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Sand Prediction and Monitoring – A key Element of Equipment Integrity and Reliability Management

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Introduction

- Background
- Effects of sand production on critical equipment
- Failure Mode and Effect Criticality analysis
- Failure consequences as a result of sand production
- Failure Elimination and prevention strategy

Background

- Reliability and integrity of production equipment
- Impact on production field economics
- Unreliability of current sand prediction techniques
- A need for a holistic approach
 - integrate sand prediction and real-time monitoring systems

Critical equipment prone to sand related failure

- Pump
- Separator
- Production tubing
- Christmas (production) tree
- Flowlines

Some common failure modes

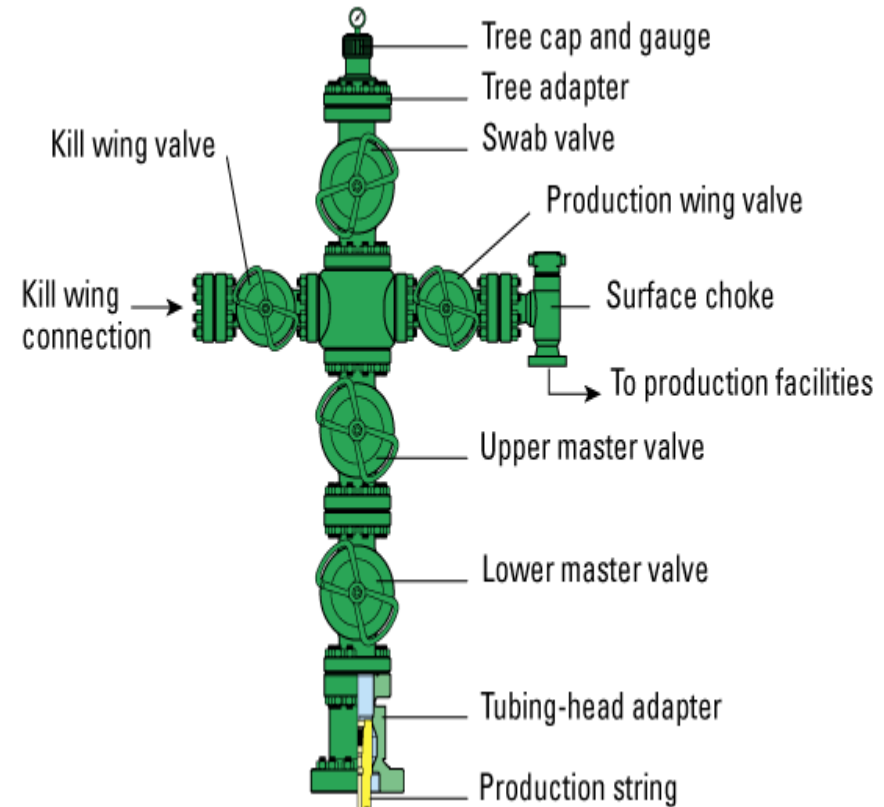
Equipment	Major components	Failure modes
<i>Pump</i>	<i>Seals Impeller Bearings Cylinder lining</i>	<i>Corrosion Erosion Plugging</i>
Separator	Perforated plates Vessel walls Inlet momentum absorber	<i>Corrosion Erosion Plugging</i>
Xmas tree	Upper Master valve Lower master Wing valves	<i>Corrosion Erosion Plugging</i>

Failure Mode and Effect Criticality Analysis

- What are the functions and associated desired standards of performance of the asset in its present operating context (functions)?
- In what ways can it fail to fulfill its functions (functional failures)?
- What causes each functional failure (failure modes)?
- What happens when each failure occurs (failure effects)?

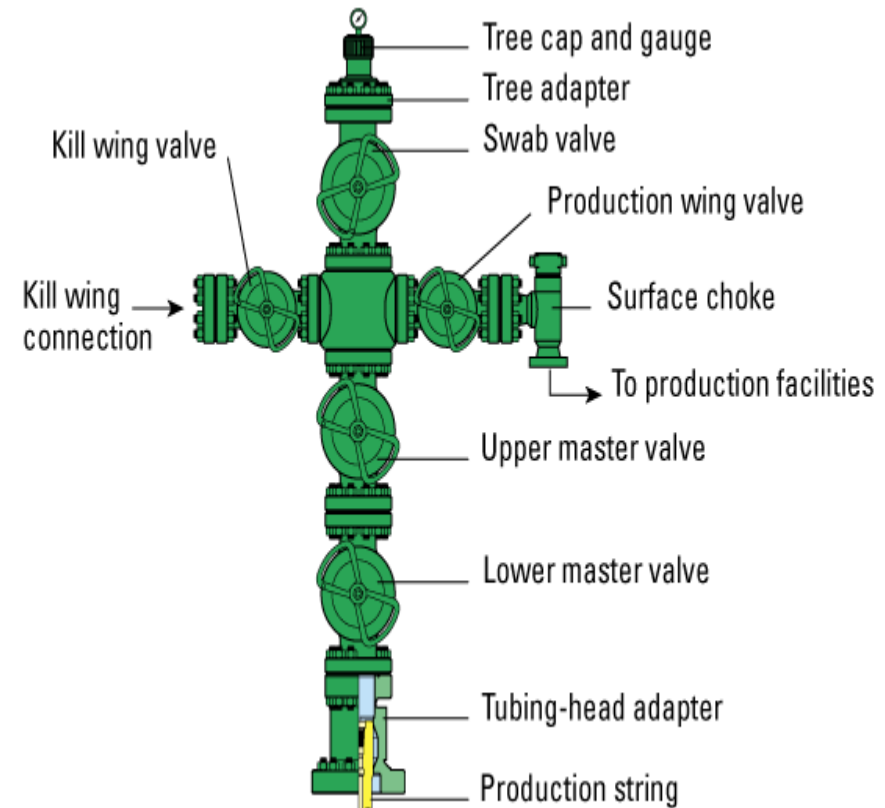
Failure Mode and Effect Criticality Analysis

- Function of a Christmas tree
 - To control the flow of fluid (oil, chemical, water, etc) and gas from and into an oil production well.



Failure Mode and Effect Criticality Analysis

- Functional Failure of a Christmas tree
 - Loss of flow control capability due to sand production

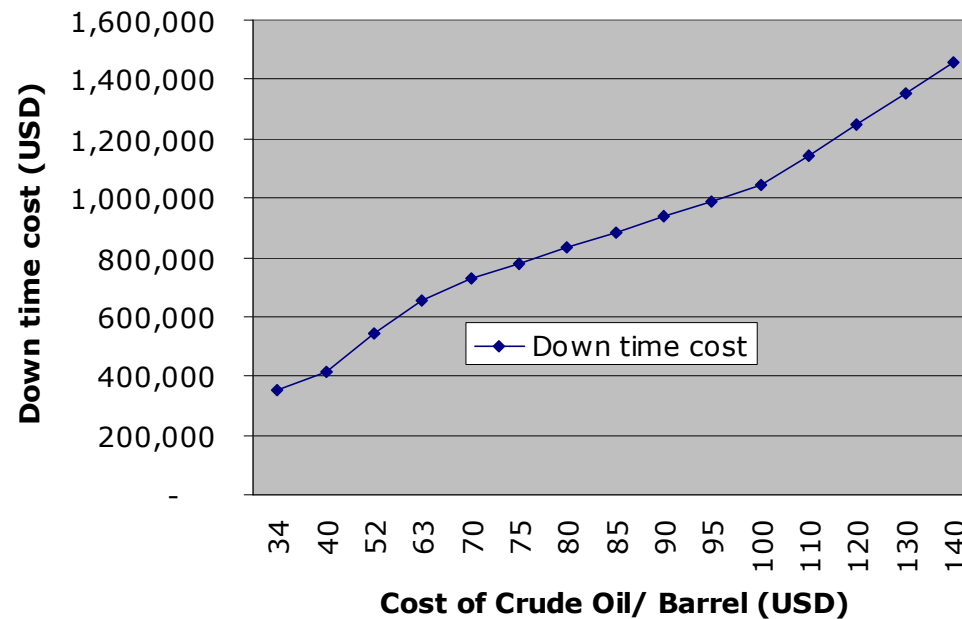


Failure Modes of Production Xmas Tree

Function	Functional failure	Failure modes
<i>To control flow of fluid</i>	<i>Loss of flow control capability due to sand production</i>	<ul style="list-style-type: none">● <i>Upper master valve fails to close on command</i>● <i>Upper master valve fail to open on command</i>● <i>Lower master valve fails to open on command</i>● <i>Lower master valve fails to close on command</i>● <i>Erosion of valve seals</i>

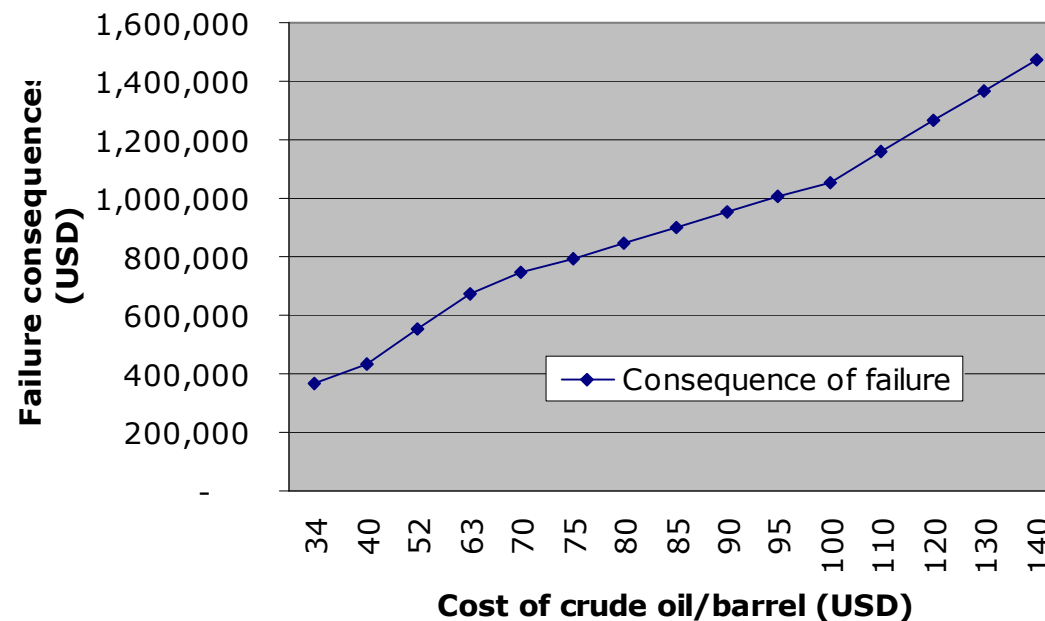
Xmas-Tree Down Time cost

- Effect of crude oil price per barrel on the downtime cost
 - The downtime costs at US\$34, US\$90 and US\$140 per barrel are about US\$354,167, US\$939,500 and US\$1,458,333 respectively.



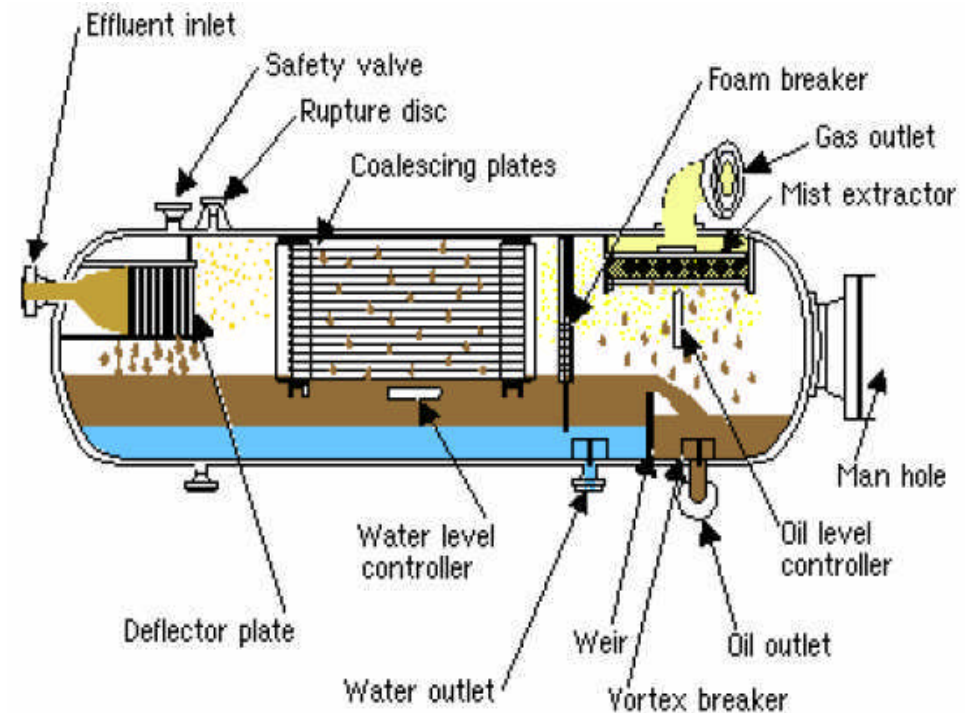
Failure Consequences

- Failure consequences at varying crude oil price
 - The consequences of failure at US\$40, US\$95 and US\$140 per barrel are about US\$431,071, US\$1,003,987 and US\$1,472,737 respectively



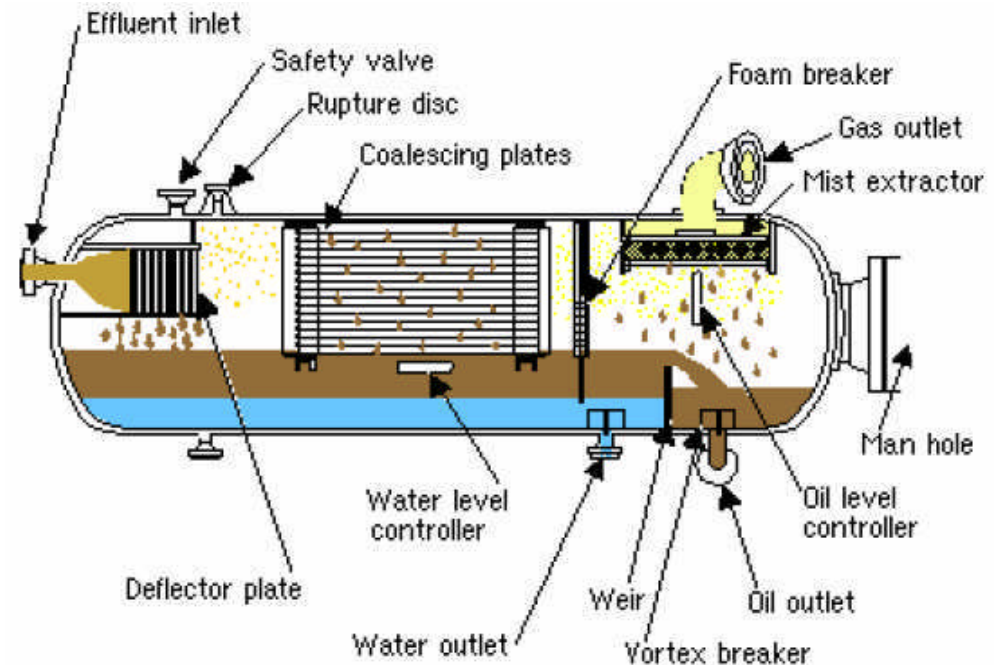
Failure Mode and Effect Criticality Analysis of a Separator

- Function of a Separator
 - The primary function of a Christmas tree is to separate fluid into different phases



Failure Mode and Effect Criticality Analysis of a Separator

- Functional Failure of a separator
 - Loss of fluid separation capability due to sand production

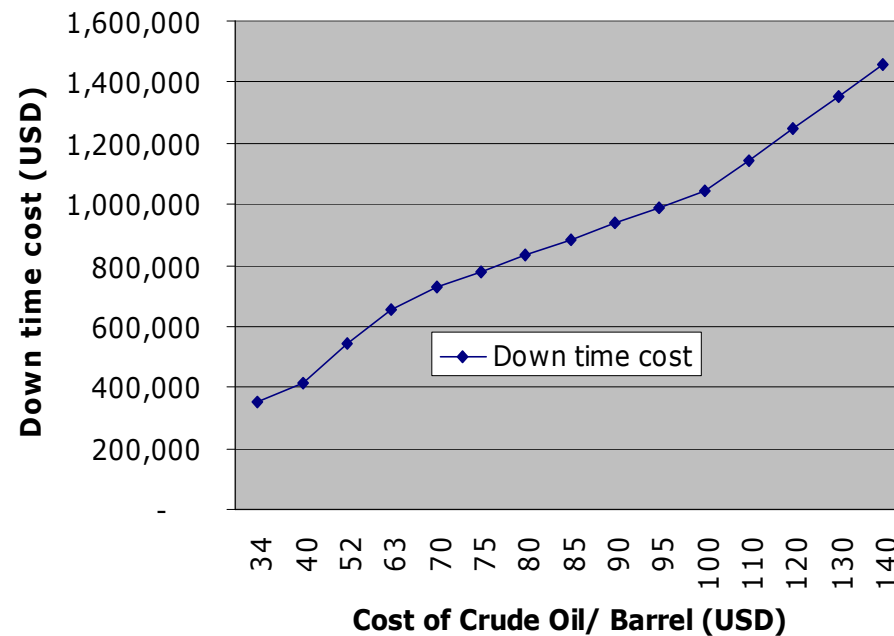


Failure modes of a Separator

Function	Functional failure	Failure modes
<i>Separation of fluid into different phases</i>	<i>Loss of fluid separation capability</i>	<i>Sand trapping failure Deflector plate failure Corrosion of internal wall Effluent inlet partially blocked</i>

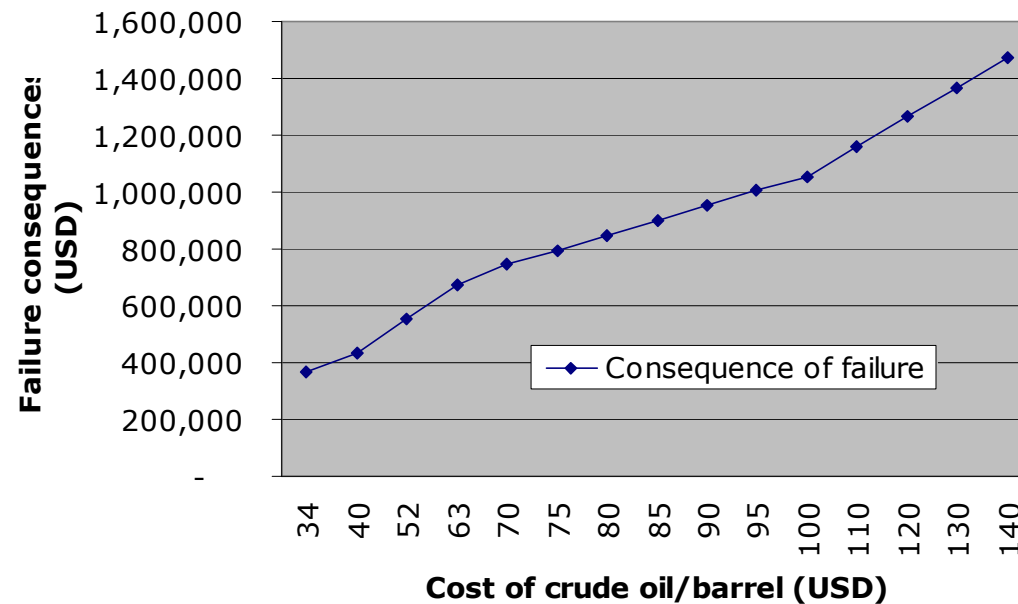
Down time cost of a separator

- Effect of crude oil price per barrel on the downtime cost
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Failure Consequences

- Failure consequences at varying crude oil price
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Mitigating measures to prevent sand induced failures

- Real time monitoring of sand production
- Appropriate mathematical model to predict the onset of sand production

Conclusion

- This paper assessed the failure characteristics of **Christmas tree** and a **Separator** using the Failure Mode and Effect Criticality Analysis (FMECA) technique.
- Functional failures and dominant failure modes due to sand production were identified.
- Failure consequences were evaluated in financial terms.
- Appropriate mitigating measures were identified