# Flow Assurance –
# The Heat Bank Solution

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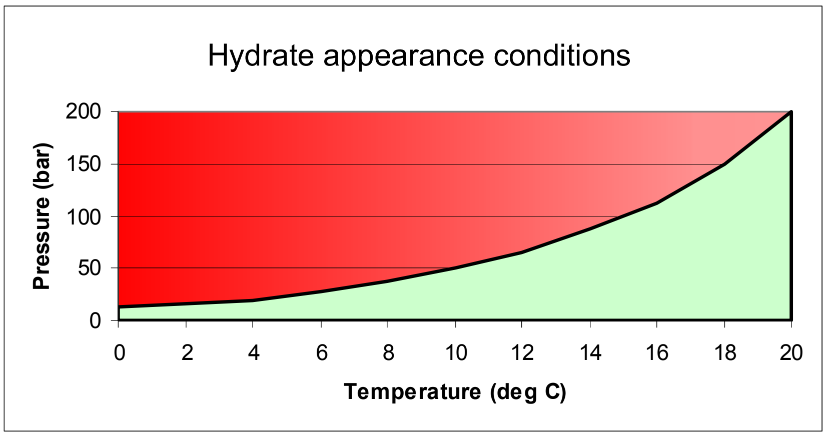
# Flow Assurance

## The flow assurance challenge

- Prevent hydrate formation




Hydrocarbon gas and water combine at a range of temperatures and pressures to form hydrate solids that can plug piping and stop production

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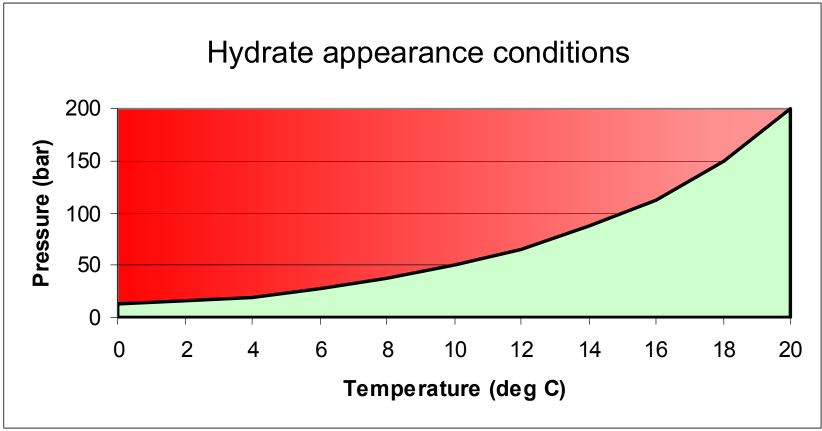
# Flow Assurance

Conditions for hydrate development:

- Typical well shut-in pressure is 100-200 bar
- Hydrate formation at 15 - 20°C.

Preventive measures available:

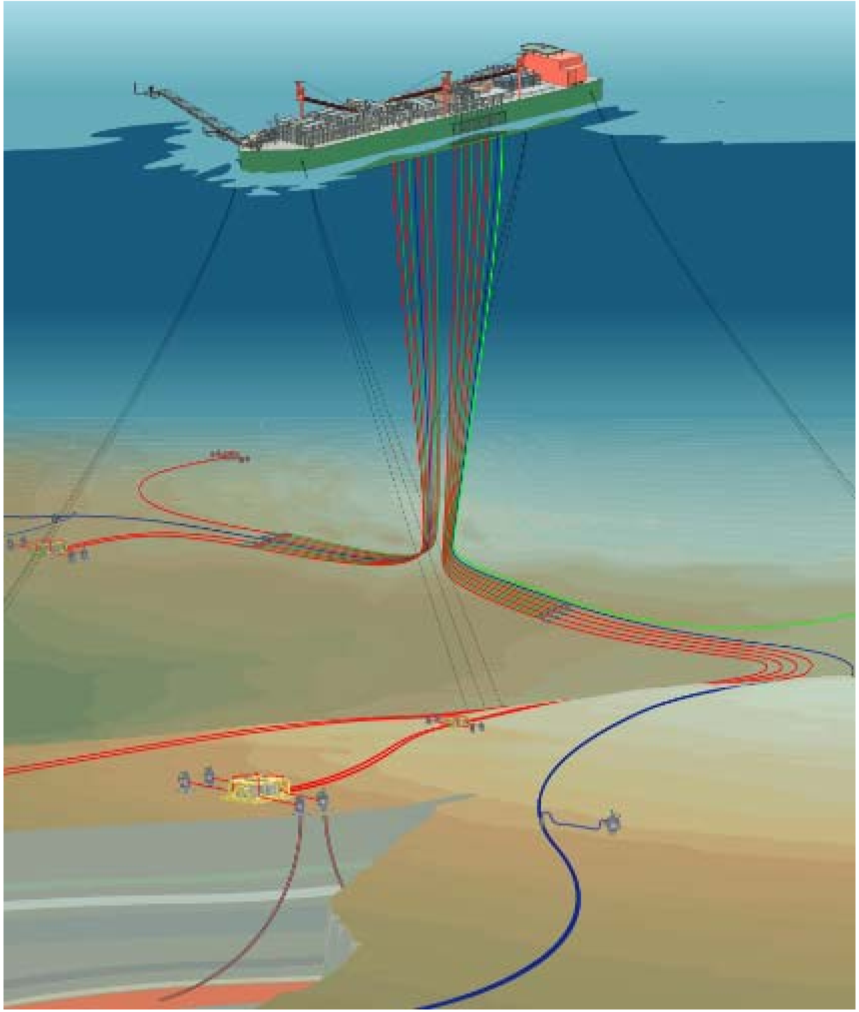
- Reduce pressure
- Insulation (no cold spots)
- Methanol Injection (environmentally unfriendly)
- Electrical Heating (expensive)



# Flow Assurance

## West of Africa challenges:

- ✓ Low reservoir temperatures (40-60°C)
- ✓ Deep Water - High hydrostatic pressure
  - 1000m => 80 bar:
    - prevents depressurization,
    - gas lift may be required
- ✓ Large subsea developments
  - 3-6 manifolds, 4-6 wells each
  - flowlines 10-20 km from production facilities.



# Flow Assurance

Operators sets requirements on cool down time to:

- avoid methanol injection if possible (production ASAP)
- have sufficent time to complete methanol injection

| Project | Component | Initial Temp. (deg. C) | Final Temp. (deg. C) | Cool Down (hrs) | Cooling Rate (degC/hr) | Req. Cond. (W/mC) |
|---|---|---|---|---|---|---|
| Bonga | 8" Header | 49 | 17 | 12 | 2.7 | 0.3 |
| Moho | 6" Jumper | 50 | 20 | 9 | 2.7 | 0.3 |
| | 8" Header | 45 | 20 | 16 | 3.3 | 0.15 |
| Bilondo | 6" Jumper | 45 | 20 | 7 | 1.6 | 0.3 |
| | 8" Header | 45 | 20 | 9 | 3.6 | 0.2 |
| Dalia | 6" Jumper | 42 | 20 | 8 | 2.8 | 0.2 |
| | 12" Header | 42 | 20 | 20 | 1.1 | 0.1 |
| Plutonio | 6" Jumper | 65 | 20 | 6 | 7.5 | 0.3 |
| | 10" Header | 65 | 20 | 6 | 7.5 | 0.3 |
| Rosaliro | 12" Header1 | 47 | 20 | 21 | 1.3 | 0.1 |
| | 12" Header2 | 48 | 20 | 30 | 0.9 | 0.06 |

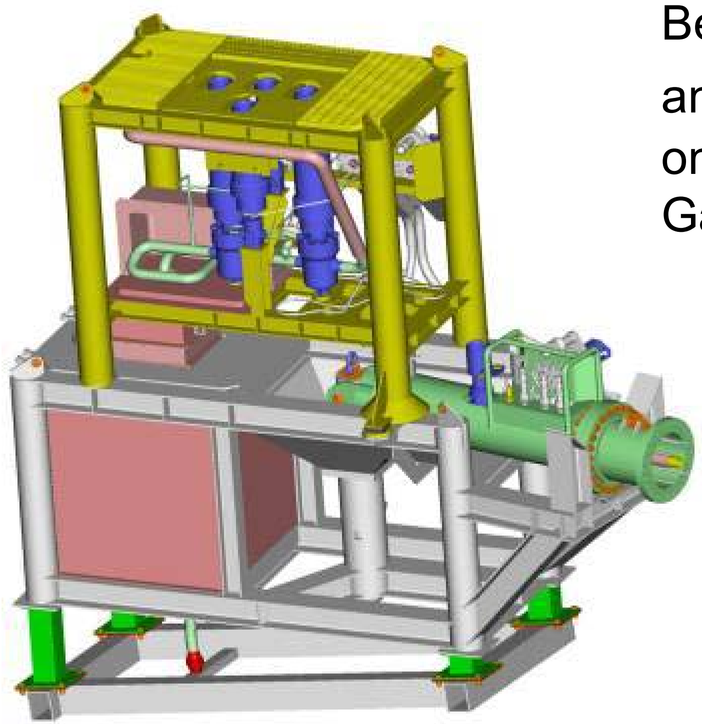
# Heat Bank

The patented Vetco Heat Bank utilises the heat capacity of water to delay the cool down process.

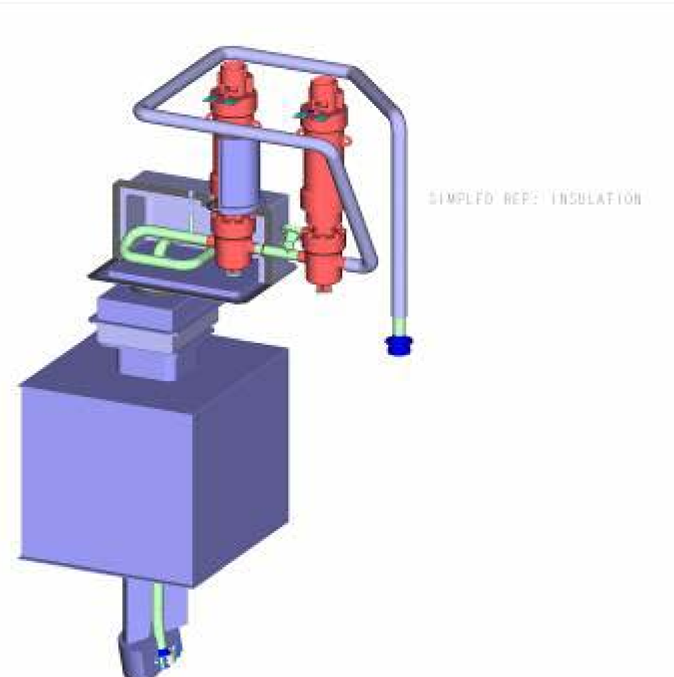
Working principle:

- A water volume is enclosed by a box around the parts to be insulated.
- The heat generated during oil/gas production, heats up the water surrounding the parts.
- If production stops, the heat stored keeps the parts warm for a longer time than polymeric insulation alone.
- The heat transport rate can be controlled by box design and material selection.
- The system i self-regulating: natural convection brings heat to colder parts.

# Gas Lift Riser Base



Lift gas provides low heating input. Because of cold spots at valve actuators and connectors, a Heat Bank may be the only feasible insulation solution to for a Gas Lift Riser Base




The modular GLRB Heat Bank is composed of 3 connectable units:

- Gate Valve (upper)
- Connector (middle)
- Tie-in Skid (lower)

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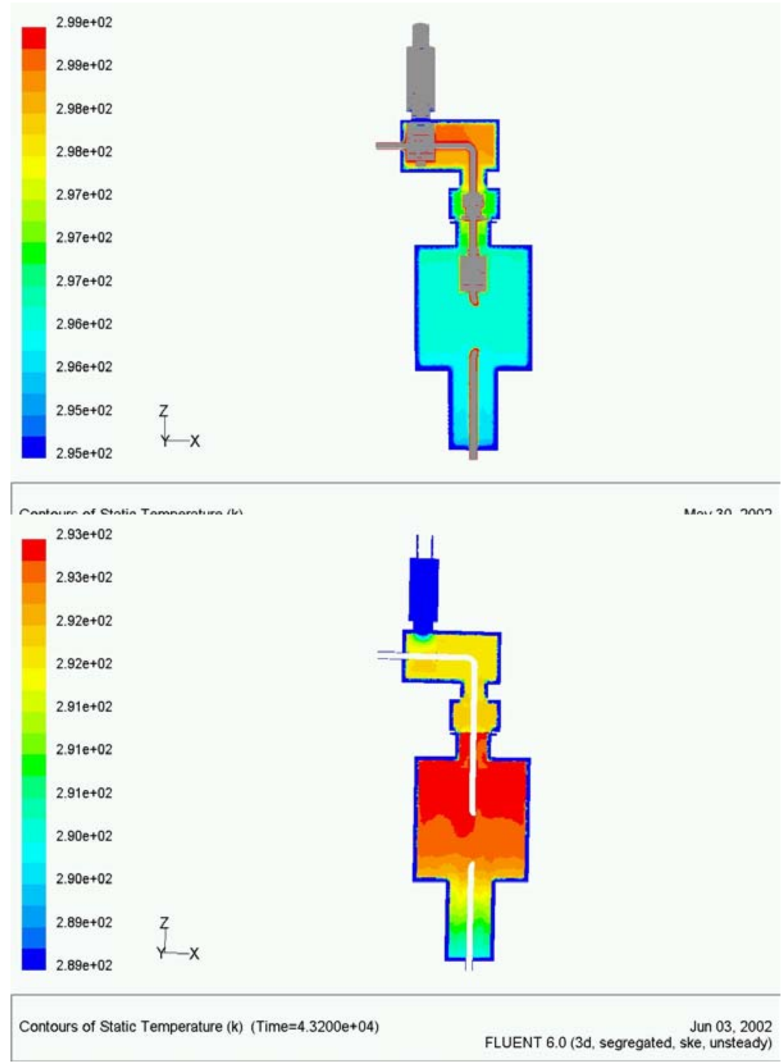
# Gas Lift Riser Base

CFD thermal simulations of Gas Lift Riser Base:

- Higher temperatures are seen in the smaller upper volume during steady state production.
- During cooldown, the larger volume provides most of the stored heat.
- Natural convection re-distributes heat to cold spots such as valves.
- “Dead” volume at the bottom is not as effective for re-distributing the heat.

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# Gas Lift Riser Base

Stack-up of Tie-in Skid
+ Gate Valve Module

The middle chamber
enclosing the connector
with ROV tool access

# Gas Lift Riser Base

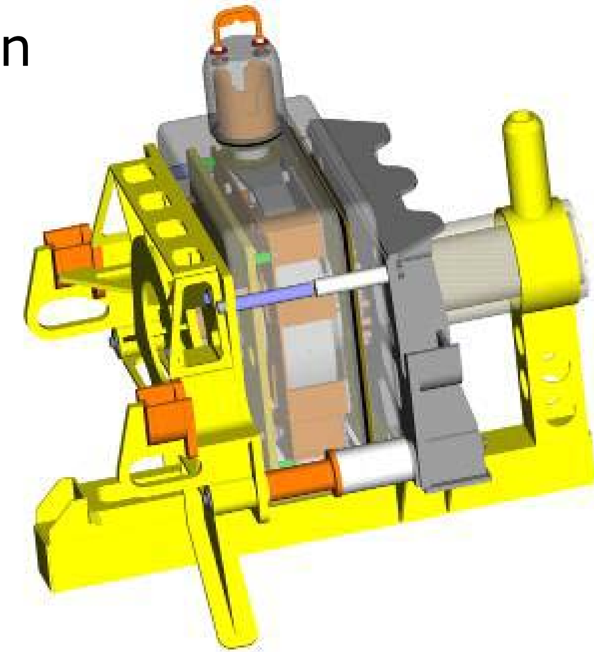
Upper chamber on the Gate Valve Module with one side removed for access

The lower chamber on the Tie-in Skid with panel removed for access

The transition piece to the middle chamber for mechanical connector is on top

# Connectors

Compact Heat bank for 8" production line connectors



# Connectors

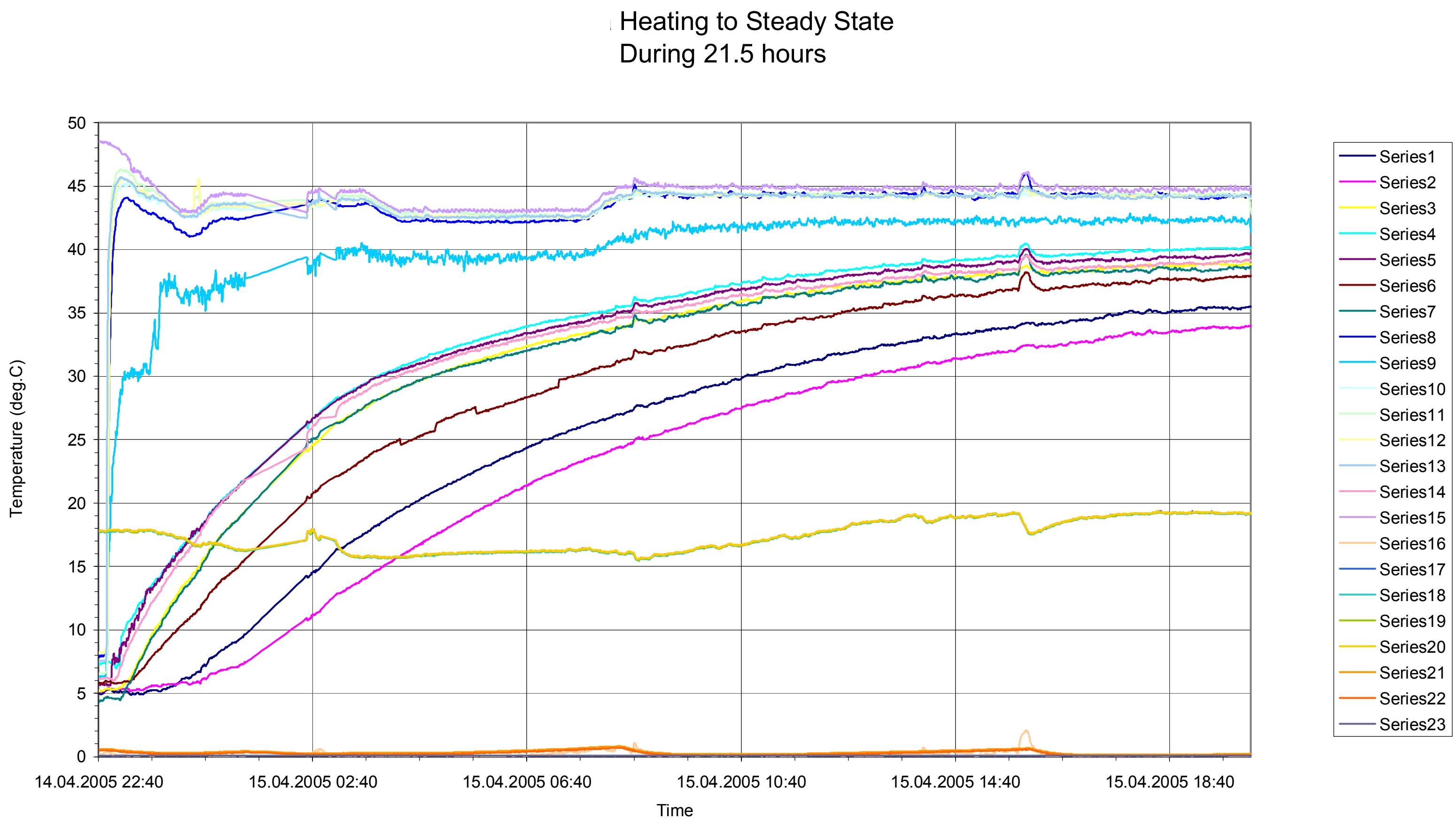
Testing

Assembly – Submerged in water, 0.1-0.7°C.

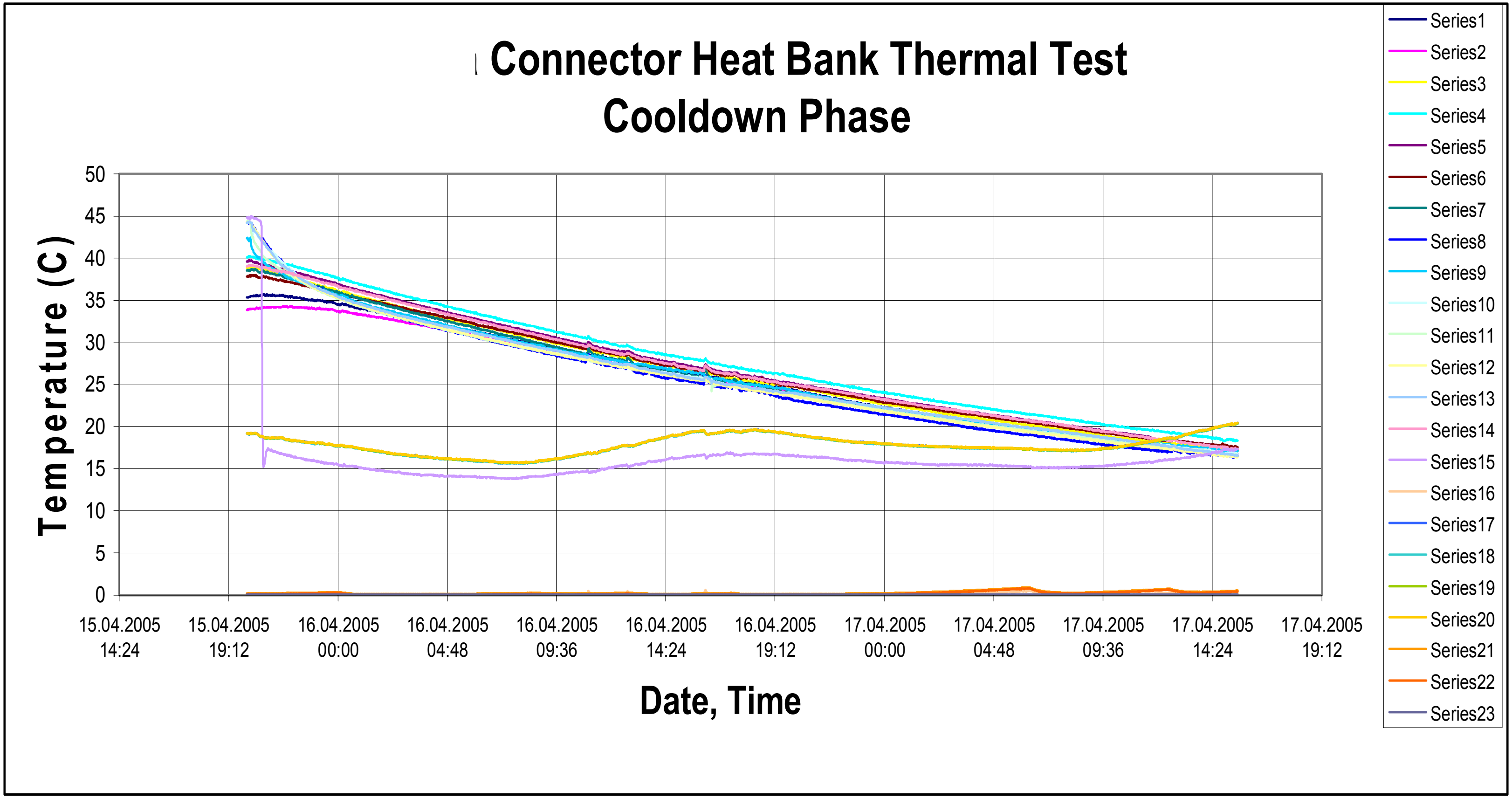
Assembly - Ready for Cool down testing

# Connectors

## Thermal test results



# Connectors


Connector Heat Bank Thermal Test
Cooldown Phase
Temperature (C)
50
45
40
35
30
25
20
15
10
5
0
15.04.2005 14:24
15.04.2005 19:12
16.04.2005 00:00
16.04.2005 04:48
16.04.2005 09:36
16.04.2005 14:24
16.04.2005 19:12
17.04.2005 00:00
17.04.2005 04:48
17.04.2005 09:36
17.04.2005 14:24
17.04.2005 19:12
Date, Time
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12
Series13
Series14
Series15
Series16
Series17
Series18
Series19
Series20
Series21
Series22
Series23

# Connectors

## Test results:

| **Parameter** | **Specified Value** | **Target Value** | **Contr. Test** | **Extended Test** |
|---|---|---|---|---|
| Steady State Fluid Temperature | 48.4 C | 45.1 C | 44.6 C | 44.6 C |
| Fluid Temperature after cooling period | 20 C | 16.9 C | 24.8 C | 16.9 C |
| Ambient Water Temperature | 4 C | 0.5-0.7 C | 0.1-0.3 C | 0.1-0.7 C |
| Cooldown Period | 21 hours | 21 hours | 21 hours | 41 hours |
| Cooling Rate | 1.4 C/hr | 1.3 C/hr | 0.9 C/hr | 0.7 C/hr |

Hydrate formation temperature: 16.9°C

# Connectors

20 Heat Banks delivered to the Rosa project