

# THE 100 LARGEST LOSSES 1972–2011

LARGE PROPERTY DAMAGE LOSSES IN THE HYDROCARBON INDUSTRY

22<sup>ND</sup> EDITION



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## ACKNOWLEDGEMENT

Marsh's Energy Practice acknowledges the significant input from various sources interested in the prevention, mitigation and analysis of large property damage losses that make this publication possible. We would like to thank contributors from the market, who continue to provide key information and aid in the development of this valuable resource. We will continue to rely on information provided from interested professionals as well as published sources, and to encourage readers to bring errors, omissions, or additional information to our attention.

Additional copies of this publication are available through the worldwide offices of Marsh's Energy Practice and on [marsh.com](http://marsh.com).

# FOREWORD



When I was invited to introduce the latest update of Marsh's 100 Largest Losses, I readily accepted the opportunity. This publication is essential reading for anyone with an interest in the energy industry and its related sub-sectors. It clearly shows what can go wrong and the scale of loss which occurs when organisations fail to pay attention to asset integrity and process safety risks. The publication also highlights some remarkable similarities which lie at the heart of major incidents in seemingly dissimilar sectors.

The Health and Safety Executive in Great Britain has carried out a significant amount of work to understand what lies behind major failures and has identified a number of causes. Included in these is the susceptibility of organisations to ignore lessons from other sectors as being irrelevant to them or to allow corporate memory to fade with the passage of time. '100 Largest Losses' proves emphatically that the worst can happen to anyone, anywhere. No-one can afford to be complacent.

Business managers must understand what can go wrong – however unlikely – and focus their attention on proactive measures to ensure that failures do not occur. Key to achieving this is the development of leading indicators that focus on the process safety elements that matter, thereby providing a true measure of how an asset is performing.

Some industry sectors and some companies are showing the right level of leadership in process safety. Those who have embraced the identification and reporting of real and meaningful leading and lagging indicators can demonstrate that it has driven performance improvement that is already delivering substantial bottom-line benefits as well as inherently safer and more reliable operations.

The vast majority of organisations promote the importance of personal safety which can be more easy to measure and, consequently, often gets more attention. But whilst holding the handrails is good for driving some parts of the safety culture it won't stop the stairs – or the rest of the plant – failing catastrophically if the condition of the hardware assets is not being properly monitored and managed.

This report is both sobering and thought provoking. Its contents should act to make us all concentrate on the importance of getting process safety right. Any time you feel tempted to think that the worst cannot happen in your company, pick it up and remind yourself of what happened to others who perhaps allowed themselves to think like that!

A handwritten signature in black ink that reads "J. Hackitt". The signature is fluid and cursive, with a long horizontal line extending from the bottom of the name.

Judith Hackitt CBE, FREng.  
Chair, UK Health and Safety Executive

# INTRODUCTION

Welcome to the twenty-second edition of our 100 Largest Losses; a detailed almanac of the 100 largest property damage losses that have occurred in the hydrocarbon processing industry since the early 1970s.

This review is based on the Marsh Energy Loss Database with information gathered in the course of our interactions with the industry as well as from the public domain. The Marsh Energy Loss Database contains over 8,000 records for the period through to 2011. Despite access to all of this information, there are still some losses for which we do not have even a basic understanding of what went wrong.

Six new losses, large enough to feature in this publication, have been identified since 100 Largest Losses was last published in 2010. Of these six, five have occurred in the Upstream category. These losses are consistent with trends in industry for developing untapped and technologically challenging sources of hydrocarbons. The sixth loss occurred in a facility falling into the Refineries category. This loss occurred on an oil sands upgrader, a site employing contemporary methods for oil recovery from a previously marginal source.

Some losses have garnered significant media attention and been at the forefront of public discussion; for others there has been very little public interest. The loss of the Deepwater Horizon drilling rig in the Gulf of Mexico made international headlines. Eleven fatalities and an uncontrolled hydrocarbon release lasting 87 days led to the total costs amounting to tens of billions of US dollars. The property damage value for this loss was just the tip of the iceberg. By comparison, the loss resulting from an FPSO (a Floating Production, Storage and Offloading vessel) moving off-station in heavy weather in the North Sea resulted in a property damage loss comparable to that of the Deepwater Horizon loss. The North Sea incident resulted in no loss of life and had little environmental impact. In this case the mainstream media took little notice and it was reported primarily as a successful rescue operation of the FPSO's personnel.

Corporations involved in the hydrocarbon processing industry are becoming ever more sophisticated in their risk management approaches. However, even with the developments in engineering practice and hazard awareness, the last two years demonstrate that large losses continue to occur. High world oil prices are driving the industry into ever more challenging environments, including

deeper water and colder climates, in search of further hydrocarbon reserves. This, in combination with seemingly ever increasing project sizes, including new FPSO and FLNG (Floating Liquefied Natural Gas) ventures, is resulting in increasing capital exposure for contemporary projects. Whether or not risk management processes will develop and scale up appropriately for such large projects remains to be seen. With this 100 Largest Losses publication we hope to increase awareness of large losses across the industry and provide a resource from which lessons can be learnt.

Marsh believes that there are a number of factors that may influence how well the industry learns from its previous mistakes:

- **Distance and Time:** Distance from the original incident and time elapsed since the event appear to be two of the factors influencing how well lessons from major incidents are learnt. As we move further from the original incident (and sometimes not too far) and wait longer after the incident occurs, the less likely we are to see the lessons learnt and improvements made. The spectacular multiple BLEVEs (Boiling Liquid Expanding Vapour Explosion) of LPG (Liquefied Petroleum Gas) spheres in Japan following the 2011 Tohoku earthquake may not have occurred if the standards exhibited in France since the Feyzin incident had been applied.
- **Learning from positive results:** There are a number of good examples of where the industry does appear to have learnt from incidents, and has made improvements on a global basis. However, in general, we do not appear to be very good at learning from positive results, even where these have been incorporated into international standards. This is perhaps because if there is a positive result, it does not feature in the chemical engineering media and has a much lower profile within the company as the loss is generally smaller. Because of these factors there is much less analysis done of what went well. In general however, learning such as this is incorporated within national and international standards, engineers have then only to apply them. We can benefit from looking outside our own

industry here, perhaps examining the nuclear and aviation sectors.

- **Cultural challenges:** It is possible that there may be a number of cultural barriers to learning from these major incidents. Trevor Kletz OBE (Kletz, T, 1993, Lessons from Disaster, IChemE), identified time, lawyers (and litigation), fear of adverse publicity, internal procedure, disclosure of confidential information, and commitment (of both companies and individuals) as barriers to publicising incident information, but this is a very western-centric viewpoint. Much of the growth in the Energy industry is happening in the Middle East, Asia, Africa and South America, and there are a number of relatively young, fast growing and now quite large, companies with significant assets. However, many of these companies may not have been operating long enough to have felt the impact of the type of incidents described in this publication.

In this publication the large property damage losses have been grouped by type of facility into five categories: Refineries, Petrochemical Plants, Gas Processing Plants, Terminals/Distribution and Upstream. The 100 largest property damage losses analysed are across all of these categories and represent approximately USD 33 billion in property damage, stated in US dollars at December 2011 prices.

Loss values, based on the cost to repair or replace assets damaged or destroyed, are stated in two manners. The original value of the loss in 'money at the time' is provided as well as an inflated value which is used to compare 'like with like'. The loss amounts include property damage, debris

removal and cleanup costs; the costs of business interruption, extra expense, employee injuries/fatalities and liability claims are excluded from this analysis. The direct, on-premises cleanup costs due to asbestos abatement, 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. These costs, to the extent that insurance is applicable, are paid by property insurance underwriters. The loss amounts are then inflated using the Nelson-Farrar Petroleum Plant Cost Index, thus allowing for a comparison of events on a constant basis across the period analysed.

As an industry, we would all benefit from a reduction in loss incidents and we commend this publication to you to promote discussion and learning within your organisations.

## **NEW**

### **NATURAL CATASTROPHE ACCUMULATION**

Natural catastrophe incidents have the potential to cause very large aggregate losses. The incidents identified in this document are generally loss events affecting a single facility, and as such this analysis does not identify the aggregated losses from natural catastrophes such as hurricanes or earthquakes. A supplementary section addressing natural catastrophe accumulation has been included for the first time in this edition of the 100 Largest Losses. The losses discussed do not technically fall within the 100 Largest Losses, however we feel they are significant enough to warrant comment.

# THE 20 LARGEST LOSSES

DATE	PLANT TYPE	EVENT TYPE	LOCATION		PROPERTY LOSS USD MILLION*
07/07/1988	Upstream	Fire/Explosion	Piper Alpha, North Sea	UK	1,800
23/10/1989	Petrochem	Vapour Cloud Explosion	Pasadena, Texas	USA	1,400
04/06/2009	Upstream	Collision	Ekofisk, North Sea	Norway	830
19/03/1989	Upstream	Fire/Explosion	Baker, Gulf of Mexico	USA	820
23/08/1991	Upstream	Structural Failure	Sleipner, North Sea	Norway	780
15/05/2001	Upstream	Explosion/Fire/Sinking	Campos Basin	Brasil	770
25/09/1998	Gas Processing	Explosion	Longford, Victoria	Australia	740
24/04/1988	Upstream	Fire	Enchova, Campos Basin	Brasil	690
21/09/2001	Petrochem	Explosion	Toulouse	France	670
04/05/1988	Petrochem	Explosion	Henderson, Nevada	USA	630
19/01/2004	Gas Processing	Fire/Explosion	Skikda	Algeria	630
05/05/1988	Refinery	Vapour Cloud Explosion	Norco, Louisiana	USA	600
06/01/2011	Refinery	Fire/Explosion	Fort McKay, Alberta	Canada	600
25/06/2000	Refinery	Fire/Explosion	Mina Al-Ahmadi	Kuwait	590
21/04/2010	Upstream	Fire/Explosion/Blowout	Gulf of Mexico	USA	590
12/09/2008	Refinery	Hurricane	Texas	USA	540
01/11/1992	Upstream	Mechanical Damage	North West Shelf	Australia	520
14/11/1987	Petrochem	Vapour Cloud Explosion	Pampa, Texas	USA	470
27/07/2005	Upstream	Fire/Explosion	Mumbai High field	India	470
25/12/1997	Gas Processing	Fire/Explosion	Bintulu, Sarawak	Malaysia	460

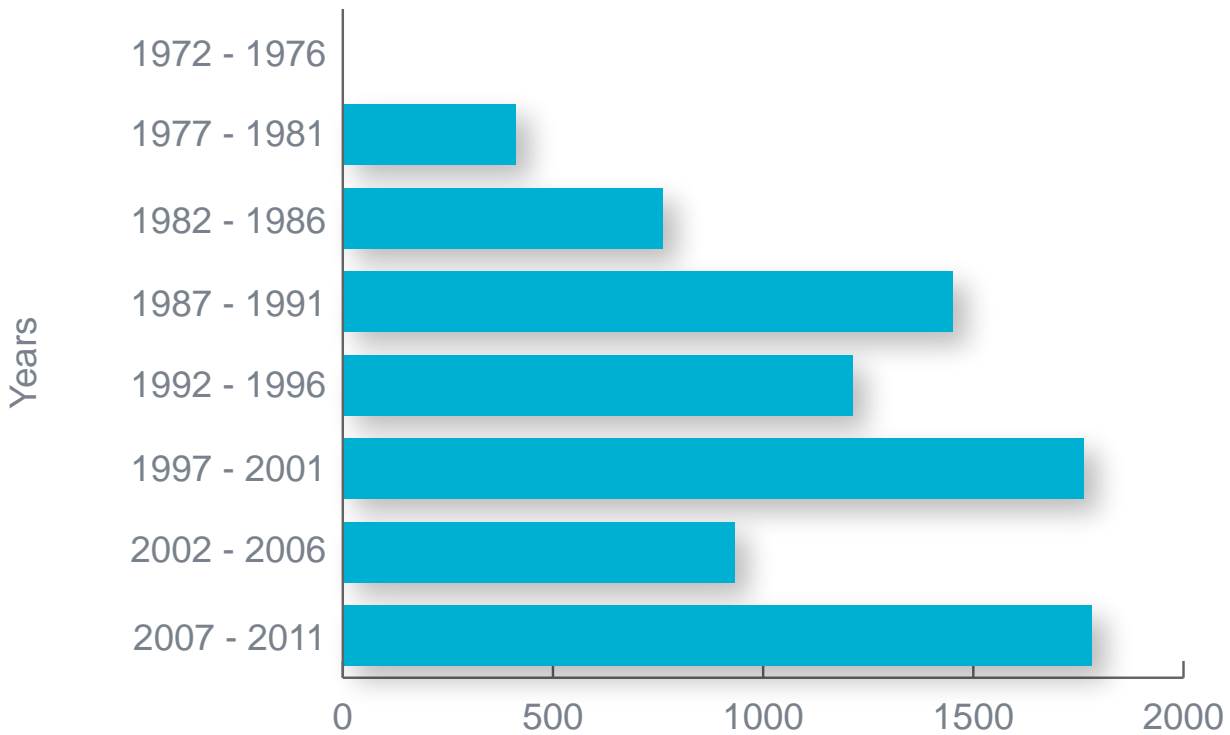
\* Inflated to December 2011 values



# REFINERIES



## REFINERY LOSSES IN FIVE YEAR PERIODS



### NOTE

In the following table the loss values to be used for comparison are the values that have been inflated to December 2011 US dollars (Estimated Current Value). A graph is presented indicating the sector's losses grouped into five year periods. Loss values stated in the body of the description text for each loss are in money of the day. bbl/d = barrels per day.

Five year loss totals in the refining sector have continued to trend upwards over the last few years. While the 2002–2006 period presented a drop in losses, the increasing trend is unlikely to have abated. Piping failures or leaks (corrosion or incorrect metallurgy) and start-up and shut-down events continue to be significant causes.

## REFINERIES

### FIRE/EXPLOSION

EVENT DATE	06/01/2011
LOCATION	Fort McKay, Alberta, Canada
VALUE	USD 600,000,000
ESTIMATED CURRENT VALUE	USD 600,000,000

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 and burned for nearly four hours. As a result two of the coke drums were disabled. Workers returned to work to 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 ignition leading 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 desk having deluge protection. Collateral freezing damage was also experienced.



<b>HURRICANE</b>		This 365,000 bbl/d refinery sustained damage during Hurricane Ike. A protective barrier was breached during the hurricane resulting in the plant flooding with sea water. The site was inundated by storm surge.
EVENT DATE	12/09/2008	
LOCATION	Texas, USA	
VALUE	USD 500,000,000	
ESTIMATED CURRENT VALUE	USD 540,000,000	
<b>FIRE/EXPLOSION</b>		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 hospitalised for burns. Another person was apparently injured when her car was struck by debris on the nearby highway. A skeleton crew of just 40 people were 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.
EVENT DATE	18/02/2008	
LOCATION	Texas, USA	
VALUE	USD 380,000,000	
ESTIMATED CURRENT VALUE	USD 410,000,000	
<b>FIRE/EXPLOSION</b>		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, though 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 and the No. 1 crude unit at the refinery remained operational.
EVENT DATE	16/08/2007	
LOCATION	Pascagoula, Mississippi, USA	
VALUE	USD 200,000,000	
ESTIMATED CURRENT VALUE	USD 230,000,000	
<b>FIRE/EXPLOSION</b>		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 shutdown 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 fabricated from incorrect material.
EVENT DATE	12/10/2006	
LOCATION	Mazeikiu, Lithuania	
VALUE	USD 140,000,000	
ESTIMATED CURRENT VALUE	USD 170,000,000	
<b>FIRE/EXPLOSION</b>		Fifteen people were killed and 105 injured following an explosion at this 460,000 bbl/d refinery. The explosion occurred in the isomerisation 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 vapour 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 vapour release from a 30 metre high vent stack moments before the ignition.
EVENT DATE	23/03/2005	
LOCATION	Texas, USA	
VALUE	USD 200,000,000	
ESTIMATED CURRENT VALUE	USD 250,000,000	

<b>FIRE/EXPLOSION</b>		A fire broke out at this oil sands refinery in Upgrader 2, an area of the plant that converts bitumen into crude oil products. 250 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 storeys 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 03 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.
EVENT DATE	04/01/2005	
LOCATION	Fort McKay, Alberta, Canada	
VALUE	USD 120,000,000	
ESTIMATED CURRENT VALUE	USD 150,000,000	
<b>FIRE/EXPLOSION</b>		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.
EVENT DATE	06/01/2003	
LOCATION	Fort McMurray, Alberta, Canada	
VALUE	USD 120,000,000	
ESTIMATED CURRENT VALUE	USD 170,000,000	
<b>FIRE/EXPLOSION</b>		Following torrential rain, rising floodwater allowed waste oil floating on its surface to be brought into contact with hot equipment on this refinery causing 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	22/11/2002	
LOCATION	Port of Mohammedia, Morocco	
VALUE	USD 130,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	
<b>FIRE</b>		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	14/08/2001	
LOCATION	Lemont, Illinois, USA	
VALUE	USD 150,000,000	
ESTIMATED CURRENT VALUE	USD 220,000,000	
<b>FIRE</b>		A piping leak resulted in a fire in this refinery coker unit. Smoke rose to over 3,000 feet and the coker was shut down for approximately two months.
EVENT DATE	23/04/2001	
LOCATION	Carson City, California, USA	
VALUE	USD 120,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	

<b>FIRE</b>		An oil spill occurred due to a failure of a block valve to seat 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 fire fighting access. Inadequately trained fire brigade 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	09/04/2001	
LOCATION	Wickland, Aruba, Dutch Antilles	
VALUE	USD 160,000,000	
ESTIMATED CURRENT VALUE	USD 250,000,000	
<b>FIRE/EXPLOSION</b>		The 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	25/06/2000	
LOCATION	Mina Al-Ahmadi, Kuwait	
VALUE	USD 380,000,000	
ESTIMATED CURRENT VALUE	USD 590,000,000	
<b>EARTHQUAKE</b>		An earthquake measuring 7.4 on the Richter scale caused a collapse of a 312 foot high concrete chimney on 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, fire fighting efforts were limited to attempts by aircraft to drop chemicals on the fires. The United States 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	17/08/1999	
LOCATION	Korfez, Gulf of Izmit, Turkey	
VALUE	USD 200,000,000	
ESTIMATED CURRENT VALUE	USD 330,000,000	
<b>EXPLOSION</b>		This explosion was caused by the failure of a valve bonnet in a high-pressure section of a 60,000 bbl/d hydrocracker. A vapour 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 in the destruction of a large fin fan cooler mounted above the rack. Many pumps were destroyed and a separator was badly damaged. Approximately 300 fire fighters and 33 fire trucks participated in the two and a half hour effort to control the fire. Foam concentrate consumed totalled 3,200 US gallons. The hydrocracker was out of service for 12 months.
EVENT DATE	25/03/1999	
LOCATION	Richmond, California, USA	
VALUE	USD 110,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	
<b>HURRICANE</b>		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 replacement 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	01/09/1998	
LOCATION	Pascagoula, Mississippi, USA	
VALUE	USD 190,000,000	
ESTIMATED CURRENT VALUE	USD 320,000,000	

<b>FIRE</b>		A severe thunderstorm passed over this refinery between 07:20 and 09:00 on 24 July. 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.
<b>EVENT DATE</b>	24/07/1994	
<b>LOCATION</b>	Pembroke, UK	
<b>VALUE</b>	USD 78,000,000	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 vapour 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.
<b>ESTIMATED CURRENT VALUE</b>	USD 140,000,000	As a result of the wet gas compressor shutdown, there was a large vapour load on the FCC flare system which lead 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 fell to the ground.
		The hydrocarbon liquid and vapour 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 centred 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 FCC, 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 27 July. The fire fighting 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 United Kingdom was lost until this complex was returned to service. The Business Interruption loss for this incident was estimated at USD 70 million, which reflects 4.5 months of downtime.

<b>VAPOUR CLOUD EXPLOSION</b>		Operations were normal at this 136,000 bbl/d refinery when a vapour cloud explosion occurred in the gas plant associated with the 29,700 bbl/d Fluid Catalytic Cracker (FCC) unit.
<b>EVENT DATE</b>	09/11/1992	The initial vapour 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.
<b>LOCATION</b>	La Mede, France	
<b>VALUE</b>	USD 230,000,000	At approximately 05:17 a gas detection system in the FCC unit sounded an alarm indicating a major gas leak. While the unit operator was contacting the security service to warn of this situation, the initial explosion occurred at approximately 05:20. 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.
<b>ESTIMATED CURRENT VALUE</b>	USD 430,000,000	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 this 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 windows were broken up to six miles away.
		The refinery fire brigade and over 250 firemen from three neighbouring industrial sites and four nearby towns were utilised for more than six hours to bring this incident under control. Approximately 37,000 US gallons of foam concentrate were used during the fire fighting effort. Some fires were intentionally left burning after the incident was under control at 11:30 to allow safe depressurising of the process units since the flare system was partially damaged by the explosions. All of the fires were extinguished by 17:30.

<b>FIRE/EXPLOSION</b>		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 hydrodesulphurisation 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 lb and 2,000 lb, respectively.
EVENT DATE	16/10/1992	
LOCATION	Sodegaura, Japan	
VALUE	USD 160,000,000	The hydrodesulphurisation 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 fire fighters using 15 fire trucks.
ESTIMATED CURRENT VALUE	USD 310,000,000	
<b>FIRE/EXPLOSION</b>		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, hydrodesulphurisation, and hydrogen processing units by the explosion and subsequent fires. The fires were fuelled 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.
EVENT DATE	08/10/1992	
LOCATION	Wilmington, California, USA	
VALUE	USD 78,000,000	The explosion resulted from the rupture of a six inch diameter carbon steel 90° elbow (outside radius) and release of a hydrocarbon-hydrogen mixture to the atmosphere. The vapour 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 a contributory cause 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.
ESTIMATED CURRENT VALUE	USD 150,000,000	
		The fire fighting effort was coordinated by the refinery emergency response team, with the Los Angeles City and Los Angeles County Fire Departments utilising 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 run-off generated by the fire fighting effort from reaching the Los Angeles Harbour. The fire was finally extinguished at 02:00 on 11 October.
		Because of this incident, the refinery's gasoline production was reduced to 35,000 bbl/d (approximately 70% of rated capacity) 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.
<b>VAPOUR CLOUD EXPLOSION</b>		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 vapour cloud was ignited, causing an unconfined vapour cloud explosion.
EVENT DATE	24/12/1989	
LOCATION	Baton Rouge, Louisiana, USA	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 3,600,000 gallons of diesel, twelve small tanks containing a total of 882,000 gallons of lube oil, and two separator units.
VALUE	USD 69,000,000	
ESTIMATED CURRENT VALUE	USD 140,000,000	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 fire fighting had to be supplied with the remaining plant fire pumps and municipal fire trucks taking draught from alternate sources.
		Approximately 48,000 gallons of AFFF foam concentrate, 200 fire brigade members and 13 pumper units were used during the fire fighting 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.

HURRICANE		
EVENT DATE	18/09/1989	Hurricane Hugo struck this refinery, causing extensive damage to fourteen of the 500,000–600,000 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.
LOCATION	St Croix, Virgin Islands, USA	
VALUE	USD 170,000,000	
ESTIMATED CURRENT VALUE	USD 340,000,000	
FIRE		
EVENT DATE	10/04/1989	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 foot high 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.
LOCATION	Richmond, California, USA	
VALUE	USD 90,000,000	
ESTIMATED CURRENT VALUE	USD 180,000,000	
		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 by-pass 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.





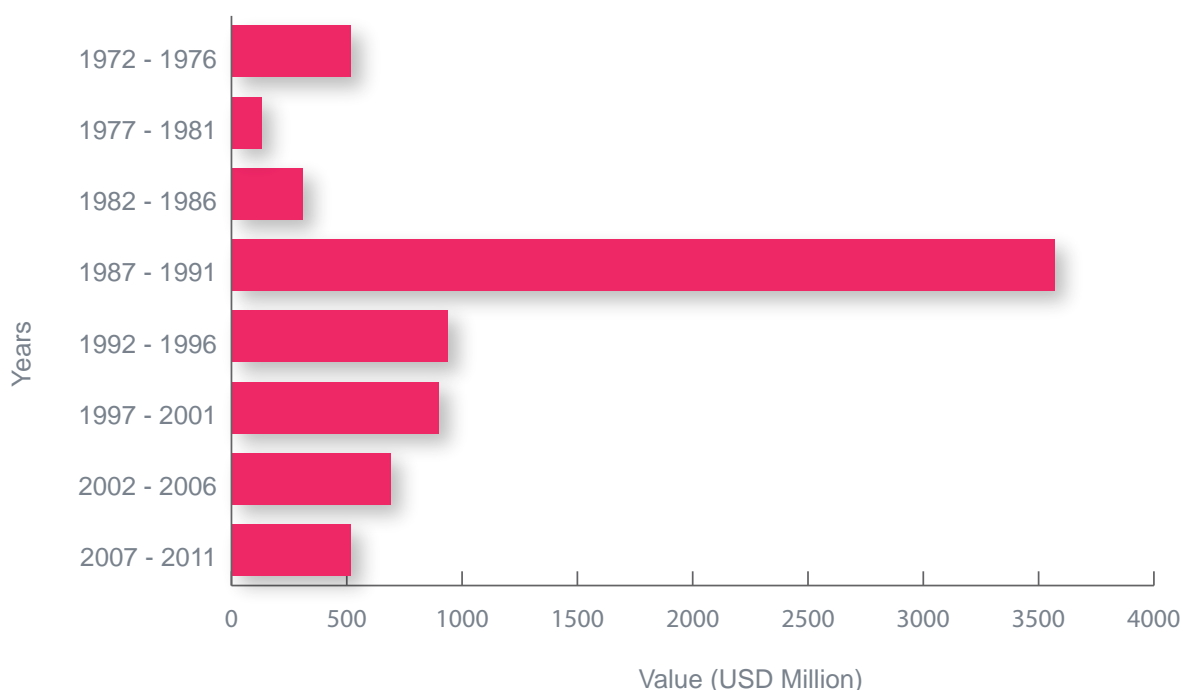
<b>VAPOUR CLOUD EXPLOSION</b>		Operations were normal in a 90,000 bbl/d Fluid Catalytic Cracking (FCC) unit when internal corrosion caused the failure of the outside radius of an eight inch diameter carbon steel elbow located 50 feet above grade in the depropaniser column overhead piping system. An estimated 20,000 lb of C3 hydrocarbons escaped through the resulting hole, forming a large vapour cloud during the 30 seconds between failure and ignition. Both the depropaniser column (operating at 270 psi and 130 °F) and the depropaniser accumulator depressurised through the opening. Ignition of the vapour cloud was probably caused by the FCC charge heater.
EVENT DATE	05/05/1988	
LOCATION	Norco, Louisiana, USA	
VALUE	USD 290,000,000	The initial blast destroyed the FCC control building and toppled the 26 foot diameter main fractionator from its 15 foot high concrete pedestal. The column separated from its 10 foot high skirt before falling. Analysis of bolt stretching of towers in the blast path indicated over pressures as high as 10 psi.
ESTIMATED CURRENT VALUE	USD 600,000,000	The refinery immediately lost all utilities, including fire water and the four diesel fire pumps, greatly limiting the fire fighting 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 6 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 depropaniser 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 shown the expected corrosion rates of 0.05 mils per year. Measurements taken at the failed elbow and in the downstream piping after the explosion revealed unexpected high localised corrosion rates.
<b>FIRE/EXPLOSION</b>		250,000 gallons of fuel leaked into subsoil causing ground water contamination. A clean-up order was issued by the local water authority.
EVENT DATE	14/04/1988	
LOCATION	USA	
VALUE	USD 89,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	
<b>FIRE</b>		A straight run of eight inch diameter pipe carrying hot oil fractured in this refinery's hydrodesulphuriser. 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 700 psi and 650°F sprayed across the roadway into the hydrogen units where ignition occurred.
EVENT DATE	13/12/1984	
LOCATION	Amuay, Venezuela	
VALUE	USD 62,000,000	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 6.5 hours, the fire was extinguished. Damage was extensive. The three hydrogen plants and the four hydrodesulphurisation (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.
ESTIMATED CURRENT VALUE	USD 140,000,000	
<b>FIRE</b>		Erosion failure in a 10 inch diameter slurry recycle oil line in an 82,000 bbl/d fluid bed coking unit released liquids near their autoignition temperature.
EVENT DATE	15/08/1984	
LOCATION	Fort McMurray, Alberta, Canada	Vapours which 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 over 100 feet.
VALUE	USD 76,000,000	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.
ESTIMATED CURRENT VALUE	USD 180,000,000	The reactor fractionator, light gasoil stripper, 15,000 hp air blower, pumps, pipe racks etc. 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 much of the flow. A 900 psig steam line, which supplied the turbine drivers of the compressors, ruptured hampering fire fighting efforts.

<b>EXPLOSION</b>		Just prior to the rupture of a 55 foot tall, 8.5 foot diameter monoethanolamine absorber column, a refinery operator noted a six inch long horizontal crack at a circumferential weld which 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 200 psig and 100°F propelled most of the 20 tonne vessel 3,500 feet where it struck and toppled a 138,000 volt power transmission tower.
<b>EVENT DATE</b>	23/07/1984	
<b>LOCATION</b>	Romeoville, Illinois, USA	
<b>VALUE</b>	USD 190,000,000	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.
<b>ESTIMATED CURRENT VALUE</b>	USD 440,000,000	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 Boiling Liquid Expanding Vapour Explosion (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 unifying unit over 600 feet away, causing a major fire where it landed.
		The first explosion, believed to be from an unconfined vapour 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 gallons 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 centre, 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 fire fighting.
<b>EXPLOSION</b>		Nearly simultaneous explosions aboard a 70,000 deadweight tonnage tanker off-loading vacuum distillate and in an 80,000 barrel (bbl) ethanol tank at a refinery occurred during a severe electrical storm. The ethanol tank was ignited when a plate section of the exploded tanker flew through the air and struck the tank, causing it to explode and burn.
<b>EVENT DATE</b>	01/09/1979	
<b>LOCATION</b>	Deer Park, Texas, USA	The ship, tied up at the refinery dock, had discharged all but 50,000 bbl of its 128,000 bbl cargo when the explosion occurred. Unloading had been suspended minutes earlier because of a storm in the area. Explosions within the ship's holds spread 5,000 to 10,000 bbl of burning distillate on the water. This involved several nearby docks and four gasoline and crude oil barges.
<b>VALUE</b>	USD 68,000,000	The 120 foot diameter cone roof alcohol tank was about a third full. It burned itself out in about 14 minutes.
<b>ESTIMATED CURRENT VALUE</b>	USD 220,000,000	
<b>FIRE</b>		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 barrel (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 Boiling Liquid Expanding Vapour Explosions (BLEVEs).
<b>EVENT DATE</b>	30/05/1978	
<b>LOCATION</b>	Texas City, Texas, USA	
<b>VALUE</b>	USD 55,000,000	Pieces of the tanks travelled 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.
<b>ESTIMATED CURRENT VALUE</b>	USD 190,000,000	

# PETROCHEMICALS



## PETROCHEMICAL LOSSES IN FIVE YEAR PERIODS



### NOTE

In the following table the loss values to be used for comparison are the values that have been inflated to December 2011 US dollars (Estimated Current Value). A graph is presented indicating the sector's losses grouped into five year periods. Loss values stated in the body of the description text for each loss are in money of the day. bbl/d = barrels per day.

There appears to be only a weak trend within this data, perhaps as the result of petrochemicals assets being generally younger than their refinery counterparts and having been rebuilt as newer, more cost efficient technologies are developed and implemented. Plant sizes are still believed to be generally increasing, which is perhaps reflected in the continuing loss figures in the more recent time periods.

The high value for the period 1987–1991 was dominated by three explosion events, two of which were vapour cloud explosions. These occurred in the USA at Pasadena, Pampa and Henderson, and account for 70% of the total for this timeframe. This shows clearly the impact of true Estimated Maximum Loss events, defined within Marsh as ‘the loss that could be sustained under abnormal conditions with the failure of all protective systems’. In 1992 the United States Department of Labor, Occupational Safety and Health

Administration (OSHA) issued the Process Safety Management of Highly Hazardous Chemicals standard (29 CFE 1910.199). This regulation set a requirement for hazard management and established a comprehensive Process Safety Management (PSM) programme integrating technology, procedures and management practices. The introduction of this standard may be credited with improving process safety performance on US hydrocarbon processing facilities from 1992 onwards.

Following the 1987–1991 period, it could be inferred that losses are decreasing. However, as demonstrated by the disproportionately large 1987–1991 loss quantum, a few high value losses can quickly skew a trend.

## PETROCHEMICALS

### HURRICANE

EVENT DATE	12/08/2008	This petrochemical facility sustained damage during Hurricane Ike. Storm surge, flooding and high winds caused significant damage at the site. Force majeure was declared and the most heavily damaged portion of the plant remained off line for 152 days.
LOCATION	Texas, USA	
VALUE	USD 220,000,000	
ESTIMATED CURRENT VALUE	USD 240,000,000	

### FIRE/EXPLOSION

EVENT DATE	20/03/2007	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, which 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 with minor injuries. There was one minor injury off site. 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.
LOCATION	Niigata, Japan	
VALUE	USD 240,000,000	
ESTIMATED CURRENT VALUE	USD 280,000,000	

### FIRE/EXPLOSION

EVENT DATE	29/04/2006	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.
LOCATION	Texas, USA	
VALUE	USD 200,000,000	
ESTIMATED CURRENT VALUE	USD 240,000,000	

### EXPLOSION

EVENT DATE	10/12/2005	A release of hexane created a vapour cloud which ignited on an electric motor causing an explosion. This resulted in damage to the unit and some 20 injuries. The plant was eventually replaced.
LOCATION	Münchsmünster, Germany	
VALUE	USD 200,000,000	
ESTIMATED CURRENT VALUE	USD 250,000,000	

### EXPLOSION

EVENT DATE	23/04/2004	Five people were killed and two seriously injured following an explosion at a plastics plant producing 200 million barrels per year of speciality 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 8 kilometres away.  OSHA later imposed fines of USD 361,500 against the company saying that it had found dozens of safety violations from defective equipment to poor worker training. There were three wilful 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.
LOCATION	Illioopolis, Illinois, USA	
VALUE	USD 150,000,000	
ESTIMATED CURRENT VALUE	USD 200,000,000	



<b>EXPLOSION</b>		A massive explosion occurred in an ammonium nitrate storage warehouse of a fertilizer plant just outside the southern French city of Toulouse. The warehouse contained approximately 300 tonnes of off-specification ammonium nitrate crystals. The explosion had the strength of a 3.2 magnitude (Richter Scale) earthquake, left most of the plant in ruins and caused damage to surrounding areas. Thirty people were killed in the blast and approximately 3,000 people were injured.
EVENT DATE	21/09/2001	
LOCATION	Toulouse, France	
VALUE	USD 430,000,000	
ESTIMATED CURRENT VALUE	USD 670,000,000	
<b>FIRE/EXPLOSION</b>		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.
EVENT DATE	22/06/1997	
LOCATION	Deer Park, Texas, USA	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.
VALUE	USD 140,000,000	
ESTIMATED CURRENT VALUE	USD 230,000,000	About 30 workers were treated for minor injuries.
<b>EXPLOSION</b>		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.
EVENT DATE	13/12/1994	
LOCATION	Port Neal, Iowa, USA	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 over 30 miles away.
VALUE	USD 200,000,000	
ESTIMATED CURRENT VALUE	USD 370,000,000	As a result of this incident, a business interruption loss estimated at USD 60 million was incurred.
<b>MECHANICAL DAMAGE</b>		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, 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.
EVENT DATE	20/10/1994	
LOCATION	Cedar Bayou, Texas, USA	The original loss figure of USD 130 million is a combination of property damage and business interruption, with the breakdown between these not known.
VALUE	USD 130,000,000	
ESTIMATED CURRENT VALUE	USD 240,000,000	
<b>EXPLOSION</b>		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.
EVENT DATE	27/05/1994	
LOCATION	Belpre, Ohio, USA	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 1,000,000 US gallon and one 500,000 US gallon styrene storage tanks exploded. A fire fighting attack utilising 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.
VALUE	USD 180,000,000	
ESTIMATED CURRENT VALUE	USD 330,000,000	



<b>EXPLOSION</b>		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 resulted which caused significant damage to this fertiliser 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	20/06/1991	
LOCATION	Dhaka, Bangladesh	
VALUE	USD 71,000,000	
ESTIMATED CURRENT VALUE	USD 140,000,000	
<b>FIRE/EXPLOSION</b>		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 this plant. Additionally, the initial explosion completely damaged an area of the plant approximately the size of a city block.
EVENT DATE	01/05/1991	
LOCATION	Sterlington, Louisiana, USA	
VALUE	USD 120,000,000	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.
ESTIMATED CURRENT VALUE	USD 230,000,000	
<b>EXPLOSION</b>		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 co-generation 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 which 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.
EVENT DATE	12/03/1991	
LOCATION	Seadrift, Texas, USA	
VALUE	USD 90,000,000	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 fire fighting effort was used to extinguish the fire involving the pipe rack once the lines in the rack were isolated.
ESTIMATED CURRENT VALUE	USD 180,000,000	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, utilising imported ethylene, while the olefins production was restarted in late April 1991.
<b>FIRE/EXPLOSION</b>		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.
EVENT DATE	11/03/1991	
LOCATION	Pajaritos, Mexico	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.
VALUE	USD 97,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	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.

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## VAPOUR CLOUD EXPLOSION

EVENT DATE 23/10/1989

LOCATION Pasadena, Texas, USA

VALUE USD 680,000,000

ESTIMATED CURRENT VALUE USD 1,400,000,000

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 vapour cloud drifted northward toward the centre 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 pressurised 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 lock-out 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 lock-out 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 represents the largest single-owner property damage loss to occur in the petrochemical industry.



<b>EXPLOSION</b>		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.
EVENT DATE	07/03/1989	
LOCATION	Antwerp, Belgium	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.
VALUE	USD 79,000,000	
ESTIMATED CURRENT VALUE	USD 160,000,000	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 USD 270 million.
<b>EXPLOSION</b>		An explosion at a plant that manufactured ammonium perchlorate (AP) for rocket fuel, flattened the local industrial park, left a crater 125 metres 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 USD 70 million. A natural gas pipeline that ran under the plant was ruptured in the event and burned for one week.
EVENT DATE	04/05/1988	
LOCATION	Henderson, Nevada, USA	
VALUE	USD 300,000,000	
ESTIMATED CURRENT VALUE	USD 630,000,000	
<b>VAPOUR CLOUD EXPLOSION</b>		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 vapourise and form a vapour cloud. A vapour 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	14/11/1987	
LOCATION	Pampa, Texas, USA	
VALUE	USD 220,000,000	
ESTIMATED CURRENT VALUE	USD 470,000,000	
<b>EXPLOSION</b>		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 decomposition of material within it, although the original ignition source has never been confirmed.
EVENT DATE	03/07/1987	
LOCATION	Zwijndrecht, Antwerp, Belgium	
VALUE	USD 78,000,000	
ESTIMATED CURRENT VALUE	USD 170,000,000	

<b>FIRE</b>		Operations within this 600,000 tonne per year 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 deethaniser column. The source of fuel is believed to be a flange at the deethaniser column reboiler or in the relief system pipe work.
<b>EVENT DATE</b>	19/05/1985	
<b>LOCATION</b>	Priolo, Italy	
<b>VALUE</b>	USD 74,000,000	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.
<b>ESTIMATED CURRENT VALUE</b>	USD 170,000,000	Eventually one vertical pressurised 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 which 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 centres, pumps etc. 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 fire fighting agencies, the plant fire brigade brought the fire under control in 40 hours and finally extinguished it four days after ignition.
<b>FIRE</b>		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.
<b>EVENT DATE</b>	15/09/1984	
<b>LOCATION</b>	Cheshire, UK	
<b>VALUE</b>	USD 62,000,000	
<b>ESTIMATED CURRENT VALUE</b>	USD 140,000,000	
<b>VAPOUR CLOUD EXPLOSION</b>		Improper maintenance procedures at this petrochemical site resulted in a vapour 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 vapour cloud which ignited after approximately two minutes.
<b>EVENT DATE</b>	29/10/1980	
<b>LOCATION</b>	Newcastle, Delaware, USA	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 polymerisation finishing and storage silo areas burned for over 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.
<b>VALUE</b>	USD 45,000,000	
<b>ESTIMATED CURRENT VALUE</b>	USD 130,000,000	
<b>FIRE/EXPLOSION</b>		A vent connection failed on a compressor suction line, releasing gas which led to a violent explosion with widespread damage. This was believed to be a fatigue failure due to vibration.
<b>EVENT DATE</b>	02/10/1975	
<b>LOCATION</b>	Antwerp, Belgium	
<b>VALUE</b>	USD 60,000,000	
<b>ESTIMATED CURRENT VALUE</b>	USD 250,000,000	

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**VAPOUR CLOUD  
EXPLOSION**

<b>EVENT DATE</b>	01/06/1974
<b>LOCATION</b>	Flixborough, UK
<b>VALUE</b>	USD 58,000,000
<b>ESTIMATED CURRENT VALUE</b>	USD 270,000,000

This incident is generally accepted to be a pipeline bellows failure due to design error and lack of modification control. The failed bellows (500 mm in diameter) released some 30 tonnes of cyclohexane which formed a vapour cloud and exploded, destroying the plant, killing 28 people on site, injuring 53, and inflicting damage to some 1,821 houses and 167 business premises. The number of fatalities would have been higher had it not been a weekend. The ensuing fire burnt for three days.

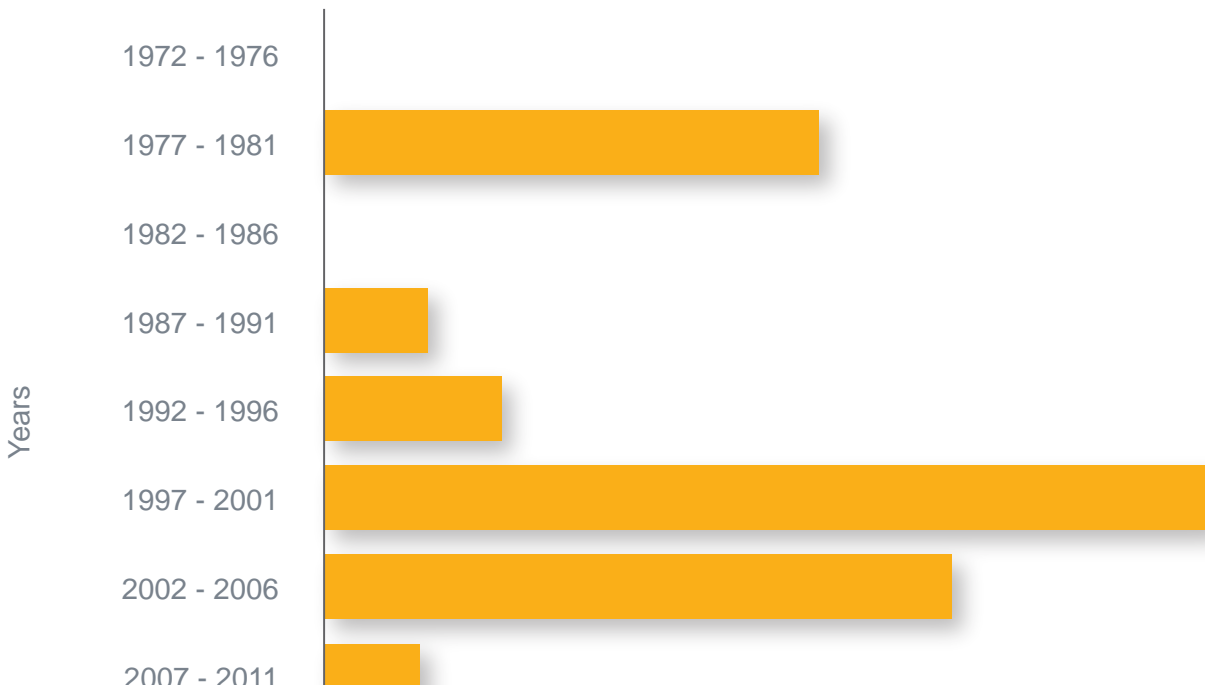


# GAS PROCESSING





## GAS PROCESSING PLANT LOSSES IN FIVE YEAR PERIODS



**NOTE**

In the following table the loss values to be used for comparison are the values that have been inflated to December 2011 US dollars (Estimated Current Value). A graph is presented indicating the sector's losses grouped into five year periods. Loss values stated in the body of the description text for each loss are in money of the day. bbl/d = barrels per day.

This sector of the industry does not present an obvious trend; a small number of losses with large loss quantum characterise this section. There are also two periods where this sub-section of our industry does not have any events that make it into the 100 Largest Losses.

built facilities often present good risk management and mitigation features such as good layout, good separation, and good levels of process isolation and gas detection. The materials processed in these facilities are generally less corrosive than those processed in some other sectors of the hydrocarbon processing industry.

New plants and systems are being built to handle gas or liquefied natural gas (LNG), although again these recently

### GAS PROCESSING

**FIRE/EXPLOSION**

<b>EVENT DATE</b>	03/06/2008
<b>LOCATION</b>	Varanus Island, Australia
<b>VALUE</b>	USD 120,000,000
<b>ESTIMATED CURRENT VALUE</b>	USD 130,000,000

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 cm 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 on line after approximately six months.

<b>MECHANICAL FAILURE</b>		No further details known.
EVENT DATE	28/08/2005	
LOCATION	New South Wales, Australia	
VALUE	USD 170,000,000	
ESTIMATED CURRENT VALUE	USD 220,000,000	
<b>FIRE/EXPLOSION</b>		Twenty seven people were killed, seventy two injured and seven reported missing following an explosion at this LNG plant. 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 neighbouring 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 re-started 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	19/01/2004	
LOCATION	Skikda, Algeria	
VALUE	USD 470,000,000	
ESTIMATED CURRENT VALUE	USD 630,000,000	
<b>EXPLOSION</b>		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 lb of hydrocarbon vapour exploded, and an estimated 26,000 lb burned as a jet fire. The fire burned for 2.5 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	25/09/1998	
LOCATION	Longford, Victoria, Australia	
VALUE	USD 440,000,000	
ESTIMATED CURRENT VALUE	USD 740,000,000	
<b>FIRE/EXPLOSION</b>		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.
EVENT DATE	25/12/1997	
LOCATION	Bintulu, Sarawak, Malaysia	The plant was 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.
VALUE	USD 275,000,000	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 aluminium heat exchanger elements in the presence of liquid oxygen, such that the elements ruptured explosively. 12 people were injured, none seriously, and the plant was shut down for several months for repairs.
ESTIMATED CURRENT VALUE	USD 460,000,000	

<b>VAPOUR CLOUD EXPLOSION</b>		A vapour cloud explosion centred 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.
EVENT DATE	26/07/1996	
LOCATION	Cactus, Reforma, Mexico	On 25 July, 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 26 July. 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 vapour 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.
VALUE	USD 140,000,000	
ESTIMATED CURRENT VALUE	USD 240,000,000	
		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 Boiling Liquid Expanding Vapour Explosion (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.
<b>VAPOUR CLOUD EXPLOSION</b>		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.
EVENT DATE	15/08/1987	
LOCATION	Juaymah, Saudi Arabia	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 vapour cloud is believed to have been by a security vehicle which had stalled and was being restarted. The probable source of the propane was a flange in a four inch diameter relief valve line.
VALUE	USD 65,000,000	
ESTIMATED CURRENT VALUE	USD 140,000,000	
<b>VAPOUR CLOUD EXPLOSION</b>		A 22 inch diameter gas transmission pipeline operating at 500 psig developed a leak due to corrosion. The leak expanded and the line parted, releasing a vapour cloud near this gas processing plant that covered a significant area. After about seven minutes, ignition occurred from a flare located 1,500 feet downwind. The jet/whipping action of escaping gas threw a 22 foot long section of pipe 400 feet where it struck the vapour space of one of two 10,000 barrel pressurised spheroid tanks. A second vapour cloud formed and was ignited, developing detonation over-pressures of 7.8 pounds per square inch.
EVENT DATE	15/04/1978	
LOCATION	Abqaiq, Saudi Arabia	
VALUE	USD 54,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	
<b>MATERIAL FAILURE</b>		A 30 inch diameter crude oil pipeline failed and destroyed three pressurised spheroids, pumping units and other equipment. Ignition was caused by motor vehicles.
EVENT DATE	11/05/1977	
LOCATION	Abqaiq, Saudi Arabia	
VALUE	USD 55,000,000	
ESTIMATED CURRENT VALUE	USD 200,000,000	

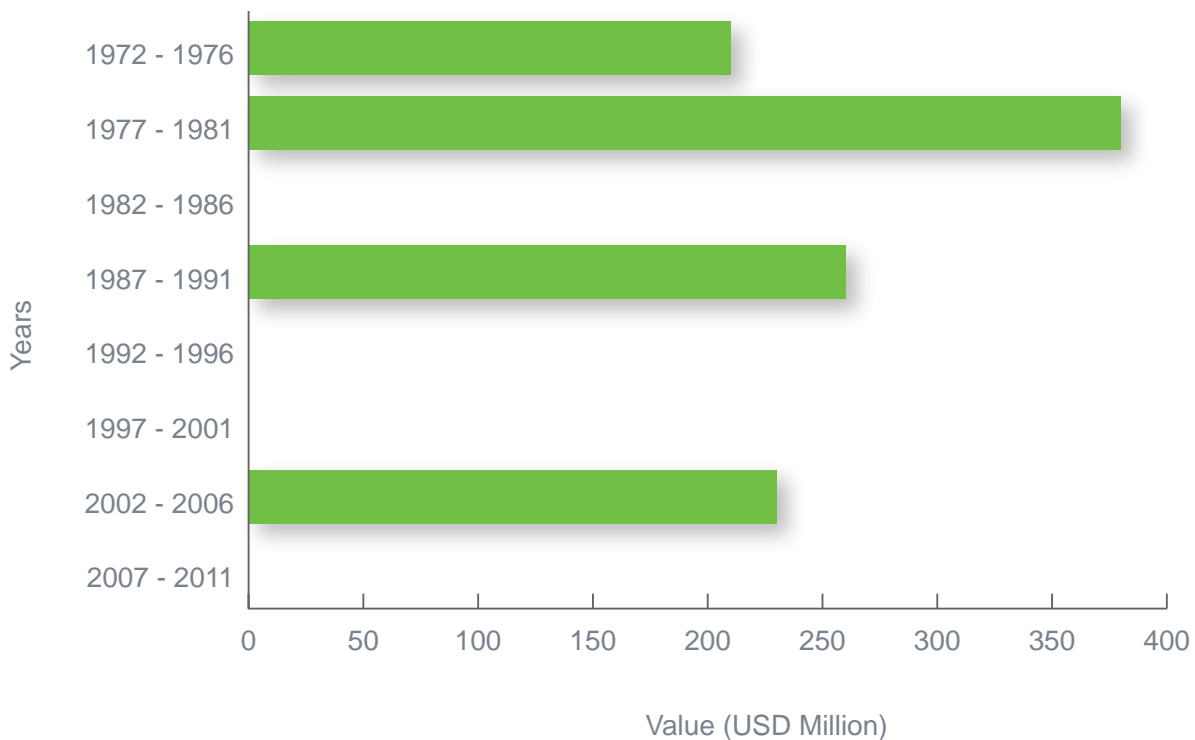
<b>FIRE</b>		A 260,000 bbl tank containing about 236,000 bbl of refrigerated propane at 45°F failed catastrophically and the wave of liquid propane swept over the dikes and inundated the 51,000 bbl/d process area before igniting. An adjoining tank containing 125,000 bbl of refrigerated butane also was destroyed, as was most of the process area. The fire burned out of control for two days and was extinguished after eight days. The tank weld failure was considered to have three possible causes, including micro-biological sulphate reducing bacteria being introduced by hydrotesting the tank with sea water.
<b>EVENT DATE</b>	03/04/1977	
<b>LOCATION</b>	Umm Said, Qatar	
<b>VALUE</b>	USD 76,000,000	Reportedly, the tank weld that failed had been repaired following a weld failure incident one year earlier in which 14,000 bbl of propane were released and a massive vapour cloud travelled 500 feet but did not ignite.
<b>ESTIMATED CURRENT VALUE</b>	USD 280,000,000	

# TERMINALS AND DISTRIBUTION





## TERMINALS AND DISTRIBUTION PLANT LOSSES IN FIVE YEAR PERIODS



### NOTE

In the following table the loss values to be used for comparison are the values that have been inflated to December 2011 US dollars (Estimated Current Value). A graph is presented indicating the sector's losses grouped into five year periods. Loss values stated in the body of the description text for each loss are in money of the day. bbl/d = barrels per day.

In the terminal and distribution sector, only five losses have been identified as large enough to be included. This sector now represents relatively few incidents in the analysis, largely due to the size of events in other sectors. As a result this chart has been generated from a low number of data points. The magnitude of individual losses at terminal and distribution facilities appears to be fairly flat; no general trend in such losses has been inferred.

Of course, whilst some losses are dramatic and of great interest to the press and the general public, this level of interest is not always reflected in the financial loss incurred.

Incidents of interest to the general public are often those with large plumes of smoke, inconvenience to the public and 'knock on' damage, as well as, sadly, high levels of death and injury. The Buncefield tank farm fire in the UK was a good example of this, with the fire closing the local motorway and causing damage to a number of third party assets. The loss does not, however, feature in this analysis as the property damage value was relatively low, particularly when compared to the third party and business interruption claims. The tank farm fire in Jaipur, India, does not feature in this analysis for similar reasons.

## TERMINALS AND DISTRIBUTION

### FIRE/EXPLOSION

		A petrol tanker caught fire and exploded as fuel was being offloaded into another fuel tanker. One driver was alleged to have been smoking when incident occurred.
EVENT DATE	08/07/2003	
LOCATION	Harare, Zimbabwe	The fire destroyed property worth over USD 160 million. A prefabricated concrete wall surrounding the premises was also destroyed and electricity cables were burnt down resulting in an electrical blackout in some parts of the area.
VALUE	USD 160,000,000	
ESTIMATED CURRENT VALUE	USD 230,000,000	

### EARTHQUAKE

		25 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 ten earthquakes in total. Repairs took several months.
EVENT DATE	05/03/1987	
LOCATION	Ecuador	
VALUE	USD 120,000,000	
ESTIMATED CURRENT VALUE	USD 260,000,000	

### EXPLOSION

		An eleven-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.
EVENT DATE	08/01/1979	
LOCATION	Bantry Bay, Ireland	
VALUE	USD 70,000,000	It is theorised 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.
ESTIMATED CURRENT VALUE	USD 230,000,000	
		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 were damaged or destroyed.

### FIRE

		A pipeline pump started whilst the strainer coverplate was being removed, and the oil released ignited. The fire was mostly confined to the pump house.
EVENT DATE	08/07/1977	
LOCATION	Fairbanks, Alaska, USA	
VALUE	USD 40,000,000	
ESTIMATED CURRENT VALUE	USD 150,000,000	

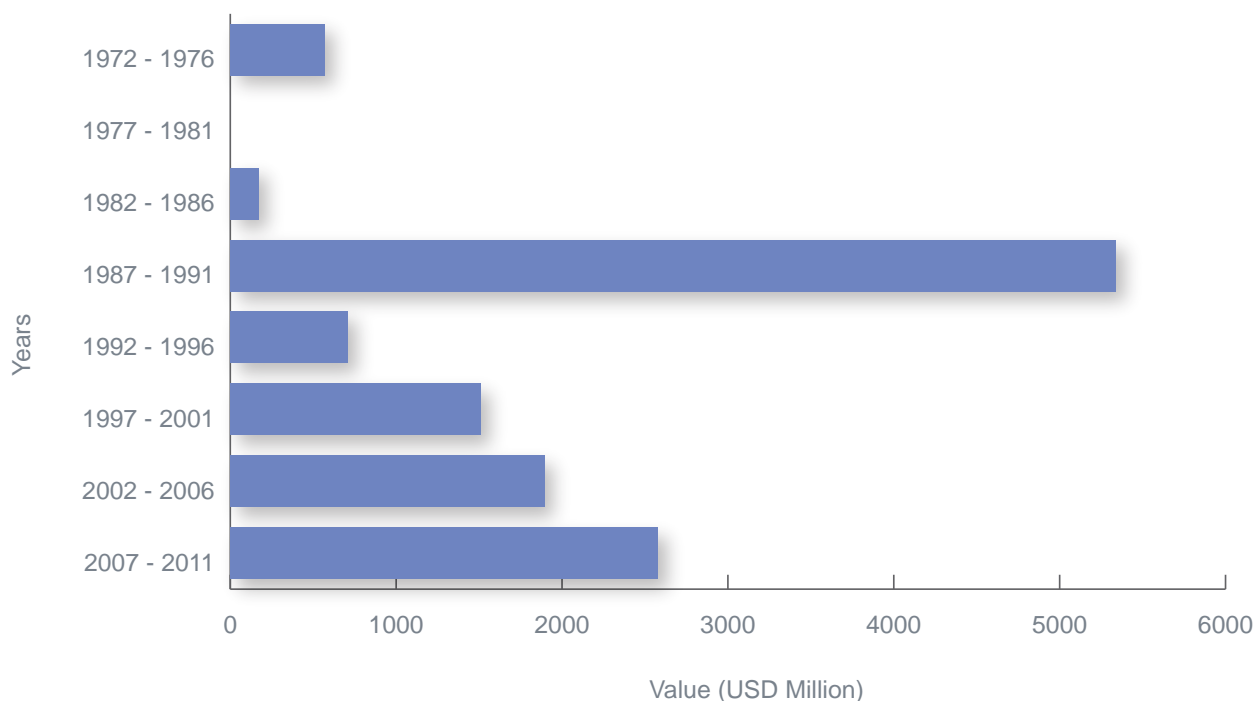
### FIRE/EXPLOSION

		The United States flag tanker 'Edgar M. Queeny' rammed the Greek tanker 'Corinthos' while the latter 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 on board this vessel, in addition to one crewman from the flag tanker. The Corinthos sank shortly afterwards and was later removed for scrapping.
EVENT DATE	31/01/1975	
LOCATION	Marcus Hook, USA	
VALUE	USD 50,000,000	
ESTIMATED CURRENT VALUE	USD 210,000,000	

# UPSTREAM



## UPSTREAM LOSSES IN FIVE YEAR PERIODS



### NOTE

In the following table the loss values to be used for comparison are the values that have been inflated to December 2011 US dollars (Estimated Current Value). A graph is presented indicating the sector's losses grouped into five year periods. Loss values stated in the body of the description text for each loss are in money of the day. bbl/d = barrels per day.

Unfortunately, the upstream loss data shows an increasing trend in the magnitude of losses over the periods analysed. The peak in the fourth period of the chart is due to the Piper Alpha incident when some 167 crew members lost their lives. This loss also represents the largest single property damage event (at current values) in this edition.

As with other sectors of the hydrocarbon and chemicals industry, facilities are generally getting larger and are being constructed to operate in deeper waters and harsher environmental conditions. Losses, when they do occur, are therefore larger, but it appears that the industry has learned from some of the serious incidents in the past, such as Piper Alpha, and newer facilities are better designed to prevent, detect and mitigate the effect of releases.

It is worth noting that five of the six new losses that have been included in this analysis have occurred in the upstream category; the sixth being on a site employing contemporary methods for oil recovery from an onshore source. As high world oil prices make previously marginal sources of hydrocarbon profitable, projects with increased capital exposure are increasingly being pursued. Such projects inherently present a greater exposure in the event of a loss.

These various factors should be a cause for concern when considering the trend in upstream loss data.

## UPSTREAM

### CAPSIZE

EVENT DATE	12/04/2011
LOCATION	Gulf of Mexico, USA
VALUE	USD 160,000,000
ESTIMATED CURRENT VALUE	USD 160,000,000

638 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 km 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.

### HEAVY WEATHER

EVENT DATE	04/02/2011
LOCATION	North Sea, UK
VALUE	USD 450,000,000
ESTIMATED CURRENT VALUE	USD 450,000,000

Heavy storm conditions in the North Sea caused four of this FPSO's ten 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 9 metre waves. Normally a complex piping system runs from the wells on the seabed up to the FPSO, 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. 74 non-essential crew were evacuated to near-by platforms and 43 essential crew remained on-board. Two members of crew 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 business interruption loss is expected to be incurred.

### LEAK

EVENT DATE	13/05/2010
LOCATION	Caribbean Sea, Venezuela
VALUE	USD 240,000,000
ESTIMATED CURRENT VALUE	USD 250,000,000

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.

### FIRE/EXPLOSION/ BLOWOUT

EVENT DATE	21/04/2010
LOCATION	Gulf of Mexico, USA
VALUE	USD 560,000,000
ESTIMATED CURRENT VALUE	USD 590,000,000

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. Eleven people were 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 ft. The exploration well had reached a depth of 18,360 ft (total depth) and was undergoing cementing works, prior to the well control event, with a view to temporarily abandoning the well.

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 sub-sea and surface spill control response. The well was declared finally killed five months after the original event by successful interception by a relief well.

The lease operator has set up a USD 20 billion compensation fund and the loss has led to attempts to place a temporary ban on drilling activity in US coastal waters.

### BLOWOUT

EVENT DATE	21/08/2009
LOCATION	Montara/Timor Sea, Australia
VALUE	USD 150,000,000
ESTIMATED CURRENT VALUE	USD 170,000,000

Oil, condensate and hydrogen sulphide leaked from a well head on a platform being serviced by a jack up rig in the Timor Sea. 69 workers on the rig were evacuated. Oil and gas started to spill after a plug blocking one of the project's 1,200 metre deep wells came free. The next day a 12 kilometre long and 30 metre 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 01 November 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 pug 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.



<b>COLLISION</b>		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 2 metres, 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	04/06/2009	
LOCATION	Ekofisk, North Sea, Norway	
VALUE	USD 750,000,000	
ESTIMATED CURRENT VALUE	USD 830,000,000	
<b>ANCHOR DRAG</b>		On 26 January 2009, communication was lost between the subsea centre 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 the vessel had lost control / steerage and had drifted back over the subsea centre. 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 well.
EVENT DATE	26/01/2009	
LOCATION	Angola	
VALUE	USD 170,000,000	
ESTIMATED CURRENT VALUE	USD 180,000,000	
<b>LEAK</b>		On 05 November 2006, 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	05/11/2006	
LOCATION	North Sea, Norway	
VALUE	USD 190,000,000	
ESTIMATED CURRENT VALUE	USD 230,000,000	
<b>DESIGN/ WORKMANSHIP</b>		On 22 June 2006, a post-installation, remote operated vehicle survey of a platform was performed revealing significant structural deformation to the jacket. The four main jacket legs suffered hydrostatic collapse which was the result of the installation of undersized ring stiffeners. The ring stiffeners that were installed were fabricated using incorrect construction drawings.
EVENT DATE	20/04/2006	
LOCATION	South China Sea, China	
VALUE	USD 120,000,000	
ESTIMATED CURRENT VALUE	USD 150,000,000	
<b>FIRE/EXPLOSION</b>		Eleven people were killed and 11 reported missing 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 centre, 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 on board 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. 73 people were evacuated from the rig but during the evacuation one employee died.  On 07 August 2005 it was reported that 70% of oil production would be resumed by the end of the month with full production by the middle of September 2005. The total disruption of production is estimated to be 123,000 bbl/d which accounts for over 15% of the company's crude oil production.
EVENT DATE	27/07/2005	
LOCATION	Mumbai High field, India	
VALUE	USD 370,000,000	
ESTIMATED CURRENT VALUE	USD 470,000,000	

<b>HURRICANE</b>		Hurricane Dennis passed through the area where the platform was located, causing it to partially sink. Design issues have been raised as a potential cause but there has been no confirmation.
EVENT DATE	10/07/2005	
LOCATION	Gulf of Mexico, USA	
VALUE	USD 250,000,000	
ESTIMATED CURRENT VALUE	USD 320,000,000	
<b>BLOWOUT</b>		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 on board the drilling rig were safely evacuated. The production platform, with 150 people onboard, had been evacuated before the fire spread.
EVENT DATE	10/08/2004	
LOCATION	Mediterranean, Egypt	
VALUE	USD 190,000,000	
ESTIMATED CURRENT VALUE	USD 250,000,000	
<b>BLOWOUT</b>		A jack-up drilling rig was drilling a natural gas well when a gas blowout occurred during drilling operations. There was an explosion followed by fire which was initially contained on the jack-up. For reasons unknown, the fire then spread to the platform where it continued to rage for over a week before being brought under control. More than 150 workers on the jack-up and platform were evacuated with no casualties. The drilling rig sank and was not salvageable. The platform was damaged beyond repair and its destruction was ordered by Egypt's petroleum minister. Less than a year after the accident, production at the Temsah field was back on-stream at full production rates.
EVENT DATE	10/07/2004	
LOCATION	Mediterranean, Egypt	
VALUE	USD 190,000,000	
ESTIMATED CURRENT VALUE	USD 250,000,000	
<b>FIRE/EXPLOSION</b>		Four people were killed in an explosion and fire at an oil gathering centre, 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 centre and the adjacent gas booster station. Nineteen people were also injured in the incident suffering mainly first and second degree burns. The fire was extinguished two days after the event.
EVENT DATE	31/01/2002	
LOCATION	Raudhatain, Kuwait	
VALUE	USD 180,000,000	
ESTIMATED CURRENT VALUE	USD 260,000,000	Kuwait's production dropped by 600,000 bbl/d after the accident, with the oil gathering centre formally re-opened on 25 January 2005.
<b>EXPLOSION/FIRE/SINKING</b>		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	15/05/2001	
LOCATION	Campos Basin, Brasil	
VALUE	USD 500,000,000	
ESTIMATED CURRENT VALUE	USD 770,000,000	

<b>DESIGN/ WORKMANSHIP</b>		No further details known.
EVENT DATE	31/12/2000	
LOCATION	North Sea, Norway	
VALUE	USD 130,000,000	
ESTIMATED CURRENT VALUE	USD 210,000,000	
<b>MECHANICAL DAMAGE</b>		A rig deck fabricated in Korea was in transit to Angola when it hit an underwater reef off the coast of Sumatra. The transport vessel capsized within four minutes in a water depth of 32 metres, resulting in five fatalities. The cause of the sinking has been attributed to the ship not following the recommended route.
EVENT DATE	02/11/1999	
LOCATION	Indonesia	
VALUE	USD 210,000,000	
ESTIMATED CURRENT VALUE	USD 350,000,000	
<b>EXPLOSION</b>		One of two topside modules was dropped while being lifted for installation. The module struck a transport barge and the installation barge causing an explosion. The module sank to the sea floor.
EVENT DATE	03/12/1998	
LOCATION	Gulf of Mexico, USA	
VALUE	USD 110,000,000	
ESTIMATED CURRENT VALUE	USD 180,000,000	
<b>EXPLOSION</b>		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	25/03/1993	
LOCATION	Lama, Lake Maracaibo, Venezuela	
VALUE	USD 100,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	
<b>MECHANICAL DAMAGE</b>		There was damage to substructure primary piles with associated insert pile installation difficulties. Specialist jacking tools were manufactured to open out primary piles.
EVENT DATE	01/11/1992	
LOCATION	North West Shelf, Australia	
VALUE	USD 270,000,000	
ESTIMATED CURRENT VALUE	USD 520,000,000	

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## STRUCTURAL FAILURE

EVENT DATE	23/08/1991
LOCATION	Sleipner, North Sea, Norway
VALUE	USD 400,000,000
ESTIMATED CURRENT VALUE	USD 780,000,000

A contractor was undertaking final submersion tests on a large gravity base structure that would support the main deck of the platform. The gravity base was approximately 110 metres tall, and approximately 600,000 tonnes of concrete were required to construct it. During the tests, contract personnel reported hearing a loud noise in one of the drilling shafts. The base began to take on water and in a matter of minutes had sunk in 200 metres of water. The cause of the cracking of the concrete was believed to be a design error. Other concrete base structures in the North Sea were surveyed for the same possible design problem as a result of this incident.

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## FIRE/EXPLOSION

EVENT DATE	19/03/1989
LOCATION	Baker, Gulf of Mexico, USA
VALUE	USD 400,000,000
ESTIMATED CURRENT VALUE	USD 820,000,000

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. Two years were required to replace the platform.

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## BLOWOUT

EVENT DATE	20/01/1989
LOCATION	Treasure Saga, North Sea, USA
VALUE	USD 220,000,000
ESTIMATED CURRENT VALUE	USD 450,000,000

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 blow-out. The well was stabilised after 11 months by pumping heavy mud down a relief well. The well was later sealed.



<b>EQUIPMENT FAILURE/BAD WEATHER</b>		A self elevating platform capsized 500 miles off Nova Scotia whilst under tow from Halifax to Great Yarmouth. Gale force winds and 40 foot high waves hindered rescue of the crew from their survival capsule. The rig sank in 17,000 feet of water, with a possible cause being a cracked ballast tank during the Force 10 to 12 wind.
EVENT DATE	17/12/1988	
LOCATION	Rowan Gorilla 1, North Atlantic, Canada	
VALUE	USD 90,000,000	
ESTIMATED CURRENT VALUE	USD 190,000,000	
<b>FIRE/EXPLOSION</b>		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 pressurised. 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.
EVENT DATE	07/07/1988	
LOCATION	Piper Alpha, North Sea, UK	
VALUE	USD 850,000,000	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.
ESTIMATED CURRENT VALUE	USD 1,800,000,000	There were 226 people on the platform at the time of the accident; only 61 survived. Contributing to the loss of life was the location of the quarters directly over the site of the initial release and resulting explosion and fire.
<b>FIRE</b>		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 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	24/04/1988	
LOCATION	Enchova, Campos Basin, Brasil	
VALUE	USD 330,000,000	
ESTIMATED CURRENT VALUE	USD 690,000,000	
<b>BLOWOUT/FIRE</b>		While cementing casing for a well, a shallow gas pocket was encountered. This caused a blowout and fire that significantly damaged the platform. The fire destroyed the helideck and damaged the accommodations module, drilling rig and a crane boom. The incident delayed the start of production for several months. The platform damage was later repaired, and development drilling and enhanced oil recovery was resumed.
EVENT DATE	20/12/1987	
LOCATION	Cook Inlet, Alaska, USA	
VALUE	USD 130,000,000	
ESTIMATED CURRENT VALUE	USD 270,000,000	
<b>BLOWOUT</b>		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 the platform. The well was killed to stabilise conditions on the seabed.
EVENT DATE	04/11/1987	
LOCATION	Gulf of Mexico, USA	
VALUE	USD 200,000,000	
ESTIMATED CURRENT VALUE	USD 440,000,000	



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**GROUNDING/  
BAD WEATHER**

A semi-submersible barge ran aground near Usulan during a typhoon.

EVENT DATE	26/08/1986
LOCATION	Sea of Japan, Japan
VALUE	USD 75,000,000
ESTIMATED CURRENT VALUE	USD 170,000,000

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**COLLISION**

This platform was struck by the 'Stad Sea'.

EVENT DATE	01/08/1975
LOCATION	North Sea, UK
VALUE	USD 55,000,000
ESTIMATED CURRENT VALUE	USD 230,000,000

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**BLOWOUT**

The Fateh field L-3 development well had reached 4,180 ft 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	01/07/1975
LOCATION	Fateh L3, Dubai, UAE
VALUE	USD 79,000,000
ESTIMATED CURRENT VALUE	USD 340,000,000

SUPPLEMENT:  
NATURAL CATASTROPHE  
ACCUMULATION



## NEW

### NATURAL CATASTROPHE ACCUMULATION

Natural catastrophe incidents have the potential to cause very large aggregate losses. The incidents identified in this document are generally loss events affecting a single facility, and as such this analysis does not identify the aggregated losses from natural catastrophes such as hurricanes or earthquakes. This supplementary section has been included since these aggregate losses warrant comment. In contrast to the core sections of this publication, the loss values stated in this supplement include elements of both property damage and business interruption.

Natural catastrophes have historically resulted in damage to multiple offshore and onshore assets. The aggregate loss values from hurricanes Andrew, Katrina, Rita and Ike run into the billions of US dollars, and the cumulative value of each hurricane's constituent incidents would rank very highly in the overall loss register. The 2011 Tohoku earthquake in Japan resulted in a significant range of losses, with some of those in the energy sector receiving considerable media exposure due to their spectacular nature. Early estimates place the total insured losses (across all market sectors) in the region of USD 15 billion. Details of individual energy sector losses were unfortunately not available at the time of publication. It is, perhaps surprisingly, expected that the losses in the hydrocarbon processing industry will be limited and individual site losses may not reach the level required to feature in the 100 Largest Losses. The stringent earthquake design standards applied in Japan appear to have successfully prevented far greater losses following such an extreme natural catastrophe event. Other very significant natural catastrophe losses have also occurred recently in Chile (an earthquake and tsunami on 27 February 2010) and in New Zealand (earthquakes on 03 September 2010 and 22 February 2011). These two events have each resulted in insured losses estimated to run into the billions of US dollars across all market sectors.

The following losses have been included in this publication to give an indication of the scale of aggregate losses that may be incurred following a natural catastrophe event.



## NATURAL CATASTROPHE ACCUMULATION

<b>DATE:</b>	11/03/2011	<b>EVENT:</b>	Earthquake and tsunami
<b>LOCATION:</b>	Japan	<b>LOSS:</b>	USD 15 billion aggregate all sectors loss

The Tohoku earthquake off the east coast of Japan was a 9.0  $M_w$  (momentum magnitude scale) event and the most powerful earthquake known to hit the country. The event triggered a tsunami that travelled up to 10 km inland and wave heights of up to 40.5 m were recorded. Large scale infrastructure damage and loss of life resulted. A number of nuclear accidents occurred and losses in the hydrocarbon processing industry received considerable media exposure due to their spectacular nature.

<b>DATE:</b>	27/02/2010	<b>EVENT:</b>	Earthquake and tsunami
<b>LOCATION:</b>	Chile	<b>LOSS:</b>	USD 4.2 to 7.3 billion aggregate all sectors loss (USD 4.0 to 7.0 billion in 2010). USD 210 million loss for a single energy industry corporation (USD 200 million in 2010).

This earthquake off the coast of Chile was an 8.8  $M_w$  event lasting for approximately three minutes. Many cities were seriously affected by the earthquake and significant infrastructure damage and loss of life resulted. Most damage was as a result of fire and structural collapse. Structural damage experienced at a number of refineries resulted in production being halted. A subsequent tsunami caused additional damage and wave heights of up to 2.6 m were recorded at sea.

<b>DATE:</b>	01/09/2008 to 14/09/2008	<b>EVENT:</b>	Hurricane Ike
<b>LOCATION:</b>	Caribbean, Louisiana and Texas, Caribbean and USA	<b>LOSS:</b>	USD 1.3 billion ground up, aggregate energy industry loss reported by a single energy insurer (USD 1.2 billion in 2008). USD 1,040 million loss for a single energy industry corporation (USD 960 million in 2008).

Hurricane Ike passed over the Turks and Caicos Islands as a Category 4 hurricane and moving west along Cuba it made landfall first as a Category 4 hurricane and two days later as a Category 1 hurricane. Final landfall was made in Texas, USA, as a strong Category 2 hurricane. Due to its immense size, hurricane Ike caused devastation along the Louisiana and Texas coastlines as well as in the Gulf of Mexico. Hydrocarbon processing facilities were shut down in anticipation of the event and onshore facilities experienced damage from wind, flood and storm surge. Over 50 offshore structures were reported to have been destroyed.

<b>DATE:</b>	8/09/2005 to 26/09/2005	<b>EVENT:</b>	Hurricane Rita
<b>LOCATION:</b>	Texas, Louisiana and most of the south-east USA, USA	<b>LOSS:</b>	Up to USD 6 billion for the energy industry, USD 1.8 billion ground up, aggregate energy industry loss reported by a single energy insurer (USD 1.4 billion in 2005)

Hurricane Rita made landfall in Texas and Louisiana as a Category 3 hurricane and continued on through south-east Texas. Storm surge caused extensive damage along the Louisiana and Texas coastlines. Onshore hydrocarbon processing facilities were subject to a range of hurricane damage, with infrastructure losses impacting some sites. Offshore losses were even larger, with over 60 offshore structures being destroyed and at least 50 more being damaged.

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<b>DATE:</b>	23/08/2005 to 30/08/2005	<b>EVENT:</b>	Hurricane Katrina
<b>LOCATION:</b>	Louisiana, Mississippi and most of the south-east USA, USA	<b>LOSS:</b>	Up to USD 6 billion for the energy industry, USD 2.5 billion ground up, aggregate energy industry loss reported by a single energy insurer (USD 2.0 billion in 2005)

Hurricane Katrina initially made landfall in Florida and briefly weakened over land, it rapidly intensified after entering the Gulf of Mexico. Katrina made its second landfall as a Category 3 hurricane in Louisiana and caused flooding and widespread destruction until being downgraded to a tropical depression upon reaching Tennessee. Rapid shut down of hydrocarbon processing facilities and sudden loss of feedstock led to some onshore energy industry losses. Damage from the hurricane also resulted in some leaks of hydrocarbon to the environment. Offshore facilities were hit particularly hard with approximately 50 offshore structures being destroyed and an additional 35 sustaining damage.

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<b>DATE:</b>	16/08/1992 to 28/08/1992	<b>EVENT:</b>	Hurricane Andrew
<b>LOCATION:</b>	Bahamas, Florida and Louisiana, USA	<b>LOSS:</b>	USD 38 billion aggregate all sectors loss (USD 20 billion in 1992).

Hurricane Andrew was only the third Category 5 hurricane on record to have made landfall in the USA. A significant amount of damage was caused in the Bahamas, south Florida and Louisiana. Offshore in the Gulf of Mexico severe damage was caused to oil and gas producing facilities. It is estimated that 36 major platforms, 145 satellites and 480 pipelines and flow lines were damaged.



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