near-misses but other leading indicators as well.

While sobering, this report is incredibly valuable in that it demonstrates the importance of process safety right across the energy sector. I hope you are able to take as much away from 100 Largest Losses as I have, and use it to help steer health and safety policy and procedures in your organization.

Dr M. Sam Mannan, PE, CSP, DHC
Regents Professor and Director, Mary Kay O'Connor Process Safety Center

INTRODUCTION

Welcome to the 23rd edition of Marsh's *The 100 Largest Losses*. In this publication we summarize the 100 largest property-damage losses that have occurred in the hydrocarbon extraction, transport, and processing industry from 1974 to 2013.

The information in the document has been taken from Marsh's energy loss database, which is used to collect information that we have gathered from our contact with the hydrocarbon industry, as well as from information that is available in the public domain. The loss database has been used to collect information for more than 40 years, and now has almost 10,000 individual records of losses. Although every effort has been made to find out as much information as possible about losses, there are still some for which we have too little information, preventing us from determining what the contributing factors were in a given accident.

We have not included losses that occurred during the construction phase of projects, and marine transportation losses are excluded, except for those involving marine vessels moored at plant docks.

The loss values are reported in two ways: the original value of the loss in "money at the time," as well as an inflated value to estimate the equivalent value of the loss at the end of 2013. This method uses the Nelson-Farrar Petroleum Plant Cost Index, which allows for an easy comparison of property damage on a constant basis across the period analyzed. It is these inflated values that have been used to select and order the largest losses. The loss amounts include property damage, debris removal, and clean-up costs. The costs of business interruption, extra expense, employee injuries/fatalities, and liability claims are excluded from this analysis. The direct on-premises clean-up costs due to asbestos abatement, polychlorinated biphenyl (PCB) removal, or released hydrocarbons and chemicals following a fire, explosion, or other loss event have traditionally been considered part of the property damage loss.

The large property losses have been grouped into five categories: refineries, petrochemical, gas processing, terminals and distribution, and upstream.

Eight new losses that have occurred since 2011 have entered the 100 largest losses list. These emanated from the refinery, petrochemicals, and upstream sectors, and include explosions, fires, flooding, blowouts, and the sinking of offshore structures. There is, therefore, no single dominant factor in these new losses.

The nature of the hydrocarbon business is such that in all operations, there are potential exposures to risk due to the nature of the materials being extracted, transported, and processed. Increasingly, the operations of the industry are moving into increasingly hazardous environments — deeper waters, more extreme climates, or more remote locations. Therefore, the decisions about any development or operation must be based on a thorough assessment of the associated risks to identify measures that can be taken to prevent losses to the operation.

Those carrying out the risk assessment need to be aware of losses in the industry, as well as the combination of events that can potentially result in significant risk exposures, and use this information in the risk-assessment process.

The complexity of the operations carried out in the hydrocarbon industry — be it the exploration and production of oil and gas, the transportation and storage of raw hydrocarbons, the refining and upgrading of raw hydrocarbons to produce commercial products, or the processing of hydrocarbon products to produce polymers and other materials — all rely on multiple systems to help prevent losses. These systems or barriers are a combination of:

- Hardware: Physical systems that may help to control the exposure.
- Management systems: Management and procedural steps that can be taken to help mitigate the risk.
- Emergency controls: Systems that can minimize the fire, explosion, or other emergency consequences of the risk.

The selection, specification, operation, and maintenance of these systems to prevent and mitigate major accidents are the function of the process-safety management system for any hydrocarbon industry asset. This is separate from, and complementary to, the occupational health and safety management system.

Accidents that result in major losses, such as those reported in this document, generally occur because of the failure of a number of these systems or barriers within the process-safety management system — all occurring at the same time; typically, none of these losses are the result of the failure of a single barrier or protection measure. The information in this publication should be used to remind industry professionals of the significance of all of the process safety and loss prevention barriers, and the potential consequences should these barriers be allowed to deteriorate or fail. The proper maintenance of these barriers depends not only on them being routinely inspected and audited, but also on senior management's clear support of the safety processes — and its ability to address any concerns that are brought to light.

None of the losses listed in this document should be considered "black swan" events.

There has been discussion in recent years about the potential exposure to "black swan" events. These are events that are inconceivable and impossible to consider as a credible threat — until they occur. None of the losses listed in this document should be considered "black swan" events. Although we can identify events in the loss database that share similar root causes with all of the 100 losses described, it was the failure of prevention and mitigation measures that resulted in maximum property damage.

For example, the database currently includes records of 165 blowout events, demonstrating that this is a foreseeable event when carrying out any drilling or well operations. Normally, there are sufficient barriers in place to contain the well pressure or, in the event these blowout prevention measures fail, mitigation measures to help minimize the consequences of a blowout — for example, cutting and sealing the drill string. However, circumstances can occur when all of the prevention and mitigation measures fail, resulting in the uncontrolled blowout of a well. The risk assessment of drilling operations should take this into account as a potential exposure. The number and reliability of the barriers put in place to prevent a blowout should be linked to the likelihood and potential consequences, and plans should be developed that could control and minimize the consequences of a potential blowout. We must recognize, however, that there are additional threats to the integrity of industry assets that have not yet resulted in a major loss, but may have the potential to do so. It is important to apply systems that are able to identify these latent or novel threats, together with appropriate measures to prevent them resulting in serious loss.

For example, in reporting on the 100 losses, we do not see any situation in which the root cause has been identified as a cyber-attack on computer control or emergency shutdown systems. We are aware of operators in the hydrocarbon business that have been subject to cyber-attacks that have affected commercial and management functions. The industry needs to maintain vigilance and apply appropriate procedural and technical measures to minimize the risk of rogue software interfering with operational software and emergency systems, which could result in serious loss. An effective process-safety management system should include this threat and identify the measures required to prevent and mitigate cyber-attack losses. Continued risk minimization depends on maintaining vigilance on new and developing threats, and forming strategies to prevent and mitigate their impact.

It is important that the industry also take into account positive examples of risk improvements, as well as learn from the negative examples of losses. International standards and codes of practice are developed in the light of experience gained by operators and regulators, but we are not always good at learning from the positive experiences of others. We could also benefit by looking at good practices in risk reduction and control in other industries, such as the nuclear power-generating sector and the aviation industry, where no-blame cultures encourage the freer exchange of lessons learned.

The losses reported here represent the worldwide operations of the hydrocarbon industry and cover 40 years of industry experience. We hope that this document will help industry participants overcome what is sometimes called "silo mentality" — the belief that only experience in one country, or in one sector of the industry, is of relevance in thinking about losses and loss prevention. For example, one of the root causes of the Piper Alpha loss is considered to be the failure of a permit-to-work system to prevent the startup of equipment that was prepared for maintenance. Even though this loss occurred in 1989 in the UK sector of the North Sea, there are still valuable lessons to be learned from it that apply in all sectors of the industry and across the world.

We hope this publication can be used to remind people working in the industry of the range of losses that can occur, the wide range of potential root causes, the fallibility of prevention measures, and the scale of potential consequences.

THE 20 LARGEST LOSSES

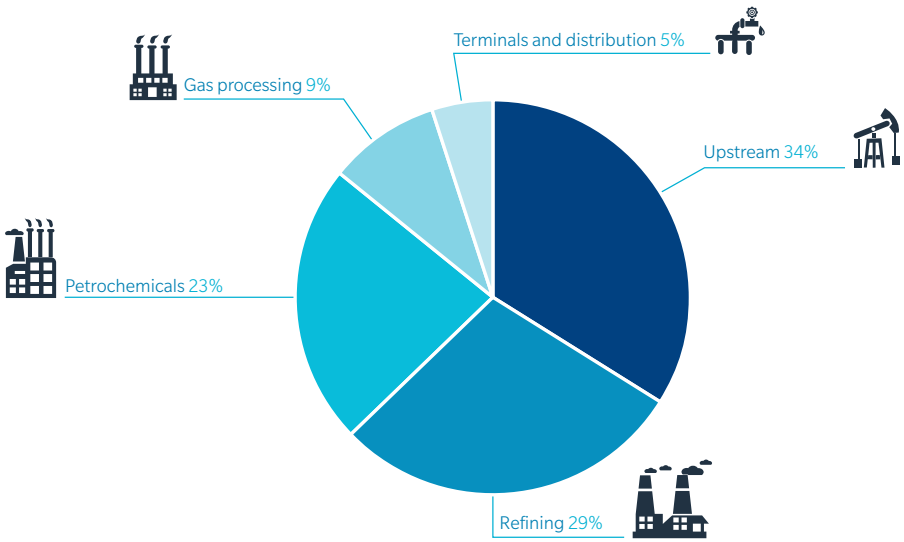
DATE	PLANT TYPE	EVENT TYPE	LOCATION	COUNTRY	PROPERTY LOSS US$ (MILLIONS[1])
07/07/1988	Upstream	Explosion/fire	Piper Alpha, North Sea	UK	1,810
10/23/1989	Petrochemical	Vapor cloud explosion	Pasadena, Texas	USA	1,400
01/19/2004	Gas processing	Explosion/fire	Skikda	Algeria	940[2]
06/04/2009	Upstream	Collision	Norwegian Sector	North Sea	840
03/19/1989	Upstream	Explosion/fire	Gulf of Mexico	US	830
06/25/2000	Refinery	Explosion/fire	Mina Al-Ahmadi	Kuwait	820[2]
05/15/2001	Upstream	Explosion/fire/sinking	Campos Basin	Brazil	790
09/25/1998	Gas processing	Explosion	Longford, Victoria	Australia	750
04/24/1988	Upstream	Blowout	Enchova, Campos Basin	Brazil	700
09/21/2001	Petrochemical	Explosion	Toulouse	France	680
05/04/1988	Petrochemical	Explosion	Henderson, Nevada	US	640
05/05/1988	Refinery	Vapor cloud explosion	Norco, Louisiana	US	610
03/11/2011	Refinery	Earthquake	Sendai	Japan	600[3]
04/21/2010	Upstream	Blowout/explosion/fire	Gulf of Mexico	US	600
09/12/2008	Refinery	Hurricane	Texas	US	550
06/13/2013	Petrochemical	Explosion/fire	Geismar, Louisiana	US	510[4]
04/02/2013	Refinery	Flooding/fire	La Plata, Ensenada	Argentina	500[4, 5]
12/25/1997	Gas processing	Explosion/fire	Bintulu, Sarawak	Malaysia	490[2]
07/27/2005	Upstream	Collision/fire	Mumbai High North Field	India	480
11/14/1987	Petrochemical	Vapor cloud explosion	Pampa, Texas	US	480

1. *Inflated to December 2013 values. Values are ground-up, property damage only.*
2. *New, higher value for the property damage for this loss supplied from the insurance market.*
3. *New data received of the value of loss at the refinery, following the Tohoku earthquake.*
4. *New loss since publication of 22nd edition of The 100 Largest Losses*
5. *It is understood that this value is still subject to resolution.*

Figure 1 represents the split of the value of the 100 losses by industry sector, based on the 2013 property damage values. The total accumulated value of the losses in the 2013 figures is more than US$34 billion.

The losses are dominated by the upstream and refining sectors, with the petrochemical sector representing a slightly smaller fraction. The gas processing and distribution sectors take a much smaller quantity of the overall property damage, reflecting the smaller capital value in any single installation in these sectors, limiting the size of the largest potential loss from these activities.

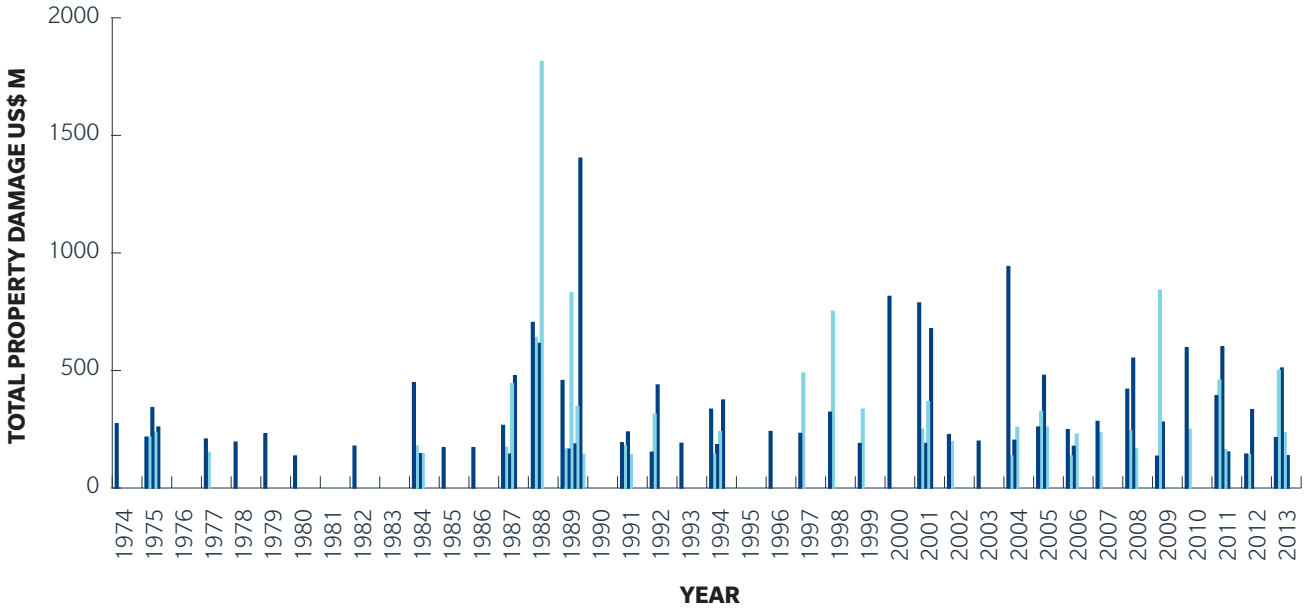
FIGURE 1: PROPERTY DAMAGE OF 100 LARGEST LOSSES BY SECTOR



The total accumulated value of the 100 largest losses is over US$34 billion.

Figure 2 shows distribution of the 100 largest losses between 1974 and 2013, and the 2013 estimated equivalent loss value for each one.

FIGURE 2: DISTRIBUTION OF 100 LARGEST LOSSES BY YEAR



Each of the 100 largest losses had a value in 2013 US dollars of more than US$130 million.

Figure 2 shows a number of large and noteworthy losses prior to 1998, but a greater concentration of these above US$130 million are losses from 1999 to the present. While it is possible that some losses occurred during the earlier period that have not been picked up in this analysis, most losses of this scale are reported in the public domain. Greater openness and improved global communications now enable us to receive reports of major losses from around the world instantly.

During the period 1974 to 2013, there was a significant increase in the quantity of crude oil extracted. The US Energy Information Administration reports an average daily global production of crude oil of 64 million barrels per day (bbl/d) in 1980, which increased to an average of 89.3 million bbl/d in 2012.

There have also been, over this period, major technological developments in the hydrocarbon industry. In particular, upstream developments have moved into progressively more hostile environments, and offshore developments have moved into deeper waters. This has resulted in a trend for individual upstream assets to be larger with a higher concentration of value. Similarly, in the refining and petrochemical sectors, technology has been applied to maximize the yield of valuable products from each barrel of oil or cubic foot of gas. This has also resulted in a concentration of value on refinery and petrochemical facilities, with the installation of units to upgrade the heavy products from atmospheric vacuum distillation, using high temperatures, high pressures, and expensive catalysts.

The value of each of the 100 largest losses exceeds US$130 million.

LARGE LOSSES: 2012-2013

The following are the large losses that have occurred in the hydrocarbon industry since the publication of the 22nd edition of *The 100 Largest Losses* in January 2012, and that are of sufficient size to make the 100 largest losses list. Further details on these losses are available in the individual sections of this publication.

DATE	PLANT TYPE	EVENT TYPE	LOCATION	COUNTRY	PROPERTY LOSS US$ (MILLIONS[1])
05/05/2012	Petrochemical	Explosion/fire	Map Ta Phut	Thailand	140
07/04/2012	Refinery	Explosion/fire	Bangkok	Thailand	140
08/25/2012	Refinery	Explosion	Falcon State	Venezuela	330
04/02/2013	Refinery	Flooding/fire	La Plata, Ensenada	Argentina	500[2]
06/13/2013	Petrochemical	Explosion/fire	Geismar, Louisiana	US	510[2]
07/01/2013	Upstream	Sinking	Atlantic Ocean, offshore	Angola	240
07/23/2013	Upstream	Blowout	Gulf of Mexico, offshore Louisiana	US	140

1. *Inflated to December 2013 values. Values are ground-up, property damage only.*
2. *It is understood that this value is still subject to resolution.*

In addition to the losses listed above, there have been a number of accidents and incidents in the hydrocarbon industry since the publication of the 22nd edition two years ago, which did not make it into the current edition, but which are still noteworthy. The most significant of these are summarized on the following pages.

UPSTREAM

NORTH SEA, UK SECTOR

Workers were evacuated from an offshore installation after a major subsea gas release. An initial evacuation left 19 essential workers on the platform, but the following day they were taken off and a no-fly zone was established around the area. The platform was left unmanned and powered down. The release was thought to be as a result of an operation to re-enter a previously plugged well of a gas reservoir. The gas leak was coming from the outer casing of the well. The release was from a gas source 4,000 meters below the seabed, but 1,500 meters above the reservoir. The installation operating company was later granted approval to mount a dynamic kill to stem the ongoing gas release. This involved pumping mud into the compromised well. A drilling rig was positioned alongside the abandoned platform to act as the pumping vessel. In parallel, work continued to drill a relief well as an alternative control solution. It was reported that the uncontrolled gas leak was finally plugged 12 hours after the company initiated the dynamic well-kill operation. Almost 1,000 tons of mud was injected into the well before it was confirmed to have stopped.

The property damage associated with this loss is considered to be relatively low, but it has been reported that the overall cost of the operation to regain control of the well was US$350 million.

PETROCHEMICAL

TEXAS, USA

An explosion occurred on a small fertilizer storage and distribution facility that was located close to a small rural community. The explosion occurred while emergency services personnel were responding to a fire at the facility. 15 people were killed, more than 160 injured, and more than 150 buildings were destroyed as a result of the explosion. The explosion had the effect of a 2.1-magnitude earthquake, or was the equivalent to the detonation of 15,000 to 20,000 pounds (6,800 to 9,000 kilograms) of TNT. It produced a 28-meter wide and 3-meter deep crater. Debris was found 2.5 miles (4 kilometers) away. The source of the explosion was thought to be stocks of ammonium nitrate fertilizer stored in a wooden bin in a seed store; however, the cause of the original fire has not been determined. It is understood that the fertilizer storage area was not equipped with firewater sprinklers, but that there were fire extinguishers in the building. Investigators determined that between 28 and 34 tons of ammonium nitrate exploded in two blasts, which were milliseconds apart and caused by the heat of the fire and the impact of falling debris. An additional 20 to 30 tons of fertilizer in the building, and 100 tons of fertilizer in a rail wagon outside the building, did not explode.

The explosion destroyed the facility, but the limited size of the site meant that the property damage loss was limited. However, the third party liability loss, as a result of the explosion, is estimated to be more than US$100 million.

TERMINALS AND DISTRIBUTION

QUEBEC, CANADA

A freight train of 74 tank wagons of crude oil ran away from an overnight parking location, running into a small town where it derailed, resulting in fires and multiple explosions of the tank cars. There were 47 fatalities, more than 30 buildings destroyed, and the explosion caused damage up to one kilometer away. Around 150 firefighters were deployed to the scene of the derailment. Approximately 1,000 people were evacuated after the derailment, and an additional 1,000 later due to the threat from toxic fumes. After 20 hours, the center of the fire zone — where pools of fuel were still burning — was still inaccessible to firefighters, and two rail tank cars were still burning 36 hours after the derailment. A total of 5.98 million liters of oil are estimated to have been leaked from the rail cars as a result of the accident.

The engine on the freight train was shut down while it was parked after reports of a fire on the locomotive. This may have disabled the compressors required to maintain the pressure in the air brakes.

The cost of the property damage to the train and rail track following this accident is relatively low, but the third party liability loss is estimated to be more than US$250 million.

NATURAL CATASTROPHE ACCUMULATION

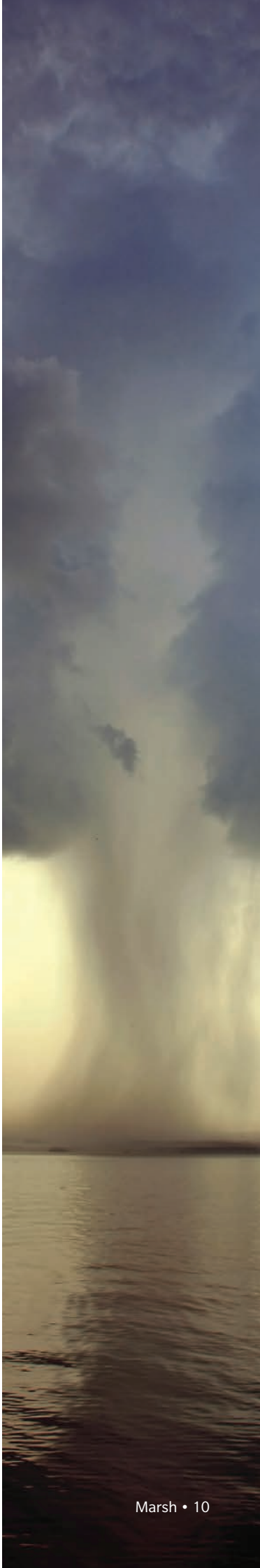
In the previous edition of this report, we included a supplement of the aggregate losses from major natural catastrophes that have affected the hydrocarbon industry.

Since 2011, the one major natural-catastrophe event that has affected the hydrocarbon industry is Superstorm Sandy in November 2012, which has been reported as resulting in accumulated property damage worth US$110 million to tank farms and terminals in the US state of New Jersey. There was also a significant amount of damage to local gas infrastructure with more than 140,000 flood-related gas outages reported.

There have been other major natural catastrophe events, in particular Typhoon Haiyan, which struck the Philippines in November 2013, and the flooding in Thailand in 2011 and early 2012.

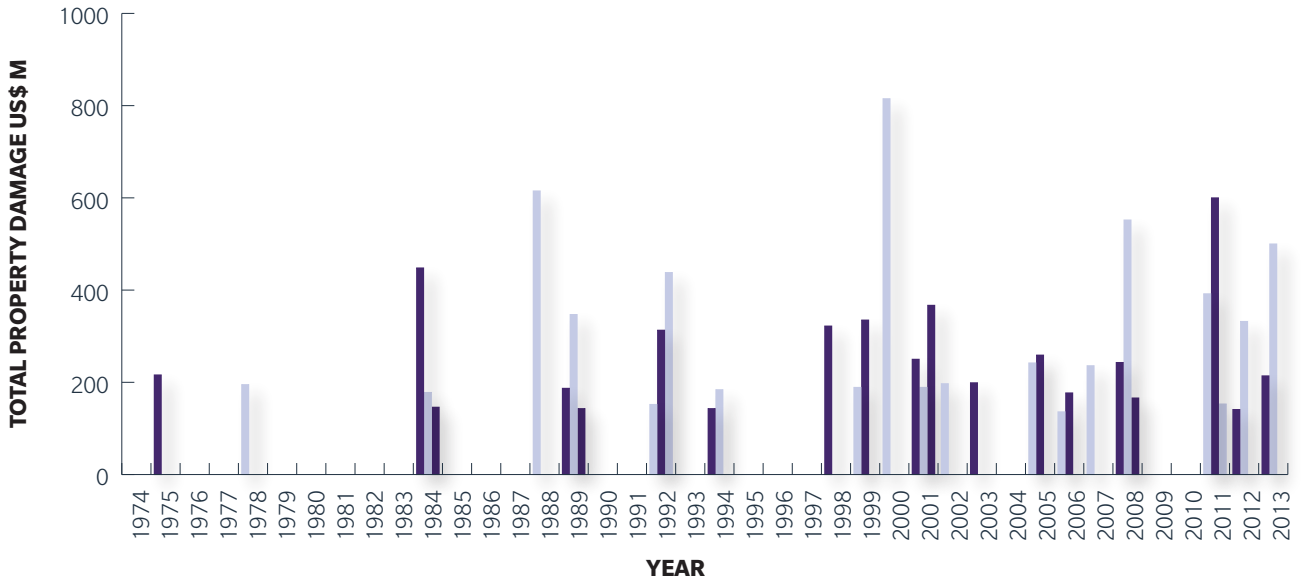
Since there are limited hydrocarbon industry assets in the Philippines, that devastating storm did not result in significant energy sector property damage. Similarly, in Thailand, the flooding did not significantly affect the areas of the country where energy industry assets are primarily located. However, losses associated with the flooding did result in some contingent business interruption losses to energy industry operators.

Superstorm Sandy reportedly caused US$110 million worth of property damage to tank farms and terminals, as well as significant damage to gas infrastructure.



REFINERIES

FIGURE 3: REFINERY PROPERTY DAMAGE BY YEAR



Note

Figure 3 shows the distribution of the property loss value of refinery incidents in the set of 100 largest losses, inflated to 2013 values.

Figure 3 shows a general increasing trend of frequency and size of losses. A contributing factor will be that oil refineries worldwide are generally mature and aging, with upgrading and expansion projects leading to greater levels of complexity and higher value concentration. The management of aging plants is an issue that some regulatory authorities are showing an increased interest in to gain assurances that the correct processes are in place to manage the risk.

REFINERIES

FLOOD		A fire broke out in the 188,000 barrels per day (bbl/d) refinery, as a result of flash-floods during heavy rain. The rain overwhelmed the storm drainage system on the refinery, resulting in hydrocarbons being washed out of the drains and around the site. An explosion was reported in the crude distillation unit (CDU). There were two fires in the CDU, one in the coking plant, and two in the topping distillation plant. The government agency said the incident had been caused by hydrocarbons exploding in one of the coke manufacturing furnaces. The furnaces had been shut down, but were still hot enough to ignite the hydrocarbon. It took eight hours to extinguish the fire and 10 hours before the incident was under control. The oil company said there were no fatalities or injuries.
EVENT DATE	04/02/2013	
LOCATION	La Plata District, Ensenada, Argentina	
VALUE	US$500,000,000	
ESTIMATED CURRENT VALUE	US$500,000,000	
EXPLOSION		A very powerful explosion occurred in an area of pressured propane and butane storage at the refinery. At least 48 people were killed and more than 80 injured. The explosion hit an area of storage tanks, damaging nine of them. It was reported that there had been a significant number of leaks at the refinery in the previous year.
EVENT DATE	08/25/2012	
LOCATION	Falcon State, Venezuela	
VALUE	US$330,000,000	
ESTIMATED CURRENT VALUE	US$330,000,000	

FIRE		An explosion and fire occurred in the kerosene stripper of the crude distillation unit at an 80,000-bbl/d refinery located in an industrial zone surrounded by residential areas. This resulted in fires in the area, but no injuries were reported. The refinery operator said it would postpone a maintenance shutdown at its refinery, which was set for late July, to reduce the risk of supply shortages as a result of the fire. The CDU that was damaged by the fire was expected to be replaced within three months.
EVENT DATE	07/04/2012	
LOCATION	Bangkok, Thailand	
VALUE	US$140,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

FIRE		A fire broke out in a refinery, reported to have started in a pump-house used for blending refined products as it was being prepared for maintenance. Site firefighters were supported by state fire authority forces. Non-essential staff was evacuated from the site, and neighboring units were shut down as a precaution. Further fire eruptions and explosions were reported the next morning, and the company began steps to shut down the whole refinery. The fire was reported as finally extinguished late in the evening of the second day, about 34 hours after it was first reported. The production units on the refinery were progressively restarted, and all units were back in production by the end of 2011.
EVENT DATE	09/28/2011	
LOCATION	Pulau Bakom, Singapore	
VALUE	US$150,000,000	
ESTIMATED CURRENT VALUE	US$150,000,000	

EARTHQUAKE		A major explosion occurred at a 145,000-bbl/d refinery in the northeastern city of Sendai, hours after the largest earthquake in the country's history which was followed by a tsunami. The fire at the Sendai refinery originated from an oil product shipping facility. Workers at the refinery were being evacuated, and there was no capacity available to extinguish the fire. Fire in the storage and shipping facilities resulted in damage to a 35,500-bbl/d fluid catalytic cracker (FCC) at the refinery.
EVENT DATE	03/11/2011	
LOCATION	Sendai, Japan	
VALUE	US$590,000,000	
ESTIMATED CURRENT VALUE	US$600,000,000	

FIRE/EXPLOSION		An explosion occurred at around 15:30 on this oil sands upgrader site north of Fort McMurray, Alberta. Five workers were injured in the blast, including one who received third-degree burns. A subsequent fire occurred at the top of one of the site's four coke drums which burned for nearly four hours. As a result, two of the coke drums were disabled. Workers returned to working normal shifts the following morning. The majority of the damage was sustained above the cutting deck and derrick infrastructure of the coke drum. At the time of the incident, the plant was operating on bypass conditions due to process upsets. An internal investigation team determined that the fire resulted from the opening of the top unheading valve on an active low-pressure coke drum. This allowed hot hydrocarbons to be released within the coker-cutting deck building, and was followed by an ignition that led to the explosion and fire. Exceptionally cold weather following the incident hampered efforts to gain access to the coker unit's cutting deck, the cutting deck having deluge protection. Collateral freezing damage was also experienced.
EVENT DATE	01/06/2011	
LOCATION	Fort McKay, Alberta, Canada	
VALUE	US$380,000,000	
ESTIMATED CURRENT VALUE	US$390,000,000	

FIRE/EXPLOSION		An explosion and fire in a 562-mw capacity integrated gasification combined cycle electricity generating plant at a refinery caused a fire in the gasification unit on a refinery. No one was injured as a result of the explosion and fire but the loss resulted in the temporary closure of the refinery.
EVENT DATE	10/13/2008	
LOCATION	Priolo Gargallo, Sicily, Italy	
VALUE	US$150,000,0000	
ESTIMATED CURRENT VALUE	US$170,000,000	

HURRICANE		This 365,000-bbl/d refinery sustained damage during Hurricane Ike. A protective barrier was breached during the hurricane which resulted in the plant flooding with sea water. The site was inundated by storm surge.
EVENT DATE	09/12/2008	
LOCATION	Texas, US	
VALUE	US$220,000,000	
ESTIMATED CURRENT VALUE	US$240,000,000	
FIRE/EXPLOSION		An explosion at this 70,000-bbl/d oil refinery caused damage to the fluid catalytic cracker (FCC), utilities, storage tanks, and asphalt unit. One employee was hospitalized with burns, and another was apparently injured when her car was struck by debris on the nearby highway. A skeleton crew of just 40 people was on site because of a public holiday. There would typically have been about four times as many people on duty at the time of the explosion. The fire was brought under control the same day by the site fire brigade, supported by local fire departments. The release is believed to have occurred during a startup on the propylene splitter unit following catastrophic failure of a pump. The source of ignition is not known. Some processing resumed about two months later, and the fluid catalytic cracker (FCC) was recommissioned some eight months after the incident.
EVENT DATE	02/18/2008	
LOCATION	Texas, US	
VALUE	US$380,000,000	
ESTIMATED CURRENT VALUE	US$420,000,000	
FIRE		This 325,000-bbl/d refinery had been operating since 1963. A fire broke out in a crude unit at 14:15 and was under control by 16:00, although it was reported to still be burning at 20:30. No injuries were reported. Company officials said a major portion of the plant continued to operate. The fire was at the no. 2 crude unit; the no. 1 crude unit at the refinery remained operational.
EVENT DATE	08/16/2007	
LOCATION	Pascagoula, Mississippi, US	
VALUE	US$200,000,000	
ESTIMATED CURRENT VALUE	US$240,000,000	
FIRE		A fire on the vacuum distillation unit of this refinery caused the main vacuum distillation column to collapse onto the heat exchange train. The unit was shut down completely, and while the refinery was left running, it was at a much reduced capacity. The fire was caused by a leak from a branch on the column, which had been made from incorrect material.
EVENT DATE	10/12/2006	
LOCATION	Mazeikiu, Lithuania	
VALUE	US$140,000,000	
ESTIMATED CURRENT VALUE	US$180,000,000	
LEAK		Two firefighters were injured tackling a blaze at a refinery. The incident occurred when crude oil leaked from a pipe supplying the refinery from bulk storage tanks.
EVENT DATE	04/30/2006	
LOCATION	Priolo, Sicily, Italy	
VALUE	US$110,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

FIRE/EXPLOSION	
EVENT DATE	03/23/2005
LOCATION	Texas, US
VALUE	US$200,000,000
ESTIMATED CURRENT VALUE	US$260,000,000

Fifteen people were killed and 105 injured following an explosion at this 460,000-bbl/d refinery. The explosion occurred in the isomerization unit, which had been shut down for its annual maintenance. This unit was gradually being brought back on stream when the incident occurred. Further investigations concentrated on a raffinate splitter, as evidence pointed to a release of a flammable liquid and vapor in that area of the plant. The distillation equipment was also being restarted following maintenance work on the reactor. Many of the dead had been attending a meeting in a pair of trailers near the area at the time of the explosion. The exact ignition source remains unknown, but evidence points to sources on the ground. Witnesses reported that there was a large hydrocarbon liquid and vapor release from a 30-meterhigh vent stack moments before the ignition.

FIRE/EXPLOSION	
EVENT DATE	01/04/2005
LOCATION	Fort McKay, Alberta, Canada
VALUE	US$190,000,000
ESTIMATED CURRENT VALUE	US$240,000,000

A fire broke out at this oil sands refinery in upgrader 2, an area of the plant that converts bitumen into crude oil products. Two hundred and fifty people were evacuated from the plant and no injuries were reported. The fire burned for nine hours before being extinguished. Witnesses reported two explosions, minutes apart, which sent a fireball six stories high into the air. The plant also suffered ice damage from water used to fight the fire as temperatures in the area fell below -35°C. On 3 February 2005, the company announced that a ruptured cycle line was the most likely cause of the fire. Oil production was reduced from 225,000 bbl/d to 110,000 bbl/d for about nine months.

FIRE/EXPLOSION	
EVENT DATE	01/06/2003
LOCATION	Fort McMurray, Alberta, Canada
VALUE	US$130,000,000
ESTIMATED CURRENT VALUE	US$200,000,000

This incident occurred at an oil sands facility, with minor explosions occurring in the froth treatment plant. Damage was limited to electrical cables in the solvent recovery area. The cause of the fire appears to have been a hydrocarbon leak from piping. The plant's emergency response team was assisted by the local fire brigade and the fire was extinguished in two hours. Only one minor injury was reported. The incident occurred eight days after the new facility began operating.

FIRE/EXPLOSION		Following torrential rain, rising floodwater allowed waste oil floating on its surface to be brought into contact with hot equipment, resulting in explosions and a fire. A second blaze broke out and several storage tanks reportedly caught fire and exploded. Damage to the refinery was extensive, and two people were killed with a further three reported missing. Later reports said that two or three production units had been affected by the fire. The processing units affected were the crude unit, the 20,000-bbl/d vacuum distillation unit, the 24,000-bbl/d catalytic reformer unit, and the 24,000-bbl/d distillate hydrotreater.
EVENT DATE	11/22/2002	
LOCATION	Port of Mohammedia, Morocco	
VALUE	US$140,000,000	
ESTIMATED CURRENT VALUE	US$200,000,000	
FIRE		This refinery, which produces 160,000 bbl/d of gasoline and distillates, was shut down due to a pool fire arising from a pipework release on the crude distillation unit. Three days later, the crude column suffered a structural failure due to an internal fire caused by air ingress from the previously ruptured pipework, pyrophoric material, and oil in the column. The crude distillation unit was shut down for 12 months. The cause of the initial pool fire was due to incorrect piping material specification in one elbow, which failed.
EVENT DATE	08/14/2001	
LOCATION	Lemont, Illinois, US	
VALUE	US$230,000,000	
ESTIMATED CURRENT VALUE	US$370,000,000	
FIRE		A piping leak resulted in a fire in this refinery coker unit. Smoke rose to above 3,000 feet and the coker was shut down for approximately two months.
EVENT DATE	04/23/2001	
LOCATION	Carson City, California, US	
VALUE	US$120,000,000	
ESTIMATED CURRENT VALUE	US$190,000,000	
FIRE		An oil spill occurred due to a failure of a block valve to seal properly during maintenance on a pump strainer in the visbreaker unit. The oil auto-ignited and the ensuing fire spread and destroyed the visbreaker and damaged adjacent equipment. Subsequent explosions and heat from the fire restricted firefighting access. Inadequately trained firebrigade personnel, and damage to the firewater distribution system, further hindered extinguishing the fire in a timely manner. The fire was spread by the firewater application and was extinguished with the help of the local fire department.
EVENT DATE	04/09/2001	
LOCATION	Wickland, Aruba, Dutch Antilles	
VALUE	US$160,000,000	
ESTIMATED CURRENT VALUE	US$250,000,000	
FIRE/EXPLOSION		An explosion occurred when employees were attempting to isolate a leak on a condensate line between an offsite NGL plant and the refinery gas plant. Three crude units were damaged and two reformers were destroyed. The fire was extinguished approximately nine hours after the initial explosion. Five people were killed and 50 others were injured. The initial investigation into the loss indicated a lack of inspection and maintenance of the condensate line, which was not owned by the refinery. Confusion caused by the ownership issue is also thought to have delayed the isolation of the line.
EVENT DATE	06/25/2000	
LOCATION	Mina Al-Ahmadi, Kuwait	
VALUE	US$510,000,000	
ESTIMATED CURRENT VALUE	US$810,000,000	

EARTHQUAKE		An earthquake measuring 7.4 on the Richter scale caused the collapse of a 312-foot high concrete chimney on to one of the crude units, setting off fires at this 226,000-bbl/d refinery. Fires also broke out on a number of storage tanks on the site. The process teams successfully isolated and tackled the crude unit fire. Fires on the tank farm were allowed to burn themselves out after storage tanks were pumped out as much as possible. Due to broken water mains, firefighting efforts were limited by attempts by aircraft to drop chemicals on the fires. The US and many other countries sent foam supplies, personnel, and equipment to fight the fires. Damage to the refinery included total loss of six storage tanks, and a further four storage tanks were deformed. There was some 50% damage to other floating roof tanks. Damage to process units included the fire on the crude distillation unit and damage to a reformer and several connecting pipelines.
EVENT DATE	08/17/1999	
LOCATION	Korfez, Gulf of Izmit, Turkey	
VALUE	US$200,000,000	
ESTIMATED CURRENT VALUE	US$330,000,000	
EXPLOSION		This explosion was caused by the failure of a valve bonnet in a high-pressure section of a 60,000-bbl/d hydrocracker. A vapor cloud formed from the release ignited and was followed by a large fire fed by escaping hydrocarbons at high pressure. The explosion resulted in the collapse of a large section of pipe rack and the destruction of a large fin fan cooler mounted above the rack. Many pumps were destroyed and a separator was badly damaged. Approximately 300 firefighters and 33 fire trucks participated in the two-and-a-half-hour effort to control the fire. Foam concentrate consumption totaled 3,200 US gallons. The hydrocracker was out of service for 12 months.
EVENT DATE	03/25/1999	
LOCATION	Richmond, California, US	
VALUE	US$110,000,000	
ESTIMATED CURRENT VALUE	US$190,000,000	
HURRICANE		This entire refinery was shut down for three months after being struck by Hurricane Georges. The hurricane left the entire plant submerged under more than four feet of salt water from the Gulf of Mexico. Although the hurricane was only a Category 2 storm, its slow movement subjected the refinery to 17 hours of high wind and rain. The storm surge overtopped the dikes built to protect the refinery. In all, approximately 2,100 motors, 1,900 pumps, 8,000 instrument components, 280 turbines, and 200 miscellaneous machinery items required replacing or extensive rebuilding. Newer control buildings and electrical substations sustained little or no damage as they had been built with their ground floors elevated approximately five feet above grade.
EVENT DATE	09/01/1998	
LOCATION	Pascagoula, Mississippi, US	
VALUE	US$190,000,000	
ESTIMATED CURRENT VALUE	US$320,000,000	
PROCEDURAL ERROR		This event occurred on a crude unit at this 360,000-bbl/d refinery. A furnace was undergoing maintenance when a worker performed a hot-cut and material was released. Inadequate flushing and blinding, and a work-scope that did not meet normal industry practices appear to be likely causes.
EVENT DATE	08/07/1994	
LOCATION	Ryazan, Russia	
VALUE	US$100,000,000	
ESTIMATED CURRENT VALUE	US$180,000,000	

FIRE

EVENT DATE 07/24/1994

LOCATION Pembroke, UK

VALUE US$78,000,000

ESTIMATED CURRENT VALUE US$140,000,000

A severe thunderstorm passed over this refinery between 07:20 and 09:00 on July 24. Lightning strikes resulted in a 0.4 second power loss and subsequent power dips throughout the refinery. Consequently, numerous pumps and overhead fin-fan coolers tripped repeatedly, resulting in the main crude distillation column pressure safety valves lifting. Major process unit upsets occurred in other refinery units, including those within the fluid catalytic cracking (FCC) complex.

The 90,000-bbl/d cracking complex included the FCC unit, butamer unit, alkylation unit, and an idle hydrogen plant. The refinery crude unit was shut down following ignition of vapor escaping from the main crude column pressure safety valves by a subsequent lightning strike. Except for the FCC unit itself, all other units in the cracking complex were also shut down. However, a process upset in the FCC unit's gas recovery section ultimately led to a high-liquid level in the on-plot flare drum and several shutdowns of the wet gas compressor together with other process anomalies.

As a result of the wet gas compressor shutdown, there was a large vapor load on the FCC flare system that led to a high liquid level in the on-plot flare drum. When the hydrocarbon liquid overflowed into the outlet line of this drum, the line ruptured due to mechanical shock. A pulsing leak appeared at the flare drum discharge elbow where the outlet line had ruptured and fallen to the ground.

The hydrocarbon liquid and vapor mixture released from this flare system became an explosive mixture that drifted within the process area prior to being ignited by a heater. The explosion, which occurred at 13:23 was centered in the process area approximately 360 feet (110 meters) from the FCC on-plot flare drum.

Following the explosion, a number of isolated fires continued to burn at locations within the boiling liquid expanding vapor explosion (BLEVE), butamer, and alkylation units. In view of the entrained hydrocarbons in damaged areas of the plant and a non-operative flare system, these small fires were allowed to burn out under controlled conditions, with the last fire being extinguished on the morning of July 27. The firefighting was handled by the refinery emergency services with assistance from the Dyfed County Fire Service.

As a result of this incident, an estimated 10% of the total refining capacity in the UK was lost until this complex was returned to service.

VAPOR CLOUD EXPLOSION

EVENT DATE 11/09/1992

LOCATION La Mede, France

VALUE US$220,000,000

ESTIMATED CURRENT VALUE US$440,000,000

Operations were normal at this 136,000-bbl/d refinery when a vapor cloud explosion occurred in the gas plant associated with the 29,700-bbl/d fluid catalytic cracker (FCC) unit.

The initial vapor cloud explosion and several subsequent lesser explosions could be heard in Marseilles, approximately 18 miles from the refinery. An estimated 11,000 pounds of light hydrocarbons were involved in the initial explosion.

At approximately 05:17, a gas detection system in the FCC unit sounded an alarm indicating a major gas leak. At approximately 05:20, while the unit operator was contacting the security service to warn of this situation, the initial explosion occurred. The initial gas release is believed to have resulted from a pipe rupture in the gas plant, which was used to recover butane and propane produced in the FCC unit.

The explosions and subsequent fires devastated about two hectares of this refinery, which covers an area of about 250 hectares. The gas plant, FCC unit, and associated control building were completely destroyed by the incident. Two new process units, which were under construction and scheduled to come into operation in 1993, were seriously damaged. Outside of the refinery, roofs were damaged in the nearby town of Chateauneuf les Martigues, and windows were broken within a radius of 3,000 feet. Some further windows were broken up to six miles away.

The refinery fire brigade and more than 250 firemen from three neighboring industrial sites and four nearby towns were utilized for more than six hours to bring this incident under control. Approximately 37,000 US gallons of foam concentrate were used during the firefighting effort. Some fires were intentionally left burning after the incident was under control at 11:30 in order to allow safe depressurizing of the process units, since the flare system was partially damaged by the explosions. All of the fires were extinguished by 17:30.

FIRE/EXPLOSION		An explosion and subsequent fire resulted in significant property damage at this 146,500-bbl/d refinery. The explosion occurred following a heat exchanger failure in the hydrodesulphurization unit for light oil. The channel cover and lock ring of this heat exchanger were hurled into an adjacent factory, which was located approximately 650 feet from this plant. The channel cover and lock ring were each five feet in diameter, and weighed 4,000 pounds and 2,000 pounds, respectively. The hydrodesulphurization unit was being restarted following catalyst exchanging work when plant personnel noticed that hydrocarbon was being released from the heat exchanger. Plant personnel were working to complete the additional tightening work required on the heat exchanger bolts due to thermal expansion when the explosion occurred at approximately 15:55. The subsequent fire was brought under control in two hours and 45 minutes by firefighters using 15 fire trucks.
EVENT DATE	10/16/1992	
LOCATION	Sodegaura, Japan	
VALUE	US$160,000,000	
ESTIMATED CURRENT VALUE	US$310,000,000	

FIRE/EXPLOSION		An explosion originating in the hydrogen processing unit occurred at 21:43 in this 75,000-bbl/d refinery. Extensive damage was caused to the hydrocracker, hydrodesulphurization, and hydrogen-processing units by the explosion and subsequent fires. The fires were fueled by hydrocarbons released from the damaged process column and equipment. The explosion, which damaged nearby buildings and shattered windows several miles away, was recorded as a 'sonic boom' at the California Institute of Technology in Pasadena, approximately 20 miles from this 350-acre refinery. The explosion resulted from the rupture of a six-inch-diameter carbon steel 90° elbow (outside radius) and release of a hydrocarbon-hydrogen mixture into the atmosphere. The vapor cloud ignited within seconds of the rupture at an undetermined point in the plant. A review of process data showed that there were no out-of-range or warning indications relevant to the incident until after the time the elbow had failed. The City of Los Angeles Department of Water and Power delivers electricity to the refinery and, about 12 hours before the incident, the city had a power outage. A review of the information showed that the power outage and restart were not contributory causes of the incident. An inspection after the failure found the line at nearly full design thickness a short distance away from the failure. On these facts, it was concluded that the line failure was the result of the thinning of the Schedule 120 carbon steel elbow due to long-term erosion/corrosion. The firefighting effort was coordinated by the refinery emergency response team, with the city of Los Angeles and Los Angeles county fire departments utilizing the joint incident command system. The refinery emergency response team, under the observation of the coast guard, placed booms in the Dominguez Channel storm drain to stop oily water runoff generated by the firefighting effort from reaching the Los Angeles harbor. The fire was finally extinguished at 02:00 on October 11. Because of this incident, the refinery's gasoline production was reduced to 35,000 bbl/d until repairs to the damaged process units were completed. By early May 1993, the repairs to these damaged units were reported to be 95% complete, and were finished shortly afterwards.
EVENT DATE	10/08/1992	
LOCATION	Wilmington, California, US	
VALUE	US$78,000,000	
ESTIMATED CURRENT VALUE	US$150,000,000	

VAPOR CLOUD EXPLOSION		An eight-inch-diameter pipeline operating at approximately 700 pounds per square inch ruptured, releasing a mix of ethane and propane. The record low temperature of 10°F for the region is believed to have contributed to the rupture. After a few minutes, the resulting vapor cloud was ignited, causing an unconfined vapor cloud explosion. The explosion shattered windows up to six miles away and could be felt as far as 15 miles away. Seventeen additional pipelines, in a pipe rack containing 70 lines, were ruptured by the explosion. The resulting fire involved two large storage tanks holding 3.6 million gallons of diesel, 12 small tanks containing a total of 882,000 gallons of lube oil, and two separator units. The explosion resulted in the partial loss of electricity, steam and fire water for the refinery since two power lines, two steam lines, and a 12-inch-diameter fire water line were located in this pipe rack. Upon the initial explosion, the lines for the dock fire pumps were damaged. Therefore, the water for firefighting had to be supplied with the remaining plant fire pumps and municipal fire trucks taking draught from alternate sources. Approximately 48,000 US gallons of AFFF concentrate, 200 fire brigade members, and 13 pumper units were used during the firefighting effort, which was successful in extinguishing the fire approximately 14 hours after the initial explosion. Because of this incident, the refinery was completely shut down for three days and operated at reduced capacity for an additional three weeks.
EVENT DATE	12/24/1989	
LOCATION	Baton Rouge, Louisiana, US	
VALUE	US$69,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

HURRICANE		Hurricane Hugo struck this refinery, causing extensive damage to 14 of the 500,000 to 600,000-bbl storage tanks in the tank farm area, the administration building, and the company housing. The damage to process units, which were idled in preparation for the hurricane, was limited to the asbestos insulation on process columns and piping. A maximum wind speed of 192 mph was reported for this hurricane before the wind-speed-measuring device at the St. Croix airport was damaged. Because of the damaged asbestos insulation, approximately 1,500 company employees and contractors worked seven days a week for 15 weeks to remove the asbestos debris from the refinery at a substantial extra expense. Additionally, an outside contractor specializing in the construction of atmospheric storage tanks worked for more than a year rebuilding the 14 storage tanks damaged in the tank farm area.
EVENT DATE	09/18/1989	
LOCATION	St Croix, Virgin Islands, US	
VALUE	US$170,000,000	
ESTIMATED CURRENT VALUE	US$350,000,000	

FIRE		A two-inch-diameter line carrying hydrogen gas at 3,000 pounds per square inch failed at a weld, resulting in a high pressure hydrogen fire. The fire resulted in flame impingement on the calcium silicate insulation of the skirt for a 100-foothigh reactor in a hydrocracker unit. The steel skirt for this reactor, which was between 10 and 12 feet in diameter and had a wall thickness of seven inches, subsequently failed. The falling reactor damaged air coolers and other process equipment, greatly increasing the size of the loss. At the time of the loss, the hydrocracker unit was being shut down for maintenance and the reactor was in a hydrogen-purge cycle. The initial hydrogen leak is believed to have resulted from the failure of an elbow-to-reducer weld in the two-inch-diameter hydrogen preheat exchanger bypass line. Because of this incident, approximately 25% of the refinery throughput capacity, including the complete hydrocracker unit production, was lost for a period of five months. Restoration of the hydrocracker itself required nearly two years.
EVENT DATE	04/10/1989	
LOCATION	Richmond, California, US	
VALUE	US$90,000,000	
ESTIMATED CURRENT VALUE	US$190,000,000	

VAPOR CLOUD EXPLOSION		Operations were normal in a 90,000-bbl/d fluid catalytic cracking (FCC) unit when internal corrosion caused the failure of the outside radius of an eight-inch-diameter carbon steel elbow located 50 feet above grade in the depropanizer column overhead piping system. An estimated 20,000 pounds of C3 hydrocarbons escaped through the resulting hole, forming a large vapor cloud during the 30 seconds between failure and ignition. Both the depropanizer column (operating at 270PSI and 130ºF) and the depropanizer accumulator depressurized through the opening. Ignition of the vapor cloud was probably caused by the FCC charge heater. The initial blast destroyed the FCC control building and toppled the 26-foot diameter main fractionator from its 15-foothigh concrete pedestal. The column separated from its 10-foot high skirt before falling. Analysis of bolt -stretching of towers in the blast path indicated pressures as high as 10PSI. The refinery immediately lost all utilities, including firewater and the four diesel fire pumps, greatly limiting the firefighting effort for several hours. Steam pressure dropped abruptly due to severed lines. Twenty major line or vessel failures occurred in the FCC and elsewhere throughout the 215,000-bbl/d refinery. Blast damage throughout the plant was extensive, but was most severe in the FCC unit. About 5,200 property claims were received for off-site damage at distances of up to six miles. The FCC unit was eventually demolished and a new unit was constructed. A preliminary report stated that the failed elbow was located downstream of an injection point where ammoniated water was added to reduce depropanizer condensation or fouling. The elbow was a designated inspection point in the overhead piping system for taking ultrasonic thickness measurements during turnarounds. These inspections had constantly confirmed expected corrosion rates of 0.05 mils per year. Measurements taken at the failed elbow and in the downstream piping after the explosion revealed unexpectedly high localized corrosion rates.
EVENT DATE	05/05/1988	
LOCATION	Norco, Louisiana, US	
VALUE	US$290,000,000	
ESTIMATED CURRENT VALUE	US$610,000,000	
FIRE		A straight run of eight-inch-diameter pipe carrying hot oil fractured in this refinery's hydrodesulphurizer. The pipe was carrying hot oil from the high-pressure separator to the low-pressure stripper. The fracture ran circumferentially in the parent metal in the heat zone about 1.5 inches from a weld. Hot oil at 700PSI and 650°F sprayed across the roadway into the hydrogen units where ignition occurred. An intense fire around the pipeway in the hydrogen plant caused a 16-inch-diameter gas line to rupture, adding a second source of fuel to the fire. In successive order, more pipes ruptured with explosive force in adjacent areas. The fire caused a crash shutdown of the entire 600,000-bbl/d refinery. After six and a half hours, the fire was extinguished. Damage was extensive. The three hydrogen plants and the four hydrodesulphurization (HDS) units were heavily damaged or destroyed. Four years after the plant was built, and nine years before the loss, the line which failed was judged as having excessive vibration. It is believed that the hot oil line failed due to fatigue, in turn, largely due to hydrogen embrittlement.
EVENT DATE	12/13/1984	
LOCATION	Amuay, Venezuela	
VALUE	US$62,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	
FIRE		Erosion failure in a 10-inch-diameter slurry recycle oil line in an 82,000-bbl/d fluid bed coking unit released liquids at close to their auto-ignition temperature. Vapors that covered a large area ignited almost immediately, resulting in a large area ground fire, which led to the failure of six or seven more lines. The fire eventually extended over a 150-foot-diameter area with damage up in the unit structure to above 100 feet. Metallurgical examination revealed that a 1.8-inch-long piece of carbon steel pipe had inadvertently been inserted into the 5-chrome slurry recycle line during an earlier metals inspection. The reactor fractionator, light gas oil stripper, 15,000 hp air blower, pumps, and pipe racks were severely damaged or destroyed. About 2,700 barrels of hydrocarbon liquids were released from process equipment during the fire. Much of this was by gravity flow from ruptured lines, although pumps, which could not be shut down, contributed to much of the flow. A 900PSIG steam line that supplied the turbine drivers of the compressors, ruptured, thereby hampering firefighting efforts.
EVENT DATE	08/15/1984	
LOCATION	Fort McMurray, Alberta, Canada	
VALUE	US$76,000,000	
ESTIMATED CURRENT VALUE	US$180,000,000	

VAPOR CLOUD EXPLOSION		Just prior to the rupture of a 55-foottall, 8.5-footdiameter monoethanolamine absorber column, a refinery operator noted a six-inch-long horizontal crack at a circumferential weld that was leaking propane. As the operator attempted to close the inlet valve, the crack spread to about 24 inches. The area was being evacuated and the plant fire brigade was arriving when the column failed massively. Propane at 200PSIG and 100º F propelled most of the 20-tonne vessel 3,500 feet, where it struck and toppled a 138,000-volt power transmission tower. The weld separation occurred along a lower girth weld joint made during a repair to the column 10 years earlier. The vessel was constructed of one-inch-thick SA 516 Gr 70 steel plates rolled and welded with full penetration submerged arc joints, but without post-weld heat treatment. This explosion resulted in severe fires in the unsaturated gas plant, as well as fires in the fluid catalytic cracker (FCC) and the alkylation units. After about 30 minutes, a BLEVE occurred in a large process vessel in the alkylation unit. One piece of this vessel travelled 500 feet, shearing off pipelines before striking a tank in the water treatment unit. Another fragment landed in a unifining unit more than 600 feet away, causing a major fire where it landed. The first explosion, believed to be from an unconfined vapor cloud, broke windows up to six miles from the plant. The explosion also caused extensive structural damage to refinery service buildings and disrupted all electric power at the refinery, rendering a 2,500-US-gallon-per-minute (US gpm) electric fire pump inoperable. One explosion sheared off a hydrant barrel, resulting in a reduction of fire water pressure from the two 2,500-US-gpm diesel-engine-driven fire pumps, which were operating at the time. The refinery's blast resistant control center, approximately 400 feet northeast of the absorber, sustained little structural damage. An estimated 30 paid and volunteer public fire departments, together with equipment from refineries and chemical plants within a 20-mile radius, responded promptly. Many of the pumpers took suction from the adjoining canal and from a quarry. The pumpers and a 12,000-US-gpm fireboat eventually provided water at pressures sufficient for firefighting.
EVENT DATE	07/23/1984	
LOCATION	Romeoville, Illinois, US	
VALUE	US$190,000,000	
ESTIMATED CURRENT VALUE	US$450,000,000	

FIRE		The cause of the loss, which started in the alkylation unit tank farm, is unknown. An unidentified failure led to the release of light hydrocarbons, which spread to an ignition source. A rather intense fire followed in the tank farm. In less than five minutes a 5,000-bbl sphere failed, causing a tremendous fireball and sending pieces of the sphere throughout the plant. Within the next 20 minutes, five 1,000-bbl horizontal vessels, four 1,000-bbl vertical vessels, and one additional 5,000-bbl sphere failed from either missile damage or BLEVEs. Pieces of the tanks traveled in all directions, falling into a number of operating units and tank farms, starting more fires. Fragments also hit the fire water storage tank and electric fire pumps, leaving only the two diesel fire pumps operational.
EVENT DATE	05/30/1978	
LOCATION	Texas City, Texas, US	
VALUE	US$55,000,000	
ESTIMATED CURRENT VALUE	US$190,000,000	

PETROCHEMICALS

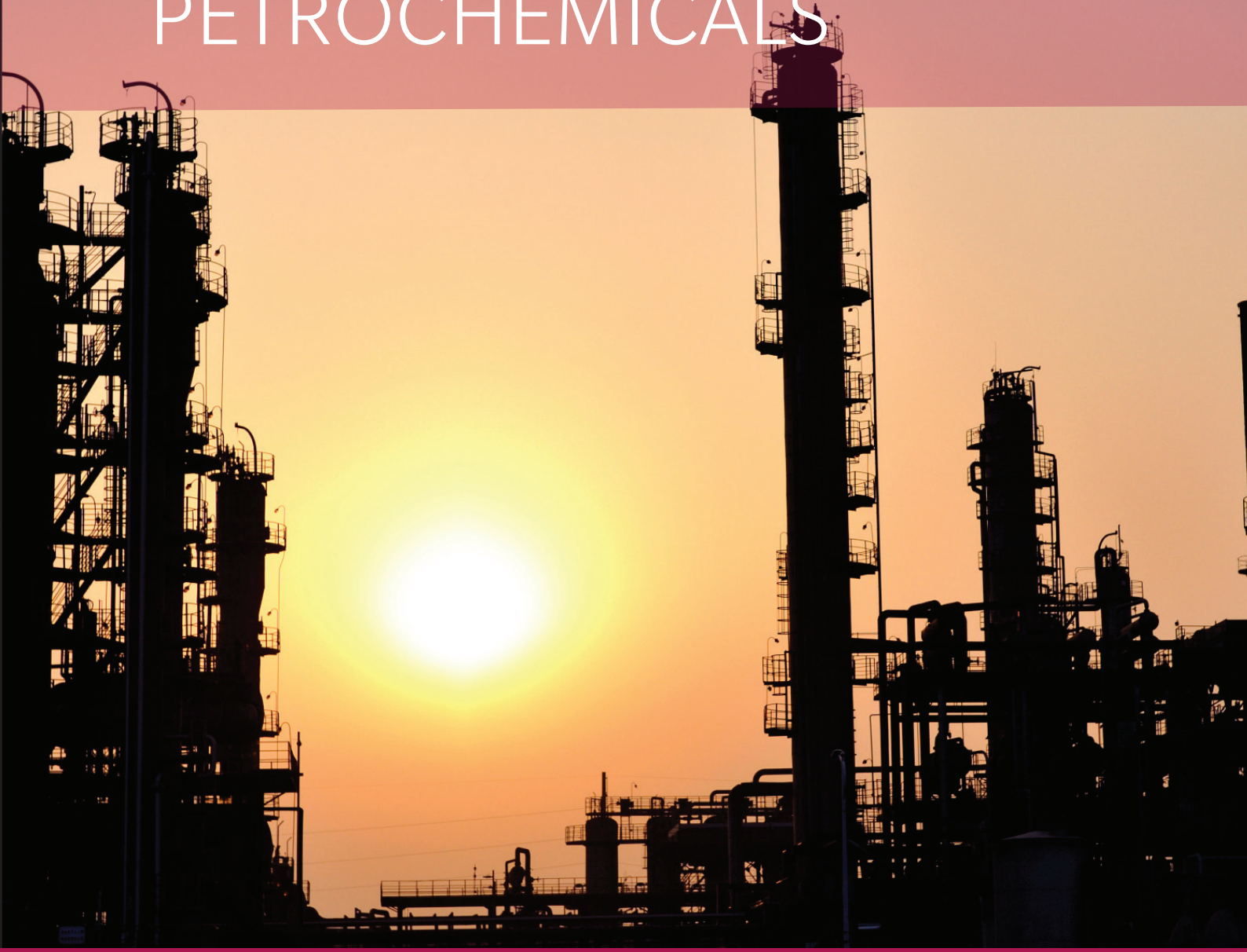
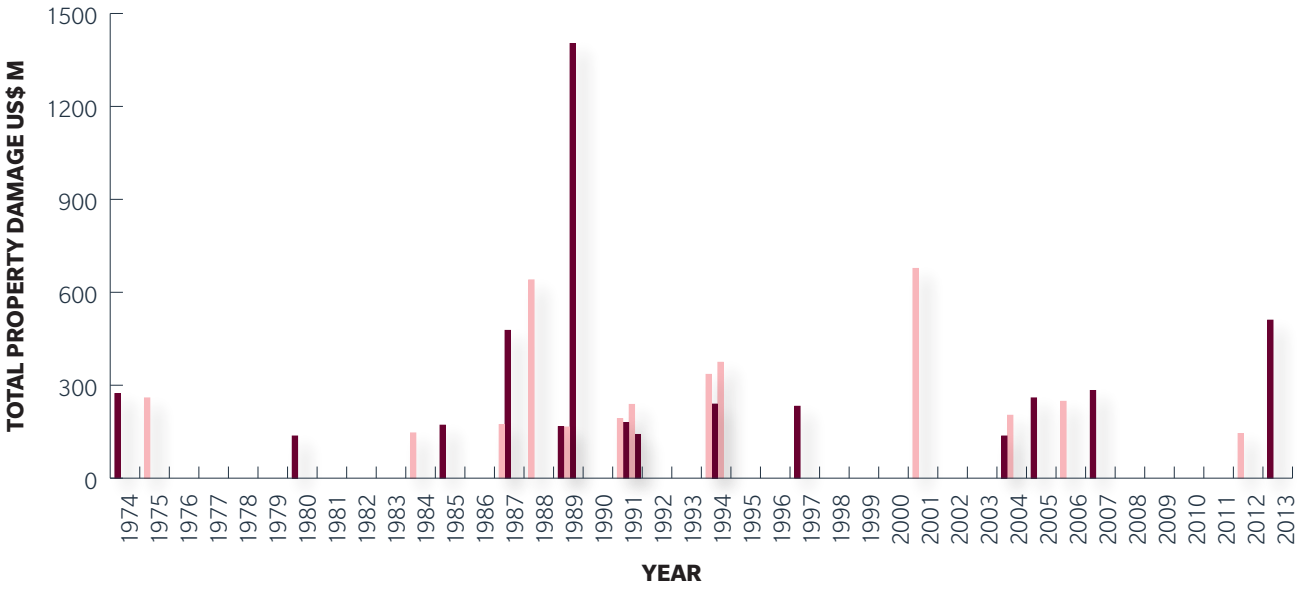


FIGURE 4: PETROCHEMICAL PROPERTY DAMAGE BY YEAR



Note

Figure 4 shows the distribution of the property loss value of petrochemical incidents in the set of 100 largest losses, inflated to 2013 values.

Figure 4 is dominated by the one event in Texas in 1989. In general, there are no strong trends demonstrated in the graph. There was a cluster of large losses between 1985 and 1995; since then, major losses in the sector have been less common. We would hope this reflects changes made by designers, operators, and regulators having learned lessons from the serious losses to improve designs, safety measures, and safe working practices. However, major losses are still occurring in the industry at a rate of about one per year, and we have seen three major losses in this sector over the past two years.

PETROCHEMICALS

FIRE/EXPLOSION		Two people were killed and 76 injured in an explosion and fire at a petrochemical plant. The fire burned for more than three hours. The plant produces ethylene and propylene. The explosion prompted the evacuation of about 300 people. The explosion is thought to have originated in the propylene fractionator. Piping, heat exchangers, and the reboiler were badly damaged by the explosion. Large portions of electrical cabling and control wiring, as well as support structures and piping, were damaged. Restart is expected in April 2014, incorporating an expansion of the unit's capacity by about 50%.
EVENT DATE	06/13/2013	
LOCATION	Geismar, Louisiana, US	
VALUE	US$510,000,000	
ESTIMATED CURRENT VALUE	US$510,000,000	

FIRE/EXPLOSION		At least 12 people were killed and 129 injured in an explosion and fire at a petrochemicals plant that manufactured polybutadiene. In addition, thousands of people were evacuated from adjacent factories and communities within a three-kilometer radius of the site. The explosion and subsequent fire sent thick black smoke into the air above the site. The deaths and injuries were as a result of blast injuries, burns, and inhalation of toxic fumes. It was reported that the explosion and fire occurred while workers were cleaning the polymer production line to change between batches, and using toluene as a cleaning solvent.
EVENT DATE	05/05/2012	
LOCATION	Map Ta Phut, Thailand	
VALUE	US$140,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

FIRE/EXPLOSION		An accident occurred at one of the methylcellulose manufacturing facilities located at this site. At 16:26, an explosion occurred and was followed by a fire. The fire was extinguished at 23:11 the same day. Seventeen people who were working at the site were injured in this accident; three critically, five seriously, and nine had minor injuries. There was one minor injury offsite. Static electricity induced the ignition of methylcellulose powders, resulting in a powder-dust explosion. All methylcellulose operations were suspended for two months before sequentially restarting.
EVENT DATE	03/20/2007	
LOCATION	Niigata, Japan	
VALUE	US$240,000,000	
ESTIMATED CURRENT VALUE	US$280,000,000	
FIRE/EXPLOSION		A shelter-in-place was ordered when a fire broke out following an explosion in the propylene refrigeration section of an ethylene unit. The fire, which burned for three days, forced the shutdown of the facility for some six months, but caused no deaths or serious injuries.
EVENT DATE	04/29/2006	
LOCATION	Texas, US	
VALUE	US$200,000,000	
ESTIMATED CURRENT VALUE	US$250,000,000	
EXPLOSION		A release of hexane created a vapor cloud that ignited on an electric motor, causing an explosion. This resulted in damage to the unit and some 20 injuries. The plant was eventually replaced.
EVENT DATE	12/10/2005	
LOCATION	Münchsmünster, Germany	
VALUE	US$200,000,000	
ESTIMATED CURRENT VALUE	US$260,000,000	
EXPLOSION		Five people were killed and two seriously injured following an explosion at a plastics plant producing 200 million barrels per year of specialty grade PVC. The highway was shut and local residents evacuated. The explosion occurred in a reactor where vinyl chloride and vinyl acetate were being mixed. Up to 75% of the plant was destroyed in the explosion. The explosion was felt eight kilometers away. OSHA later imposed fines of US$361,500 against the company, saying that it had found dozens of safety violations from defective equipment to poor worker training. There were three willful violations (failing to maintain fire protection equipment, inadequate inspection of equipment used to process hazardous materials, and failure to repair equipment involved with dangerous chemicals) and 45 other serious violations.
EVENT DATE	04/23/2004	
LOCATION	Illiopolis, Illinois, US	
VALUE	US$150,000,000	
ESTIMATED CURRENT VALUE	US$200,000,000	
FIRE		A machine at a chemical plant overheated, resulting in a fire which spread, engulfing the plant compound. Two people were killed in the incident, and 68 injured. Several hundred people were evacuated and at least five houses near the plant were destroyed.
EVENT DATE	01/20/2004	
LOCATION	Gresik, East Java, Indonesia	
VALUE	US$100,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

EXPLOSION		An explosion at this fertilizer plant killed 31 people, and hospitalized more than 600. The blast, which occurred in a tower containing 200 to 300 tonnes of ammonium nitrate, shattered windows, and ripped doors from their hinges in the center of the city, 3 km away. Two chimneys and several buildings were flattened, and more than 3,000 homes were damaged, 500 of which were reported uninhabitable. There was a secondary blast at a nearby explosives factory, said to be caused by sparks from the first explosion. The thick red and yellow fumes that spread over the city were first thought to be toxic and the public was advised to remain indoors. The blast left a crater 50 meters in diameter and 15 meters deep.
EVENT DATE	09/21/2001	
LOCATION	Toulouse, France	
VALUE	US$430,000,000	
ESTIMATED CURRENT VALUE	US$680,000,000	

FIRE/EXPLOSION		An explosion and fire occurred in an olefins unit at this petrochemical plant. The incident originated at the cracked-gas compressor in the olefins unit and was caused by a failed air-assisted check valve on a five-inch-diameter, 500-PSI-discharge line from the compressor. Upon closure of the check valve, one of the pins holding the two-piece check valve stem broke and allowed it to open in the opposite direction. This led to a gas leak, ignition, explosion, and ensuing fire at the partially enclosed compressor building. The explosion damaged a line to the quench tower, which fed the fire. The fire was allowed to burn itself out. About 30 workers were treated for minor injuries.
EVENT DATE	06/22/1997	
LOCATION	Deer Park, Texas, US	
VALUE	US$130,000,000	
ESTIMATED CURRENT VALUE	US$230,000,000	

EXPLOSION		Shortly after 06:00, an explosion occurred in the ammonium nitrate process area of this plant. As a result of the explosion, the seven-story main process building was completely destroyed and a 30-foot-diameter crater was created. Additionally, metal fragments from the explosion punctured one of the plant's two 15,000-tonne refrigerated ammonia storage tanks. The punctured tank released an estimated 5,700 tonnes of ammonia, causing the evacuation of approximately 2,500 people from the surrounding area. Metal fragments also punctured a nitric acid tank, resulting in the release of approximately 100 tonnes of this acid. The explosion tore metal siding from adjacent buildings, damaged three third-party electric generating stations, broke windows of buildings 16 miles away in Sioux City, and was felt more than 30 miles away.
EVENT DATE	12/13/1994	
LOCATION	Port Neal, Iowa, US	
VALUE	US$200,000,000	
ESTIMATED CURRENT VALUE	US$370,000,000	

FLOODING		The Texas floods along the San Jacinto river shut down this site. The site's capacity was as follows: 650,000 tonnes per year (t/y) ethylene, 200,000 t/y LLDPE, and 280,000 t/y LDPE. Flood water breached dikes around the main substation and inundated control rooms and offices. The loss of utilities affected further downstream clients. The original loss figure of US$130 million contains an element of business interruption.
EVENT DATE	10/20/1994	
LOCATION	Cedar Bayou, Texas, US	
VALUE	US$130,000,000	
ESTIMATED CURRENT VALUE	US$240,000,000	

EXPLOSION		At approximately 06:30, an abnormal chemical reaction occurred during the batch production of a thermoplastic rubber product, resulting in an explosion at this plant. As a result of the explosion, the reactor, process controls, appurtenances, control room, and building for this production unit were completely destroyed. The fire then spread to involve part of the tank farm, resulting in the destruction of five atmospheric storage tanks. At approximately 12:30, the first of four 1-million-US gallon styrene storage tanks exploded, along with one 500,000 US-gallon tank. A firefighting attack utilizing cooling water and foam hose streams was used to prevent the fire from involving other nearby storage tanks, two of which contained butadiene. The fire was extinguished at approximately 15:30.
EVENT DATE	05/27/1994	
LOCATION	Belpre, Ohio, US	
VALUE	US$180,000,000	
ESTIMATED CURRENT VALUE	US$330,000,000	

EXPLOSION		At this petrochemical site, the failure of a welded joint between a carbon dioxide stripper and the main cylindrical body resulted in the release of gas under high pressure. The release consisted of ammonia, carbon dioxide, and carbamate liquids. Subsequent to the release, an explosion took place that caused significant damage to this fertilizer plant. The source of ignition for this explosion is unknown. This plant, which was constructed in 1970 and upgraded in 1988, had an annual production capacity of 340,000 tonnes.
EVENT DATE	06/20/1991	
LOCATION	Dhaka, Bangladesh	
VALUE	US$71,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

FIRE/EXPLOSION		Workers were preparing to check a compressor in the nitroparaffin unit when they noticed a small fire and sounded the plant fire alarm. Approximately 30 seconds later, an explosion occurred, which was followed by a series of smaller explosions. The effects of the initial explosion were reported as far away as eight miles from the plant. Additionally, the initial explosion completely damaged an area of the plant approximately the size of a city block. Subsequent fires were reported to have burned for more than seven hours. Although the incident did not damage the two ammonia units on site, the entire plant was temporarily shut down for precautionary measures.
EVENT DATE	05/01/1991	
LOCATION	Sterlington, Louisiana, US	
VALUE	US$120,000,000	
ESTIMATED CURRENT VALUE	US$240,000,000	

EXPLOSION		At 01:18, an explosion occurred in the ethylene oxide process unit at this plant. As a result of the explosion, the ethylene oxide refining column was completely destroyed, the ethylene glycol unit was substantially damaged, and the cogeneration unit was partially damaged. A pipe rack near the storage area for liquid ethylene oxide was damaged when a large piece of shrapnel from the explosion hit the rack, rupturing lines that contained methane and other hydrocarbon products. The subsequent fire that resulted from the released products was the only significant fire to occur during the incident. As a result of the explosion, all utilities at the plant were lost for approximately one week. Additionally, a significant number of the water-spray systems were damaged by the explosion or inadvertently actuated due to a loss of plant air. These systems were shut off and placed back in service as appropriate. A manual firefighting effort was used to extinguish the fire involving the pipe rack once the lines in the rack were isolated. As a result of this incident, a business interruption loss resulted mainly from the almost full-year reduction in ethylene oxide production. The polyethylene production was restarted in early April 1991, utilizing imported ethylene, while the olefins production was restarted in late April 1991.
EVENT DATE	03/12/1991	
LOCATION	Seadrift, Texas, US	
VALUE	US$90,000,000	
ESTIMATED CURRENT VALUE	US$180,000,000	

FIRE/EXPLOSION		At approximately 08:30, a gas leak involving the pipe rack that runs from Cangrejera to the terminal in this petrochemical complex, led to an explosion. This explosion, which occurred near to the complex chemical plant, caused additional damage to the pipe rack, resulting in a major gas leak. A powerful second explosion occurred that could reportedly be felt more than 15 miles from the complex. This explosion and the subsequent fire completely destroyed the chemical plant, caused significant damage to the pipe rack, and resulted in moderate damage to other complex buildings and adjacent third-party facilities. The fire was extinguished in approximately three hours. Because of this incident, the chemical plant at this complex was completely shut down for seven months, being the time required to rebuild the plant and the pipe rack. During this period, the vinyl chloride production at this complex was lost, disrupting most of Mexico's total annual output of 200,000 tonnes.
EVENT DATE	03/11/1991	
LOCATION	Pajaritos, Mexico	
VALUE	US$97,000,000	
ESTIMATED CURRENT VALUE	US$190,000,000	
VAPOR CLOUD EXPLOSION		Shortly after 13:00, a large flow of ethylene (the reactant) and isobutane (a catalyst carrier) was released from one of the high-density polyethylene (HDPE) units at this chemical complex. The vapor cloud drifted northward toward the center of the HDPE process area before ignition, which is believed to have occurred approximately 60 seconds after the release. Seismograph data from recording stations in the area suggested the blast was equivalent to the detonation of 10 tonnes of TNT. The explosion destroyed two HDPE units, which included a total of eight particle form, loop-reactor trains. The heat from the explosion caused BLEVEs of nearby pressurized storage tanks. Other process units at this chemical complex sustained only minor damage and resumed normal production within a few weeks of the incident. The initial release of ethylene and isobutane occurred through an eight-inch-diameter ball valve on the no. 4 settling leg of a reactor in Plant V. The major function of this pneumatic valve is to isolate the settling leg and other downstream equipment from the reactor for maintenance. The company maintenance procedures for opening a settling leg included closing the ball valve, inserting a lockout device into this closed valve, closing the block valves to the air hoses for the valve operator, and disconnecting these air hoses. Company personnel confirmed that these maintenance procedures were performed on Saturday, October 21. Due to changes in maintenance priorities, the work on settling leg no. 4 was not started until Monday, October 23. After the explosion, investigations indicated that the lockout device had been removed from the valve and the air hoses had been reconnected to the valve operator on settling leg no. 4. The valve was found in the open position, and the settling leg was open to atmosphere at the bottom of the leg where a swedge/reducer spool leading to the product take-off valve should have been connected. A significant business interruption loss resulted from this incident, since a period of approximately 24 months was required to restore the full HDPE production capacity at this chemical complex. This incident still represents the largest single-owner property damage loss to occur in the petrochemical industry.
EVENT DATE	10/23/1989	
LOCATION	Pasadena, Texas, US	
VALUE	US$670,000,000	
ESTIMATED CURRENT VALUE	US$1,400,000,000	
EXPLOSION		A hairline crack in a welded seam of piping to the level indicator system on the aldehyde column resulted in a minor ethylene oxide leak on this gas-processing plant. As a result of this crack, which was caused by low cycle fatigue, ethylene oxide escaped near the level indicator and formed polyethylene glycols (PEG) in the mineral wool insulation. It is believed that both the leak and accumulation of PEG occurred over a period of time. During repairs to the level indicator, the metal sheathing of the insulation was removed and air contacted the insulation soaked with PEG. Auto-oxidation of the PEG resulted, and the insulating material was ignited. The piping for the level indicator system was heated to such a degree that auto-decomposition of the ethylene oxide within the piping occurred. This auto-decomposition then propagated into the aldehyde column, which subsequently exploded. The force of the explosion completely destroyed the distillation section of this plant. The large resulting fire and impact of flying debris to other process sections resulted in extensive damage throughout the plant. Because of this incident, this plant was closed for at least 24 months, resulting in an additional business interruption loss of approximately US$270 million.
EVENT DATE	03/07/1989	
LOCATION	Antwerp, Belgium	
VALUE	US$79,000,000	
ESTIMATED CURRENT VALUE	US$160,000,000	

EXPLOSION		A runaway reaction triggered an explosion and fire that destroyed the plant and a neighboring building. It is believed this occurred when the wrong components were added to chemical mixture.
EVENT DATE	02/14/1989	
LOCATION	Antwerp, Belgium	
VALUE	US$80,000,000	
ESTIMATED CURRENT VALUE	US$170,000,000	
EXPLOSION		An explosion at a plant that manufactured ammonium perchlorate (AP) for rocket fuel, flattened the local industrial park, left a crater 125 meters in diameter, and cracked walls 15 miles away. Two people were killed. The cause was thought to be a fire in a batch dryer. The initial explosion was at 11:53 and was equivalent to 108 tonnes of TNT, with a second explosion at 11:57 equivalent to 235 tonnes of TNT. Approximately 50% of the buildings in the nearby town of Henderson, Nevada, were destroyed at cost of US$70 million. A natural gas pipeline that ran under the plant was ruptured in the event and burned for one week.
EVENT DATE	05/04/1988	
LOCATION	Henderson, Nevada, US	
VALUE	US$300,000,000	
ESTIMATED CURRENT VALUE	US$640,000,000	
VAPOR CLOUD EXPLOSION		At 15:50 on Saturday afternoon, an explosion occurred in an air-line in a reactor used for the liquid phase oxidation of butane as it was being started up. The explosion ruptured the external portion of the air-line to the reactor, allowing the reactor contents to rapidly vaporize and form a vapor cloud. A vapor cloud explosion occurred about 25 to 30 seconds after the first explosion. There was extensive property damage in the immediate area and significant damage throughout the site. Windows were broken seven miles away. The root cause was believed to be insufficient purging of the reactor when it was shut down.
EVENT DATE	11/14/1987	
LOCATION	Pampa, Texas, US	
VALUE	US$210,000,000	
ESTIMATED CURRENT VALUE	US$480,000,000	
EXPLOSION		An explosion occurred in the final purification column of this plant, resulting in 14 people being injured. The explosion initiated several secondary fires on the original units as well as others nearby, but all were under control within 30 minutes. The root cause was confirmed to be a rapid increase in column pressure due to the decomposition of material within it, although the original ignition source has never been confirmed.
EVENT DATE	07/03/1987	
LOCATION	Zwijndrecht, Antwerp, Belgium	
VALUE	US$78,000,000	
ESTIMATED CURRENT VALUE	US$170,000,000	

FIRE		Operations within this 600,000-t/y ethylene plant were normal until a faulty temperature probe initiated an isolation of the hydrogenation equipment located within the cold section. While the operators were attempting to regain normal control, the pressure relief system came into operation. At about the same time, fire was noted near grade level at the base of the de-ethanizer column. The source of fuel is believed to be a flange at the de-ethanizer column reboiler, or in the relief system pipe work. Leaking hydrocarbon, mostly propylene at 375 pounds per square inch gauge, was possibly ignited by hot steam piping. The intense fire rapidly engulfed the adjoining ethylene and propylene distillation columns, and spread 180 feet to the storage area. Eventually one vertical pressurized propane storage tank exploded; its top section travelling 1,500 feet and missing a gas holder by 30 feet. Two other propylene tanks toppled; one onto a pipe rack and another against an ethylene tank. All were protected by deluge waterspray systems that, apparently, were ineffective under the intense fire exposure. Five of the eight ethylene and propylene tanks collapsed or exploded. The fire also spread to the API separator and to three floating roof tanks. Pipe racks, motor control centers, and pumps were severely damaged or destroyed. Within a few minutes after the fire brigade responded, the ethylene column released its 9,300-US-gallon inventory, destroying one of the plant's two foam trucks. Assisted by outside firefighting agencies, the plant fire brigade brought the fire under control in 40 hours, and finally extinguished it four days after ignition.
EVENT DATE	05/19/1985	
LOCATION	Priolo, Italy	
VALUE	US$74,000,000	
ESTIMATED CURRENT VALUE	US$170,000,000	

FIRE		A fire occurred in this petrochemical site's oxidation plant. 130 firemen using 25 appliances controlled the blaze after four hours. The local railway line, ship canal, and roads were closed, and 200 people were evacuated. The plant was rebuilt with larger spacing to obtain the authority's approval.
EVENT DATE	09/15/1984	
LOCATION	Cheshire, UK	
VALUE	US$62,000,000	
ESTIMATED CURRENT VALUE	US$150,000,000	

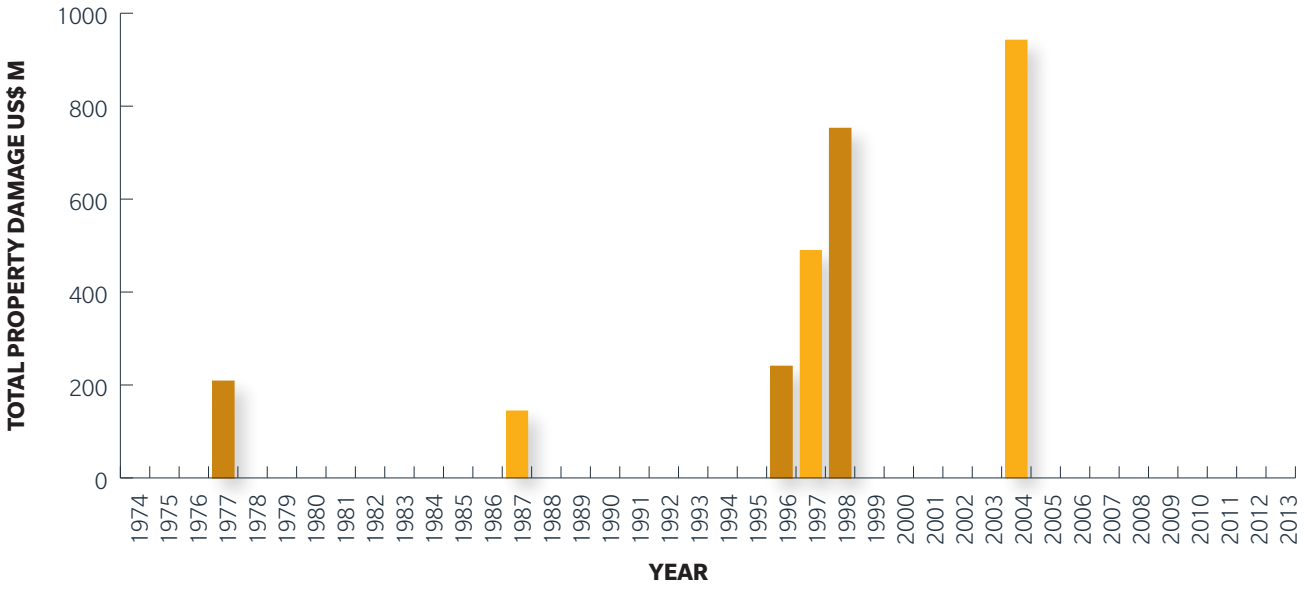
VAPOR CLOUD EXPLOSION		Improper maintenance procedures at this petrochemical site resulted in a vapor cloud explosion during cleaning of a plugged recycle cooling line on a 10,000-US-gallon polypropylene reactor. Instead of removing only the motor operator of a four-inch-diameter plug valve, the valve itself was accidentally removed. The release of between 12,000 to 16,000 pounds of monomer produced a vapor cloud that ignited after approximately two minutes. The explosion broke flammable liquid lines throughout the three process trains and opened polymer lines in the finishing area. The blast also broke fire protection system risers, disrupting all firewater. Fires throughout the polymerization finishing and storage silo areas burned for more than 10 hours. Two of the three process lines, the control building, and the finishing area were severely damaged. The compressor building, solvent recovery area, finished product warehouse, and cooling tower were moderately damaged.
EVENT DATE	10/29/1980	
LOCATION	Newcastle, Delaware, US	
VALUE	US$45,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

FIRE/EXPLOSION		An explosion and fire caused extensive damage at a low density polyethylene plant. The cause was a leak of ethylene at high pressure due to fatigue failure of a vent connection on the suction of a compressor. Six people were killed, and 13 injured.
EVENT DATE	10/02/1975	
LOCATION	Antwerp, Belgium	
VALUE	US$60,000,000	
ESTIMATED CURRENT VALUE	US$260,000,000	

VAPOR CLOUD EXPLOSION		This chemical facility was severely damaged by a large vapor cloud explosion. Twenty-eight workers were killed, and a further 36 suffered injuries. The number of fatalities would have been higher had it not been a weekend, as the main office block was not occupied. Offsite consequences resulted in 53 reported injuries. Properties in the surrounding area were damaged to varying degrees. Prior to the loss, a reactor had been removed and a bypass assembly was installed to enable production to continue. On June 1, the 20-inch bypass system ruptured. This may have been caused by a fire on a nearby eight-inch pipe. This resulted in the release of 30 tonnes of hot cyclohexane that formed a flammable cloud and subsequently found a source of ignition. Eighteen fatalities occurred in the control room as a result of windows shattering and the collapse of the roof. The ensuing fires burned for more than three days.
EVENT DATE	06/01/1974	
LOCATION	Flixborough, UK	
VALUE	US$57,000,000	
ESTIMATED CURRENT VALUE	US$270,000,000	

GAS PROCESSING

FIGURE 5: GAS PROCESSING PROPERTY DAMAGE BY YEAR



Note

Figure 5 shows the distribution of the property loss value of gas plant incidents in the set of 100 largest losses, inflated to 2013 values.

Large losses with a value of more than US$130 million do not happen frequently in this sector. The materials processed in gas plants are generally less corrosive than those in the upstream or refining sectors. However, losses have occurred and there is a general upward trend in the value of the losses. This probably reflects an increase in size, complexity, and value concentration on gas-processing facilities over 40 years. New plants have been built, and projects continue to be developed to liquefy, transport, and regasify natural gas, although it is considered that these new projects generally incorporate good risk management practices and apply standards to minimize the risk, such as good layout, separation, and standards of process isolation.

GAS PROCESSING

FIRE/EXPLOSION		A gas release (understood to be from a corroded pipe) resulted in an explosion at this gas plant in Western Australia. Subsequently a 30% reduction in the state's domestic gas supply occurred as well as a 45% reduction in gas supplies to mines and other industries. 153 workers on the island were evacuated as a precaution, with only a skeleton crew remaining behind. The release was from a 30-centimeter-diameter pipeline, and has been attributed to an ineffective anti-corrosion coating, combined with poor inspection and monitoring. Some 60% of the plant's capacity was restored within three months, with the plant completely back online after approximately six months.
EVENT DATE	06/03/2008	
LOCATION	Varanus Island, Australia	
VALUE	US$120,000,000	
ESTIMATED CURRENT VALUE	US$130,000,000	

FIRE/EXPLOSION		An explosion at this liquid natural gas (LNG) plant killed 27, injured 72, and resulted in seven missing persons. The explosion destroyed three out of six liquefaction trains, damaged a nearby power plant, and led to the shutdown of a 335,000-bbl/d refinery. There was also some damage to the neighboring industrial facilities. A faulty boiler was initially blamed for the incident. Investigations, however, indicated that a large release of hydrocarbon from a cold-box exchanger was ignited upon ingestion into the boiler. Train 6 of the LNG complex restarted in May 2004, and trains 5 and 10 in September 2004. Trains 20, 30, and 40 were destroyed in the incident representing 50% of the capacity of the LNG complex.
EVENT DATE	01/19/2004	
LOCATION	Skikda, Algeria	
VALUE	US$690,000,000	
ESTIMATED CURRENT VALUE	US$940,000,000	

EXPLOSION		Gas supplies to Australia's Victoria State were virtually shut down following an explosion and fire at this gas-processing plant. The specific cause of the accident was attributed to the rupture of a heat exchanger, following a process upset that was set in motion by the unintended, sudden shutdown of hot oil pumps. The loss of hot oil supply allowed some vessels to be chilled by cold oil, and when the hot oil was re-introduced to the heat exchanger, the vessel ruptured due to a brittle fracture. An initial release of approximately 22,000 pounds of hydrocarbon vapor exploded, and an estimated 26,000 pounds burned as a jet fire. The fire burned for two and a half days. Operator error and improper training of employees was cited in the report issued by the Longford Royal Commission formed to study the incident.
EVENT DATE	09/25/1998	
LOCATION	Longford, Victoria, Australia	
VALUE	US$440,000,000	
ESTIMATED CURRENT VALUE	US$750,000,000	

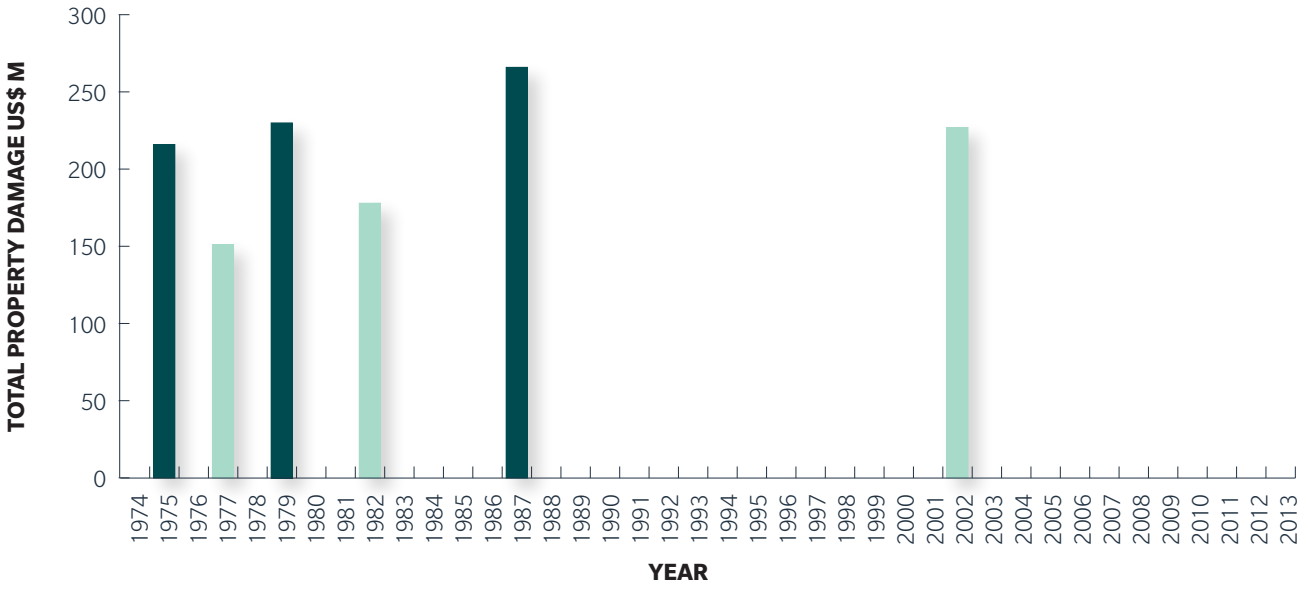
FIRE/EXPLOSION		At 22:30 on December 25, an explosion and fire occurred at a gas-to-liquids (GTL) plant in Bintulu, Sarawak. The fire was brought under control on December 26. The plant was then one of only two commercially successful GTL plants in the world with a capacity to produce 12,500 bbl/d of middle distillates and waxes from natural gas feedstocks. The explosion occurred in the Air Separation Unit (ASU) which supplies oxygen for the production of synthesis gas feedstock. The investigation into the incident pointed to an incipient combustion event in the ASU as the most probable cause. This combustion event is thought to have initiated explosive burning of the aluminum heat exchanger elements in the presence of liquid oxygen, such that the elements ruptured explosively. A dozen people were injured (none seriously) and the plant was shut down for several months for repairs.
EVENT DATE	12/25/1997	
LOCATION	Bintulu, Sarawak, Malaysia	
VALUE	US$280,000,000	
ESTIMATED CURRENT VALUE	US$490,000,000	

VAPOR CLOUD EXPLOSION		A vapor cloud explosion centered in the cryogenic unit no. 2, and two subsequent explosions in the cryogenic unit no. 1 occurred at this gas- processing complex. As a result of the explosions, the cryogenic unit no. 2 and LPG product pumps in the cryogenic unit no. 1 were extensively damaged, the control rooms for both units were destroyed, and the remainder of the cryogenic unit no. 1 experienced minor damage. On July 25, plant personnel noticed that one of the two LPG product pumps in the cryogenic unit no. 1 had a seal leak. Consequently, plant personnel decided to have the faulty seal replaced on July 26. In preparation for the maintenance work on the LPG product pump, the motor-operated valve (MOV) in the suction line and the isolation valve in the discharge line of this pump were manually closed. A spectacle blind was then inserted into the pump flange on the suction side of the pump. After the seal was replaced, plant personnel removed the blind and were in the process of tightening the flange bolts when LPG product began to leak from this flange. A vapor cloud formed and drifted into the cryogenic unit no. 2. It was ignited and this resulted in the initial explosion. Following the explosions, it was determined that the MOV in the suction line of the pump was in the open position, which allowed the LPG product to reach the pump flange. The fire brigades successfully extinguished the fire following the explosions in approximately three hours, and protected the adjacent LPG spheres. If these spheres had failed due to BLEVE, the property plant damage would have been substantially greater. Although the explosions damaged the electric power in the plant and rendered the electric motor-driven fire water pumps non-operational, fire water was provided by two diesel engine-driven fire water pumps. Because of this incident, the 2.13-billion-cubic-feet-per-year gas- processing capacity at this complex was shut down, disrupting one-third of Mexico's total gas-processing capacity. An estimated 18 months was required to repair or replace the damaged cryogenic units, including the associated control rooms.
EVENT DATE	07/26/1996	
LOCATION	Cactus, Reforma, Mexico	
VALUE	US$140,000,000	
ESTIMATED CURRENT VALUE	US$240,000,000	

VAPOR CLOUD EXPLOSION		At this gas-processing plant, a series of electrical power interruptions caused several shutdowns of one or both of the identical 165,000-bbl/d gas-fractionation-process trains. The parallel trains were separated from one another by approximately 100 feet. At the time of the loss, the propane feed was approximately 100% of design capacity for plant I, and 25% of design capacity for plant II. It is believed that there was a release of approximately 1,900 bbl of propane in plant I over a 30-minute period. Ignition of the large vapor cloud is believed to have been by a security vehicle that had stalled and was being restarted. The probable source of the propane was a flange in a four-inch-diameter relief valve line.
EVENT DATE	08/15/1987	
LOCATION	Juaymah, Saudi Arabia	
VALUE	US$65,000,000	
ESTIMATED CURRENT VALUE	US$140,000,000	

TERMINALS AND DISTRIBUTION

FIGURE 6: TERMINALS AND DISTRIBUTION PROPERTY DAMAGE BY YEAR



Note

Figure 6 shows the distribution of the property loss value of terminals and distribution incidents in the set of 100 largest losses, inflated to 2013 values.

Figure 6 shows the majority of terminal and distribution losses that exceeded US$130 million were in the early part of the time period under consideration. More modern fuel distribution terminals are laid out to minimize the risk of major accident escalation, and the cost of rebuilding even quite large terminal facilities, or relaying distribution pipelines, is relatively low.

There are, of course, some major terminal losses that, while resulting in significant impact, are not included in the list of 100 largest losses, as the property damage value is not great enough. Major fires at the Buncefield, UK tank farm in 2005, at a tank farm in Jaipur, India in 2009, and at a tank terminal in Puerto Rico in 2009 all resulted in significant damage. The incident in India resulted in eleven fatalities, and all of the incidents resulted in major damage on the sites and to third parties. However, the level of property damage from these incidents was insufficient to place them in the 100 largest losses list.

Similarly, major pipeline losses, while having the potential to have significant third party liability impact, do not generally result in a very high level of property damage and, therefore, do not make the list.

We have seen recently an increasing number of losses due to the derailment of trains transporting crude oil from remote onshore facilities not linked to a pipeline network, resulting in fires or spillages. These accidents have not resulted in large property damage losses, but have the potential to lead to major third party liability losses. It is reported that the number of rail car movements of crude oil in the US has increased from 9,500 in 2008 to 234,000 in 2012 (and the figures for 2013 are expected to be twice the 2012 figure).

TERMINALS AND DISTRIBUTION

FIRE/EXPLOSION		Four people were killed in an explosion and fire at an oil-gathering center, gas-booster station, and power substation. The explosion occurred after a leak from a buried oil pipeline in the gathering station spread to a power substation, sparking the blaze. The flash explosion and resulting blaze hit the gathering center and the adjacent gas-booster station. Nineteen people were also injured in the incident, and suffered mainly first- and second-degree burns. The fire was extinguished two days after the event.
EVENT DATE	01/31/2002	
LOCATION	Raudhatain, Kuwait	
VALUE	US$150,000,000	
ESTIMATED CURRENT VALUE	US$230,000,000	

EARTHQUAKE		Twenty-five miles of trans-Andean pipeline disappeared in this event, which also damaged natural gas and gasoline pipelines. All 285 producing wells were shut down and oil exports were suspended and swap arrangement made with Venezuelan suppliers. The first earthquake registered 6.0 on the Richter scale, the second 6.8, and there were a total of 10 earthquakes in that period. Repairs took several months.
EVENT DATE	03/05/1987	
LOCATION	Ecuador	
VALUE	US$120,000,000	
ESTIMATED CURRENT VALUE	US$270,000,000	

FIRE		A huge boil-over occurred on a fuel oil tank, killing at least 160 people in a huge fireball. An explosion occurred on a fuel oil tank while it was being gauged, blowing the roof off the tank and setting it on fire. Eight hours after the tank fire started, a violent boil-over occurred. Burning oil flowed down the hill where the tank was located and surrounded a second tank.
EVENT DATE	12/19/1982	
LOCATION	Tacoa, Venezuela	
VALUE	US$70,000,000	
ESTIMATED CURRENT VALUE	US$180,000,000	

EXPLOSION		An 11-year-old, 121,000-deadweight-tonnage tanker had completed unloading its first parcel of Arabian heavy crude at a deep-water port. No transfer operations between the ship and the jetty were in process when a small fire was noticed on deck. About 10 minutes later, the fire had spread along the length of the ship and was observed on the sea at both sides of the ship. After 30 minutes, a massive explosion occurred. It is theorized that the initiating event of the disaster was the buckling of the ship's structure at or about deck level. This was immediately followed by explosions in the ballast tanks and the breaking of the ship's back. These events were produced by the conjunction of two separate factors: a seriously weakened hull due to inadequate maintenance, and an excessive stress due to incorrect ballasting at the time of the disaster. A fragment of the ship, weighing 1,000 pounds, was found at the base of a large crude oil tank, a distance of 1,800 feet from the ship. In addition to total loss of the ship, 50 people lost their lives, and 1,130 feet of the concrete and steel jetty was damaged or destroyed.
EVENT DATE	01/08/1979	
LOCATION	Bantry Bay, Ireland	
VALUE	US$70,000,000	
ESTIMATED CURRENT VALUE	US$230,000,000	

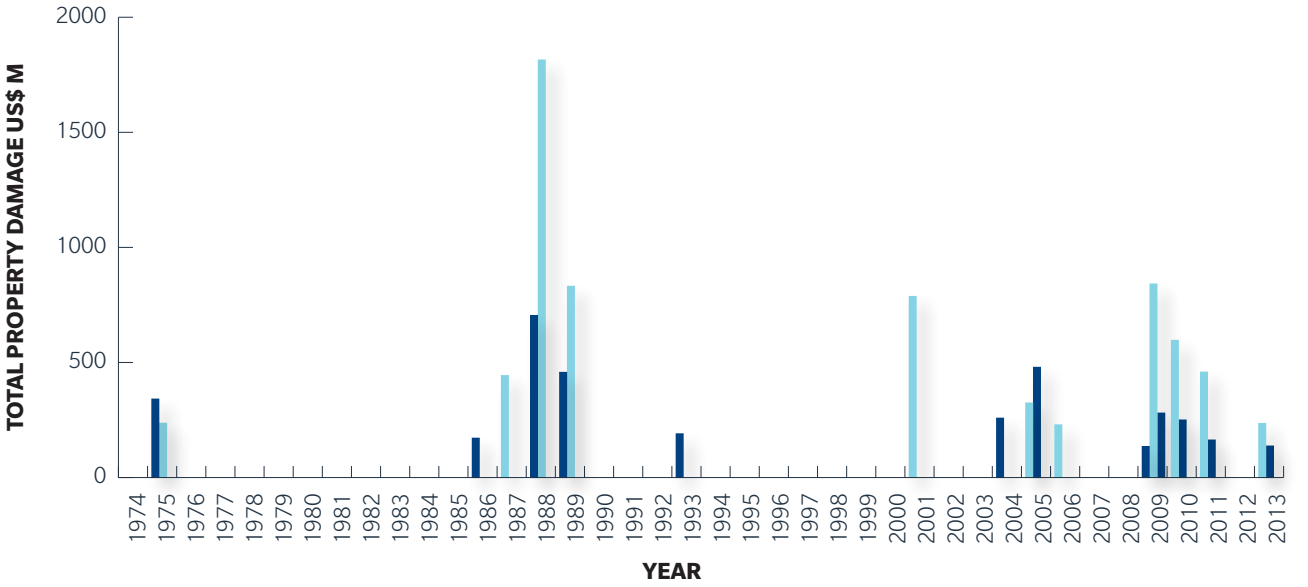
FIRE		A pipeline pump started while the strainer cover-plate was being removed, and the oil that was released ignited. The fire was mostly confined to the pump house.
EVENT DATE	07/08/1977	
LOCATION	Fairbanks, Alaska, US	
VALUE	US$40,000,000	
ESTIMATED CURRENT VALUE	US$150,000,000	

MATERIAL FAILURE		A 30-inch-diameter crude oil pipeline failed and destroyed three spheroids, pumping units, and other equipment. Ignition was caused by motor vehicles.
EVENT DATE	05/11/1977	
LOCATION	Abqaiq, Saudi Arabia	
VALUE	US$54,000,000	
ESTIMATED CURRENT VALUE	US$210,000,000	

FIRE		US flag tanker *Edgar M. Queeny* rammed the Greek tanker *Corinthos* while it was discharging 400,000 barrels of crude oil at a refinery jetty at Marcus Hook on the Delaware River. A massive initial explosion, and subsequent explosions and fires, occurred on the Greek ship as a result of the collision. Some 25 crew members were killed onboard this vessel, in addition to one crewman from the flag tanker. The *Corinthos* sank shortly afterwards and was later removed for scrapping.
EVENT DATE	01/31/1975	
LOCATION	Marcus Hook, US	
VALUE	US$50,000,000	
ESTIMATED CURRENT VALUE	US$220,000,000	

UPSTREAM

FIGURE 7: UPSTREAM PROPERTY DAMAGE BY YEAR



Note

Figure 7 shows the distribution of the property loss value of upstream incidents in the set of 100 largest losses, inflated to 2013 values.

The upstream property loss graph is dominated by the value of the Piper Alpha loss in 1988, but there continues to be regular losses in the upstream sector with a value of more than US$130 million. The operations in the upstream sector are taking place in progressively more challenging environments, in deeper waters, and the facilities are generally getting larger. High oil prices make marginal hydrocarbon- development projects potentially profitable, but they are increasingly dependent upon economies of scale, resulting in increased capital exposure.

Lessons have been learned from losses in the sector, and these have been applied in the standards, for example, for facility layout, fire protection, and loss mitigation. However, such development projects present greater exposures in the event of a loss.

At the other end of project timeline, there is a fleet of upstream assets that have been operational for many years, for example, in the UK and Norwegian sectors of the North Sea. Some of these assets are supporting fields with depleting hydrocarbon reserves, so there is reduced cash flow available to support any major developments or improvements in asset integrity. As for refining, the management of aging plants is again a challenge for this set of assets.

The information presented above is for the property damage values only, and there is no consideration of the additional costs of well control or third party liability, which in many cases can be a significantly greater exposure. For example, the Macondo loss in the Gulf of Mexico in 2010 is included in the 100 largest losses (the property damage as a result of the loss of the rig has an estimated current value of US$600 million.) However, the additional cost of well control because of the depth of water of the blowout was enormous, and the operator had, by the end of 2013, paid more than US$12 billion in individual, company, and government thirdparty liability claims.

UPSTREAM

BLOWOUT	
EVENT DATE	07/23/2013
LOCATION	Gulf of Mexico, Louisiana, US
VALUE	US$140,000,000
ESTIMATED CURRENT VALUE	US$140,000,000

Natural gas flowed uncontrolled from a well after a blowout that forced the evacuation of 47 workers abroad a drilling rig. No injuries or fires were reported. The water depth of the rig was reported as 154 feet. The incident occurred near an unmanned offshore gas platform that was not producing natural gas. The well ignited after the evacuation. The rig partially collapsed after catching fire because of a ruptured natural gas well, and the failure of beams supporting the derrick and rig floor. The jack-up rig also collapsed over the rig structure.

COLLAPSE		A jack-up rig sank after the seabed collapsed under one of the three legs. The rig sank while being positioned for drilling operations in approximately 40 meters of water. There were 103 workers onboard the rig when it suddenly tilted, causing the rig to take on water and capsize. One crew member went missing and six others received minor injuries.
EVENT DATE	07/01/2013	
LOCATION	Atlantic Ocean, Angola	
VALUE	US$230,000,000	
ESTIMATED CURRENT VALUE	US$230,000,000	

CAPSIZE		Mo re than 600 workers were evacuated from this flotel after it began to lean to one side when water entered a pontoon. The flotel was located about 80 kilometers offshore near Campeche state, Mexico. There were no injuries reported as a result of the sudden inclination. It was reported that a total loss of the flotel resulted.
EVENT DATE	04/12/2011	
LOCATION	Gulf of Mexico, US	
VALUE	US$160,000,000	
ESTIMATED CURRENT VALUE	US$160,000,000	

HEAVY WEATHER		Heavy storm conditions in the North Sea caused four of this floating production storage and offloading (FPSO) unit's 10 anchor chains to break, resulting in the vessel moving off its position. It is estimated that the FPSO was subject to 53-knot winds and waves in excess of nine meters. Normally, a complex piping system runs from the wells on the seabed up to the FPSO, but this infrastructure was damaged in the incident. Following the vessel moving off its position, all of the wells were immediately shut in. Subsequent surveys showed that no oil had been lost. As a result, 74 non-essential crew members were evacuated to nearby platforms, and 43 essential crew members remained onboard. Two crew members received minor injuries. The facility was projected to be producing an average of 18,400 bbl/d of oil in 2011. As a result of this incident, a significant loss of production was recorded..
EVENT DATE	02/04/2011	
LOCATION	North Sea, UK	
VALUE	US$450,000,000	
ESTIMATED CURRENT VALUE	US$460,000,000	

LEAK		This natural gas drilling rig sank in the Caribbean sea. All 95 workers were evacuated safely and there was no reported leakage. The sinking was caused by a sudden surge of water entering one of the submarine rafts that the platform legs floated on. Automatic subsea safety valves secured the well and prevented a leak from occurring.
EVENT DATE	05/13/2010	
LOCATION	Caribbean Sea, Venezuela	
VALUE	US$230,000,000	
ESTIMATED CURRENT VALUE	US$250,000,000	

FIRE/EXPLOSION/ BLOWOUT		A semi-submersible drilling rig working in the Mississippi Canyon Block 252, approximately 48 miles off the coast of Louisiana, suffered a major explosion and fire following a well integrity failure. The rig had a crew of 126. There were 11 people immediately identified as missing and subsequently confirmed as fatalities, with a further 17 injured. The rig sank within 36 hours of the initial explosion in a water depth of approximately 5,000 feet. The exploration well had reached a depth of 18,360 feet (total depth) and was undergoing cementing works with a view to temporarily abandoning the well, prior to the well control event. Hydrocarbons continued to flow through the damaged blowout preventer (BOP) for 87 days before a successful static kill was performed. The release caused a spill of national significance and resulted in an unprecedented subsea and surface spill control response. The well was declared finally killed five months after the original event, following successful interception by a relief well. The lease operator has set up a US$20 billion compensation fund, and the loss has led to attempts to place a temporary ban on drilling activity in US coastal waters.
EVENT DATE	04/21/2010	
LOCATION	Gulf of Mexico, US	
VALUE	US$560,000,000	
ESTIMATED CURRENT VALUE	US$590,000,000	

BLOWOUT		Oil, condensate, and hydrogen sulfide leaked from a well head on a platform being serviced by a jack-up rig in the Timor Sea. There were 69 workers on the rig who were evacuated. Oil and gas started to spill after a plug blocking one of the project's 1,200 meter-deep wells came free. The next day, a 12-kilometer-long and 30-meter-wide spill was reported. Attempts were made to plug the well over the next two months. It was estimated that the well was leaking 400 bbl/d of oil and gas. On November 1, it was reported that drillers had successfully intercepted the well and were beginning to put heavy mud into the shaft. However, a fire broke out on the drilling platform as it attempted to plug a deeper leak. The fire was extinguished two days later. A total of 4,140 tonnes of oil was estimated to have been lost. This incident affected both the platform and the drilling rig.
EVENT DATE	08/21/2009	
LOCATION	Montara, Timor Sea, Australia	
VALUE	US$250,000,000	
ESTIMATED CURRENT VALUE	US$280,000,000	
COLLISION		A well-intervention vessel lost power and collided with an unmanned platform forming part of this 230,000-bbl/d complex. Heavy damage was caused to the vessel and the platform, including damage to the platform structure, linking access bridge, and well equipment. Some 23,000 bbl/d of oil production was reportedly affected. The force of the collision caused the bow of the vessel to compress by about two meters, with the platform pushed partly out of position, loosening several support legs from the main load-bearing structure. One of the water injection risers on the platform was bent extensively and several wellheads were moved, with a catalogue of further damage from the collision also identified.
EVENT DATE	06/04/2009	
LOCATION	Ekofisk, North Sea, Norway	
VALUE	US$750,000,000	
ESTIMATED CURRENT VALUE	US$840,000,000	
ANCHOR DRAG		On January 26, communication was lost between the subsea center and the platform, resulting in damage to these assets offshore of Angola. Investigations determined that an anchor-handling tug had been operating in the field, and that the vessel had lost control/steerage and drifted back over the subsea center. Its anchor wire snagged the subsea assets, causing damage to a Christmas tree, well conductor, and subsea control module. Remedial operations included the plugging and abandonment of one well, and the drilling of a replacement.
EVENT DATE	01/26/2009	
LOCATION	Angola	
VALUE	US$120,000,000	
ESTIMATED CURRENT VALUE	US$130,000,000	
LEAK		On November 5, offshore gas alarms were triggered on this floating production unit and, upon investigation, it was established that a leak was emanating from one of the production risers. Upon further investigation, five other risers were found to be similarly affected. Remedial work was subsequently carried out.
EVENT DATE	11/05/2006	
LOCATION	North Sea, Norway	
VALUE	US$180,000,000	
ESTIMATED CURRENT VALUE	US$230,000,000	
FIRE/EXPLOSION		Twenty-two people were killed when a fire completely destroyed an oil platform. It is believed that a multi-purpose support vessel, which was evacuating a worker to a medical center, hit the platform's riser causing an explosion. The vessel also caught fire and sank, but two nearby platforms were saved when connecting bridges collapsed. The 150 people onboard managed to transfer to a nearby water-injection platform, and a further 348 people were evacuated from the oil platform. However, the rescue operation was hampered by bad weather. It was further reported that a cantilever jack-up rig, linked by a bridge to the process platform, was also involved in the fire. A total of 73 people were evacuated from the rig, but during the evacuation one employee died. On August 7 it was reported that 70% of oil production would be resumed by the end of the month, with full production under way by the middle of September 2005. The total disruption of production is estimated to be 123,000 bbl/d, which accounted for more than 15% of the company's crude oil production.
EVENT DATE	07/27/2005	
LOCATION	Mumbai High field, India	
VALUE	US$370,000,000	
ESTIMATED CURRENT VALUE	US$480,000,000	

HURRICANE		Hurricane Dennis passed through the area where the platform was located, causing it to partially sink. A seawater valve in a ballast tank had been incorrectly installed, resulting in excess water in the tanks. The platform had already been evacuated and there was no leakage of oil, fuel, or other hazardous substances. The loss resulted in the project commencing production three years behind schedule. The company retrieved, and rebuilt all the seabed production equipment after a series of tests revealed metallurgical failure in components of the field subsea systems.
EVENT DATE	07/10/2005	
LOCATION	Gulf of Mexico, US	
VALUE	US$250,000,000	
ESTIMATED CURRENT VALUE	US$320,000,000	
BLOWOUT		A fire broke out during drilling operations at an offshore gas production platform, following a well control incident. The fire on the production platform, initially under control, spread to a nearby jack-up drilling rig (owned by a major drilling contractor), which suffered significant damage and collapsed. All 79 people onboard the drilling rig were safely evacuated. The production platform, with 150 people onboard, had been evacuated before the fire spread. The drilling rig sank and was not salvageable, and the platform was damaged beyond repair so its destruction was ordered by the state.
EVENT DATE	08/10/2004	
LOCATION	Mediterranean, Egypt	
VALUE	US$190,000,000	
ESTIMATED CURRENT VALUE	US$260,000,000	
EXPLOSION/FIRE/ SINKING		The world's largest offshore production facility was rocked by a series of explosions caused by a gas release. The explosions knocked out a support pillar of the semi-submersible platform, allowing seawater to enter the vessel. Workers pumped in nitrogen and compressed air and tried to pump out almost 3,000 tonnes of seawater to keep the rig afloat, but were unsuccessful. On March 20, the rig sank to the sea floor. The incident killed a total of 11 workers.
EVENT DATE	03/15/2001	
LOCATION	Campos Basin, Brazil	
VALUE	US$500,000,000	
ESTIMATED CURRENT VALUE	US$790,000,000	
EXPLOSION		An apparent failure of a propane intercooler liquid level controller during unsupervised maintenance led to an explosion and fire. The control room on the main platform was destroyed and adjacent platforms were affected by the blast wave. Eleven fatalities resulted from the incident.
EVENT DATE	03/25/1993	
LOCATION	Lama, Lake Maracaibo, Venezuela	
VALUE	US$100,000,000	
ESTIMATED CURRENT VALUE	US$190,000,000	
FIRE/EXPLOSION		Contract personnel were installing a pig trap on an 18-inch-diameter sales gas pipeline on the platform. As a cold cut was made into the pipeline, hydrocarbons sprayed from the cut and ignited. The explosion and fire burned the main structure and caused subsequent explosions, when six other pipelines ruptured due to the intense heat. The accident resulted in the total destruction of the platform and seven fatalities. It took two years to replace the platform.
EVENT DATE	03/19/1989	
LOCATION	Baker, Gulf of Mexico, US	
VALUE	US$400,000,000	
ESTIMATED CURRENT VALUE	US$830,000,000	

BLOWOUT		A semi-submersible rig had a gas kick at 15,527 feet during an attempt to clear the drill pipe of cement previously pumped in to control the well, and the well then suffered a blowout. The well was stabilized after 11 months by pumping heavy mud down a relief well. The well was later sealed.
EVENT DATE	01/20/1989	
LOCATION	Treasure Saga, North Sea, UK	
VALUE	US$220,000,000	
ESTIMATED CURRENT VALUE	US$460,000,000	

FIRE/EXPLOSION		A release and ignition of gas condensate from a section of piping in the gas-compression module of this platform set off a chain of fires and explosions, resulting in the almost total destruction of the facility. The condensate was released from the site of a pressure-relief valve, which had been removed for maintenance, when this section of piping was inadvertently pressurized. The severity of the accident was due, in large part, to the contribution of oil and gas from ruptured pipelines connected to the platform, and the disabling of nearly all emergency systems, as a result of the initial explosion. The compression module had been retrofitted to the platform adjacent to the control room, and the control room was rendered useless by the initial explosion. In addition, the firewater pumps had been placed in the manual operation mode, due to divers being in the water prior to the accident. There were 226 people on the platform at the time of the accident; only 59 survived. Contributing to the loss of life was the location of the quarters directly above the site of the initial release and resulting explosion and fire.
EVENT DATE	06/07/1988	
LOCATION	Piper Alpha, North Sea, UK	
VALUE	US$850,000,000	
ESTIMATED CURRENT VALUE	US$1,800,000,000	

FIRE		During the conversion of one of the platform wells from oil to gas production, a high-pressure gas pocket was encountered that forced the drill pipe out of the well. The blowout preventer (BOP) failed to shut in the well, and sparks, caused by the drill pipe that was ejected from the well hitting one of the platform legs, ignited the escaping gas. The fire lasted for 31 days. Most of the topside structure was destroyed, and the facility was later declared a total loss. Redesign of the production module was completed in 45 days in an effort to shorten, as much as possible, the loss of production. Full production was restored 18 months after the loss.
EVENT DATE	04/24/1988	
LOCATION	Enchova, Campos Basin, Brasil	
VALUE	US$330,000,000	
ESTIMATED CURRENT VALUE	US$700,000,000	
BLOWOUT		Sustained casing head pressure leaked from the production casing into the outer casing strings, resulting in the failure of one of the casing strings. This caused an underground blowout that resulted in extensive damage to the platform and a gas plume around it. The well was killed to stabilize conditions on the seabed.
EVENT DATE	11/04/1987	
LOCATION	Gulf of Mexico, US	
VALUE	US$200,000,000	
ESTIMATED CURRENT VALUE	US$440,000,000	
GROUNDING/ BAD WEATHER		A semi-submersible barge ran aground near Uslan, Korea during a typhoon.
EVENT DATE	08/26/1986	
LOCATION	Sea of Japan, Japan	
VALUE	US$75,000,000	
ESTIMATED CURRENT VALUE	US$170,000,000	
COLLISION		This platform was struck by the *Stad Sea*.
EVENT DATE	08/01/1975	
LOCATION	North Sea, UK	
VALUE	US$55,000,000	
ESTIMATED CURRENT VALUE	US$240,000,000	
BLOWOUT		The Fateh field L-3 development well had reached 4,180 feet when a "kick" occurred. The kick control effort was terminated and the rig abandoned when gas broke around the 20-inch shoe and bubbled up under the platform. Eight days after the blowout, the gas ignited, and after two weeks the rig and platform disappeared beneath the Arabian Gulf.
EVENT DATE	07/01/1975	
LOCATION	Fateh L3, Dubai, UAE	
VALUE	US$79,000,000	
ESTIMATED CURRENT VALUE	US$340,000,000	

MARSH

For further information, please contact your local Marsh office or visit our web site at: www.marsh.com

CALGARY
222 – 3rd Avenue S.W.
Suite 1100
Calgary, Alberta T2P 0B4
Canada
Tel: +1 403 290 7900

DUBAI
Al Gurg Tower 3
Riggat Al Buteen
Baniyas Road, Deira
P.O.Box 14937, Dubai
United Arab Emirates
Tel: +971 4 223 7700

HOUSTON
1000 Main Street, Suite 3000
Houston
Texas 77002
United States
Tel: +1 713 276 8000

LONDON
Tower Place
London
EC3R 5BU
United Kingdom
Tel: +44 20 7357 1000

MADRID
Edificio Puerta Europa,
Paseo de la Castellana, 216
Madrid, E-28046
Spain
Tel: +34 914 569 400

MIAMI
200 S. Biscayne Blvd.
Suite 950, Miami
Florida
United States, 33131
Tel: +1 305 341 5075

MUMBAI
1201-02, Tower 2, One Indiabulls Centre
Jupiter Mills Compound
841 Senapati Bapat Marg
Elphinstone Road (W)
Mumbai, 400013, India
Tel: +91 226 651 2900

NEW YORK
1166 Avenue of the Americas
New York
New York 10036-2708
United States
Tel: +1 212 345 6000

OSLO
Vika Atrium,
Munkedamsveien 45 D
Oslo
N-0123
Norway
Tel: +47 22 01 10 00

PERTH
Level 28, Exchange Plaza
2 The Esplanade
Perth, WA 6000
Australia
Tel: +61 8 9289 3888

RIO DE JANEIRO
Av. Rio Branco, 125 - 19º andar
CEP 20.040-006
Rio de Janeiro
Brazil
Tel: +55 21 2141 1650

SAN FRANCISCO
345 California Street
Suite 1300
San Francisco, CA 94104
United States
Tel: +1 415 743 8000

SINGAPORE
8 Marina View #09-02
Asia Square Tower 1
Singapore 018960
Tel: +65 6922 8048