COGENT – Capture Operation with Greater Economy for Net-zero Targets

UK-China (Guangdong) CCUS Centre
UK CCS Research Centre
University of Sheffield
Guangdong Carbon Capture Test Platform

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EXECUTIVE SUMMARY

The COGENT project, led by the UK-China (Guangdong) CCUS Centre in collaboration with the Guangdong Carbon Capture Test (GCCT) Platform and the University of Sheffield/UKCCSRC, aimed to demonstrate post-combustion carbon capture technology operating at up to 100% CO_2 capture rates in natural gas and biomass plant applications. This large-scale pilot testing was conducted at the Guangdong Carbon Capture Test platform, utilising a combination of optimising the lean loading of the amine solvent and simultaneously controlling the lean flow to the absorber. The goal was to maximise CO_2 capture rates while minimising energy penalties.

Testing took place in October 2024 at a scale of approximately 40 tCO_2/day, significantly larger than the ~1 tCO_2/day unit used in the UK for FOCUSS tests or the ~10 tCO_2/day unit at the National Carbon Capture Center (NCCC) in the US. The desorber reboiler configuration employed a once-through thermosyphon, which is more representative of full-scale industrial plants compared to most other pilots. However, the operating pressure for the desorber was limited to 1.9 bara.

The project successfully demonstrated the STRETCHER method—System Tuning for Regenerator Efficiency and Target Capture with High Exit Rich—which aims to maximise CO_2 capture rates to help achieve net zero emissions. Using this method, capture rates of around 98% were achieved for up to approximately six hours at a time, with relatively modest regeneration energy requirements (3.6-3.7 GJ/tCO_2 for 35% w/w MEA, see Annex A1-A4 for comparative MEA test data), provided that the solvent flow rate to the absorber and other operational factors were also optimised. It also appears that even higher capture rates could be achieved with suitable novel instrumentation.

Key findings from the project include:

- The successful implementation of the STRETCHER principles, which allow for high CO_2 capture rates while maintaining low energy consumption.
- Challenges encountered with cyclical fluctuations in desorber operation, leading to foaming when the plant was left unattended overnight. These issues will need to be resolved through solvent reclaiming to achieve extended operation.
- Absorber control was satisfactory, but the exit flue gas CO_2 concentration was not a suitable indicator for controlling the capture solvent flow rate for capture rates above about 98%. Novel solvent monitoring methods developed during FOCUSS testing in the UK are proposed for future testing to enable up to 100% capture with fully optimised operation.

The COGENT project is expected to facilitate the deployment of high carbon capture rate technology, supporting the power and industrial sectors in their transition to achieving net-zero targets over the coming decades. Early demonstration at a large pilot scale is crucial, as it will be viewed by industry as proving the concept for commercial use in the many new CCS projects being initiated in the UK, China, and globally.

Dissemination activities included workshops at Haifeng Power Plant in China with Guangdong Carbon Capture Test Platform and Tsinghua University staff in October 2024, DESNZ staff visits for knowledge exchange at the University of Sheffield in November and December 2024, and presentations at the 8th UK-China Energy Dialogue and the UKCCSRC Spring Conference in March 2025. These activities ensured that key stakeholders, including policymakers, academics, industries, and businesses, were informed about the research findings and collaborative discussions on next steps were facilitated.

1. OVERVIEW OF PROJECT OUTCOMES

The FCDO CLEEN project 'COGENT – Capture Operation with Greater Economy for Net-zero Targets' led by the UK-China (Guangdong) CCUS Centre and involving the Guangdong Carbon Capture Test Platform and the University of Sheffield/UKCCSRC extended the work in the DESNZ CCUS Innovation 2.0 Call project FOCUSS, Flexibly Operated Capture using Solvent Storage, and shared data analysis activities with that project.

The achieved outcomes against stated objectives are summarised below.

Project Summary in the submitted proposal	Project Outcomes
The COGENT project aims to demonstrate post-combustion carbon capture technology operating in steady state at up to 100% CO_2 capture rate in natural gas and biomass plant applications. This will be achieved in large-scale pilot testing at the GCCT by a combination of optimising the lean loading of the amine solvent and simultaneously controlling the lean flow to the absorber, thereby maximising CO_2 capture rates with the minimum energy penalty.	Tests took place in October, 2024 at ~ 40 tCO_2/day scale, much larger than the ~ 1 tCO_2/day unit used in the UK for the FOCUSS tests or the ~10 tCO_2/day unit at NCCC in the US, and with a desorber reboiler configuration (a once-through thermosyphon) more representative of full scale plant than either of these smaller pilots. The operating pressure for the desorber was, however, limited to 1.9 bara. The STRETCHER (System Tuning for Regenerator Efficiency and Target Capture with High Exit Rich) principles outlined in Section 2 were successfully demonstrated. Capture rates of around 98% were achieved for up to ~ 6 hours at a time with relatively modest regeneration energy requirements (3.6/3.7 GJ/tCO_2), provided that the solvent flow rate to the absorber and other operational factors were also optimised.
The COGENT project is expected to facilitate the deployment of high carbon capture rate technology, thereby supporting the power and industrial sectors in their transition to achieving net-zero targets over the coming decades. A key factor in achieving impact is early demonstration at a large pilot scale, that will be viewed by industry as proving the concept for commercial use in the many new CCS projects being started in the UK, China and globally.	Satisfactory desorber control using the packing temperature profile method predicted from modelling and NCCC data could be implemented with practise on a system that is representative of full-scale industrial capture plants. There were, however, some problems with cyclical fluctuations in the desorber operation that appeared to give rise to foaming when the plant was left unattended overnight, and these will need to be resolved by solvent reclaiming to achieve extended operation. Absorber control was also satisfactory, but the exit flue gas CO_2 concentration was not a suitable indicator for controlling the capture solvent flow rate for capture rates above about 98%. It is therefore proposed to use novel solvent monitoring methods, developed in FOCUSS testing in the UK, in future testing to allow up to 100% capture with fully optimised operation.

The project funding will be used for experimental costs of the testing in China, organising dissemination workshops in both UK and China, and developing a report. The project team will reach out to key CCUS stakeholders in both countries including policy makers, academics, industries and businesses to communicate the research findings and collaboratively discuss the next steps.

- Workshops at Haifeng Power Plant, China with Guangdong Carbon Capture Test Platform and Tsinghua University staff in October 2024.
- DESNZ staff visits for FOCUSS and COGENT results knowledge exchange took place at the University of Sheffield on 20th November and 10th December, 2024.
- Presentation at the 8th UK-China Energy Dialogue, UK-China CCUS Seminar Side Event, 18th March, 2025.
- Presentation at the UKCCSRC Spring Conference, Glasgow, 24-25th March, 2025.

2. THE 'STRETCHER' METHOD FOR MAXIMISING AMINE POST-COMBUSTION CAPTURE RATES

The COGENT project applied the 'STRETCHER' – System Tuning for Regenerator Efficiency and Target Capture with High Exit Rich – method that was developed in the FOCUSS project in order to optimise the fraction of CO_2 captured. The STRETCHER method complements the use of lean and rich solvent storage, which allows the design capture fraction to be obtained at all times, and builds on work involving Stavros Michailos, Daniel Mullen, Muhammad Akram and Mathieu Lucquiaud on the UKCCSRC PCC-CARER and FOCUSS projects and collaboration with the US National Carbon Capture Center (NCCC) in Wilsonville, Alabama. While FOCUSS and COGENT work is being undertaken using 35%w/w monoethanolamine (MEA) as the solvent, which allows full publication of the results, it is expected that the approach would be generally applicable to PCC with all amines, within the limits of their thermal stability, reclaimability etc.

The key features of the STRETCHER method can be summarised as follows:

a) Produce the lowest possible lean loading without wasted energy for a given desorber pressure

b) Control the lean flow to the absorber to give the highest possible rich loading for the target CO_2 capture rate, given this lean loading

c) Use lean and rich solvent storage to allow desorber and absorber performance to be optimised independently in the short term (i.e. FOCUSS – flexibly operated capture using solvent storage)

a) Lean loading optimisation – the inflection point: The lowest possible lean loading without wasted energy at a given desorber pressure will be achieved when, as described in Michailos (2022), the desorber is operating at its 'inflection point', where as much as possible of the water vapour water produced with the CO_2 in the reboiler can still be condensed by the time the CO_2/vapour reaches the rich solvent entry point in the desorber column.

The 'inflection point' is where there is a rapid rise in the curve of specific reboiler duty (SRD – energy per unit mass of CO_2 desorbed) vs. lean loading, as shown in Figure 2.1 (left panel)

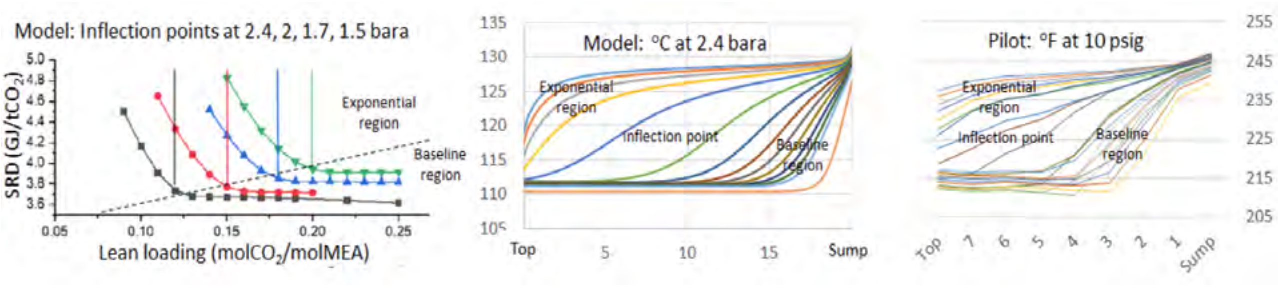

Figure 2.1 The desorber 'inflection point' and associated desorber packing temperature profiles

It has often been thought that the very low lean loadings (around 0.1 molCO_2/molMEA) required to achieve high capture rates would require excessive thermal energy input in the desorber reboiler but, as the graph shows, the inflection point – and hence the lean loading that can be achieved without excessive SRD - can be shifted to lower lean loadings by increasing the desorber operating pressure, with a corresponding increase in reboiler temperature.

Through additional modelling work and discussions with the National Carbon Capture Center (NCCC) in Wilsonville, Alabama a practical way for operators to be able to reliably hit the inflection point 'sweet spot' on operating plants was developed. It was observed in modelling runs that the switch from as much water vapour as possible being condensed in the desorber packing to more than necessary leaving with the CO_2, i.e. the inflection point, could be seen as a marked change in the modelled desorber packing temperature profiles, as shown in the central diagram in Figure 2.1. And, subsequently, qualitatively very similar measured desorber temperature profiles were obtained from a data for a series of MEA baseline tests at NCCC, shown on the right in Figure 2.1, confirming that the temperature profiles in the solvent/vapour counterflow section of the desorber packing could indeed be used to ensure that a desorber is operating at the inflection point.

At lean loadings higher than the inflection point value the gas and liquid temperatures in the packing drop rapidly going up the column from the reboiler (the 'Baseline region' curves). At lean loadings below the inflection point value (the 'Exponential region' curves) desorber column temperatures stay high, falling to an extent at the top but never reaching the rich solvent inlet temperature (after any flashing). In the 'Inflection point' region, however, the temperatures in the desorber packing fall approximately linearly from bottom to top, with the differences from the other profiles most striking around the mid-height.

A practically-relevant feature is that, with such large changes in mid-height temperature, the mid-point thermocouple accuracy, or whether it is measuring gas or liquid phase temperature, should not be a concern - the flip in temperature profile around the inflection point will always be far too big to miss.

b) Absorber target CO_2 capture level and lean flow optimisation:

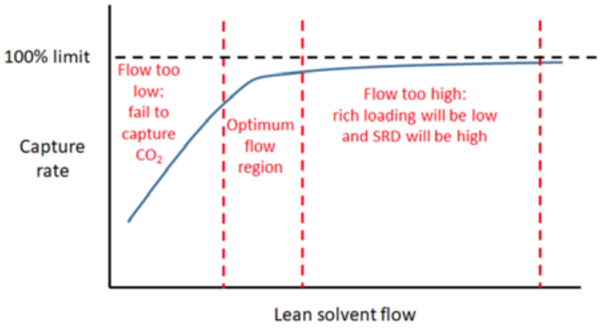

Figure 2.1 The 'absorber corner'

Capture rate will vary with lean solvent flow as shown in the 'absorber corner' diagram in Figure 2.2. Operators need to maintain the lean solvent flow to the absorber at the minimum value required to achieve the targeted exit CO_2 concentration, the 'Optimum flow region'. This will maximise the rich loading and so give the minimum specific reboiler duty (SRD). But, while a low lean solvent flow can readily be identified from a reduced CO_2 capture rate (higher exit CO_2 concentration), excess lean solvent flow may not be so readily determined by this measurement because the exit CO_2 concentration will be relatively insensitive to further increases in lean solvent flow beyond the 'absorber corner'. The absorber column temperatures may give some additional indication, but expected changes are also small.

A supplementary measurement of the rich loading at the absorber exit is therefore expected to be of significant value in implementing the STRETCHER method. This can be done by extraction of solvent samples for offline analyses, but obviously real-time measurements are better so that immediate corrective action can be undertaken rapidly if rich loadings start to deviate from the desired value.

Real time rich solvent loading measurement methods were developed in the tests on the TERC amine capture plant but suitable instrumentation was not available on the Haifeng pilot plant. Only exit CO_2 concentrations measurements were available and, as described in Section 3, these could be no lower than about 0.3% v/v before the loss of sensitivity to lean solvent flow noted above occurred. This limited the maximum capture rate with continuous control to around 98% of the inlet CO_2 although higher values appeared otherwise to be feasible.

3. PREPARATIONS FOR THE HAIFENG TEST PROGRAMME AND RESULTS

3.1 PLANT DESCRIPTION AND PREPARATORY WORK

An outline system diagram for the Haifeng pilot plant is shown in outline in Figure 3.1. Photographs of the plant and the operators' control panel are in Figures 3.2 and 3.3 and more detailed arrangements for the absorber and desorber in Figures 3.4 and 3.5. Further details of the plant are available in a paper from GHGT-14 (Ren, 2018).

The pilot plant is attached to Unit 1 of the Haifeng Power Plant and receives flue gas, steam and other services from the power plant – this is an important consideration since flue gas CO_2 content, and also steam and cooling water temperatures to some extent, are unavoidably affected by the operating patterns of the power plant. This does, however, have the benefit of mimicking some of the challenges of other real-world applications where similar uncontrolled input fluctuations occur.

A preparatory visit to the plant was made in August 2024 to see if there was plant instrumentation in place, in particular with respect to desorber temperature profiles, to allow the necessary optimisation. At the time there was some confusion because specimen data was presented from a previous, unrelated, test that showed a significant drop in the CO_2/vapour temperature occurring across the chimney tray feeding the once-through thermosyphon reboiler. Since this tray/reboiler arrangement is not com-

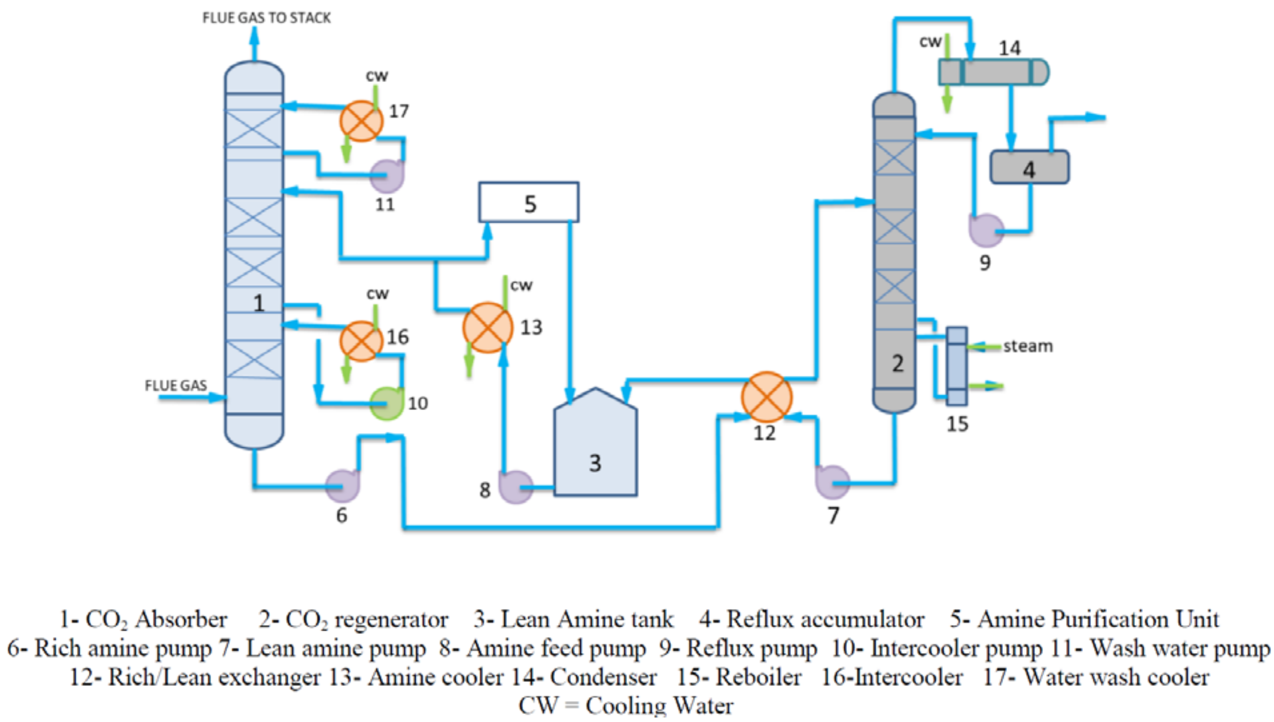

Figure 3.1 Simplified process flow diagram for the Haifeng pilot plant (Ren, 2018)

mon in pilot plant testing (e.g. TERC, NCCC and TCM all have different types of reboiler), the reasons for this were not understood at the time and an additional thermocouple was subsequently added in the desorber sump (DT1 in Figure 3.5) before the COGENT tests took place. In retrospect, however, it is apparent that this data was obtained with a relatively low water vapour content in the CO_2 leaving the reboiler and so even the small amount of heat transfer to the tray and in the chimneys was sufficient to make a difference in temperature. With the high vapour/CO_2 ratios seen in the current tests, associated with relatively low lean loadings and operation around the inflection point, temperature differences across the chimney tray were, however, negligible.

Figure 3.2 Pilot plant view
showing the scale of the unit. The absorber and flue gas duct are clearly visible at the top. One of the station's flue gas desulphurisation units is in the background.

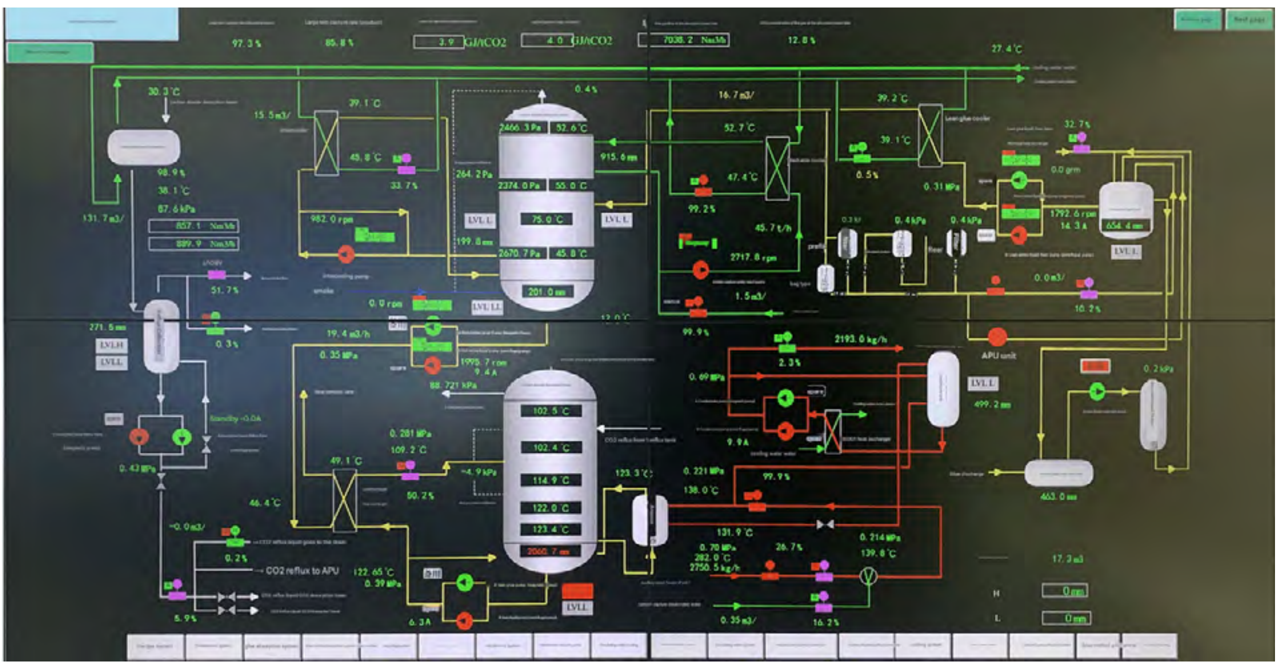

Figure 3.3 Control system main screen (with some Google Translate text translations)
Selected data can also be plotted on supplementary screens to show trends for the operators

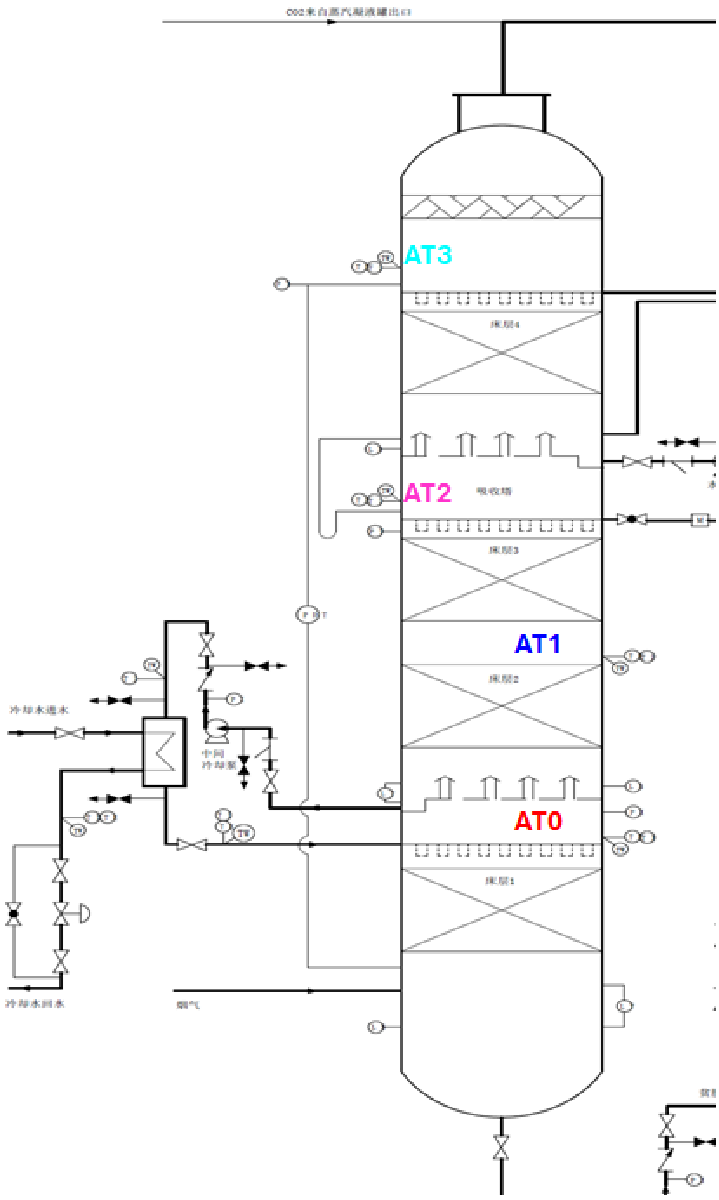

Figure 3.4 Absorber configuration

Height: 41,700 mm overall
Inner Diameter: 1,800 mm
3 beds with 5,300 mm packing (absorption section)
1 bed with 2,700 mm packing (water wash section)
Packing Type: Sulzer Mellapak CC Structured Packing

A significant feature of the absorber is the provision of solvent intercooling above the lowest of the three absorption section packing beds. At the flue gas CO_2 concentrations being used, approximately 12-16% v/v dry, and especially at the low lean loadings used to achieve high capture rates, the heat of reaction when the CO_2 is absorbed is greater than the heat capacity of the solvent and flue gas alone can take up without temperatures becoming too high for effective operation.

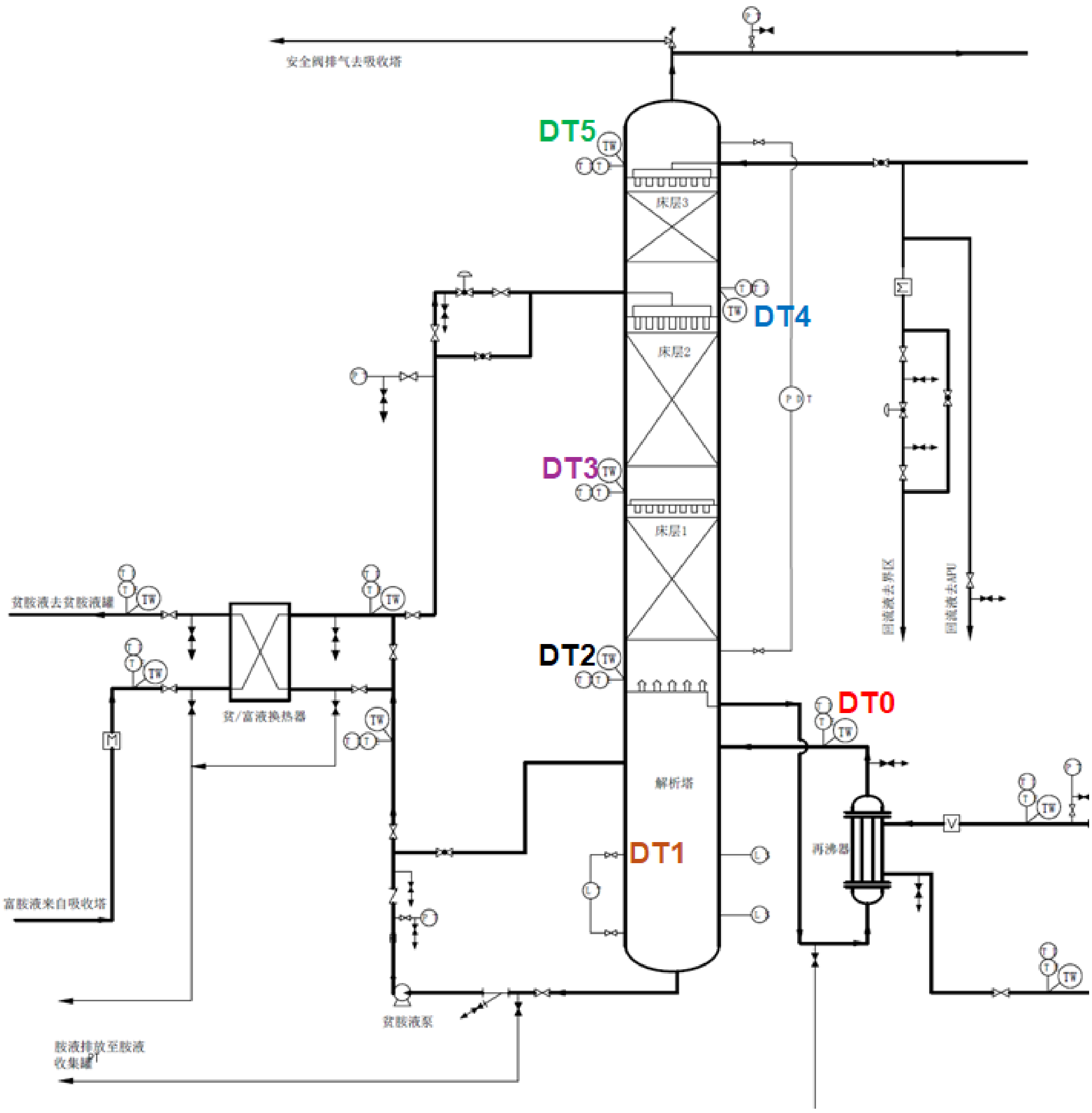

Figure 3.5 Desorber configuration

Height: 27,976 mm Inner Diameter: 1,000 mm 2 beds with 4,260 mm packing 1 bed with 1,704 mm packing Packing Type: Sulzer Mellapak CC Structured Packing

The reboiler is an important part of the desorber. In this design, in common with all full-scale commercial units built to date, a Once Through ThermoSyphon (OTTS) design is used. As shown in the diagram, this type of reboiler takes all of the solvent from a chimney tray below the packing, heats it and then vents the mixture below the tray to flash into the regenerated lean solvent and a CO_2/water vapour mixture that passes up through the 'chimneys' in the tray and into the desorber packing.

3.2 SYSTEM OPERATING EXPERIENCE AND RESULTS

In the latter half of October a series of tests were undertaken to examine the feasibility of achieving high capture rates with the low energy inputs.

The pilot plant could be run continuously, but operating staff were only available for up to around 12 hours per day.

The principles for desorber control to achieve the lowest possible lean loading without excessive specific reboiler duty (SRD) were known in advance; the packing midway temperature was to be held in or near the midpoint between sump and packing to temperatures. This midpoint temperature measurement corresponds directly with the following factors affecting desorber performance:

a) The water vapour/CO_2 ratio in the sump must be as high as possible to achieve the lowest possible lean loading at the prevailing reboiler pressure, but

b) it must be feasible to condense the steam and bring the exiting CO_2/vapour mixture close to the incoming rich solvent temperature, after flashing, to avoid an increase in SRD.

The ease with which this condition could be achieved was not, however, known to in advance. As far as we are aware this type of control has never been attempted on a desorber with an OTTS reboiler before.

The principle for absorber operation at high capture rates and also moderate SRD was also known; the solvent flow should not be so high that the rich loading would be below around 0.45 molCO_2/molMEA and ideally higher. The corresponding capture rate would then be determined by the lean loading and the absorber packing performance, with more packing giving a higher capture rate without a significant decrease in rich loading. It was not, however, feasible to infer the rich loading directly from any of the instrumentation available on the plant.

Two methods were explored to achieve an acceptable rich loading:

a) A feed-forward method - assuming the lean loading was kept reasonably constant by the desorber the lean solvent flow rate was to be adjusted in proportion to the inlet CO_2 content of the flue gas, with the flue gas flow rate kept as constant as possible. This approach proved infeasible, however, due the frequent changes in the inlet CO_2 content of the flue gas from the power plant, the time lag as lean solvent passed through the storage tank and fluctuations in the flue gas flow rate with the manual adjustment being used. Its fundamental viability is, however, confirmed by the observation that optimum results can achieved only at a sufficiently low ratio between the lean solvent flow rate and the amount of CO_2 captured (see Figure 3.6).

b) A feedback method therefore had to be employed, controlling the lean solvent flow rate to the absorber so as to achieve a constant exit CO_2 concentration (i.e. higher exit CO_2 concentrations indicated an increase in lean solvent flow was required and *vice versa*). This CO_2 measurement was made using a FTIR analyser with limited resolution at very low CO_2 concentrations and it was found by experience that below a minimum exit CO_2 of around 0.3%v/v the relationship between lean solvent flow and exit CO_2 was lost, i.e. below this CO_2 level it appeared that lean solvent flow could increase, and hence rich loading decrease, without a clear reduction in exit CO_2 level. This limit on minimum exit CO_2 then inherently restricted the maximum capture rate in controlled operation to around 98%, although higher capture rates appeared to be feasible and were apparently obtained at times. [As discussed, if the rich loading could be measured directly in real time (using the methods developed in the TERC tests) and used for absorber lean flow control then this artificial upper limit on capture rate would be overcome and the maximum capture rate would be determined only by the inherent plant characteristics (i.e. absorber packing height etc.)].

Taking these factors together defines some of conditions for successful high capture in this particular test campaign:

1. The steam supply to the reboiler should be adjusted to keep the desorber midpoint temperature (DT3) between the values at the bottom (DT0) and top (DT4) of the packing – the conditions expected to operate the desorber at the inflection point.

2. The absorber exit CO_2 should be controlled to be around 0.3% v/v by varying the lean solvent flow.

It also became clear as the tests progressed and in the retrospective analysis of the data that other conditions had to be met if the desorber and absorber were to operate at their maximum effectiveness. These limits are also indicated in Figure 3.6.

Absorber

Two absorber operating parameters that appeared to be necessary for a low SRD in these tests, via their impact on the rich loading, which needs to be as high as possible, are:

3. A gas temperature above the lowest bed at 50°C or below, achieved in these tests by effective intercooling. This is not surprising since the aim in achieving high capture rates with minimum energy penalty is to maximise the loading increase and hence heat input per unit mass of solvent. Without effective intercooling, for the relatively high CO_2 concentrations in the coal plant flue gas being used, temperatures in the lower bed will be too high for high rich loadings to be close to equilibrium with the incoming flue gas. The limiting factor here appears to be the mass of CO_2 being captured per unit time from this flue gas, and hence the reaction heat generated in the absorber, with a satisfactory maximum value in these tests of around 40 tCO_2/day. This translates into a superficial flue gas flow velocity of around 7.5 m/s, a somewhat lower value than in typical commercial practise, but this also compensates for the relatively low packing height (15.9m) vs what might be included in a high-capture-rate design (perhaps 20-25m). Obviously, if flue gas with a lower CO_2 concentration was being processed then intercooling would probably not be needed to maintain lower temperatures and gas flow velocities might also be increased.

4. The peak temperature measured in the absorber between beds 2 and 3 (AT1) also needs to be above 70°C and ideally around 75°C, representing a suitably low liquid to gas ratio and also an appropriate distribution of mass transfer across the absorber packing sections, with the middle bed doing the bulk of the work and so leaving the top bed to for the relatively slow approach to low CO_2 levels and the bottom bed to build up a high rich loading. This temperature cannot be controlled directly but can be used, along with AT0, as an indicator of satisfactory performance.

Desorber

The desorber operating conditions fluctuated cyclically under apparently all conditions where a multiphase flow was generated in the reboiler. This was attributed to a mismatch between the thermosyphon driving force and the pressure drop across the reboiler leg at the, essentially fixed, average solvent flow set by the incoming rich flow. In addition, the rich solvent flashed as it entered the desorber, with the amount of flashing varying with the fluctuating desorber pressure. The magnitude of the fluctuations varied to some extent (e.g. see the desorber pressure traces in Figures 3.7-3.9), but they never completely stopped. Possibly because of these fluctuations, in addition to the impurities present in the MEA solvent in the plant at the time, it appeared that foaming was occurring in the desorber and preventing the packing operating effectively, resulting in a higher SRD. This led to two further conditions being noted that would prevent low SRD values being achieved:

5. The measured pressure drop across the desorber packing being close to, or higher than, the gauge upper limit of 6 kPa.

6. The plant being left on overnight, which was always done without operator control. If, however, the plant was turned off overnight then it would mostly have a lower pressure drop for the period of controlled operation (up to 12 hours) during the following day and could be operated satisfactorily if other parameters were in the appropriate ranges.

This type of desorber behaviour is not uncommon in practice but the very limited test time available in this campaign did not allow any remedies for the foaming to be implemented. Possible countermeasures for a future series of tests might include:

a) Continuous controlled operation, including overnight – when operating at close to steady-state conditions under operator control the desorber bed packing pressure drop (and SRD) appeared to either stay constant or increase only very slightly (see Figures 3.7 – 3.9).

b) Reducing reboiler fluctuations by controlling the condensate level in the reboiler or adding a valve to modify the reboiler circuit pressure drop characteristics.

c) Reducing the rich solvent's tendency to flash in the expansion valve upstream of the reboiler by increasing the upstream pressure or by reducing the rich solvent temperature.

d) Reclaiming the solvent to remove impurities.

e) Using an anti-foam agent (but this may conflict with reclaiming, especially continuous reclaiming).

The immediate objective of this campaign, which was demonstrating plant control methods to achieve low lean loading and hence high capture rates without excessive energy consumption, was, however, almost entirely satisfied by the two ~6 hour periods of ~98% capture (based on flue gas CO_2 concentrations in and out of the absorber) at moderate SRD values (based on reboiler heat inputs and desorber CO_2 output) of around 3.6/3.7 GJ/tCO_2 achieved over the last four days of the campaign. Operating data for these two examples, plus a third day with good performance but for shorter periods, is shown in greater detail in Figures 3.7, 3.8 and 3.9.

As can be seen by comparison with other MEA test data in the Annex, this represents a combination of a higher capture rate and/or a lower SRD energy requirements than has been achieved so far. In addition, this optimisation was achieved by the operator's application of pre-defined control principles to go straight to the best operating condition rather than, as in at least some other cases, extended periods of incremental experimentation.

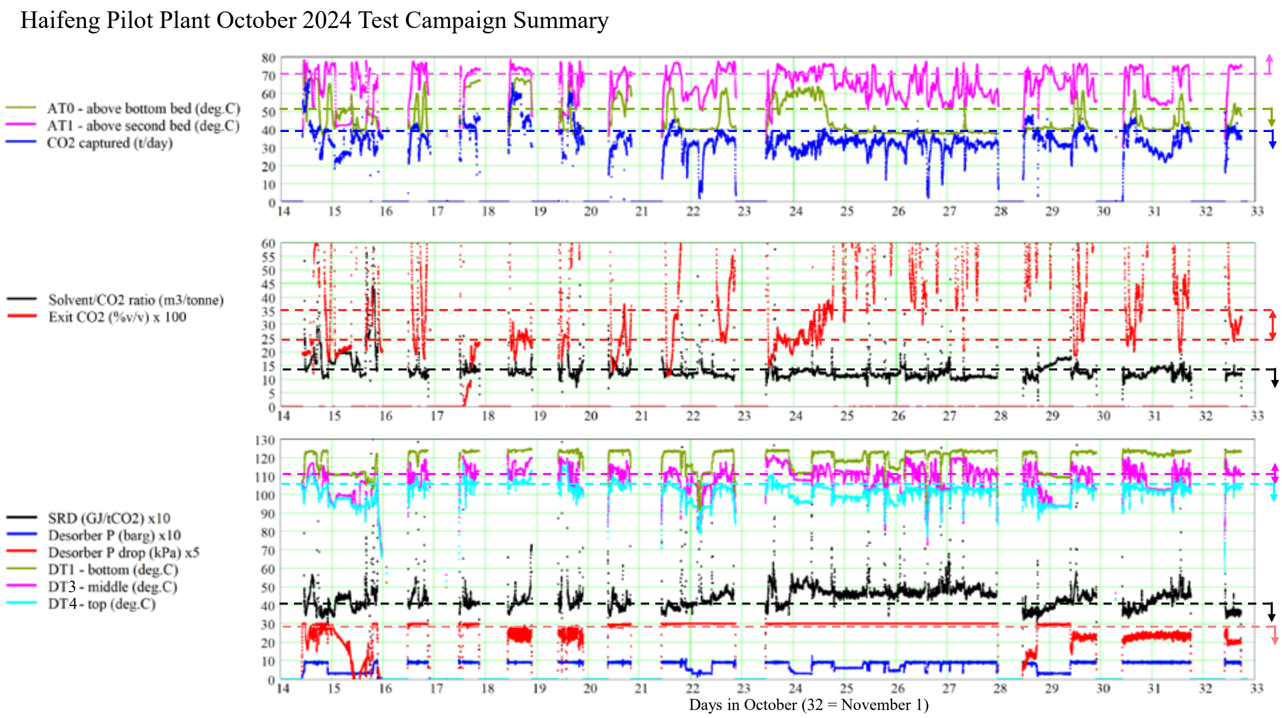

Figure 3.6 Overview of the Haifeng test campaign, showing approximate limits on key parameters for high capture at low SRD

In addition, operation overnight without operator control also appears to adversely effect performance the next day, assumed due to be due to foam buildup.

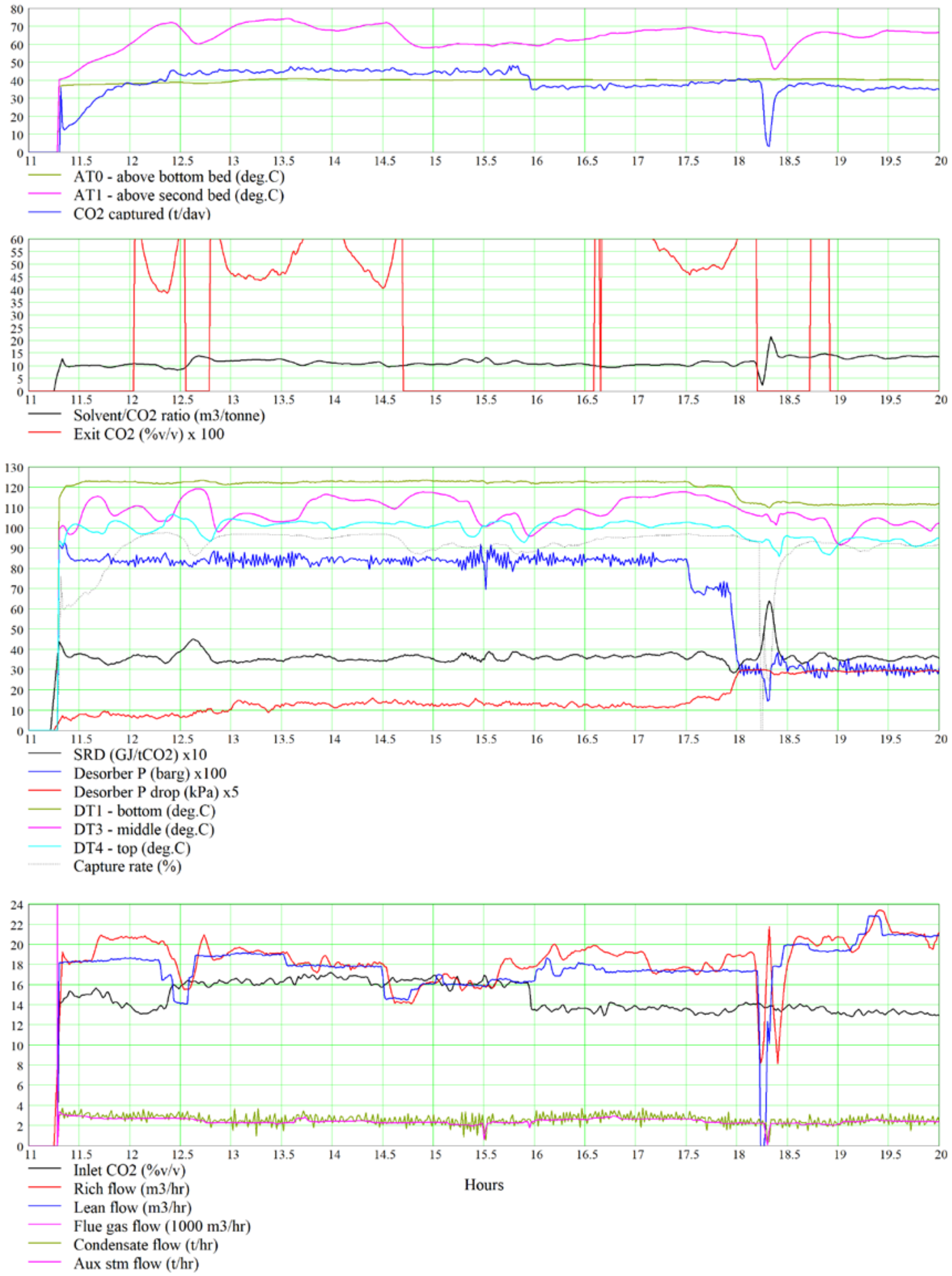

Figure 3.7 Plant operating data for 28 October, 2024

As well as two periods of ~1.5 hours (13:00-14:30 & 16:30-18:00) of moderately high capture (~95%) operation at low SRD with a desorber pressure of ~84 kPa there is another period of 1.5 hours operation (18:30-20:00) at a similar SRD but at 90% capture rate with a mean desorber pressure of 0.3 barg. This last period also had the desorber operated at the inflection point, with the mid-packing temperature kept between bottom and top temperatures as far as possible, but presumably the lean loading was higher than at the higher pressure.

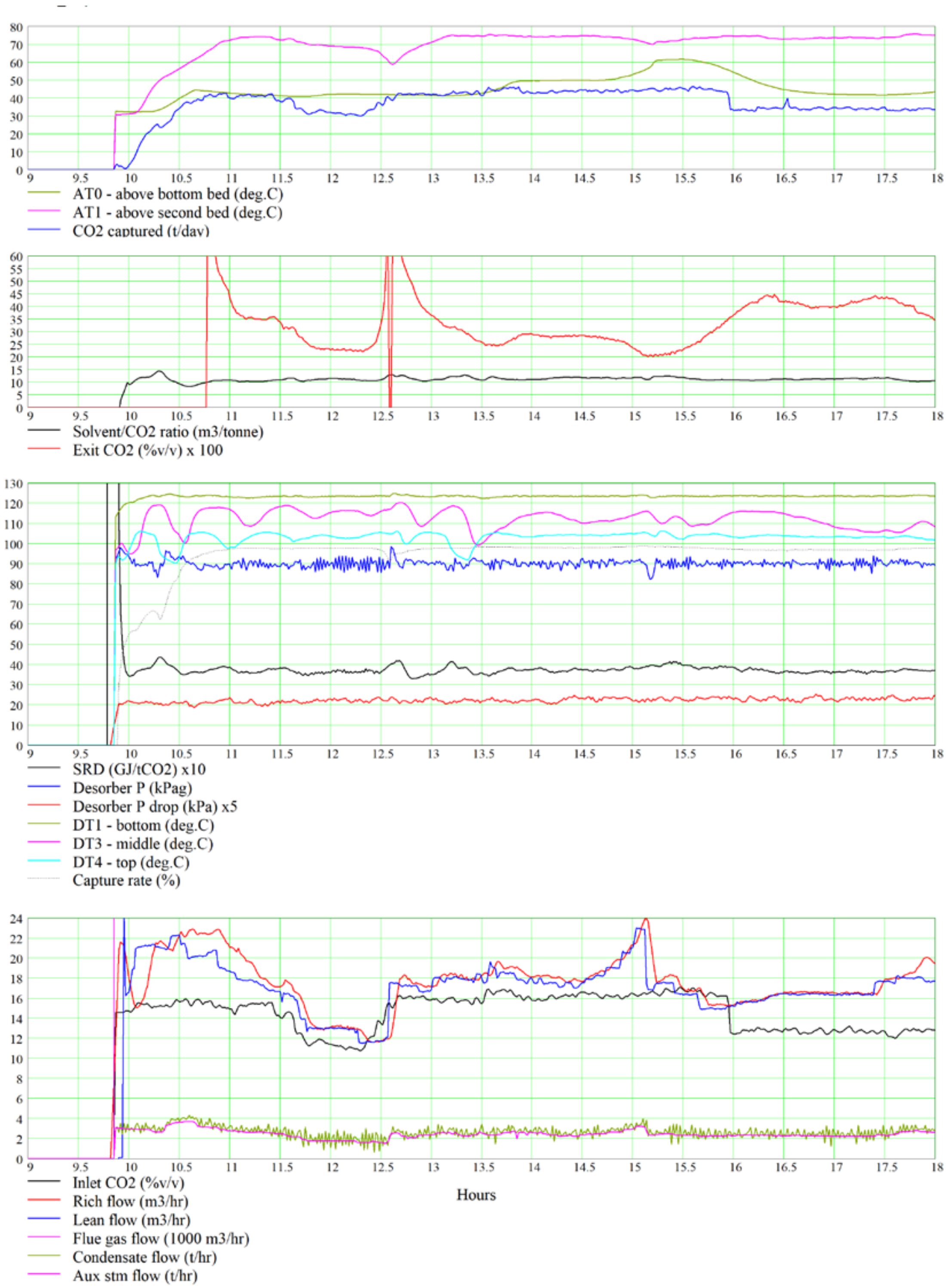

Figure 3.8 Plant operating data for 30 October, 2024

An extended period of operation (11:00-18:00) at an average desorber pressure of 90 kPa with high capture (average 97.5%) operation at moderate SRD (average 3.71 GJ/tCO_2). Some challenges were experienced in keeping the operations at the optimum conditions as the inlet CO_2 concentration changed quickly between ~12% v/v and 16% v/v.

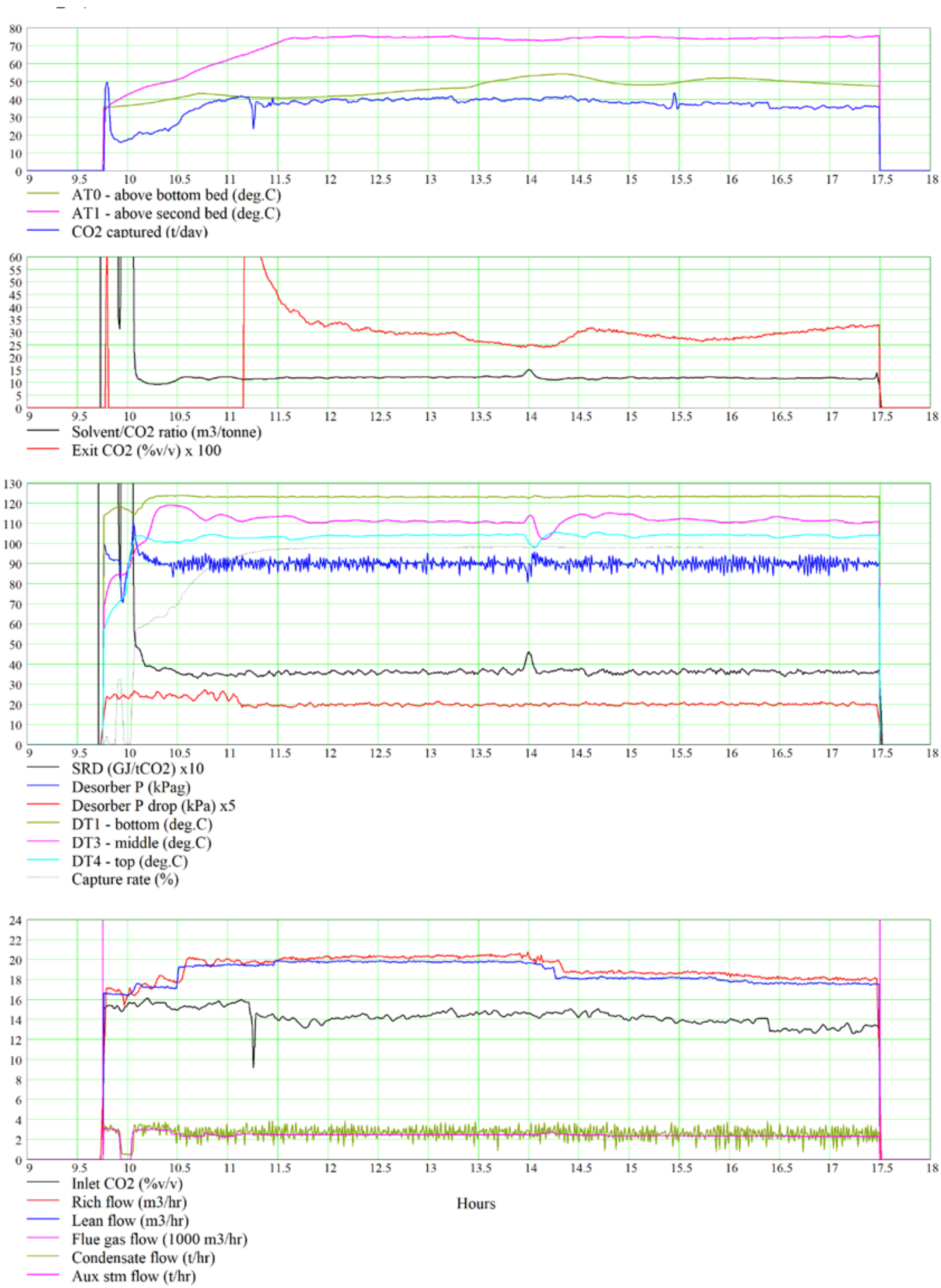

Figure 3.9 Plant operating data for 1 November, 2024

An extended period of operation (11:30-17:30) at an average desorber pressure of 90 kPa with high capture (average 97.9%) operation at moderate SRD (average 3.61 GJ/tCO_2). Steady operation was assisted by the relatively stable inlet flue gas CO_2 concentration.

4. DISSEMINATION AND IMPACT ACTIVITIES

- Workshops at Haifeng Power Plant, China with Guangdong Carbon Capture Test Platform and Tsinghua University staff in October 2024.

- DESNZ staff visits for FOCUSS and COGENT results knowledge exchange took place at the University of Sheffield on 20th November and 10th December.
- Presentation at the 8th UK-China Energy Dialogue, UK-China CCUS Seminar Side Event, 18th March, 2025.
- Presentation at the UKCCSRC Spring Conference, Glasgow, 24-25th March, 2025.
- Individual discussions with a number of UK industrial PCC suppliers and users.
- An abstract has been submitted for presentation at the world's main conference on amine post-combustion capture, the IEAGHG PCCC-8 conference, taking place in Marseille on 16-18th September, 2025.
- LinkedIn and WeChat articles are also planned for later in the year.

ANNEX: PUBLIC DOMAIN CAPTURE RATE AND REGENERATION ENERGY DATA FOR MEA IN OTHER PILOT TESTS

A1 Tests at Test Centre Mongstad on CHP (gas turbine) flue gas, ~3.5-3.7% v/v CO_2 [1]

TCM run series	%w/w MEA	Capture rate	Packing height (m)	SRD (GJ/tCO_2)
MEA: MEA-3	43%	86%	18	3.6
F2	36%	90%	18	3.8
B3-rep	37%	91%	18	3.6
D3-rep	36%	97%	24	3.7

A2 Tests on Test Centre Mongstad on RFCC flue gas, 13-14% v/v CO_2 [2]

TCM run series	%w/w MEA in water	Capture rate	Packing height (m)	SRD (GJ/tCO_2)
1A-1	30%	90.5%	18	3.5
1A-2	30%	89.4%	18	3.54

A3 RWE Niederaussem tests, ~15% v/v CO_2 [3]

Run series	**%w/w MEA in water**	**Capture rate**	**Packing height (m)**	**SRD (GJ/tCO_2)**
MEA 90%	30%	90%	18	3.6

A4 National Carbon Capture Center tests – ~30%w/w MEA, ~10.3% v/v CO_2 [4]

These tests were undertaken as part of a pre-determined matrix of test conditions for model calibration, i.e. they were not optimised high capture rate tests. As a result the lean loadings were relatively high and rich loadings were relatively low and, although capture rates were still high, SRD values are unlikely to be optimally low values. Each packing bed is 6 m high, i.e. 18 m in total.

Case No.	Capture rate (gas data)	L/G (w/w)	Lean loading (molCO_2/molMEA)	Rich loading (molCO_2/molMEA)	SRD (GJ/tCO_2)	Number of beds (Inter-coolers)
K15	99.4%	3.042	0.224	0.413	3.81	3 (2)
K14	98.3%	3.055	0.224	0.42	3.86	3 (2)

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