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Gás Natural e Biocombustíveis

Safety Alert 003 - ANP/SSM

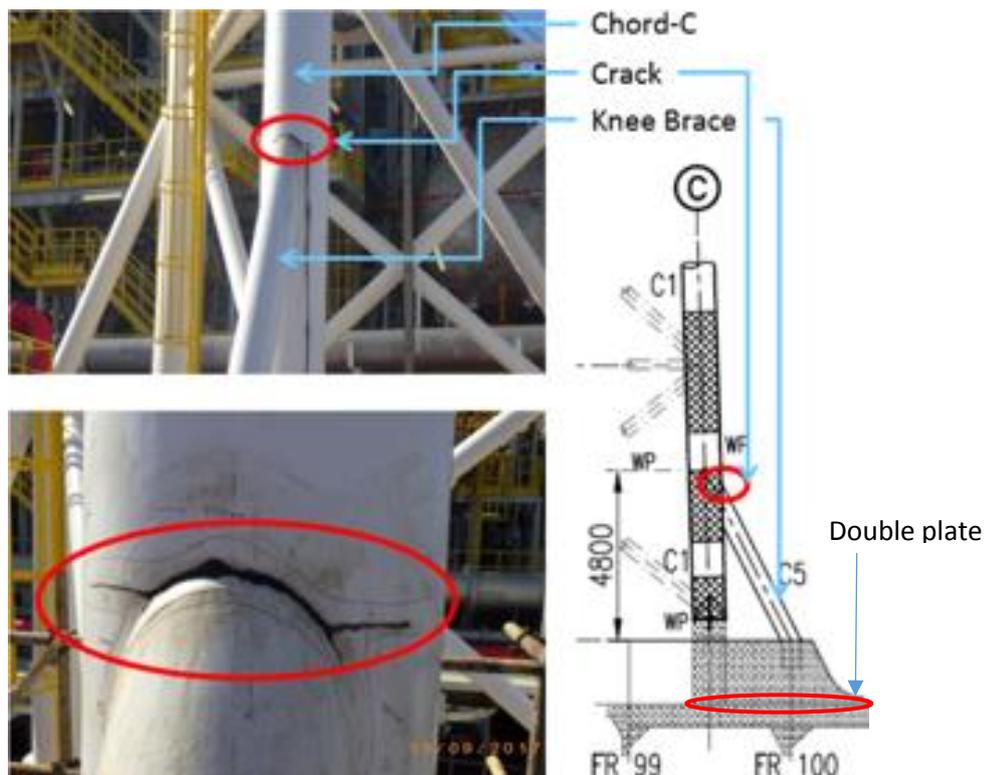
Flare tower failure due to resonance effect

The Superintendence of Operational Safety and Environment (ANP/SSM) is issuing this safety alert to notify the petroleum and gas industry and other stakeholders about a failure mechanism of the flare tower due to excessive vibration caused by hull natural frequency excitation coinciding with the flare tower natural frequency.

What happened?

The incident that motivated this alert occurred in September 2017 in a floating, production, storage and offloading unit (FPSO), after around one year of operation. An excessive flare tower vibration led to a major crack, circa 950 mm length, in the bracing connected to the forward leg at the flare foundation on the hull, leading to the complete shutdown and evacuation of non-essential personnel.

This flare tower is a fixed stack supported by three main elements, which are reinforced at the base by knee braces. The crack occurred at the connection weld of the knee brace to the leg, as well as at doubling plate connection of the flare legs on the hull deck, as showed in the picture:



Potential consequences

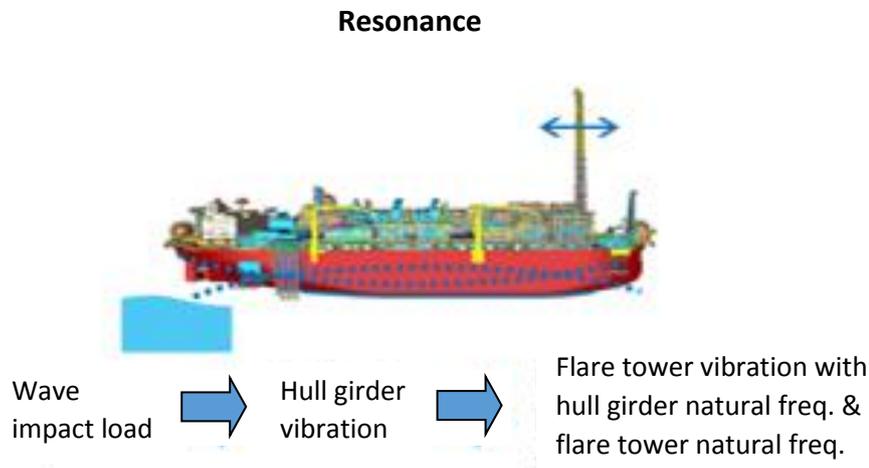
Excessive vibration may cause unexpected and catastrophic failure of the structure, leading asset and environmental damage and ultimately to human impacts including fatalities and production losses.

Identified causes

The investigation conducted by the operator identified the following causes of the failure:

- Resonance effect due to hull girder natural frequency coinciding with the flare natural frequency at a specific draft;
- Inadequate engineering design (knee brace location, doubling plate);
- Excessive stress concentration;
- Slamming inducing whipping and excitation of the flare tower natural frequency (resonance).

Therefore, significant amplification and excessive flare movements were observed leading to cracks occurring at the weakest part of the structure:



The Root Cause Analysis performed by the operator confirmed that the severe conditions and dynamic amplification due to nonlinear response (whipping effect) would lead to a flare tower structure reduced fatigue life down to couple of months.

Regulatory Framework

According to SGSO item 10.3 (a): *“... The Operator of the Installation must establish a system in a way that:*

- all aspects that could introduce risk to Operational Safety are duly considered in the Installation project and in subsequent revisions of the design, construction, installation and deactivation/abandonment phases;”

Additionally, also in agreement with SGSO item 10.3 (c): *“... The Operator of the Installation must establish a system in a way that:*

- means of altering the project are established when aspects that could introduce risk to Operational Safety are encountered during the construction and installation phases.”

Lessons learned

ANP recommends ensuring during engineering phase of FPSO units that all structural natural frequencies are separated, including hull natural frequency for all draft condition to avoid significant dynamic amplification and fatigue sensitivity.

Additionally, it is recommended that all FPSO units in operation are checked to ensure that flare tower natural frequency is sufficiently away from the hull natural frequency for all cargo conditions. The identified risks shall be managed in accordance with operational safety management practices.

Contact

For additional information regarding this Safety Alert, please contact ANP’s Superintendence of Operational Safety and Environment at sgso@anp.gov.br.