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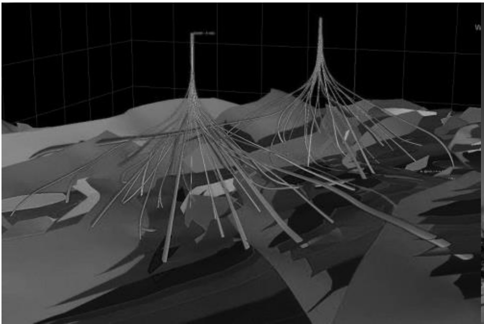
Blowout Risk Assessment Services

Sensitivity analysis of a Blowout Spill with K-BOS

13/08/2024




Introduction

Objective and Methodology of the sensitivity analysis

- The Objective of the presentation is to quantify the ALARP effect of the K-BOS **on the risk of a spill in the case of a well blowout** and the impact on the probability of the event to pass from a minor spill to a major spill event

(duration more than 1 day = estimated maximum time to activate K-BOS through ROV in the case where it was not activated by the crew or in case of a rig loss/explosion)

- The used methodology is to calculate **the probability of a well blowout** and combine it with **the probability of failure of the K-BOS** in E-SID configuration solely used as an emergency source control device

- Principle applied on a selected well to **calculate the reduced risk of a major blowout spill.**

Probability of a well blowout

Ways of determining the probability of a well blowout

- IOGP Risk Assessment Data Directory 2019 (Appendix 1):

Depending on the type of well and the standards applied, one can determine the probability of a blowout based on historical frequencies of similar wells; or

- Fault Tree Analysis approach (Appendix 2)

For the estimation of the Blowout probability of the well, a Fault Tree Analysis approach considering the different barriers in the well and their individual failure probability.

The singular probabilities are grouped into Intermediate events using AND/OR logic and subsequently added up to calculate the blowout probability of the entire well.

Probability of failure of K-BOS

In an E-SID mode (Emergency Shut-in Device), with independent controls and used as a source control device.

- Fault Tree Analysis approach (Appendix 3)

A thorough analysis of K-BOS equipment has been carried out to identify all the components involved in the closure of the ram during a blowout emergency event and to quantify the reliability of the overall K-BOS system regarding its activation function and its capability to cut the tubular elements inside the wellbore and to seal the well from potential uncontrolled flows.

K-BOS Probability of Failure on Demand = 1.2 x 10^{-4}

Calculation of the probability of a major blowout spill

Selected well: Exploration well in the Otway basin in Australia

Likelihood of occurrence	LOC MDO: Highly Unlikely (2) based upon AMSA Annual Report 2017-18 (serious incident reports) LOWC condensate: Remote (1) (1.6 x 10^{-4} for drilling of a normal deep exploration wells and a probability of 1.5 x 10^{-4} for drilling of appraisal wells based upon gas wells operated to North Sea Standard) ref IOGP Risk Assessment Data Directory Blowout Frequencies September 2019: https://www.iogp.org/bookstore/product/risk-assessment-data-directory-blowout-frequencies/

Source: Extracts of the Environmental Plan

Average spill duration

Base Case = Per Environmental Plan

K-BOS E-SID Case = K-BOS installed on top of wellhead as a pre-positioned capping stack / Emergency Shut-in Device

	K-BOS	Capping	Relief Well	Blowout Expected Spill Duration
Base Case	✗	✓	✓	**> 20 days (best case)***
K-BOS E-SID Case	✓	✗	✓	**< 1 day (worst case)**

*** A capping stack cannot prevent a major spill** (major spill = spill that lasts more than one day)

Calculation of the probability of a major blowout spill

Base Case = Per Environmental Plan

K-BOS E-SID Case = K-BOS installed on top of wellhead as a pre-positioned capping stack / Emergency Shut-in Device

	K-BOS	Capping	Relief Well	Blowout Major Spill probability
Base Case	✗	✓	✓	1.6×10^{-4}
K-BOS E-SID Case	✓	✗	✓	1.92×10^{-8} *

* (1.6×10^{-4}) x (1.2×10^{-4}) = 1.92×10^{-8}

Blowout probability x K-BOS probability of failure

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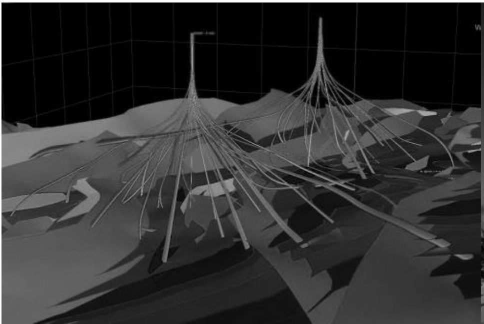
Appendices




Appendix 1 - IOGP Risk Assessment Data Directory 2019

International Association of Oil & Gas Producers

REPORT
434-02

SEPTEMBER
2019

RISK ASSESSMENT DATA DIRECTORY

Blowout Frequencies

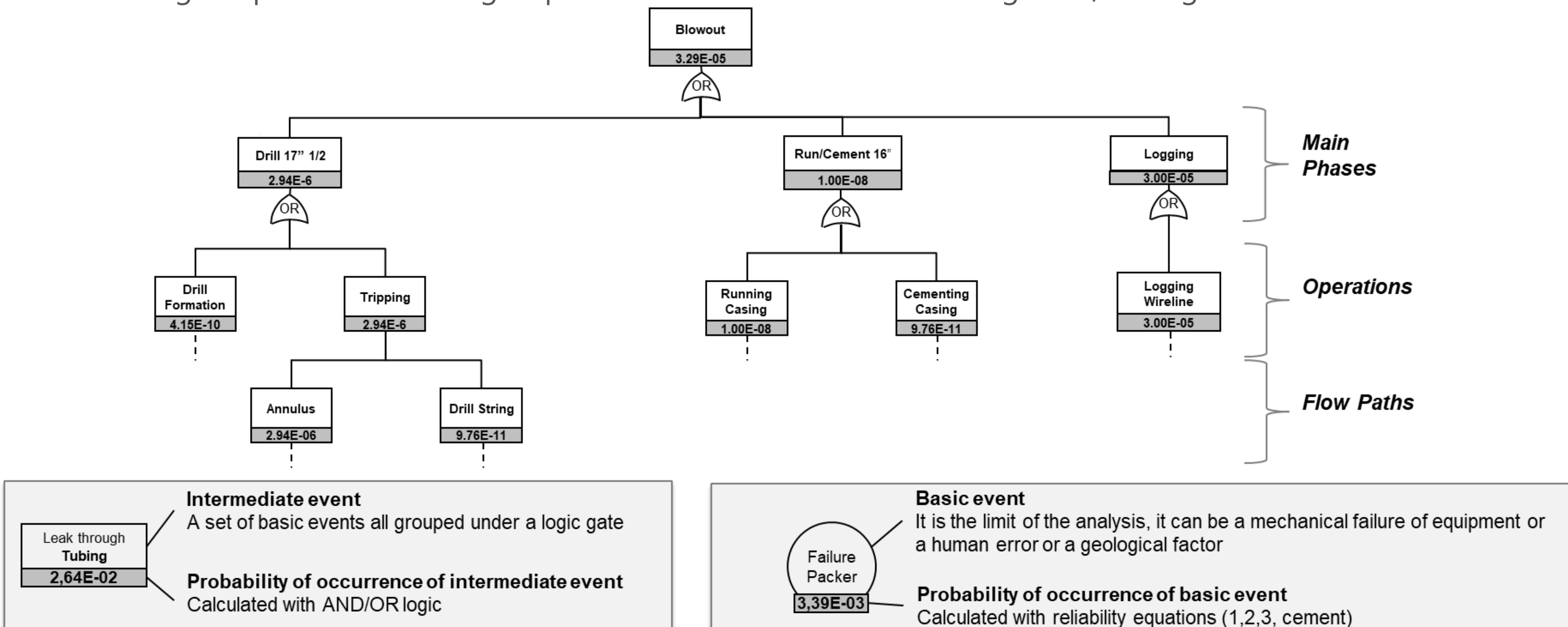
Appendix 1 - IOGP Risk Assessment Data Directory 2019

Table 2-1: Blowout and Well Release Frequencies for Offshore Operations of North Sea Standard

Operation	Category	Frequency, Average Well	Frequency, Gas Well	Frequency, Oil Well	Unit	Fraction Subsea[1]
Exploration Drilling, Shallow Gas[2]	**Appraisal Well**					
	Topside Blowout	2.1×10^{-3}	-	-	per drilled well	0
	Blowout (Subsea)	1.3×10^{-3}	-	-	per drilled well	1
	Wildcat Well					
	Topside Blowout	2.1×10^{-3}	-	-	per drilled well	0
	Blowout (Subsea)	1.2×10^{-3}	-	-	per drilled well	1
Development Drilling, Shallow Gas[2]	Topside Blowout	1.7×10^{-3}	-	-	per drilled well	0
	Blowout (Subsea)	1.0×10^{-3}	-	-	per drilled well	1
Exploration Drilling, Deep, Normal Wells[3]	**Appraisal Well**					
	Blowout	1.4×10^{-4}	1.5×10^{-4}	1.2×10^{-4}	per drilled well	0.47
	Well Release	1.3×10^{-3}	1.4×10^{-3}	1.2×10^{-3}	per drilled well	0
	Wildcat Well					
	Blowout	1.5×10^{-4}	1.6×10^{-4}	1.3×10^{-4}	per drilled well	0.47
	Well Release	1.4×10^{-3}	1.5×10^{-3}	1.2×10^{-3}	per drilled well	0

Appendix 2 – Fault Tree Analysis of a well blowout

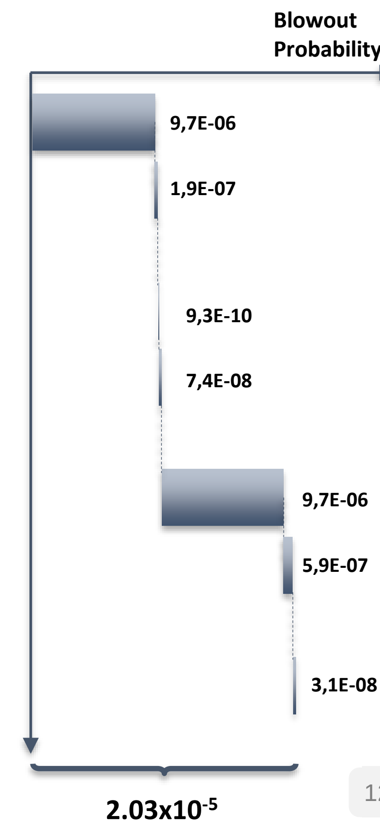
- For the estimation of the Blowout probability of the well, a Fault Tree Analysis approach considering the different barriers in the well and their individual failure probability.
- The singular probabilities are grouped into Intermediate events using AND/OR logic as illustrated below



Appendix 2 – Example well blowout probability calculations

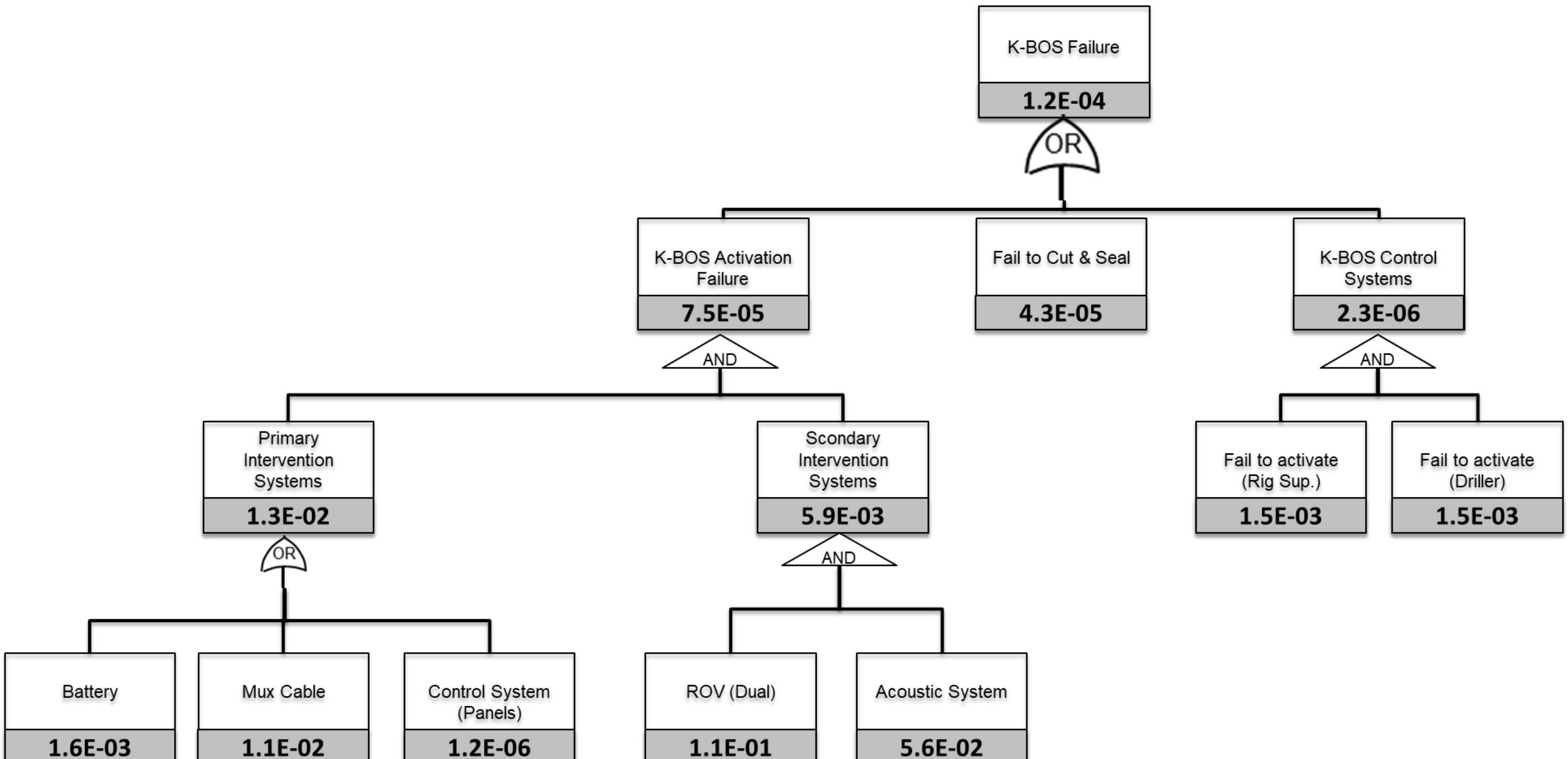
- Based on example well below, total probability for that well is calculated for each flowpath and operation and presented as below

Phase Name	Operation	Primary Flowpath	Secondary Flowpath
Drill 17 ½ Intermediate Section	Drill Formation	Annulus – $9.7x10^{-6}$	Drill String – $9.3x10^{-14}$
	Tripping	Annulus – $1.9x10^{-7}$	Drill String - $8.9x10^{-14}$
Run/Cement Intermediate Casing	Running Casing	Annulus – $9.3x10^{-10}$	Casing – $4.2x10^{-15}$
	Cementing Casing	Annulus – $7.4x10^{-8}$	Casing - $2.8x10^{-15}$
Drill 12" ¼ Section	Drill Formation	Annulus – $9.7x10^{-6}$	Drill String – $1.2x10^{-15}$
	Tripping	Annulus – $5.9x10^{-7}$	Drill String - $3.6x10^{-13}$
Logging	Logging Wireline	Annulus – $3.1x10^{-8}$	Full Bore – $1.1x10^{-11}$



Appendix 3 – K-BOS Fault Tree Analysis

Calculation of Probability of Failure on Demand



Thank you

ITALY

Via Santa Sofia, 27
20122 Milano

FRANCE

71/73 rue Desnouettes
75015 Paris

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