

# Lesson learnt from Aasgard - Development of new generation cooler

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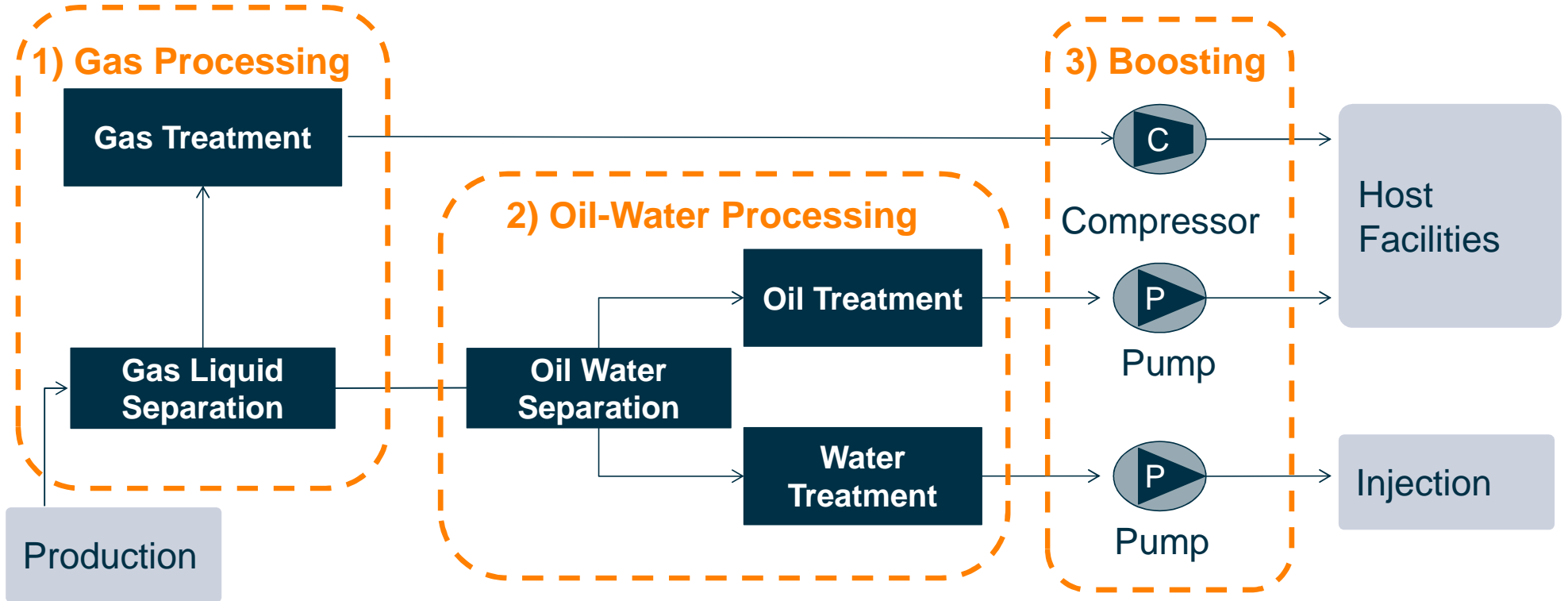


# Agenda

- Introduction
- Aasgard Subsea Compression Project
- Next Generation – Subsea Cooler

# Advanced Subsea Production

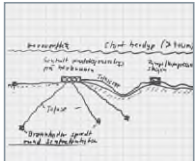
## Typical Subsea Process Block Diagram - Building Blocks



# Subsea Technology Development Timeline

## Concept

1985



Conceptual development

## Qualification

1989-1993  
Kværner  
Booster  
Station



2001-2003  
Demo 2000  
GasBooster™  
Qualification



## Project

2004-2013  
Ormen Lange  
Subsea  
Compression  
Pilot  
  
System Testing  
at Nyhamna



2010-2015  
Åsgard  
Subsea  
Compression  
system EPC



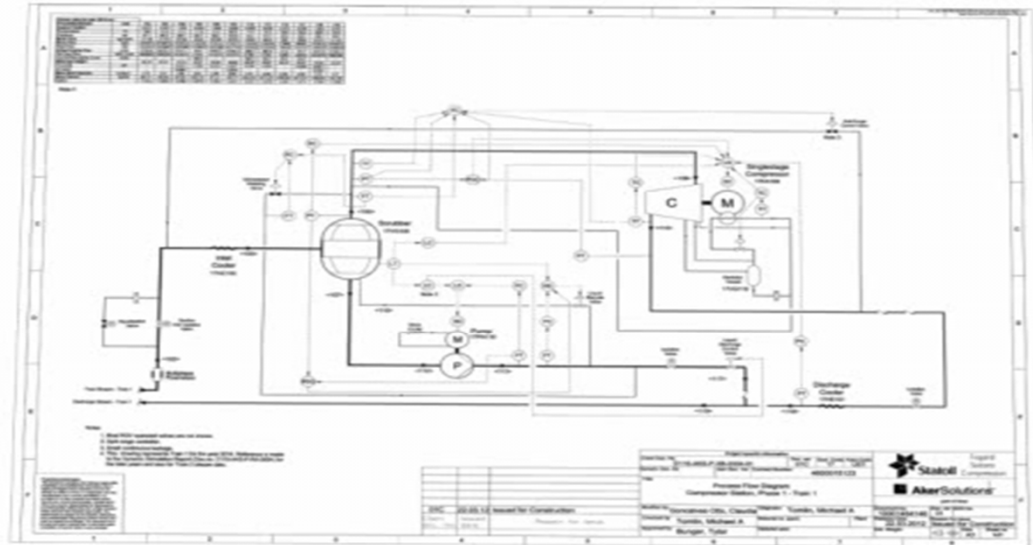
Operating since  
**Sept 2015**

2016-

## Next steps:

- Next Gen Compression System Development
- Next Gen Cooler
- Subsea Dehydration
- Gas Treatment – CO2 Removal

# Åsgard Subsea Compression – Process System



# Åsgard Subsea coolers

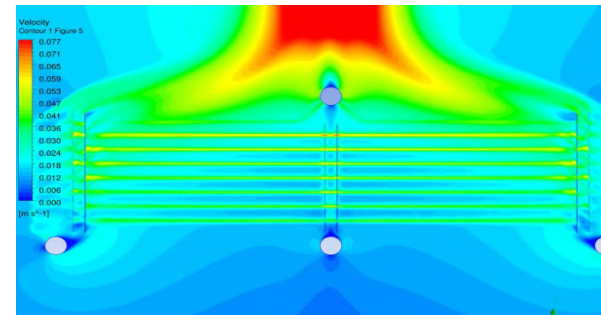
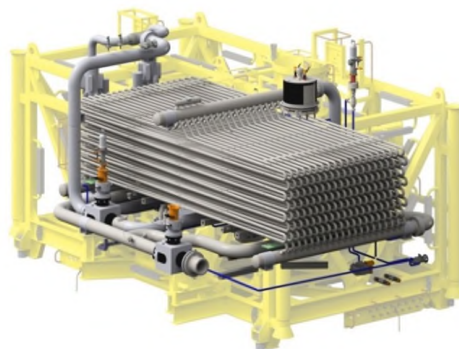
In Åsgard:

- Inlet/recycle coolers, multiphase, duty approx. 11 MW each
- Discharge coolers, single phase, duty approx. 8 MW each

Passive cooler module design is characterized by the following components:

- Inlet piping and header, ensuring even liquid/MEG distribution
- Cooler pipes, cooling the process fluid
- Structure, including sacrificial anodes
- Instrumentation, valves, connectors etc.

Based on experience from design, fabrication and operation there is potential for improvement to reduce size, weight and cost and at the same time improve the efficiency.



# Cooler walls

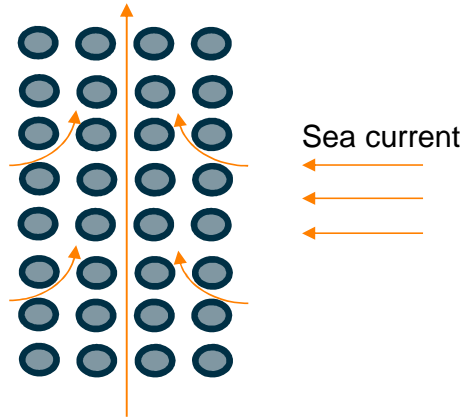
## Asgard cooler – no walls

- Natural convection
- Seawater can be drawn from the side – weakening the cooling
- Sea current may increase cooler performance – however lower predictability

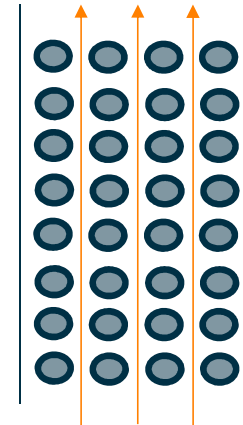
## With walls

- Enhanced natural convection (chimney effect)
- Better cooling performance
- Less susceptible to seawater current – leading to reliable cooling duty with increased predictability

### Cooler without walls



### Cooler with walls



# Active vs Passive

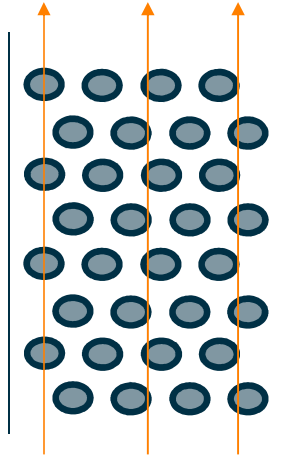
## Passive cooling

- Natural convection by seawater
- Chimney effect

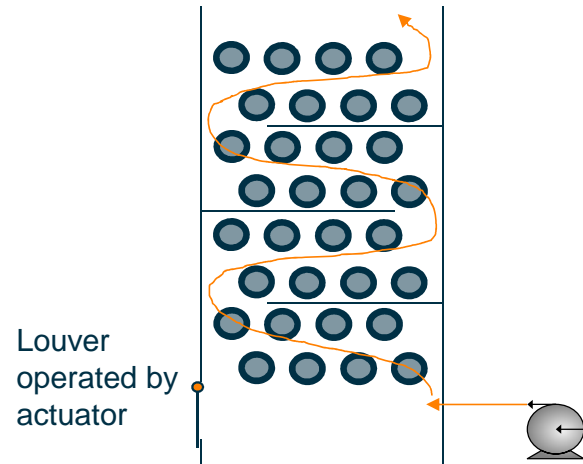
## Active Cooling

- Subsea pump (already qualified) is used to increase the seawater velocity hence the performance.
- Utilize baffles to channel the seawater through the cooler
- Incorporates louvers (open / close) in the lower section – to switch active / passive mode

### Passive Cooler



### Active Cooler





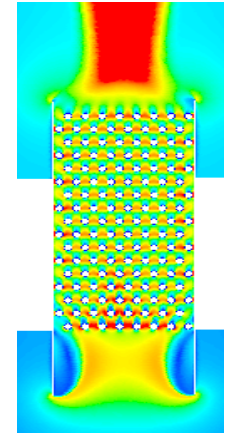
# Aker Boxed Cooler

## Key Features

- Reduced size, weight and cost
- Increase efficiency, especially for low process fluid temperatures
- Enable temperature regulation for more advanced cooling requirements i.e. hydrate control
- Standardized system solution both for active and passive cooler

## Current Qualification Activities

- Qualify TSA coating system for cooler application
- Detail cooler design for constructability and fabrication (baffles, support, stacking, walls etc.)
- Develop solution for CP protection in a compact cooler
- Verify design tools to optimize cooler for efficient heat transfer with minimum pressure drop
- Cooler regulation (temperature control, response time, turndown)



Boxed



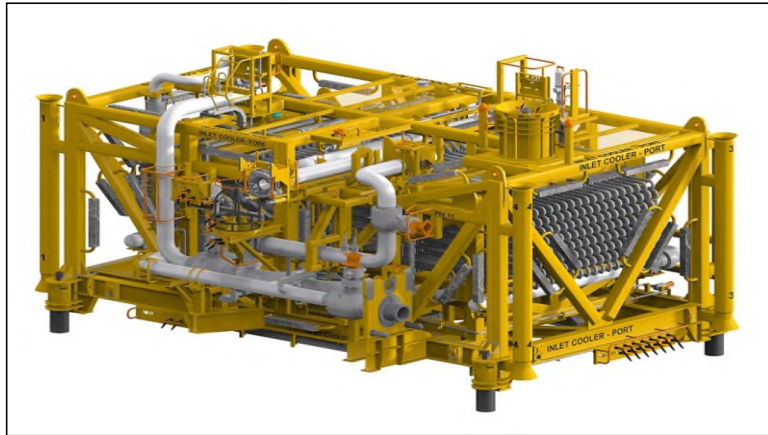
# Performance comparison

- The measured performance of the Åsgard Inlet Cooler is compared towards a CFD simulation of the new improved cooler (same operating case).

## Åsgard Inlet /Recycle Cooler

Dimensions (L x W x H): 5.1m x 11.4m x 2.4m (140m<sup>3</sup>)

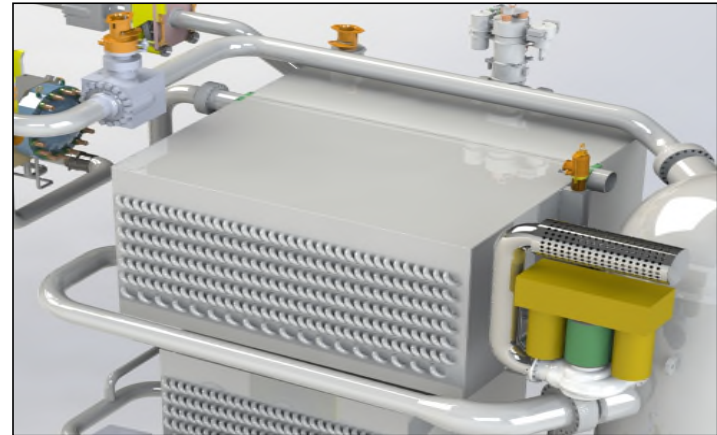
# 3" pipes:	40
Pipe length:	85 m
Outer surface:	950 m <sup>2</sup>
Coating:	Painted
OHTC:	260 W/m <sup>2</sup> K (Passive)
Pressure drop:	0.5 - 1 bar
Design case:	Compressor full recycle stream



## Åsgard 2.0 Inlet /Recycle Cooler

Dimensions (L x W x H): 4.5m x 4.9m x 2.3m (51m<sup>3</sup>) (-63%)

# 3" pipes:	36
Pipe length:	69 m
Outer surface:	784 m <sup>2</sup> (-17%)
Coating:	TSA
Minimum OHTC:	350 W/m <sup>2</sup> K (Passive) (+34%)
Pressure drop:	0.5 - 1 bar
Design case:	Compressor full recycle stream



# Summary

Standardized solution for both passive and active

Actuated hatches for passive mode operation

Using proven passive cooler tube design and size



- Aker Boxed Cooler is technology development stemmed out of past project experiences
- A high efficiency cooler using proven cooler design
- Better temperature predictability / regulation
- Reduced size, weight and cost

# Thank You!! Question?



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