



That Sinking Feeling: Total Loss of Petrobras P-36 *

* A floating oil drilling platform designed and operated by **Petróleo Brasileiro S/A** (aka Petrobras)

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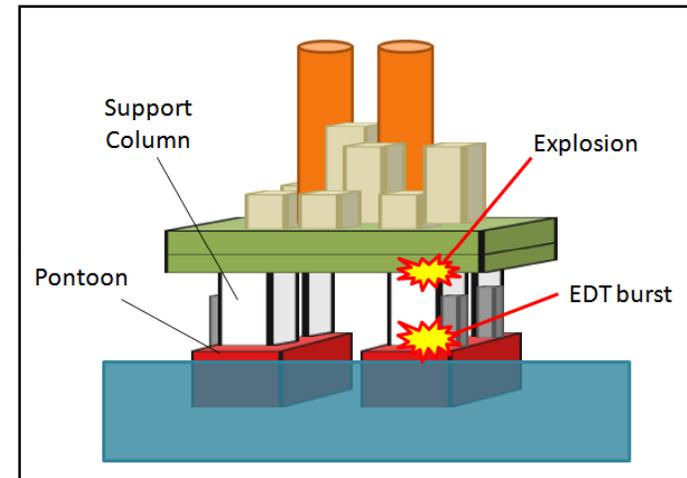
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The World's Largest Oil Rig Sinks

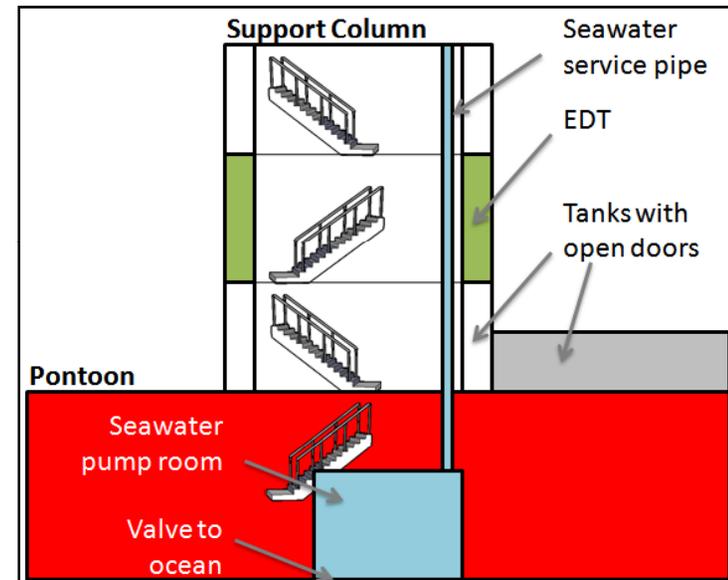
- The Petrobras Platform 36 (P-36) was a drilling platform designed to be completely supported by the buoyancy of two pontoons and four support columns.
- An emergency drain tank (EDT) located in one of the four support columns had been shut down and supposedly isolated by the closure of a valve, however, leakage of volatile fluids and gases through the valve over-pressurized the tank and the tank violently burst at 12:22 am on March 15, 2001.
- The seawater service pipe adjacent to the EDT ruptured in the burst. Over the next 17 minutes, 1,723 alarms were triggered. Operations dispatched the fire-fighting team and activated the seawater service pipe, which instead of supplying water to the fire-fighting team was now flooding the support column.
- The volatile mixture of fluids and gases from the burst EDT was later ignited by an unidentified ignition source resulting in an explosion that **killed the 11 members** of the fire-fighting team.
- Flooding of the column also short circuited the seawater pump located at the bottom of the column in the pontoon. The valve to the ocean failed and locked in the open position allowing uncontrolled flooding of both the column and pontoon.
- Within minutes, P-36 tilted by 5 degrees. By 6:03 am, the rig was abandoned. At 8:15 am, the flooding exceeded the capability for the platform to maintain stable floatation and an entire corner of the rig submerged.
- Five days later the entire \$496 million oil rig hit the bottom of the Atlantic Ocean.





Proximity of Critical Parts and Subsystems

- EDTs are a key subsystem element of oil production operations and exist to store fluids and gases if over-pressurization of the pipes occurs. EDTs are usually located on the bottom deck of the platform, but to save space and money for the design of P-36, the EDTs were installed into the support columns.
- The seawater service pipe was installed inside the column adjacent to the EDT, running inside the support column and leading from the pump room located inside the pontoon.
- Doors inside the column and used to access tanks and compartments needed for control of buoyancy and stability had been left open for inspections scheduled later that day. These compartments were therefore susceptible to flooding easily.
- Each of the several floors inside the column and extending inside the pontoon contained air vents as a part of the ventilation system, which allowed flooding progressively into the upper levels.
- There were no records indicating the existence of any hazard analysis that might have identified the creation of a catastrophic hazard by placing so many safety-critical parts and subsystems next to one another and susceptible to a common cause failure.





Proximate Cause

- The leakage of volatile fluids into a purposely isolated EDT resulted in over-pressurization and mechanical bursting of the tank, rupturing the seawater service pipe and releasing flammable materials into the support column.

Root Cause/Underlying Issues

- **Poor design placement of key safety-critical parts**
 - The proximity of the EDT to the seawater service pipe inside a key support column created a common mode of failure, but there was no record of hazard analysis conducted for this design.
 - The ruptured seawater service pipe was no longer able to adequately provide for fire-fighting, and there was no alarm to notify operators that seawater was flooding the column and pontoon.
- **Component failure without sufficient backups**
 - The valve closing off the isolated EDT had no redundancy in case of leakage.
 - When the seawater pump short-circuited from the flooding, the valves to the ocean were fail-set and thus locked in the open position allowing uncontrollable flooding of column and pontoon.
- **Lack of training and communication**
 - An overwhelming 1,723 alarms were triggered in 17 minutes after the EDT burst with no method of prioritization.
 - A number of water-sealed doors to key ballast compartments were left open even after flooding. The workers' union blamed poor training of contracted workers, citing that 66 of the 81 Petrobras workers killed over three years were all contractors.
 - Managers on the rig had reported pressurization problems in the pipes in the days leading up to the accident, and even recommended temporary shut down, but the head office stated that they had never been notified.
- **Focus on cost-cutting**
 - The company publically extolled its shedding of prescriptive engineering, inspections, and quality requirements in the interests of increasing profits.
 - Over a decade, the workforce had been downsized to half its size while production and operations had actually increased over the same period.



NASA Applicability

- Efficiency and performance should not supersede the need and continuous pursuit of safe operations.
- Designs and modifications must be carefully analyzed for failure modes, even if the modifications have become common practice or industry standards. Redundancy should be used where appropriate, but a systems engineering outlook is needed to prevent simultaneous or cascading failures created by the proximity of many safety-critical parts and subsystems from leading to an uncontrolled catastrophe.
- Operators need an established methodology to prioritize and focus response that could be triggered by multiple alarms sounding simultaneously or within a short time frame.
- Fail-set components are components that lock in pre-determined final positions. These positions must be well understood for how the potential fixed state will affect operations in an emergency.



“THE PROJECT SUCCESSFULLY REJECTED ... PRESCRIPTIVE ENGINEERING, ONEROUS QUALITY REQUIREMENTS, AND OUTDATED CONCEPTS OF INSPECTION ...”

A PETROBRAS EXECUTIVE, PRIOR TO THE ACCIDENT, ON DELIVERING SUPERIOR FINANCIALS