CiTECH

# Product and Design

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**Prepared for:** sCO2


**29th February 2024**

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MUHIBBAH ENGINEERING (M) BHD

A member of the Muhibbah Engineering group of companies

# Dedicated to Heat Recovery since 1938

**1938** – Meten (Metallurgical Engineers) London Ltd established, supplying the Steel and Glass Industries with heat recovery systems.

**1995** – Meten is acquired by SHG Schack GmbH who were a part of the GEC Alsthom Group

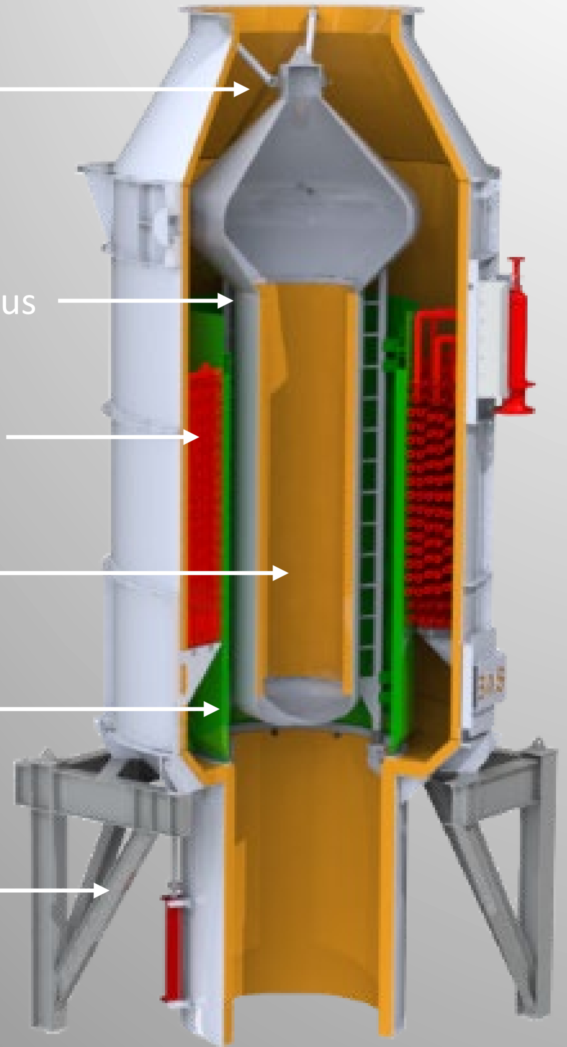
**1998** – GEC Alsthom becomes Alstom. Schack group divested, later renamed Alstom Energy Systems

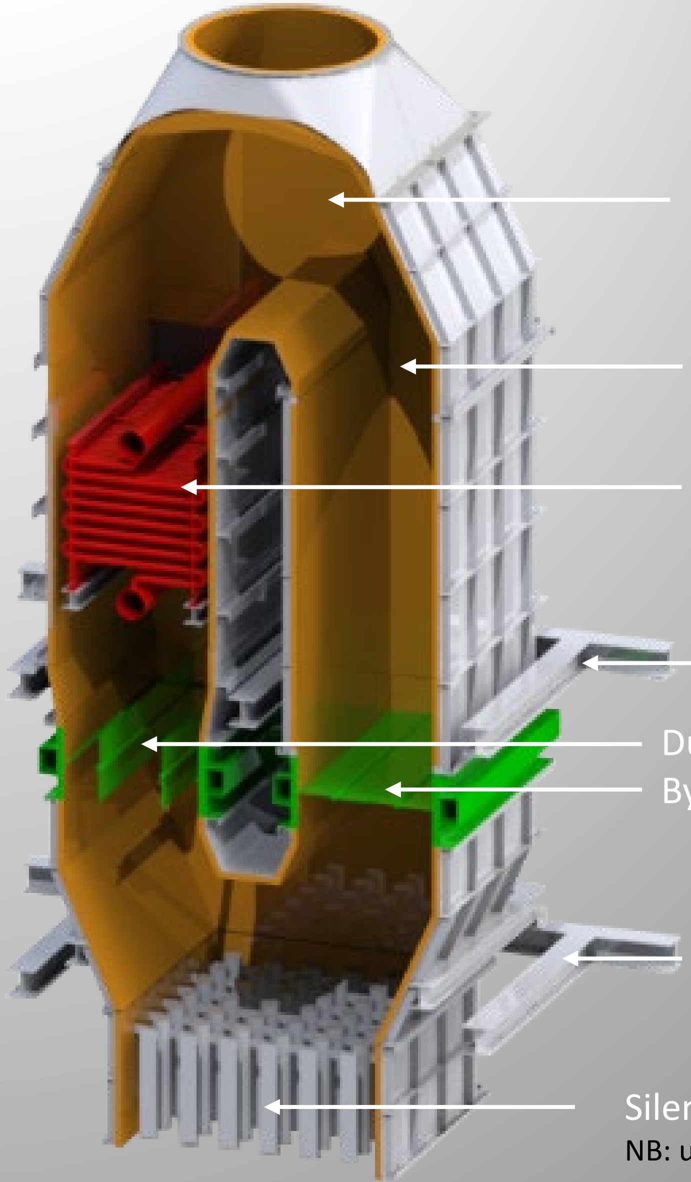
**2006** – CiTECH Energy Recovery Systems was formed from a management buyout from Alstom.

**2012** – Muhibbah Engineering (M) Sdn Bhd acquires the assets and right of CiTECH

**2022** – CITECH acquires the assets and rights of Power Damper Services (multi-louvre damper systems).

# WHRU Cross Section Comparison




Note: Support Steelwork for the Traditional WHRU image has been omitted for clarity

# CiBAS Diverter Function

# Concentric Helical Coil Pack (Heat Exchanger)

- Higher Heat Transfer Coefficient due to turbulent flow within the helical coil*

- Coils manufactured from 12m finned seamless pipe

- Each coil is heat treated to stress relieve

- Inherently rigid design – less prone to vibration

- Preheater coil – P91
- Design Temp: 400°C, 750°F
- Design Pressure: 270 barg, 3,900 psig

- Main heater coil – P91
- Design Temp: 400°C, 750°F
- Design Pressure: 270 barg, 3,900 psig

**Materials of choice:**

- Due to the high temperature and pressure of the systems, high grade materials are required.
- For temperatures above 400°C, Stainless Steel (347H) or Inconel is required subject to design pressure.
- For temperatures below 400°C, P91 is suitable.

**Transient Conditions:**

- Can sCO2 flow be maintained when the gas turbine is operating?
- Will the sCO2 be subject to a phase change during start-up?
- Pint, B., Keiser, J. and Brese, R. (2016). THE EFFECT OF TEMPERATURE AND PRESSURE ON SUPERCRITICAL CO2 COMPATIBILITY OF CONVENTIONAL STRUCTURAL ALLOYS. [online] Available at: https://sco2symposium.com/papers2016/Materials/056paper.pdf [Accessed 23 Feb. 2024].

# Sizing of WHRU

## Site Ambient Temperature

| High Temperature | Low Temperature |
|---|---|
| • Greater water content in Exhaust gas (better heat transfer)<br>• Higher exhaust gas temperature at outlet<br>• Lower Exhaust flow rate (better exhaust pressure drop) | • Lower insulation requirements<br>• Higher exhaust flow rate (more available for heat transfer)<br>• Lower exhaust temperature, possible material savings |

## Allowable sCO2 Pressure Drop

| High Process Pressure Drop | Low Process Pressure Drop |
|---|---|
| • Less tube passes required<br>• Reduced outer dimension of the casings<br>• Smaller tubes can be used allowing for an increased surface area to volume | • Lower capital cost for pump or compressor. |

## Allowable Exhaust Pressure Drop

| High Exhaust Pressure Drop | Low Exhaust Pressure Drop |
|---|---|
| • Increased pressure drop allows smaller tube spacing and more rows<br>• Increased heat transfer due to higher velocity (closer tubes)<br>• Casing dimensions can be reduced<br>• Reduced overall tube length required | • Typically has an increased efficiency for the GT |

## Fuel for Operation

| Natural Gas | Diesel Fuel |
|---|---|
| • Low acid dew point (low sulphur content)<br>• More relaxed fin dimensions<br>• Not always available on platform start-up<br>• Lower fouling factors | • Increased fouling factors<br>• Readily available on platform start-up<br>• Less efficient fin dimensions<br>• Increased acid dew point |

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## Parallel Flow vs Counter Flow Coil Design

| Counter Flow Coil | Parallel Flow Coil |
|---|---|
| • Lower minimum tube wall / fin temperature<br>• Higher maximum tube wall / fin temperature<br>• Greater heat transfer<br>• Greater approach temperature | • Lower heat transfer<br>• Higher minimum tube wall / fin temperature<br>• Lower maximum tube wall / fin temperature |

## Design standards for Fins

| API560 | ISO21905 | CiTECH |
|---|---|---|
| Gas fin dimensions:<br>• 1.3 mm thickness (min)<br>• 25.4 mm fin height (max)<br>• 197 fins per metre (max)<br><br>Oil fin dimensions:<br>• 2.5 mm thickness (min)<br>• 19.1 mm fin height (max)<br>• 118 fins per metre (max) | Gas fin dimensions:<br>• 1.25 mm thickness (min)<br>• 25 mm fin height (max)<br>• 236 fins per metre (max)<br><br>Oil fin dimensions:<br>• 1.5 mm thickness (min)<br>• 16 mm fin height (max)<br>• 157 fins per metre (max) | Gas fin dimensions:<br>• 1 mm thickness (min)<br>• 25.4 mm fin height (max)<br>• 236 fins per metre (max)<br><br>Oil fin dimensions:<br>• 1.5 mm thickness (min)<br>• 16 mm fin height (max)<br>• 160 fins per metre (max) |

## GT operating load for design

- A higher load is beneficial for a leaner WHRU
- Load case should be based on worst case scenario to allow end user to recover duty

## Humidity

- The greater the water content of the exhaust gas the greater the heat transfer
- Acid dew point is subject to the water content of the Exhaust gas.

## Run dry Requirements

- Carbon steel fins if always flooded, for better heat transfer. (subject to maximum fin temperature)

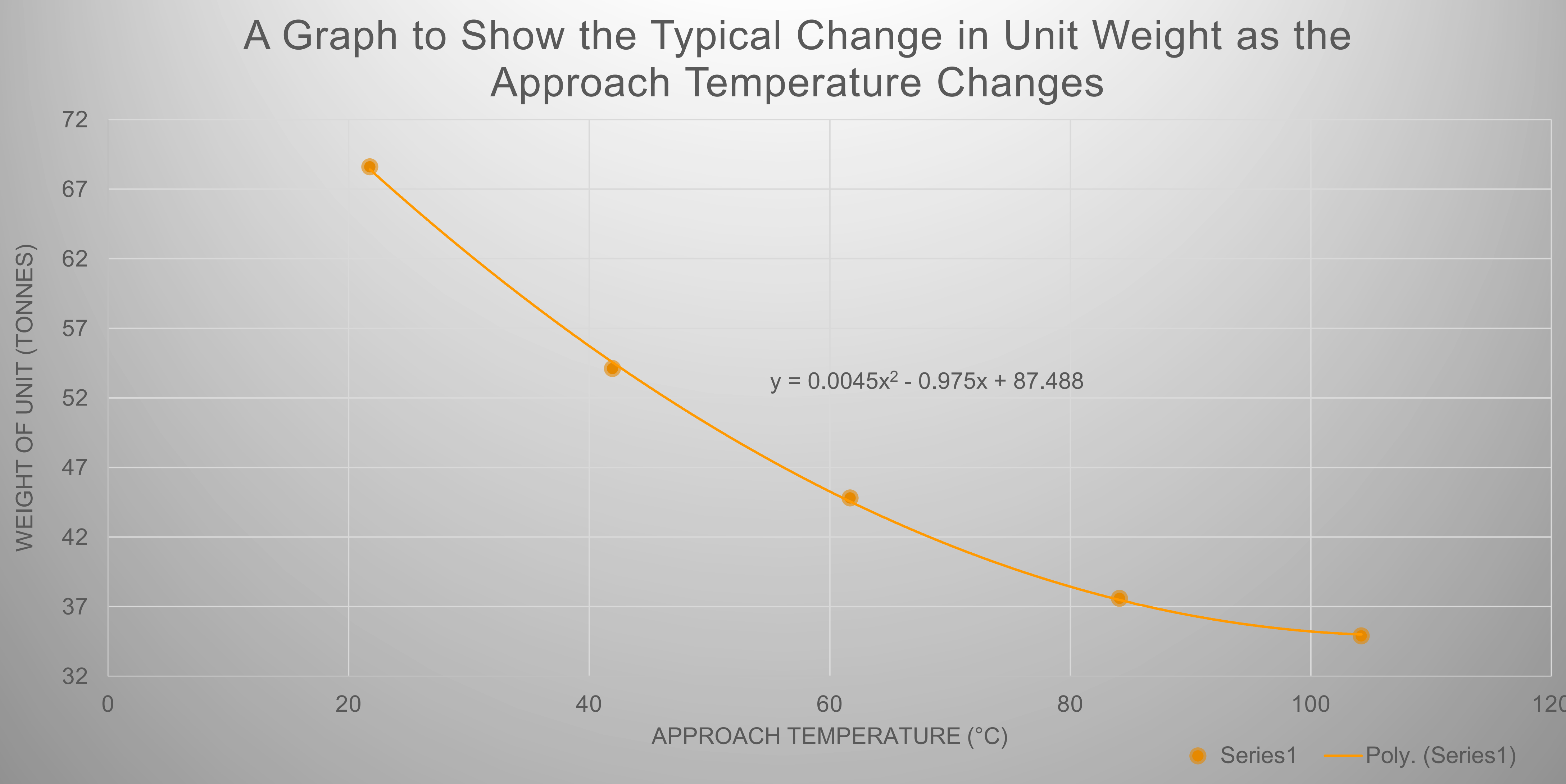
## Duty required

- Is the energy content of the exhaust sufficient?
- Will the approach temperature allow for a lean design?

## Approach Temperature

- The approach temperature is defined as the difference in temperature between the exhaust temperature outlet and the HM temperature that meets the outlet of the exhaust.
- Parallel flow is the outlet HM temperature.
- Counter flow is the inlet HM temperature.

# Approach Temperature



# Sizing Comparison

| Case No. | Total Duty Recovered, MW | Pressure Drop Utilised (Main Heater), bar | Pressure Drop Utilised (Pre Heater), bar | Approach Temperature (Main Heater), °C | Approach Temperature (Pre Heater), °C | Flange to Flange Unit Weight, Tonnes | Flange to Flange Unit Height, m | Unit Diameter, m |
|---|---|---|---|---|---|---|---|---|
| 1 | 21.5 | 2.2 | 1.3 | 31.3 | 31.3 | 143.5 | 17.2 | 5.9 |
| 2 | 26.3 | 2.6 | 2.0 | 13.9 | 15.5 | 287.8 | 21.9 | 6.0 |
| 3 | 26.5 | 2.4 | 1.8 | 9.4 | 16.2 | 341.1 | 23.5 | 6.4 |
| 4 | 26.2 | 2.4 | 1.8 | 18.5 | 11.3 | 282.5 | 21.2 | 6.0 |
| 5 | 27.2 | 3.3 | 1.7 | 2.0 | 11.2 | 495.1 | 29.1 | 6.6 |
| 6 | 24.8 | 2.2 | 1.7 | 15.9 | 14.0 | 266.3 | 20.8 | 6.0 |
| 7 | 23.6 | 2.2 | 1.4 | 19.4 | 16.7 | 237.8 | 19.4 | 6.0 |
| 2.1 (Adjusted) | 23.3 | 1.9 | 2.0 | 25.0 | 25.0 | 197.8 | 17.8 | 6.0 |
| 2.2 (Adjusted) | 22.1 | 2.2 | 1.9 | 31.3 | 31.3 | 163.0 | 16.8 | 5.7 |

# Sizing Comparison

| Case No. | Total Duty Recovered, MW | Main Heater Flow, kg/s | Pre Heater Flow, kg/s | Main Heater Outlet Temperature, °C | Pre Heater Outlet Temperature, °C | Pressure Drop Utilised (Main Heater), bar | Pressure Drop Utilised (Pre Heater), bar | Unit Weight, Tonnes | Unit Height, m | Unit Diameter, m |
|---|---|---|---|---|---|---|---|---|---|---|
| Case 7 | 23.6 | 95.0 | 30.4 | 365.2 | 254.3 | 2.0 | 1.5 | 175 | 18 | 6.0 |
| Case 7.1 (Adjusted) | 23.6 | 97.9 | 34.0 | 340.0 | 230.0 | 3.4 | 3.1 | 110 | 15 | 5.3 |
| Case 7.2 (Adjusted) | 23.6 | 96.0 | 30.5 | 365.2 | 254.3 | 3.4 | 2.5 | 150 | 17 | 5.6 |

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Thank you

Any questions?

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