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The Equilon Refinery Coking Plant Accident, Puget Sound, Washington, USA, 25th November 1998

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The Equilon Refinery Coking Plant Accident 25th November 1998

Equilon Oil Refinery – Puget Sound, Washington State, USA

Multiple Fatalities – 6 workers killed

Sources:
https://www.csb.gov/assets/1/20/moc082801.pdf
https://nsc.nasa.gov/docs/default-source/system-failure-case-studies/sfcs-2005-08-01-equilonrefineryaccidentanacortes-wa-vits.pdf?sfvrsn=7e40ecf8_4
http://www.historylink.org/File/5618
https://prezi.com/p/ylfw8gzt3pwc/wa-state-incident-timeline/

Shell Puget Sound refinery, Anacortes, WA

Google Earth image September 2020

Coking plant

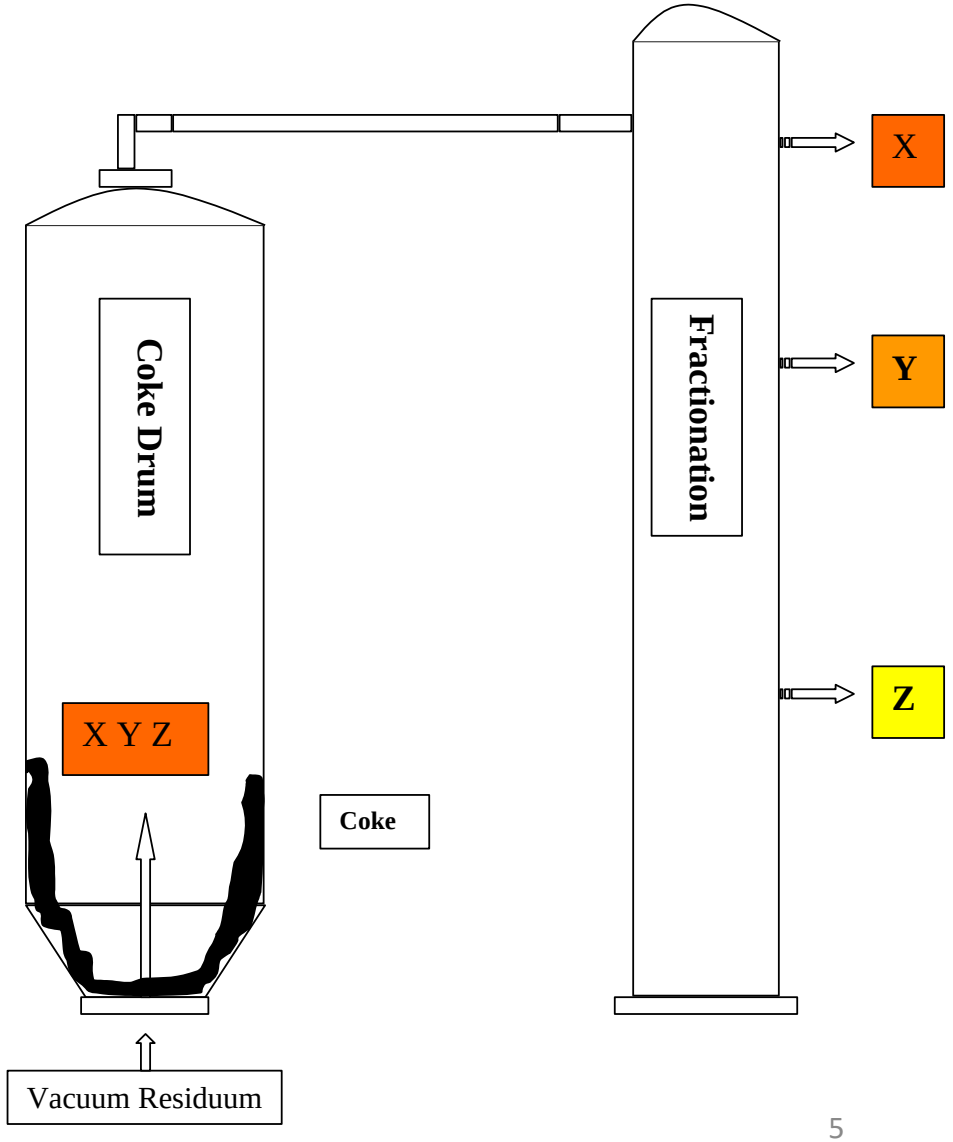
Events Leading Up to Incident

- Early in the morning of Tuesday 24th November 1998, high winds caused a power outage and a complete refinery shutdown.
- The large coking vessel ***Drum A*** was partially filled, about 1 hour into a routine charging cycle.
- 200 m^3 (46000 gallons) of hot coke and hydrocarbons at 550°C (900°F) became trapped in Drum A.
- This occurred close to Thanksgiving (US holiday), so some support staff may have been unavailable.

Coke Producing Process

Heavy oil from crude oil processing is heated and pumped into an on-line coke drum. Heavy long-chain hydrocarbon molecules are cracked under high temperature and pressure. The lighter hydrocarbons produced are carried to the top of the drum and over to a fractionation column for further processing.

The remaining long chain molecules combine to form coke which ends up at the bottom of the drum and must be removed at the end of the cycle before the process can be repeated.

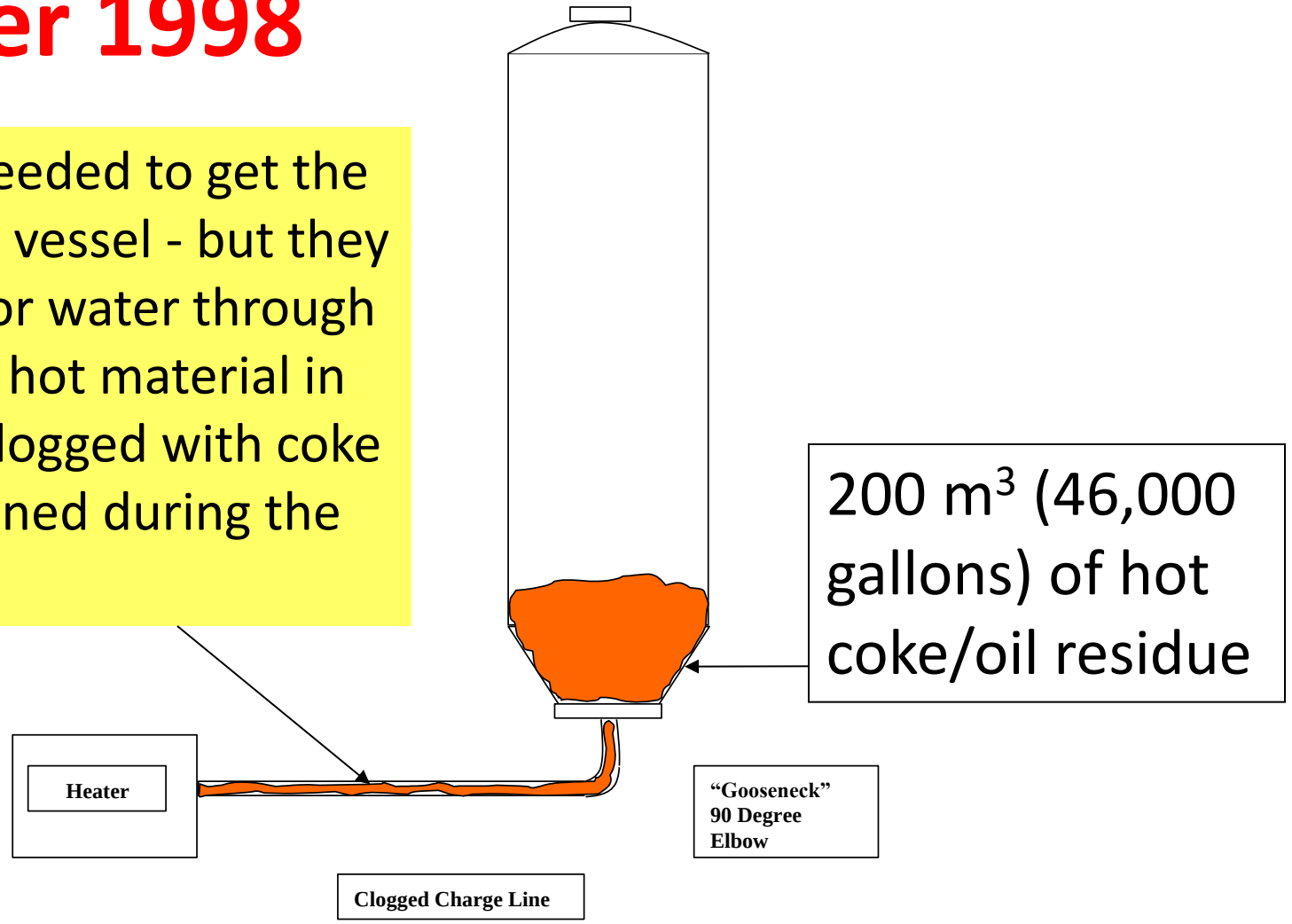


Normal Coke Removal Procedure

- Drum A is cooled first with steam followed by water.
- When acceptable temperatures are reached work permits are issued and acknowledged by the coke cutting contractor to un-head the drum.
- A high-pressure water jet is lowered into the drum, and coke is cut into chunks which flow out of the bottom of Drum A into a pit below.

Drum A situation after power failure on 24th November 1998

In this situation workers needed to get the coke/oil residue out of the vessel - but they couldn't move any steam or water through the charge line to cool the hot material in the drum because it was clogged with coke that had cooled and hardened during the power outage.



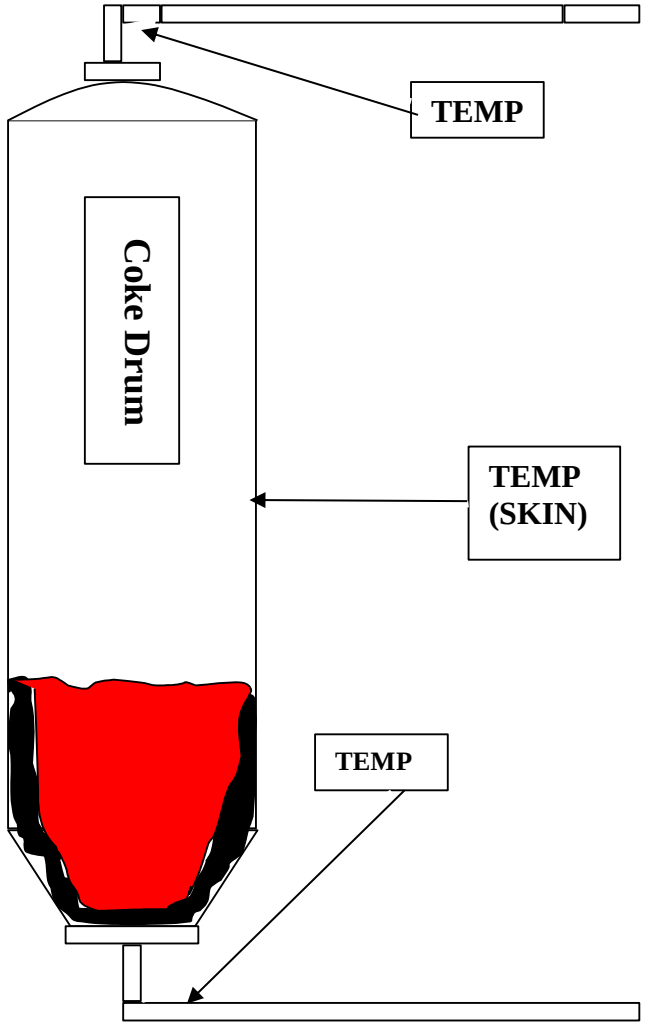
24th November, during the day

- **Attempts were made to clear the DCU heater lines after power and steam were restored at around 10:00 am.**
- **Operators were optimistic that steam had made its way through the heater and up into the bottom of Drum A.**
- ***Instead, it is likely pressure relief valves were lifting and simply diverting steam to their blowdown system.***

Overnight 24th/25th and early 25th November

- The unit foreman wrote the night orders and discussed at a 1500hrs management meeting on November 24th. "…drum is cooling without water. Do not put water into drum. Day shift will un-head Wednesday morning."
- Little activity during the night shift, drum sits idle.
- Several impromptu meetings were held the next morning (25th) between unit foreman and operators.
- Additional attempts were made to clear the line into the drum without success.

Actual temperature of the coke/oil was unknown



Temperature indicators were located at the gooseneck, the overhead vapor line, and one skin temperature sensor about a third of the way up (above the level of material in the drum). **There was no way to determine the temperature of the material inside the drum**. No technical assistance was requested or provided to estimate the temperatures. **Later estimates were that it would have taken over 200 days for the coke/oil residue to cool down to a safe temperature**.

On November 25th, the unit foreman and the operators reviewed the available drum parameters and concluded that the drum contents were sufficiently cooled (or else non-existent?) to un-head.

The top head of the drum was removed at about 1330 hrs without incident, and then preparations were made for removing the bottom head.

The accident

Using hydraulic controls, employees lowered the bottom head while they were standing underneath.

They did WHAT?????!!!!!????

Plant foreman's perspective? *(JT conjecture)*

- He couldn't see any oil level from the top of the drum (*black-on-black, poor visibility*).
- The drum temperature (*from the instrument above the oil level*) was low-ish.
- He believed steam had passed into the drum. Hence did he think either (i) cooling had been achieved, or else (ii) drum was empty? (*Steam actually went to blowdown*.)
- So, **did the foremen think grid loss had occurred before the charge cycle had properly started?**

Postscript after RefComm 2020: *I was wrong here – the operators definitely did know that there was hot oil in the drum. The explanation seems to be that they had become inured to the hazard posed by hot oil in the drum, so they went ahead and removed the bottom head anyway.*

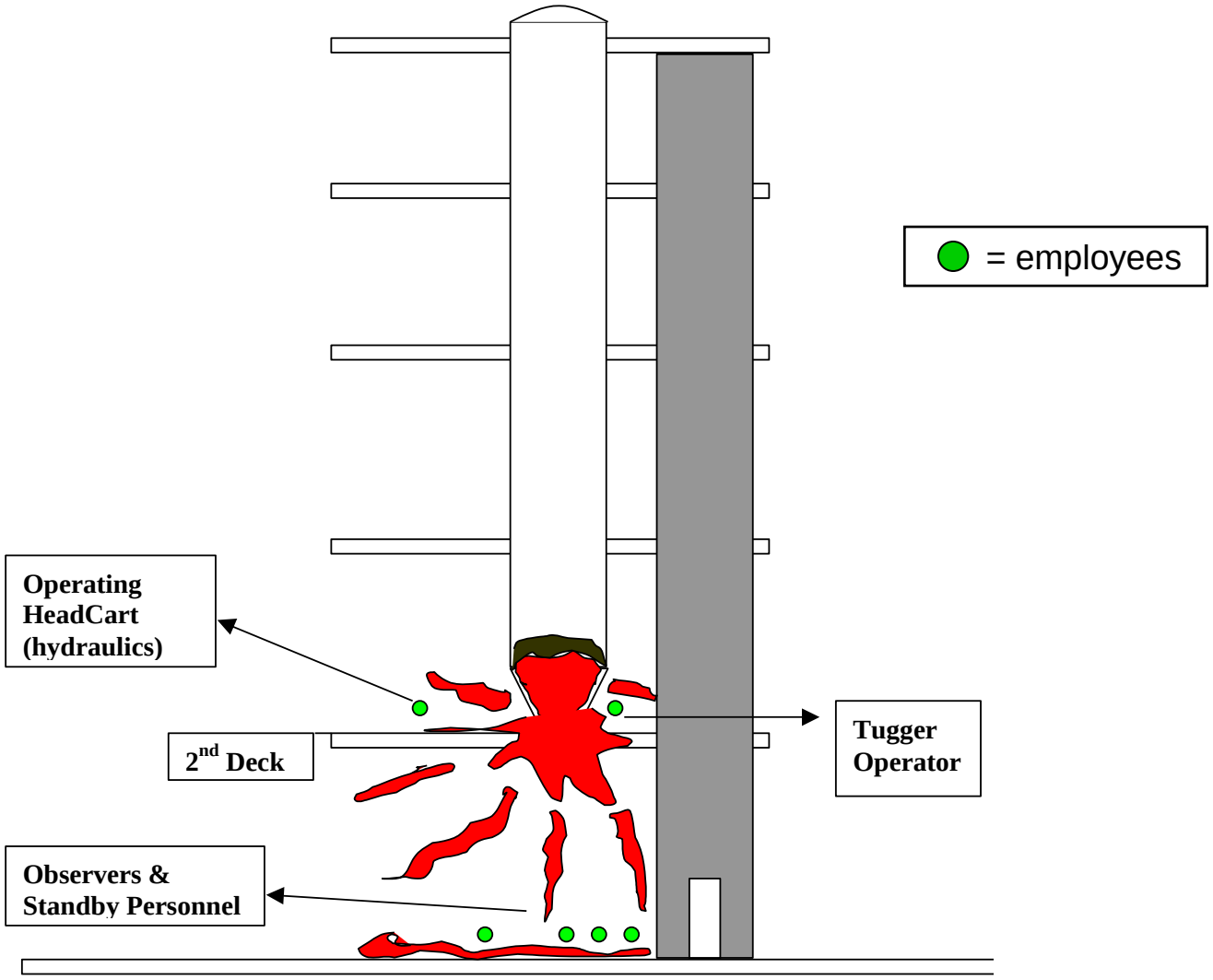
Plant manager's perspective? *(JT conjecture)*

- The plant manager will have been busy dealing with the aftermath of the grid loss throughout the refinery.
- Did the plant manager expressly state (or even just ***imply***) urgency to the coking plant foreman?
- Did the foreman perhaps ***infer*** that the manager had given him decision making responsibility for removing the top and bottom heads?

The Tragic Results

- **Heavy oil spewed out in all directions.**
- **Oil was above auto-ignition temperature.**
- **200 m^3 dumped in about 6 seconds and ignited, enveloping six workers in flames. All were killed.**

Postscript after RefComm 2020: *It is believed that there was a thin crust of coke (a good insulator) on top of the hot oil, and some steam had condensed on top of the coke to form a pool of water. When the bottom head was removed, the coke layer cracked and let water enter the hot oil below. This led to a steam explosion which drove the hot oil out in all directions, killing the operators below.*



The Aftermath

The Washington State Department of Labor and Industries set up an investigation that lasted eight months. Their report identified root causes:

1. Plant manager's decision to allow cooling for only 37 hours.
2. Failure to train employees properly.
3. Inadequate Management of Change procedures.

Equilon subsequently installed a remotely-controlled system for removing the drum lids, and installed a gas-fired back-up system to maintain steam supplies in the event of a power failure.

What should have happened?

The situation was <u>significantly different from normal plant operating procedures</u>.

- Some attempt to investigate the interior of drum could perhaps have been made, possibly by lowering a temperature measurement device in form the top of the vessel. Specialist contractors may have been needed to do this.

- The plant manager should also have contacted specialist technical support, who would have tried to calculate temperatures inside the drum.

These steps would have required off-site specialist assistance. There would have been delays to operation.

Why did it happen? (1)

Design failure

The plant should never have looked like this!

Remote removal of the bottom head was introduced after the accident.

Any basic safety analysis would have indicated that improvements to the head removal arrangements were a high priority.

Inadequate instrumentation.

***Postscript after RefComm 2020:** Most refineries have now backfitted hydraulic removal systems, and some have control system interlocks and/or mechanical interlocks preventing bottom head removal if the situation is inappropriate.*

Why did it happen? (2)

Management of Change failure

It appears that the foreman concluded that the Drum A charge cycle had not yet started at the time of grid loss.*

Hence he decided it was safe to remove the bottom head.

Non-standard operating conditions **should (of course)** have led to a time-out for managerial/technical review via MoC process.

Postscript after RefComm 2020: *I was wrong here – the operators definitely did know that there was hot oil in the drum. The explanation seems to be that they had become inured to the hazard posed by hot oil in the drum, so they went ahead and removed the bottom head anyway.*

Contributory factors? (*JT conjecture*)

- **Thanksgiving holiday:** did this lead to a shortage of support staff and advice?
- **Cost and time pressure** (actual or perceived) to get the plant available again quickly?
- Coking plant: **was it seen as a 'Cinderella' plant?** Unsexy, and getting minimal attention from management and technical support staff?

Costs to Equilon: $50 million

1. $4.4 million settlement package. The agreement included a $1.1 million fine; a $1 million donation to the Fallen Worker Scholarship Fund, established on behalf of Equilon employees' families; $1 million to establish a Worker Safety and Health Institute at a state institution; a $350,000 donation to the City of Anacortes Fire Department to purchase a new fire engine, and $350,000 for an independent safety audit of the refinery.

2. The company installed a **new $575,000 remote-controlled system at the delayed coking unit that allows operators to unseal the giant steel drums from a shed 200 feet away.** The company also designed and installed **a $30,000 natural gas backup system to create steam for purging the unit in the event of a power failure.**

3. On January 19, 2001, a **$45 million settlement was reached between Equilon Enterprises and the families of the six men killed in the Puget Sound Refinery accident.** The settlement, which came 10 days before a trial was to begin in Skagit County Superior Court, was the biggest single cash settlement in a wrongful death lawsuit in Washington history. Under the agreement, Equilon and their insurers paid $45 million into a trust fund for the families of the six victims.

In memoriam

Ron Granfors, 49, foreman (Equilon)
Wayne Dowe, 44, operator (Equilon)
Dave Murdzia, 30, supervisor (Western Plant Services)
Warren Fry, 50, coke-cutter (Western Plant Services)
Ted Cade, 23, coke-cutter (Western Plant Services)
Jim Berlin, 38, coke-cutter (Western Plant Services)

Summary

- **A bizarre accident – we shall never know *exactly* why it happened because the plant foreman was killed.**

<u>Contributory factors included:</u>

- **Poor design**
- **Weak management of change following power loss**
- **Thanksgiving holiday?**
- **Perceived time pressure?**
- **Lack of management attention to coking plant?**

Final words:

“Optimism and stupidity are nearly synonymous.” Hyman G. Rickover.

“The big accidents are just waiting for the little ones to get out of the way.” Carolyn Merritt.