Petrobras P-36 Incident

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• I was born and raised in Bucaramanga, Colombia

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Outline

• Background

• Petrobras P-36 incident description

• Sequence of events

• Investigation-what went wrong?

• Causes and root causes

• Conclusions and recommendations
Floating Production Unit (FPU) Background

• Original name: “Spirit of Columbus”
• Designed and constructed in 1984-1994 in Italy
• Original intent: oil drilling and small production unit [3]
• Contracted by Petrobras in 1996, and renamed to P-36
• Adapted into a large oil production platform (FPU) by Canadian Shipyard Davie Industry [3]
• Major changes:
  ✓ Designed to operate at 500 m water depth → adapted to 1360 m [4,5]
  ✓ Capacity 180,000 bpd of oil and 7.2 million m³/day of gas
  ✓ Installed buoyancy boxes to accommodate extra weight of topsides
  ✓ Average production on March 15: 84,000 bpd of oil and 1.3 millions m³/day gas [4,5]
• Installed at the Roncador Field in 2000

Fig 1. Location of Campos Basin’s Rocandor field [1,2]
Accident Description [6, 7]

When – 15\textsuperscript{th} March, 2001

Where – Roncador field in Campos Basin, 125 km from the coast of Brazil

2 explosions in one of the support legs, followed by flooding of the leg

The FPU sank (on March 20\textsuperscript{th})

Consequences

• 11 fatalities

• Financial losses nearing 1 billion dollars

• Around 316,000 gal of diesel and 80,000 gal of crude oil spilled
Accident Description

Fig 4. General view of P-36 [6]

Fig 5. Semi-submersible platform model
Adapted from [10]

Fire pumps (seawater pumps):
A: Portside aft
B: Portside fore
C: Starboard fore
D: Starboard aft
Platform Layout “Aerial view” [6,12]

Emergency Drain Tank

Fig 6. Emergency Drain Tank, Top view. Source: The Accident of P-36 FPS [6].

Fire pumps:
A: Portside aft
B: Portside fore
C: Starboard fore
D: Starboard aft

Fig 7. Special drawings created, Platform aerial view. Source: Accident Investigation Petrobras P-36 Sinking (DNV) [12].
Sequence of events (March 10\textsuperscript{th} - 20\textsuperscript{th}, 2001)\textsuperscript{[4,6]}

Fig 7. Adapted general timeline of the P-36 accident. Source: Petrobras and Brazilian navy reports [4,6].
Sequence of events (March 15th)\cite{4,6}

- First explosion (Mechanical explosion – pressure burst)
  - Due to pressure build-up in a drain tank

- Second explosion (Chemical explosion)
  - Due to ignition of released vapors

- Fire alarm system operations

Fig 8. Inclination six degrees
Source: Acidente da P-36 – Explosao e Naufragio \cite{11}
Investigation – what went wrong? [4,6,12]

Initial conditions [4,6,12]

- Both tanks contained 50% of water
- The pump of the Starboard-aft Emergency Drain Tank was removed for maintenance
- 3 valves were closed and properly isolated with blind flanges
- 1 valve was manually closed but no blind flange was installed (allowing liquid to enter)

Fig 9. Flow chart Emergency Drain tank system on the aft site (initial conditions on March 14th).
Source: Adapted from [4,7,11,12]
Investigation – what went wrong? [4,6,12]

Emptying portside TDE [4,6]

- Port pump aligned towards the production header
- Outflow line valves (starboard) opened
- Delay to start up the drain pump of the port aft TDE
- Reverse flow during 54 min

PRODUCTION HEADER

10 bar

HEADER VALVE

CAISSON VALVE

BLIND FLANGE

WATER

OIL

VAPOR

PORT EMERGENCY DRAIN TANK

STARBOARD EMERGENCY DRAIN TANK

ATMOSPHERIC VENT

Fig 10. Flow chart Emergency Drain tank system on the aft site (unsuccessful activation of the port tank pump).

Source: Adapted from [4,7,11,12]
Investigation – what went wrong? [6,11]

Fig 11. Flow chart Emergency Drain tank system on the aft site (Port tank pump start up).
Source: Adapted from [4,7,11,12]
Investigation – what went wrong? [6,11]

Fig 12. Adapted From Acidente da P-36 – Explosao e Naufragio.
Source: Acidente da P-36 – Explosao e Naufragio (Petrobras – 15.03.2001)
Investigation – what went wrong? [6,12]

• The fire alarm system was activated and the starboard pump was automatically started.

• Water reached the ventilation duct rupture, and filled the pump room (pontoon).

• Manholes connecting the pontoon with the stability box and ballast tanks were opened for inspection.

Fig 13. Starboard aft column. Source: Accident Investigation Petrobras P-36 Sinking (DNV) [12].
Cause and effect – (Fishbone) \([4,6,7]\)
Causes $^{[4,6]}$

**Explosion**
- Absence of a blind flange in the intake valve on the starboard aft tank
- The port pump was aligned towards production header, instead of caisson production.

**Unit Sinking**
- Failure of the ventilation system- watertight dampers actuators
- Manholes opened on the ballast tank and stability box
- Lack of training in emergency stability control
- Design of the sea-chest valve (fail mode)
Conclusions

• Investigation results indicate that the most likely scenario was overpressure in the starboard aft emergency drain tank, which caused a mechanical explosion and lead to the rupture of the tank. This initial event allowed the release of flammable hydrocarbon gas, which eventually originated a second explosion.

• It was concluded that the main cause of these events was failure to provide effective isolation in the intake valve at the starboard aft tank during maintenance (i.e., absence of blind flange), which allowed unexpected reverse oil and gas flow into the starboard aft tank.
Conclusions

• Although there were many factors that contributed to the flooding process of the unit. However, this process was accelerated because of the fail mode / fail state of the sea-chest valves and because several buoyancy boxes were open at the same time for inspection and thus when water entered they flooded.
Recommendations [4,6,14]

Petrobras Inquiry Commission

• Improve offshore operations and enhance safety on board offshore units.

• Do not install pressure vessels and atmospheric tanks connected to the production process facilities (i.e. hydrocarbons) inside columns or pontoons: Re-assess the risk and review the design of the units that operate with these design issues.

Brazilian Governmental Petroleum Agency (ANP) & Brazilian Port Administration (DPC)

• Review the criteria for a number of simultaneous work permits in offshore activities.

• Review the content of the current contingency plans.

Key Recommendation: Creation of the Operational Excellence Program – PEO

Engineering design/ Safety/ Ballast and Stability/ Maintenance/ Operation/ Human Resources
Recommendation

Budget cutting – needs Risk Based review

Understand impacts of cuts in budgets in important areas such as SAFETY and QUALITY
References

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Thank you!

Questions?

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