# Appendix 8

## Sour Gas Field Location in the Irish Sea

## Shown on a

## 3D Image of the Continental Shelf

## That is shared between

## European Countries



3D View of Continental Shelf. shared with Ireland and Britain. Note Location of Sour Gas Well in the Irish Sea

# Appendix 9

## New Mexico Gas Pipeline Explosion

## Detailed Report

## of the Seismological Society of America, Vol. 93 No. 4.

## pp 1427-1432, August 2003

Bulletin of the Seismological Society of America, Vol. 93, No. 4, pp. 1427–1432, August 2003

# Seismic Recordings of the Carlsbad, New Mexico, Pipeline Explosion of 19 August 2000

by Keith D. Koper, Terry C. Wallace, and Richard C. Aster

**Abstract** On 19 August 2000 two seismometer networks in southeastern New Mexico recorded signals from a natural gas pipeline explosion. Analysis of the particle motion, arrival times, and durations of the seismic signals indicates that three impulsive events occurred with origin times of 11:26:18.8 ± 1.9, 11:26:43.6 ± 2.1, and 11:27:01.7 ± 2.0 (UCT). The first event was caused by the explosive blowout of the buried, high-pressure pipeline, and the second event was caused by the ignition of the vented natural gas. The nature of the third event is unclear; however, it was likely created by a secondary ignition. There were also two extended seismic events that originated at the same time as the first two impulsive events. The first resulted from the preignition venting of the gas and lasted for about 24 sec, while the second resulted from the postignition roaring of the flames and lasted for about 1 hr. Many of the source constraints provided by the seismic data were not available from any other investigative technique and thus were valuable to a diverse range of parties including the New Mexico state police, law firms involved in litigation related to the accident, the National Transportation and Safety Board, and the general public.



## Introduction

On 19 August 2000 a buried natural gas pipeline in southeastern New Mexico ruptured and exploded. The resulting fire burned for nearly an hour until maintenance workers were able to shut off the flow of gas. The incident was the deadliest pipeline accident in the United States in the last 25 years and resulted in the deaths of 12 nearby campers. Investigations of this tragedy have been performed by the New Mexico state police, the National Transportation Safety Board, and private experts contracted by lawyers representing the victims' estates in a lawsuit against the pipeline operator. The investigations have been significantly influenced by seismic data that were recorded by two nearby seismometer networks. Analysis of the seismic data has helped answer questions related to the fundamental nature of the accident and has affected the amount of legal damages that were awarded to the families of the victims. The seismic data constrain (1) the number of discrete sources, (2) the relative and absolute timing of the sources, and (3) the underlying cause of two of the sources. Some of the timing constraints are unique to the seismic data and are unavailable from other means of investigation, such as witness interviews, records of pipeline pressure from the gas company, observations of rescue personnel, or postaccident crater analysis. In this note we describe the seismic observations, present a basic source model, and comment on the importance of the seismic results in determining the details of the accident.

## Specifics of the Pipeline Disaster

At approximately 5:30 a.m. local time on 19 August 2000, fire and rescue personnel from Carlsbad, New Mexico, and surrounding areas were alerted to an explosion near the Pecos River compressor station along the El Paso natural gas pipeline in southeastern New Mexico. The workers were initially able to venture only within about 1.2 km of the blowout because of the intense heat from the burning gas. Analysis of damage to two nearby concrete pads indicate that the temperature was as high as 1150°C. The flames reached a height of 150 m and were visible for tens of kilometers. Maintenance workers for El Paso Energy Corporation had arrived at nearly the same time as the rescue personnel and began shutting off the gas flow at valves upstream of the blowout. By about 6:30 a.m. the fire had died out and rescue workers were able to approach the accident site. It then became clear that an extended family group had been camping in the vicinity of the pipeline during the accident and needed medical attention. Ultimately all 12 of these individuals died from injuries sustained at the scene.

## Summary of Seismic Observations

Two seismic networks were deployed in southern New Mexico at the time of the pipeline accident (Fig. 1). One network consisted of three-component, PASSCAL broadband

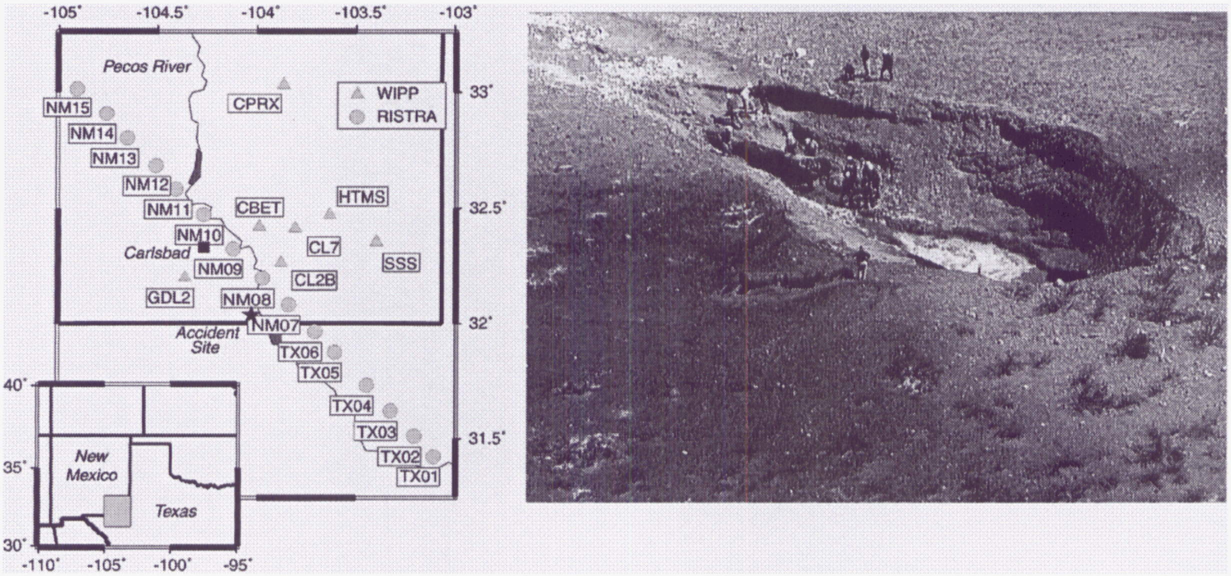


Figure 1. Station geometry for the two seismic networks deployed at the time of the pipeline accident. The WIPP stations, indicated by triangles, are short-period vertical component instruments, while the RISTRA stations, indicated by circles, are broadband, three-component instruments. Two of the stations shown, NM08 and TX04, were not operating properly at the time of the accident. The crater created by the pipeline blowout, shown on the right, was located at 104.0286° W, 32.0378° N.



seismometers that were temporarily deployed as part the Rio Grande Rift Seismic Transect (RISTRA) passive source experiment (Wilson *et al.*, 2002). The other network consists of permanently deployed, short-period, vertical component seismometers that monitor regional seismicity in support of the Waste Isolation Pilot Plant (WIPP) (Sanford *et al.*, 1980). Seismic signals from the pipeline accident were clearly visible at 17 of the sites shown in Figure 1 and were recorded as far away as NM15 (136 km). However, the propagation efficiency was strongly dependent on azimuth, and signals were observed only as far as TX05 (43 km) to the southeast.

The seismograms from broadband station NM09 are presented in Figure 2. Six discrete arrivals are clearly visible, all of which have particle motion that is dominantly retrograde elliptical in the plane of propagation, implying that they are Rayleigh waves. These arrivals naturally break into two groups, consisting of the first and last three arrivals. The first group ($A_1$, $A_2$, $A_3$) has nearly equal amplitude on the radial and vertical components, while the second group ($A_4$, $A_5$, $A_6$) shows much higher amplitude on the vertical. However, the differential arrival times and relative durations among the arrivals in the first group match the corresponding values among the second group exceptionally well. For example, the differential time between the first and second arrivals ($A_1$ and $A_2$) is 24.1 sec, while the differential times between the fourth and fifth arrivals ($A_4$ and $A_5$) is 24.6 sec. The 0.5-sec difference can easily be accounted for by observational uncertainties in the arrival time picks. Therefore it appears that three discrete seismic sources occurred, each of which generated two Rayleigh waves propagating at different velocities.

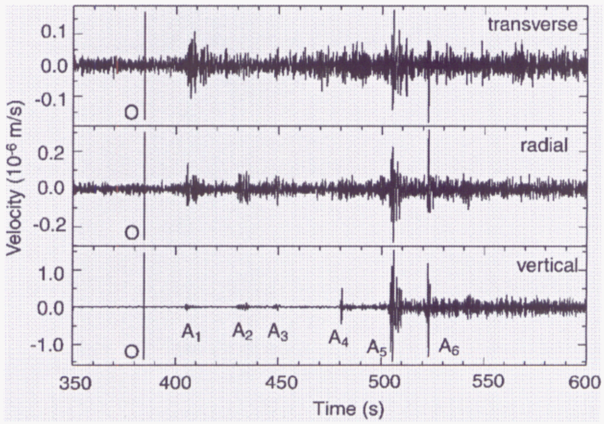


Figure 2. Seismograms of the pipeline accident at station NM09 (Fig. 1). The data have been bandpass filtered from 0.5 to 2.0 Hz using a Butterworth filter. Note that the vertical scales differ among the components. The six primary Rayleigh-wave arrivals are labeled $A_1$–$A_6$, and the origin time of the first of the three main sources is labeled with an *O*. This station is 31.4 km away from the accident site.

This interpretation is further supported by a record section of the second group of arrivals (Fig. 3). These phases have much higher amplitude than those in the first group and

so are visible at the more distant stations. Precise arrival time picks show that the move-out of each arrival is linear and that the differential times among the arrivals are independent of distance. A linear fit to each set of arrival times gives estimates of the apparent velocity of each phase as well as the absolute origin time of each seismic source (Table 1). The apparent velocity of the phases, about 355 m/sec, is only slightly higher than the expected value for atmospheric wave speed at a temperature of 22°C (345 m/sec). Air-coupled Rayleigh waves are often generated by near-surface explosions and form when the shallow geologic structure has a surface wave phase velocity equivalent to the local atmospheric wave speed (Murphy, 1981; Kitov *et al.*, 1997). The exceptionally large amplitudes of the air-coupled Rayleigh waves are most likely related to a thermal inversion at the time of the accident. This weather condition is especially common in New Mexico valleys during the early morning hours. The relatively cool air near the surface creates a low-velocity zone, which acts as a wave guide for acoustic energy (e.g., Garces *et al.*, 1998). This also explains the azimuthal dependence of the amplitudes, since the Pecos River valley extends to the northwest from the explosion site but not to the southeast.

The first group of Rayleigh waves ($A_1$, $A_2$, $A_3$) is most clearly visible at stations CL2B, NM09, NM10, and CBET. At the closest station, NM07, the waves have not yet emerged as distinct phases and are obscured by diffuse high-frequency energy. At more distant stations, such as NM11 and SSS, the amplitudes have decayed below the ambient noise level. Combining the origin times derived from regressing the air-coupled Rayleigh waves with arrival time picks of the first group of Rayleigh waves gives apparent velocities of 1.7–1.9 km/sec. Solid-earth Rayleigh waves recorded at local distances ($R_g$) are often generated by explosions and shallow earthquakes with group velocities near 3.0 km/sec (Lay and Wallace, 1995); however, since these phases travel in the uppermost 2–3 km of the crust, they have large regional variations and $R_g$ group velocities below 2.0 km/sec are common (e.g., Kocaoglu and Long, 1993; Goforth and Bonner, 1995; Mackenzie *et al.*, 2001). Hence, our group-velocity estimates are consistent with previous $R_g$ observations. Furthermore, the lack of $R_g$ observations at the more distant stations is consistent with the strong attenuation of $R_g$ (e.g., Myers *et al.*, 1999).

A remarkable feature of the seismic data is the extended codalike signal that begins with the second air-coupled Rayleigh wave and continues for approximately 1 hr (Fig. 4). Because of its high frequency content this signal is particularly clear on the unfiltered short-period instruments. On the three-component instruments the signal shows particle motion similar to that of the air-coupled Rayleigh waves but



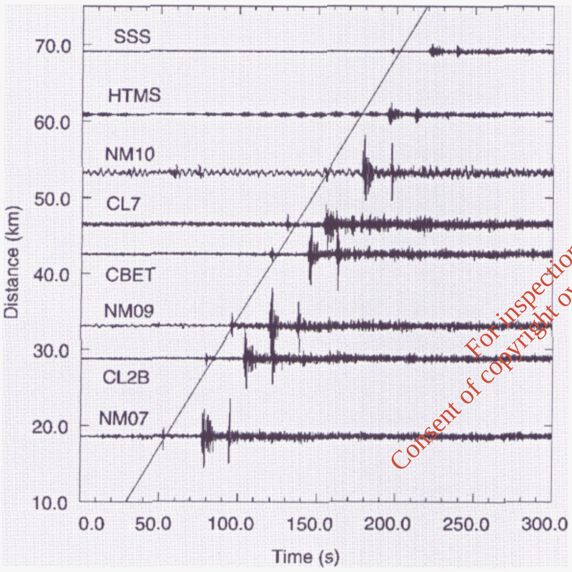


Figure 3. Record section of the seismic data associated with the pipeline accident. All the data have been bandpass filtered at 0.5–3.0 Hz. The zero time is the origin time of the first subevent. The sonic travel-time curve, shown as a solid line, has a velocity of 0.342 km/sec. The move-out and particle motion of the three large impulsive arrivals implies that they are air-coupled Rayleigh waves.

Table 1
Seismic Sources Related to the Pipeline Disaster

| Source Number | Origin Time (UCT) | Approximate Duration | Cause |
|---|---|---|---|
| 1 | 11:26:18.8 ± 1.9 | 1.0 sec | Pipeline blowout |
| 2 | 11:26:43.6 ± 2.1 | 3.0 sec | Primary ignition |
| 3 | 11:27:01.7 ± 2.0 | 1.0 sec | Secondary ignition (?) |
| 4 | Same as 1 | 24 sec | Venting of gas |
| 5 | Same as 2 | 1 hr | Roaring of flames |

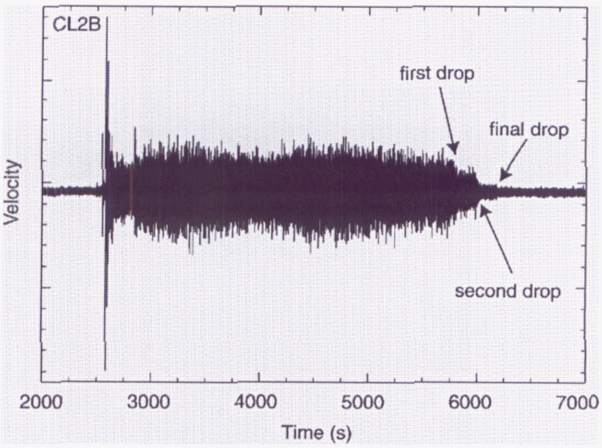


Figure 4. Unfiltered seismogram from the short-period station CL2B. The extended coda was created by the roaring of the flames at the accident site. The amplitude drops occurred as gas valves were successively shut down by maintenance workers.

with less coherence. The signal amplitude shows two distinct reductions after about 53 and 57 min and totally fades into the noise after about 60 min. These times are only accurate to within about 20 sec because of the gradual nature of the amplitude drops. There also appears to be a more subtle, higher-frequency coda between the first two air-coupled Rayleigh-wave arrivals (Fig. 5); however, this feature is visible only at the closer stations.

## Nature of the Seismic Sources

The hour-long duration of the extended coda presented in Figure 4 implies that its source was the roaring flames at the accident site. At each station this coda begins at a time indistinguishable from the arrival time of the second air-coupled Rayleigh wave ($A_5$). Therefore the coda either consists of seismic waves driven by near-receiver loading of the surface by acoustic energy that has traveled through the atmosphere or is itself air-coupled Rayleigh-type energy. At most stations the ground motion after $A_2$ is similar to the motion between $A_1$ and $A_2$, and so the roaring of the flames appears to have generated little near-source seismic energy. The main exception to this comes from the seismogram of the closest broadband station (NM07), which shows diffuse high-frequency energy in the time window of expected $R_g$ arrivals.

It follows that the source responsible for the second set of Rayleigh waves ($A_2$ and $A_5$) was the main ignition of the natural gas that had presumably been pooling in the area since the initial blowout of the pipeline. The blowout is likely responsible for the first set of Rayleigh waves ($A_1$ and $A_4$). The waveforms of the first set of Rayleigh waves are shorter and simpler than the second set as is expected for the localized, impulsive blowout source compared to the diffuse, ignition source. The high-frequency coda visible at the closer stations between the first and second air-coupled Rayleigh arrivals would then represent the jetting of gas from the broken pipeline. The source of the third set of Rayleigh waves ($A_3$ and $A_6$) is unclear. One possibility is a secondary ignition of gas that remained intact after the primary ignition.

The relative times among the three main impulsive sources can be obtained with higher accuracy than the absolute origin times by averaging the differences in the Rayleigh-wave arrival times from all the stations. This gives 24.04 $\pm$ 0.66 sec between the blowout and primary ignition and 17.77 $\pm$ 0.68 sec between the primary ignition and the third impulsive source. The delay between blowout and ignition implies that the ignition was unrelated to the blowout process and so, for example, was not caused by the initial rending of the pipeline. The delay may be related to the time it took for the venting gas to reach an ignition source near the campsite.

A likely source for the primary ignition is the campers' vehicles, which were parked about 140 m downstream of the blowout site. If any of the vehicles were idling or if any of the electrical systems were in use, then the natural gas cloud could have ignited. This would imply a minimum velocity of 5–6 m/sec for the escaping gas. This is slightly faster than the nominal flow rate within the pipe of 3–4 m/sec; however, the gas velocity may be expected to increase when encountering the low-pressure atmosphere. A second possibility for the source of the primary ignition is the lanterns of the campers, which were located an additional 30–50 m away from the vehicles in the downstream direction. However, this site was on the banks of the Pecos River, with an elevation about 10 m lower than that near the blowout site, and since natural gas is lighter than air it is not clear that the gas could attain the minimum concentration for combustion (4%–5% by volume) near the lanterns.

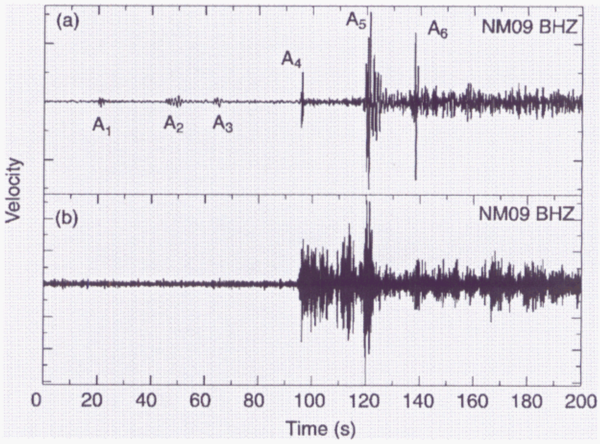


Figure 5. Vertical component seismogram from station NM09 shown (a) bandpass filtered at 0.5–3.0 Hz and (b) highpassed filtered at 3.0 Hz. The zero time is the origin time of the first subevent. The high-frequency coda between $A_4$ and $A_5$ is due to the venting of the natural gas.

## Energy Release

The blowout of the pipeline was an exceptionally energetic event because of the high pressure ($4.6 \times 10^6$ Pa) of the natural gas. Three sections of the 0.76-m-diameter pipe were ejected, the largest of which was 8 m long and landed 87 m from the blowout site. The resulting crater was elongated in the direction parallel to the pipeline and measured 34 m (length) by 15 m (width) by 6 m (depth); however, the width decreased with depth in an irregular manner, resulting in an estimated volume of 1180 $m^3$. Calculations made with a model based on previous chemical explosion data show that it would take approximately 5700 kg of TNT, buried at a depth of 4 m, to create a crater of similar volume in a similar medium (J. K. Ingram, personal comm., 2002). This implies that the energy released during the blowout was approximately $2.4 \times 10^{10}$ J. However, it is unlikely that the entire crater volume was created during the blowout, and so

the value given above is probably a gross overestimate. We prefer to determine an upper bound based on the overpressure of the natural gas. We estimate a scale volume of 6.75 $m^3$ based on the fact that a total length of 15 m of pipeline was ejected. Combining this with an overpressure of $4.5 \times 10^6$ Pa yields a potential energy of $3.0 \times 10^7$ J, about 3 orders of magnitude smaller than the estimate based on crater volume.

An upper bound for the energy release of the primary ignition can be obtained by assuming that the entire volume of gas that had been vented up to that point exploded at one time. We further assume that the venting velocity is approximately equal to the transport velocity (4 m/sec) and that both ends of the pipeline were leaking gas after rupture. Using a cross-sectional area of 0.45 $m^2$, a time lapse of 24 sec between blowout and ignition, and an energy content of $3.9 \times 10^7$ J/$m^3$ for the natural gas gives an energy release of $3.4 \times 10^9$ J, or about 100 times larger than the energy release associated with the blowout.

It is difficult to estimate absolute seismic magnitudes for each event because solid-earth energy is only seen for a few close-in stations and the only distinguishable phase is $R_g$. A duration-based magnitude scale that has been developed for local events (Sanford *et al.*, 1998) is not appropriate for these data, and we are not aware of any calibrated $M_l$ scale for the region. Nevertheless, if we assume that the peak amplitudes of the $R_g$ waves ($A_1$ and $A_2$) can be used as proxies for the amount of energy radiated seismically, then it appears that the two sources were approximately equivalent in the release of seismic energy. This can be reconciled with the 2-orders-of-magnitude difference in total energy release between the two events by recognizing that the seismic efficiency of the buried, impulsive blowout source would be expected to be much larger than that the of diffuse, ignition source occurring in the atmosphere. It is also worthwhile to note that although the first and second $R_g$ arrivals have similar amplitudes, the first air-coupled Rayleigh wave is substantially smaller than the second air-coupled Rayleigh wave. This is again consistent with the model of the first source being buried and the second occurring on the surface within the atmospheric wave guide.

## Conclusions

The seismic recordings of the natural gas pipeline accident in southeastern New Mexico provide source constraints that are unavailable from traditional investigative techniques. The seismic analysis reveals that three discrete events occurred and constrains the absolute origin times of these events to within ±2.0 sec. More importantly, the seismic data constrain the first event to be the blowout of the pressurized pipeline and the second event to be the primary ignition of the vented gas and constrain the differential time between these two events be 24.04 ± 0.66 sec. Such a large time between the two events implies that the source of the ignition was not sparking or heat produced by the pipeline rupture but more likely a heat source at the victims' campsite 100–200 m away. This 24-sec time span also bears on the amount of punitive damages the pipeline operator is responsible for, since the victims were in a state of extreme distress during this time period. The seismic data also corroborate gas company records and witness interviews as to precisely when the gas company was able to shut off the flow of gas, thus extinguishing the fire and allowing rescue workers to approach the scene.

In many forensic seismology studies the seismic analysis gives results that are important, but mainly in a corroborative sense (e.g., Byerly, 1946; Holzer *et al.*, 1996; Ichinose *et al.*, 1999; Koper *et al.*, 1999; Kim *et al.*, 2001; Koper *et al.*, 2002). In other instances forensic seismology can provide constraints that are unique with respect to publicly available information and complementary with respect to classified information (e.g., Koper *et al.*, 2001; Gitterman, 2002). In contrast, in the case presented here the seismic constraints are unique with respect to all other sources of data and means of investigation.



## Acknowledgments

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# Appendix 10

## Explosion & Fires : 1992-2002

## Sampling and Incidents

## At

## Shell Group Companies & Joint Ventures

# Explosions & Fires: 1992-2002

Sampling of Incidents at Shell Group Companies & Joint Ventures

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| | |
|---|---|
| 21 Jun 92 | *Choon Hong III* oil tanker explodes and burns while unloading xylene at the Port Klang, Malaysia oil depot, run by Tiram Kimia, a Shell joint venture. The fire spread onshore and engulfed three nearby storage tanks. Thirteen workers and crewmen were killed, and more than 200 families living in the port vicinity were evacuated. The ship later sank, spilling its cargo into the bay. A lawsuit was filed by the families of the 13 dead workers in October 1994 charging negligence and seeking $13 million in damages from Shell. (the final outcome of that case was unavailable at publication). Shell reported that recommendations from an unidentified investigation were adopted at the terminal, with subsequent activities restricted to non-flammable products and blending. Shell also reported that the depot ceased operations in 1997.[1] |
| 29 Sep 92 | fire at Shell's Deer Park, Texas refinery shuts down the plant's 160,000-barrels-a-day crude distillation unit.[2] |
| March 93 | fire at Shell's Pernis, Netherlands refinery shuts down polypropylene plant until June.[3] |
| 1 Apr 93 | explosion of a sludge collection storage tank at Shell's Martinez, California refinery sends 8-by-10-foot tank lid into a power line, cutting the area's electricity supply, causing a blackout.[4] |
| 26 Aug 93 | fire at Shell's Martinez, California refinery damages a furnace that heats heavy crude oil.[5] |
| 8 Oct 93 | explosion and fire at a sulfuric acid storage tank at Shell's Martinez, California refinery sends a giant, red cloud of smoke into the area. No injuries or evacuations reported.[6] |
| 20 Jan 94 | fire at Shell's Pernis, Netherlands oil refinery.[7] |
| 27 May 94 | a fire at Shell Chemical's Belpre, Ohio plant spreads to a nearby chemical storage tank area, touching off an explosion and ferocious chemical fire, causing four of the big tanks to burn and lose millions of gallons of chemicals. Four workers are killed in the incident and 1,700 people evacuated. The fire burns for about nine hours, and chemical leakage from the site pollutes the Ohio River with a 22-mile plume of ethylene dibromide, killing fish and forcing downstream municipalities to seek alternative water supplies. Shell later agrees to pay OSHA a $3 million dollar fine for federal safety violations and also settles wrongful death lawsuits with the families of the dead workers, making payments in the range of $2.1 to $2.4 million per family.[8] |
| 18 Aug 94 | fire and explosion at Shell chemical plant at Norco, Louisiana. In February 1995, the US OSHA issues a $201,600 penalty to Shell in connection with the incident.[9] |
| 13 Jan 95 | fire at Shell's Geelong refinery in Australia forces closure of catalytic cracker. The fire broke out in a heat exchange unit.[10] |
| 10 Jun 95 | oil well blow-out & fire occur in the El Isba oil field at Shell Syria venture near the desert town of Deiral-Zur, Syria. Five workers are killed in the incident, with the fire continuing to burn for at least ten days. According to reports, the blow-out and fire resulted when oil and gas that had been seeping from fissures around the well since May 3rd – more than a month prior to the blow-out – ignited. A wrongful death suit has been filed by at least one of the families of the dead workers.[11] |
| 1 Dec 95 | explosion and fire at Shell Oil tank farm at McCamey, Texas kills two workers and injures three others. Two of the workers were airlifted to the burn unit of the University Medical |

*__Note:__ This 1992-2002 listing breaks out separately "explosions & fires" from those covered under all incidents in Appendix A of *Riding the Dragon*, and also includes *additional incidents* not included in the book or its appendix..

| | |
|---|---|
| | Center in Lubbock, Texas — Liberato Martinez, 23, with third-degree burns over his entire body, and Jimmie Jimenez, 23, with second- and third-degree burns over 70 percent of his body. Martinez died that night. Two other injured men, with less severe burns, were taken to McCamey Hospital. Robert Leroy Muncy, 40, was killed at the scene. The workers were performing maintenance work at the time of the accident.[12] |
| 3 Feb 96 | explosion at hydrogen unit operated by contractor Air Products at Shell's Martinez, California refinery; workers evacuated, 2 injured, community rattled. |
| 1 April 96 | explosion and fire at Shell's Martinez, California refinery, damages two hydro treating units, shakes up local community, and later invokes two violation notices from regional air pollution officials.[13] |
| 3 April 96 | fire in the desulfurization unit of Shell's Pernis, Netherlands refinery.[14] |
| 24 Feb 97 | fire at the Pilipinas Shell storage depot at Pandacan, near Manila, in the Philippines occurs after a loading hose disconnects from a truck at the LPG bulk filling station, resulting in property damage and lost work days.[15] |
| 22 Jun 97 | explosion and fire occur at Shell's Deer Park, Texas chemical plant after a flammable gas leak; blast felt 25 miles away, fire burns for 10 hours. More than 200 emergency responders involved; several workers injured with about 30 receiving medical treatment. A mile-long smoke plume prompts warning to residents from local health officials to stay indoors. Damaged unit inside the plant out of service for more than six months. Nearby residential property also damaged . Joint EPA/OSHA accident investigation report suggests accident was preventable. Shell is subsequently fined by OSHA and EPA for violations and infractions related to the incident.[16] |
| 24 June 97 | Shell Offshore, Inc., fined $10,000 by the US Department of the Interior for operational and/or environmental violations. "The gas & fire detection systems were not tested within the required time frames." Fine paid, June 15, 1998.[17] |
| 20 Jul 97 | small fire erupts at Shell Oil's 150,000 barrel-a-day refinery in Martinez, California; fire occurs in the refinery's lubricant/asphalt plant.[18] |
| 13 Aug 97 | fire in distillation unit shuts down Shell 28,000 barrels-per-day refinery at Odessa, Texas for about one week.[19] |
| 31 Oct 97 | flash fire occurs in one of the loading bays at the main fuels terminal of the Pilipinas Shell storage depot at Pandacan, near Manila, in the Philippines – caused by a faulty grounding system.[20] |
| 16 Dec 97 | fire at Shell Chemical's Geismar, Louisiana plant disables one of plant's three alcohol units; Shell declares *force majeure* on all alcohols and derivatives; unit shut down for weeks.[21] |
| 17 Dec 97 | electrical fire in 625,000 mt/yr steam cracker unit at Shell Chemical plant at Moerdijk, Netherlands shuts down various petrochemical units at the complex for about a week.[22] |
| 19 May 98 | explosion and fire at SAPREF oil refinery in Durban, South Africa due to a failure at the alkylation unit. The explosion is heard several kilometers away and the fire is fought for more than six hours. No injuries were reported at the time, but an estimated five tons of hydrogen fluoride (HF), a highly dangerous substance, were released.[23] |
| 2 Jun 98 | storage tank explosion at Shell's Pernis, Netherlands refinery in Rotterdam kills one person, injures another.[24] |
| 15 July 98 | Shell Petroleum Development Company pays $258,000 to owners of farmland destroyed by fire caused by a leak in a gas pipeline in Rivers State, Nigeria.[25] |
| 10 Aug 98 | hydrogen explosion in a compressor unit at Shell Chemical's Belpre, Ohio plant rattles buildings up to five miles away. A fire followed the blast, but was brought under control by the plant's firefighters within 30 minutes.[26] |

14 Aug 98 hydrocracking unit at Shell's Deer Park, Texas oil refinery, shut by a fire the week of August 3rd, is scheduled to be back on line.[27]

27 Aug 98 Environmental Rights Action (ERA) of Nigeria reports pipeline explosion at Well #13 at Shell's Awoba flow station, at Bille, Rivers State, Nigeria. A subsequent fire "set the facility ablaze and the adjacent mangrove forest was inflamed. Several fishing traps and nets around the affected area were burnt." Several people harvesting produce in a nearby mangrove forest were injured in a stampede during the incident.[28]

6 Oct 98 fire occurs at Shell's Berre-L'Etang, France refinery as it is being closed down for a turnaround. A gas oil line fails "due to accelerated naphthenic acid corrosion" and ignites. A kerosene air cooler also fails, adding additional fuel to the fire. A crude unit and a reformer are damaged. Losses are estimated at $22 million.[29]

25 Nov 98 six workers are killed at Equilon refinery near Seattle trying to remove residue from a coking unit; a flaming mass of hot liquid poured out of the unit setting off a huge explosion. State investigators later calculated it would have taken 236 days for the ambient air to cool the drum enough to allow the residue to be removed safely.[30]

25 Dec 98 explosion and fire at Shell's gas-to-liquids plant at Bintulu, Malaysia .[31]

2 Jan 99 US Minerals Management Service reports "small fire" at Shell Offshore, Inc. platform A in block 128 of Garden Banks area in the Gulf of Mexico. Equipment failure is cited as cause; "minor damage" to pipeline pump noted. "...The seals failed, allowing excessive temperature to build up... this ignited the remaining lubricating oil..."[32]

15 Jan 99 US Minerals Management Service reports "minor flash fire" at Shell Offshore, Inc. platform JC in block 176 of Eugene Island area in the Gulf of Mexico. Human error cited as cause. "...A welding operation to repair a handrailing on the top deck was in progress at the same time as a natural gas crane was in use. Slag sparks from the welding operation came into contact with the gas being exhausted from the crane. The crane was shut down and the fire was extinguished. No damage was reported."[33]

6 Feb 99 eight oil workers suffered severe burns after a Shell Oil pipeline explodes in southern Nigeria, state health authorities reported.[34]

7 Feb 99 US Minerals Management Service reports fire, platform damage, and worker injury at Shell Offshore, Inc. platform JA in block 40 of South Marsh Island area in the Gulf of Mexico. Equipment failure & human error cited as cause. Lone platform worker in living quarters is burned and injured after trying to stop liquid escaping from condensate pipe, which ignites, burning the worker and causing him to fall down a 15-foot stairway, sustaining injuries. Automatic emergency shutdown of the platform ensued, but fire continued to burn due to uncontrolled release of hydrocarbons. A pilot flying in the area reported the fire to a nearby Shell facility, and the operator was rescued. Ceramic plungers/pistons #2 and #3 in condensate pump were severely cracked. Condensate gas under 500 psi released uncontrolled to the atmosphere due to an apparent failure of the #1 ceramic plunger/piston in the pump.[35]

23 Feb 99 fire at Motiva refinery in Convent, Louisiana damages & shuts down part of the operation for several months, through May.[36]

4 Mar 99 a mid-afternoon explosion at the polymerization unit at Equilon's Puget Sound refinery in Anacortes, Washington injures five contract workers. Four of the workers were treated at local hospitals and released that evening. One 18-year-old worker was admitted to Island Hospital with head and neck injures and held for observation. "He mainly just remembers being blown through the air," said the mother of the man being held after visiting him in the hospital. "First I heard a boom, and then a big cloud of steam came out and a bunch of debris," recounted Mike Lee, another worker at the scene of the explosion. "Everyone hit

the ground." The polymerization unit was then down for maintenance, and no cause for the explosion was immediately apparent, although the state had begun an investigation.[37]

10 Jun 99 — massive fireball and explosion of the Olympic Pipeline near Bellingham, Washington following a gasoline leak of 277,000 gallons kills two ten-year-old boys and another young man. The pipeline, jointly operated by Equilon, ARCO and GATX, was found to have anomalies in the section that ruptured, requiring certain actions that did not occur. In May 2002, EPA and the US Department of Justice filed a civil suit against Shell and Olympic, alleging gross negligence and seeking civil fines of $18.6 million against each company. The complaint charges that the pipeline rupture was caused by gross negligence in the operation and maintenance of the pipeline.[38]

12 Aug 99 — fire reported at Motiva's refinery in Convent, Louisiana.[39]

24 Aug 99 — small fire near the hydrogen unit at Equilon Enterprises' refinery in Bakersfield, California forces reduced runs to the hydrocracker.[40]

17 Sep 99 — leaking oil from the Ugehelli-Rapele pipeline at Ekakpamre, Urhobo in Delta State, Nigeria, owned by the Shell Petroleum Development Company of Nigeria (SPDC), catches fire. The fire burns for a reported three days over several kilometers of farmland and wetlands, burning up boats, fishing nets, and forests according to some accounts. Among the communities affected are Ekakpamre, Ighwrekreka, Ughevwughe, Ekrejegbe, and Otor-Edo. Local officials from four of the villages later call the incident "one of the worst environmental disasters to happen in Urhobo country in 40 years of oil exploration." At an October 2, 1999 press conference these local officials reject claims that sabotage caused the spill and fire. They call for an independent inquiry and compensation to the affected communities.[41] According to SPDC, an immediate investigation of the incident by a joint team, including representatives of the affected communities, concluded that the pipeline had been blown up with explosives placed beneath it. SPDC says it has tried to clean up the site, but is being denied access.[42]

24 Mar 00 — fire and two explosions at Shell's Godorf oil refinery in Cologne, Germany – the country's fourth-largest – causes more than $5 million in losses, cutting production by half. The fire started at one of two crude oil distillation stations where a heated oil product leaked, ignited, and set off a small explosion, then a second, larger explosion fed by several tons of oil. About 120 firemen fought the blaze for about three hours. A bilious cloud of smoke rose 1,000 feet into air at the scene, and over a nearby autobahn, which was closed for several hours. No injuries were reported. A small "controlled" fire was allowed to continue burning at the site to consume remaining oil that escaped during the incident. Some people at a nearby shopping center and residents close to the plant complained of irritated eyes and breathing difficulties, although state experts said no dangerous pollution occurred. Water used to fight the blaze was being contained and would be treated before it was released to the nearby Rhine River, according to refinery officials. Shell reported that removal of damaged parts of the crude distiller had begun in mid-April 2000, with new equipment slated to arrive through June, with the unit expected to be shut down for many weeks ahead.[43]

27 Apr 00 — hundreds of residents living in a Brunei Shell company housing complex near the oilfield town of Seria, Brunei, are forced to abandon their homes following an explosion at one of the company's gas pipelines. The explosion destroys two homes and damages at least two others. "It was truly a miracle," reported one resident. "The occupants of the two affected houses were out at work when the blast occurred. Luckily, there were also no children playing near the area or vehicles passing by when the incident occurred. . . ." The cause of the explosion was later found to be a corroded pipeline.[44]

18 Aug 00 — explosion at Motiva's Convent, Louisiana refinery injures nine workers; two treated at the scene with seven others taken to area hospitals, including one transported to the burn unit at Baton Rouge General Hospital. Some evacuation was also reported.[45]

26 Oct 00 — fire starts in storage tank being demolished at Shell's Deer Park, Texas refinery. The burning tank – which held naphtha, a gasoline component – produced heavy black smoke in the area, prompting the temporary closure of the Harris County Toll road.[46]

January 01 — the Shell/BP joint venture South Africa Petroleum Refinery (SAPREF) in Durban, South Africa has two refinery fires in January – one in early January in the refinery's bitumen blending area, and another on January 23rd at the refinery's No. 2 crude distillation unit.[47]

23 May 01 — gas explosion at the partially Shell-owned (46%) Gorm oilfield in North Sea injures two workers. Rig is a Danish Underground Consortium facility operated by Danish oil and shipping group A.P. Moeller (39%), also partially owned by Texaco (15%). Oil and gas production at the 46,900 bpd operation was suspended following the accident, which occurred just prior to midnight. No oil pollution was reported.[48]

6 Jun 01 — a Shell pipeline, which passes through the community of Baraale in Rivers State, Nigeria, spills crude oil into the community, forests, and on farmland. According to an Environmental Rights Action field report, local officials reported the leak to Shell and local police, but they were told the community should suffer because the lines were cut by saboteurs. Several months later, in October, the leaking oil caught fire. Again, local officials reported the fire to Shell officials, and they were again told they should pay the consequences of their actions. The fire continued to burn at least though January 2002. Burnt-over farmland is ruined, soot has contaminated drinking water, and some local residents fell ill from thick pall of smoke that hung over the area.[49]

17 July 01 — a large aboveground storage tank holding spent sulfuric acid at Motiva's Delaware City, Delaware refinery explodes, killing one worker and injuring eight other workers. A fire followed. The tank, which had lifted off its foundation pad in the explosion, also collapsed, releasing more than 600,000 gallons of acid, some into a large bermed area which was later breached, with acid also reaching storm sewers polluting the nearby Delaware River, and killing thousands of fish and hundreds of crab. One week after the accident, Motiva admitted the collapsed tank had a history of leaks and corrosion and was overdue for an inspection. One plant worker had labeled the tank unsafe three weeks before the accident, and a company inspector had called for an immediate shutdown on June 26th. In January 2002, US OSHA recommended a $259,000 fine, citing Motiva for three "willful" and seven "serious" violations. In July 2002, the US EPA and the Delaware Department of Natural Resources and Environmental Control (DNREC), sued Motiva, accusing the company of gross negligence, seeking penalties that could exceed $50 million. In August 2002, the US Chemical Safety and Hazard Investigation Board (CSB) charged that the accident occurred because of neglected warnings, slipshod equipment changes, and chronic, unrepaired corrosion and leaks in the 415,000-gallon storage tank. "Had any one of these elements been handled more effectively," said CSB chairwoman, Carolyn W. Merritt, "this accident probably would not have occurred."[50]

7 Aug 01 — well blow-out and fire occur at the Zauliyah-16 well in Oman, 120 km northwest of Haima. Well is operated by Petroleum Development Oman, a 34%-owned Shell company. Fire continued to burn for at least 12 days, through August 16th.[51]

23 Sept 01 — fire at Shell's Pernis, Netherlands refinery shuts down two hydro desulfurization units curtailing production of low-sulfur diesel and gasoil at the refinery for at least two weeks.[52]

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| 22 Jan 02 | "contained explosion" and fire in sulfur removal unit at Motiva's Delaware City, Delaware refinery sends thick plume of black smoke into area. One worker reported scrambling away from flames on hands and knees to activate firefighting systems. Gas reportedly ignited in the heater structure of the unit, followed by a fire that burned for an hour and half, shutting down one part of the refinery. A state fire marshal ruled the fire accidental, but the Department of Natural Resources and Environmental Control was conducting a review of the incident.[53] |
| 12 Feb 02 | an explosion and flash fire at Shell Chemical Co.'s Geismar, Louisiana plant kills one worker and injures another during maintenance and cleaning. Gregory Gibson, 40, died of injuries at the Gonzales Hospital following the incident. He had worked at the plant for four years. At the time, Shell and the Louisiana State Police were investigating the incident.[54] |
| 3 April 02 | fire at Shell's Deer Park, Texas plant burns for five hours after an out-of-service crude oil storage tank being cleaned caught fire; no injuries reported. |
| 13 May 02 | fire at Shell's Deer Park, Texas chemical plant, in olefins-3 unit sends large plumes of smoke into area, forcing nearby roads, including Texas Highway 225, to be shut temporarily; residents of Pasadena and Deer Park ordered to shelter-in-place.[55] |
| 24 July 02 | fire at the hydrotreater unit of Motiva's Port Arthur, Texas refinery shuts unit down for a few days. In August, unit is taken down for early maintenance & repairs.[56] |
| 18 Aug 02 | storage tank containing 30,000 bbls of residual fuel oil explodes at Houston Fuel Oil Terminal Co., a 50%-owned Shell joint venture specializing in oil handling and storage in Houston, Texas. The explosion and fire produced a dark, billowing cloud of soot and smoke that rose more than a mile into the air. It took five hours and 20 fire and foam trucks to extinguish the blaze. About a dozen workers were evacuated from the site during the fire. Although the tank did not collapse, the roof caved in. "We were very fortunate there were no injuries to our people and that we were able to quickly isolate the fire to one tank," said Willis Rossler, CEO of the company. There were about 80 other tanks in the area, located along the Houston Ship Channel, which was shut down for a few hours during the blaze. The cause of the explosion was believed to be a failed joint on a pipe supplying the tank. Property damage was estimated in the "millions of dollars."[57] |
| 1 Sept 02 | explosion of storage tank – a sulfur pressure vessel – occurs at the Shell/BP South Africa Petroleum Refinery (SAPREF) in Durban, South Africa.[58] |

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*Compiled by Jack Doyle for the Environmental Health Fund, November 2002. The incidents listed above are taken from the available public record, government reports, court records, company documents, and third-party reports. It is not a complete and comprehensive listing of all such incidents at Shell companies and joint ventures for the indicated period, or their resolution in every instance. Sources cited are believed to be reliable and accurate.*

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