

<b>Incident Title</b>		<b>Furnace Stack Collapse During Earthquake</b>	
<b>Incident Type</b>		Fire	
<b>Date</b>		17 <sup>th</sup> August 1999	
<b>Country</b>		Turkey	
<b>Location</b>		Izmit (Kocaeli Province)	
<b>Fatalities</b>		<b>Injuries</b>	<b>Cost</b>
0		0	US\$ 439 m (2021) – Ref. 3
<b>Incident Description</b>		<p>Following a magnitude 7.4 earthquake on the Richter scale, a 115 m (377 ft) high reinforced concrete crude distillation unit (CDU) charge furnace flue stack catastrophically failed and collapsed onto the furnace and a pipe rack, rupturing 63 product and utility lines and triggering a major fire. Concurrently, 4 floating roof naphtha storage tanks caught fire (which subsequently spread to 2 more tanks). Meanwhile, a smaller fire developed in a chemical storage warehouse when glass containers fell to the floor and smashed. The refinery's firefighting capability was lost because of electrical power failure and rupture of the water pipeline supplying all the refinery's water from a lake 45 km (28 miles) away. Fire tugs were sent to feed the fire main but it had been breached by earth movement and could not supply the tank farm area. Some fires burned for 5 days and had to be contained by aerial bombardment with foam. International support was needed to finally extinguish the fires.</p> <p>Fortunately, there were no fatalities at the site. All process units were safely shut down and were undamaged (except the CDU) but 30 out of 45 floating roof tanks were damaged. During firefighting operations, large quantities of oily water leaked from tank bunds, spilled into the water drainage system, flooded the wastewater treatment plant (WWTP) and overflowed into the sea resulting in significant oil pollution. Lost production was ~ 6 months operation.</p>	
 <p>Credit: Enric Marti/AP/Shutterstock</p>			
<b>Incident Analysis</b>		<p><b>Basic cause</b> was an earthquake which caused collapse of a CDU furnace stack (pipe ruptures), liquid sloshing and bouncing of floating roofs against walls of the naphtha tanks (sparking ignition) and breakage of glass chemical storage containers (spillage, mixing and exothermic chemical reaction).</p> <p><b>Critical factors</b> included: 1) Proximity to the epicentre of the earthquake, 2) Loss of electrical power (national grid infrastructure damage), 3) Loss of all telephonic communication systems (power failure), 4) Loss of water supply (pipeline ruptures), 5) Failure of CDU stack internal lining and concrete reinforcing bar splices (collapsing brick mass increased stress on stack shell).</p> <p><b>Root causes</b> included: 1) Inadequate design (backup fire water system), 2) Inadequate emergency planning (for "Natech" events), 3) Inadequate first response (insufficient personnel and equipment, road access compromised), 4) Inadequate disaster management (co-ordination of aid agencies).</p>	
<b>Lessons Learned</b>		<p>1) Earthquakes can cause underground piping to become displaced and fail, 2) Portable diesel pumps with large bore hose connections and enough fire hose to reach the most remote process plant/storage tanks should be held on site to ensure adequate backup fire water supply from the sea, 3) All tanks containing flammable fluids in earthquake zones should have full coverage water sprinkler and foam systems with in-situ foam stocks, 4) Emergency response plans for sites in earthquake zones should consider total and immediate loss of all utilities with compromised telecommunications and road access, 5) Regular emergency response exercises ("gun drills") should be conducted covering "Natech" events and involving all refinery personnel.</p>	
<b>More Information</b>		<p>1) <a href="http://www.nat-hazards-earth-syst-sci.net/11/1129/2011/">www.nat-hazards-earth-syst-sci.net/11/1129/2011/</a>                  2) <a href="https://enatech.jrc.ec.europa.eu/view/natech/2">https://enatech.jrc.ec.europa.eu/view/natech/2</a>                  3) "100 Largest Losses in the Hydrocarbon Industry", Marsh Property Risk Consulting Practice, 27th Edition (2022).</p>	
<b>Industry Sector</b>		<b>Process Type</b>	<b>Incident Type</b>
Oil & Gas		Atmospheric Crude Distillation	Fire
<b>Equipment Category</b>		<b>Equipment Class</b>	<b>Equipment Type</b>
Mechanical		Heaters & Boilers	Stack