Annexure C Part 1 – Measurement Requirements (Net Zero North Sea Storage)

1. Definitions and interpretation

1.1 The following terms shall have the following meanings:

(a) CO_2 Rich Stream means Carbon Dioxide and impurities; and

(b) Teesside CO_2 Gas Gathering Pipelines means the T&S Network in respect of which the User's Delivery Point relates.

~~(a)~~

~~CO_2 Rich Stream~~	~~means Carbon Dioxide + impurities~~
~~Teesside CO2 Gas Gathering Pipelines~~	~~means the T&S Network in respect of which the User's Delivery Point relates~~

1.2 Unless the subject matter or context otherwise requires or is inconsistent therewith, terms and expressions defined in Section K (Glossary) of the Code and in the Connection Agreement and Construction Agreement have the same meanings, interpretations or construction in this Annexure C (Measurement Requirements – Net Zero North Sea Storage).

1.3 For the purposes of this Annexure C (Measurement Requirements – Net Zero North Sea Storage):

(a) "shall" is to be understood as mandatory; and

(b) "should" indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment and or cost benefit analysis must be completed to show that the alternative method delivers the same, or better, level of protection.

2. General

~~1.1 **Purpose**~~

2.1 The purpose of this Annexure C (Measurement Requirements – Net Zero North Sea Storage) is to specify the requirements that shall be addressed in the design and operation of gas phase CO_2 metering and analysis systems for Users delivering carbon dioxide into the Net Zero North Sea Storage Teesside CO_2 Gas Gathering Pipelines.

3. Regulations, Codes & Standards

~~1.2 **Codes and Standards**~~

3.1 Any metering and analysis shall be designed, manufactured, tested and delivered in accordance with the relevant sections of the latest editions (including addendums) of the following international and national codes and standards:

Document Number	Title
(EU) 2018/2066	Monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012
ASME B31.3	Process Piping
ASME B16.5	Pipe Flanges and Flanged fittings NPS ½ through NPS 24 Metric/Inch Standard
BS ISO 5168	Measurement of fluid flow – Procedures for the evaluation of uncertainties
ASME PTC 19.3 TW	Thermowells Performance Test Codes
BS EN ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories
BS EN 14181	Stationary source emissions. Quality assurance of automated measuring systems
BS EN 15267-3	Air quality – Certification of automated measuring systems – Part 3: Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources
BS EN 15259	Air quality. Measurement of stationary source emissions. Requirements for measurement sections and sites and for the measurement objective, plan and report
IEC 60079	Explosive Atmospheres (All Parts)
IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
IEC 61326-1	Electrical equipment for measurement, control and laboratory use – EMC requirements
IEC 61285	Industrial Process Control – Safety of analyser houses
IEC TR 61831	On-line analyser systems – Guide to design and installation
ISO 19230	Gas analysis – Sampling guidelines
BS EN ISO 6974	Natural Gas – Determination of composition and associated uncertainty by gas chromatography
BS ISO 27919-1	Carbon Dioxide Capture
BS ISO 10790	Measurement of fluid flow in closed conduits – Guidance to the selection, installation and use of Coriolis flowmeters
BS ISO 15848	Industrial valves – Measurement, test and qualification procedures for fugitive emissions
ISO 5208	Industrial valves – Pressure testing of metallic valves
ISO 9000	Quality Systems. Relevant Parts
MCERTS	Environment Agency Monitoring Certification Scheme for environmental permit holders
IEC 61508	Functional safety of electrical / electronic / programmable electronic safety-related Systems
IEC 61511	Functional safety – Safety instrumented systems for the process industry sector

4. Responsible Persons

4.1 Each of the:

(a) T&SCo; and

(b) User

shall appoint a responsible person to observe and perform the obligations- of the T&SCo or User (as applicable) set out in this Annexure C (Measurement Requirements – Net Zero North Sea Storage) as they relate to metering, analysis and measurement.

5. Summary

5.1 This Annexure C (Measurement Requirements – Net Zero North Sea Storage) sets out the details in respect of:

(a) CO_2 Rich Stream flow measurement uncertainty of ±1.0%;

(b) Coriolis flow metering;

(c) Individual, dedicated meter flow computers;

(d) Online analysers / detectors for quality monitoring purposes of selected components of carbon dioxide rich stream;

(e) Periodic sampling facility for laboratory testing; and

(f) Transmission of metering and analysis data, diagnostics and meter station status to the T&SCo's Remote Terminal Unit (RTU).

6. Deviations from these Measurement Requirements

6.1 Any deviations from the requirements detailed within this Annexure shall be formally submitted to T&SCo for consideration; full justification including technology readiness of alternative hardware shall be provided.

6.2 In considering any proposed deviations, T&SCo shall have regard to the possibility of the deviation resulting in an unfair advantage over other Users or increases risk to people, environment or business.

~~6.1~~6.3 Any deviations from the Measurement Requirements shall only be permitted through a Modification to this Annexure C (Measurement Requirements – Net Zero North Sea Storage) or a User-specific derogation under Schedule 2 to the Connection Agreement.

7. Measurement Uncertainty

7.1 The following quantities shall be measured and reported to the T&SCo to an uncertainty of ±1.0% at a 95% confidence level over the continuous operating range of flow rates and process conditions:

(a) All CO_2 Rich Stream mass flow rate measurements.

8. Units

8.1 The following units shall be used:

(a) Mass Flow - metric tonnes per hour (t/h)

(b) Pressure - bara

(c) Temperature - deg C

(d) Density - kg/m³

9. Daily Reporting

9.1 Daily reports for the previous Day from User shall be made available by the User to the T&SCo by 10:00am the following day.

9.2 Reporting of data to the Central Data Service (CDS) shall be in accordance with the CCS Network Code.

10. Process Conditions

10.1 The fluid passing through the metering system shall be in single phase - gas.

10.2 The T&SCo Teesside Gas Gathering Pipelines are controlled by adjusting the downstream high pressure (HP) compressor(s) export flow to maintain a constant pressure at the inlet manifold upstream of the high pressure (HP) compressors. When pipeline entry isolation valves are open, the pressure at the User's metering point will therefore be floating and affected by the total flow of all Users exporting into the pipelines.

10.3 The flowing fluid temperature at the tie in point between the User and the pipeline shall meet the operating temperature requirements of the Carbon Dioxide Specifications. Flowing fluid temperature through the metering point shall therefore be constrained by a User in order to meet the Entry Provisions requirements downstream of the metering point.

10.4 The User shall ensure that no liquid drop out occurs within and downstream of the metering point to prevent carbon dioxide liquefaction leading to higher pipeline velocities or slug flow at the point of connection to the Teesside CO2 Gas Gathering Pipelines.

11. Metering System Configuration

User Export Flow Metering

11.1 Flow measurement shall be continuous.

11.2 Metering system shall be supplied with N + 1 Coriolis meters, where N is the number of meters in service. Each meter shall have the capacity of no less than the maximum metering system throughput divided by N. Each meter shall be provided with appropriate isolation to allow removal for off-site calibration by a T&SCo approved facility.

11.3 It shall not be possible to divert flow to vent between flow metering point and the tie-in with the Teesside CO2 Gas Gathering Pipelines, any required venting shall occur upstream of the metering point. Any manually operated valves for maintenance vent or drain must be fully closed and of high integrity to minimise leak paths and fugitive emissions. Valves shall be sealed closed as per the User’s site practice.

11.4 Inline analysers / detectors (if applicable) and analyser / detector sample take off shall be located upstream of the metering point. Piping shall be configured such that the carbon dioxide stream can be diverted to vent between the analysers / detectors and the metering to

allow for the carbon dioxide to be proved to be within specification prior to being allowed to be exported into the Teesside CO2 Gas Gathering Pipelines.

User Re-use Flow Metering

11.5 Where the T&SCo has approved the User re-using carbon dioxide from the gas gathering network for a short term and intermittent basis to aid startup of low pressure (LP) compression facilities, the following requirements shall apply:

(a) as a minimum, a single Coriolis meter stream shall be supplied with appropriate isolation to allow removal for off-site calibration. The provision of a spare meter stream is not a requirement but may be provided by the User to increase availability; a correctly working flow meter shall be a requirement of the T&SCo opening and allowing use of the Re-use Service;

(b) it shall not be possible to divert flow to vent between the tie-in with the Teesside CO2 Gas Gathering Pipelines and the flow metering. Any manually operated valves for maintenance vent or drain must be fully closed and of high integrity to minimise leak paths and fugitive emissions. Valves shall be sealed closed as per the User's site practice; and

(c) the Re-use Meter shall be connected to a flow computer and report via the station computer provided for export flow.

12. Instrumentation

12.1 Pressure, temperature and composition shall be measured using high stability SMART instruments of proven performance and reliability with a preferred minimum technology readiness of two (2) years in similar service. The User shall seek the T&SCo's approval for any proposed instrumentation with less than two (2) years similar service. The User shall be required to demonstrate technology readiness level (TRL) as part of the approval process (Refer to Appendix A for TRL Level definitions). The sensitivity to environmental and process conditions shall be taken into account in the design of the installation arrangement.

13. Flow Meters

13.1 Coriolis flow metering in conformance with ISO 10790 is the required technique for flow metering.

14. Analysis

14.1 Online analysers / detectors shall be provided by the User based on a risk assessment of the potential challenges to the pipeline network and storage operation created by components in the User's raw emission stream. Analysers and/or detector selection shall be approved by the T&SCo. Approval by the T&SCo does not relieve the User of compliance with any analyser requirements imposed by the applicable Revenue Support Contract or similar agreement.

14.2 Where the selected technology allows, online analysers / detectors shall provide continuous output measurement of the component measured. Safety related alarm and trip points shall be agreed with the T&SCo to ensure compliance with Annexure D – $CO_2$2 Quality Monitoring Procedure. Credit can only be taken for alarms in risk assessments such as LOPA if the User Operator has a minimum of 15 minutes, from the alarm being initiated, to take corrective action before the trip or breach of the alarm occurs. Any such trip or breach of the alarm shall not be treated as confirmation of suspected or actual Non-Compliant $CO_2$2, identification of which shall only be determined in accordance with the $CO_2$2 Quality Monitoring Procedure.

14.3 As a minimum the following online analysers / detectors shall be provided by Users for continuous monitoring of the following components:

(a) Carbon dioxide content/quality;

(b) Water;

(c) Oxygen;

(d) NOx; and

(e) SOx.

14.4 Where manual sampling identifies regular breaches of limits for components not online monitored, the T&SCo reserves the right to add those components to the list of components subject to the online analyser provision set out at paragraph 15(c) above, in accordance with the provisions of the CO_2 Quality Monitoring Procedure and subject to the revisions provisions set out in Section G (Common Interface Procedures) to the CCS Network Code.

14.5 Online analysers / detectors used for proving conformance with Annexure D – $CO_2$2 Quality Monitoring Procedure shall not be used for control of equipment upstream.

14.6 Periodic sampling for testing within a laboratory shall be undertaken for all other components that are present in the User raw gas stream.

Analyser / Detector Selection

14.7 Analysers and/or detectors selected shall be of high availability and high reliability to ensure that any deviation towards the limits stated in Annexure D – $CO_2$2 Quality Monitoring Procedure is detected such that appropriate action can be taken to ensure the Teesside pipeline entry requirements are not breached.

14.8 Analyser and/or detector performance shall meet or exceed that required to achieve the process objectives, including parameters such as analyser and/or detector response time and lower detection limit.

14.9 Analysers and/or detectors shall be housed suitably to ensure stable operation in the ambient conditions within which they are installed. It shall be noted that although many analysers have a wide ambient operating temperature range, they do not necessarily provide stable operation in the event of large temperature swings within this range, such as those

caused by diurnal variations, and some degree of temperature control is therefore recommended.

14.10 Where multiple analysers and/or detectors, especially if including some complex types, are installed at the same location, then it is recommended that a comfortable maintenance environment is provided, e.g., analyser house, to ensure prompt maintenance and maximise analyser and/or detector availability; this shall ensure that adverse weather conditions do not prevent the maintainer working at the analyser and/or detector location when essential maintenance of the analyser and/or detector system is required.

14.11 Analysers and/or detectors selected shall have inbuilt diagnostics to allow the reporting of analyser health to supervisory systems. For all online analysers and/or detectors a fault signal shall be provided that shall be triggered when any fault that affects the reliability of the analysis signal occurs. It shall not be triggered by advanced warnings of maintenance/ calibration due, but shall be triggered by calibration overdue. This fault signal and diagnostic information shall be made available in the T&SCo pipeline control room via the remote terminal unit (RTU) interface.

14.12 A preventative maintenance plan shall be implemented for each analyser system including the identification of key spares and consumables.

Sampling System

14.13 Where the sensor type/design requires it, a sampling system shall be provided to extract and transport representative samples to the online analysers and/or detectors at process conditions suitable for use by the analysers and/or detectors.

14.14 The sample system shall be designed to minimise the transit time between the sampling point and the analysers and/or detectors. It shall be assured that the combined transit time and analyser and/or detector response (overall response) is rapid enough to guarantee the pipeline entry requirements and to ensure pipeline safety. Given that fast, turbulent flow is required in the sample transport line to maintain a representative sample, transit time shall not exceed ninety (90) seconds unless technical justification is provided and approved by the T&SCo. If a single line sample transport system does not meet the transit time requirement for the application, then a fast loop shall be provided.

14.15 For gas analysers and/or detectors the sample handling system shall be designed so that the sample is in its gaseous phase at the point of entry to the on-line analyser and/or detector, across the full range of compositions that may be encountered in service. If applicable, the sample system shall be designed to prevent ingress of liquid droplets into the transport system. If necessary, the sample shall be kept above the dew point or frost forming temperature, if this is higher than the minimum ambient temperature.

14.16 The sample systems for trace moisture analysers shall have tubing and components that have appropriate treatments applied for trace measurement, such as electropolishing and passification. A change in concentration at the sample take-off point shall be detected at the analyser and/or detector inlet faster than the permitted sample transit time. Minimal moisture hold-up within the sample system is permitted.

14.17 Sample system diagnostics shall be included with the analyser and/or detector diagnostics to verify that the complete analyser and/or detector system is working correctly. Sample system faults are a frequent cause of analyser system malfunction, with loss of sample flow being one of the most common reasons. Sample system fault diagnostics shall be included in the analyser alarm group.

14.18 Exhaust gas from the analysers and/or detectors and fast loop systems shall be vented to atmosphere at a safe location.

Carbon Dioxide Analysis

14.19 For carbon dioxide concentration the carbon dioxide composition analysis equipment required for the User's Revenue Support Contract or similar agreement shall be utilised.

14.20 Should Gas Chromatographs (GC) be utilised, these shall be optimised for high purity carbon dioxide as set out by BS ISO 27919-1.

14.21 For the carbon dioxide analysis, as a minimum, one (1) duty and one (1) standby analyser shall be installed. The duty analyser shall provide a composition reading at least every ten (10) minutes or more often if the time interval specified within Revenue Support Contract is shorter.

14.22 The analyser shall be able to detect and report carbon dioxide purity measurement values between 92 and 100mol% with a sensitivity better than 0.1%. Accuracy shall be better than ±0.3% of reading.

14.23 User shall develop calibration / validation strategy for the gas chromatographs (GC) to ensure accuracy is maintained.

Water Content Detector

14.24 The water content detector shall be highly reliable and achieve a minimum TRL of 8 at the start of commissioning. Where a Safety Instrumented Function (SIF) is required to meet the Target Mitigated Event Likelihood (TMEL) requirements stipulated in the Entry Specification, the water content detector shall be certified as per IEC 61508 / 61511 to allow their use as a trip initiator.

14.25 As a minimum one (1) duty and one (1) standby water content detector shall be provided.

14.26 It is expected that the analyser should utilise tunable diode laser (TDL) as the measuring principle.

14.27 The water content detector shall be able to detect and report moisture measurement between 10 and 100ppmv with a sensitivity better than 2ppmv in 96% carbon dioxide. Accuracy shall be better than ±3ppmv.

14.28 The User shall develop calibration / validation strategy for detector to ensure accuracy is maintained.

Oxygen Detector

14.29 The oxygen content detector shall be highly reliable and achieve a minimum TRL of 8 at the start of commissioning.

14.30 As a minimum one (1) duty and one (1) standby oxygen detector shall be provided.

14.31 If electrochemical technology is proposed for this application, electrochemical type sensors shall be carefully selected to ensure these are not poisoned or rapidly depleted by the high concentration of carbon dioxide.

14.32 Quenched UV luminescence may be a more suitable measuring technique.

14.33 The oxygen content detector shall be able to detect and report an oxygen measurement between 2 and 50ppmv with a sensitivity better than 1ppmv, Accuracy shall be better than ±2ppmv.

14.34 The User shall develop calibration / validation strategy for detector to ensure accuracy is maintained.

Analysis of Nitrogen Oxides

14.35 For NOx analysis, UV, fourier transform infra-red (FTIR) or nondispersive infra-red (NDIR) absorption analyser or Chemiluminescence analyser shall be utilised which shall be highly reliable and proven in use in carbon dioxide stream applications.

14.36 The User shall provide suitable redundancy in the form of an installed or a warehouse spare analyser.

14.37 Spectroscopy based photometers requires individual components to be analysed e.g. NO, NO2 etc. as opposed to a single conglomerate. The User's raw gas shall be used to determine the individual components required to be analysed.

14.38 The analyser shall be able to detect and report NOx measurement between 0.1 and 15ppmv with a sensitivity better than 0.1ppmv, Repeatability shall be better than ±0.25ppmv.

14.39 User shall develop calibration / validation strategy for detector to ensure accuracy is maintained.

Analysis of Sulphur Oxides

14.40 For SOx analysis, UV, fourier transform infra-red (FTIR) or nondispersive infra-red (NDIR) absorption analyser or UV-fluorescence analyser shall be utilised which shall be highly reliable and proven in use in carbon dioxide stream applications.

14.41 The Users shall provide suitable redundancy in the form of an installed or a warehouse spare analyser.

14.42 Spectroscopy based photometers requires individual components to be analysed e.g. SO2, SO3 etc. as opposed to a single conglomerate. The User's raw gas shall be used to determine the individual components required to be analysed.

14.43 The analyser shall be able to detect and report SOx measurement between 1 and 25ppmv with a sensitivity better than 0.5ppmv, Repeatability shall be better than ±1ppmv.

14.44 The User shall develop calibration / validation strategy for detector to ensure accuracy is maintained.

15. Periodic Sampling Requirements

15.1 Users shall have the necessary facilities for taking periodic samples of the User's export carbon dioxide stream for laboratory analysis.

15.2 Due to the toxic nature of the carbon dioxide stream, the periodic sampling system shall be designed to ensure that risk to the operator is as low as reasonably practicable. This may involve for example the use of actuated valves and a vent system that can be controlled from a panel located a safe distance from the periodic sampling unit.

15.3 The periodic sampling system shall allow for up to three (3) sample vessels to be filled simultaneously to allow for laboratory testing by the User's selected laboratory, the T&SCo's selected laboratory and with the third sample acting as a control for independent verification in the event of a dispute.

15.4 Samples shall be taken to confirm component levels remain within specification and to verify online analyser readings. The Users shall notify T&SCo if any test results indicate that components not specified in the Carbon Dioxide Specifications are present in the carbon dioxide stream. For details of sampling frequency refer to Annexure D – CO_2 Quality Monitoring Procedure.

15.5 The sample probe shall be designed and installed to ensure a representative sample is obtained.

15.6 The probe and sampling equipment shall be suitably treated to ensure that trace components within the stream are not lost and the sample contained within the sample vessel is a true reflection of the export stream.

15.7 The T&SCo or delegate shall have the right to be present at the sampling arrangement during sample takeoff and to be able to remove sample vessels from the User premises for analysis, or request a sample vessel is to be sent for analysis, at a laboratory of the T&SCo's choosing.

15.8 The User's selected laboratory shall be United Kingdom Accreditation Service (UKAS) accredited and in conformance with ISO/IEC 17025.

15.9 The results of the User's laboratory testing shall be made available electronically to the T&SCo within eight (8) hours of being received by the User.

15.10 The User must retain all historical analysis (online or laboratory), for auditing and submission on request by the T&SCo or the Regulator, for at least ten (10) years.

16. Density Measurement

16.1 Coriolis meter shall provide density readings for density reporting.

17. Flow Metering Package

17.1 The metering configuration shall be designed to meet Coriolis flow meter manufacturer's recommended installation configuration including any straight run requirements.

17.2 The Measurement Equipment shall not sit in a pipework low point where liquids may collect.

17.3 High quality double block and bleeds valves suitable for the service shall be used.

18. Equipment Certification

18.1 All instrumentation including analysers and/or detectors shall be certified for the operating range by a United Kingdom Accreditation Service (UKAS) accredited laboratory to be within agreed tolerances.

18.2 Flow Meters shall be calibrated using carbon dioxide, unless such facilities are not available. Where carbon dioxide cannot be used for calibration, any alternative medium proposed shall be subject to the T&SCo's approval.

19. Flow Computer System

19.1 Flow computation shall be performed on high-speed digital flow computers. It is recommended that one (1) flow computer is supplied per meter run to provide a high degree of availability.

19.2 Each flow computer shall hold high integrity registers for the following sets of totals:

(a) Accumulative (non-re-settable) totals;

(b) Flow (Rolling) over last twenty four (24) hours;

(c) Current Day (since last daily reporting cut-off time) totals; and

(d) Previous day (between previous two (2) daily cut-off times) totals.

19.3 This shall allow twenty four (24) hour carbon dioxide emission totals to be reported. In the event of station computer failure or communications failure, the previous Day totals may be manually read from each flow computer. The provision of a display and/or keypad for each flow computer is recommended to facilitate manual reading of totals.

19.4 A low flow cut-off arrangement is recommended to prevent spurious totalisation from small zero (0) errors in transducers when a stream is off-line. A maintenance mode must be provided to prevent transmitter testing or flow calculation tests corrupting the operational totals.

19.5 The use of keypad values for flow rate in operational mode is not permitted.

19.6 The transducer inputs shall be continuously monitored for failures, if one is detected a default value shall be used in the calculations, an alarm raised and an investigation initiated. Default values shall be representative of flowing conditions. For the Coriolis meters the default value shall be 0 kg/hr in order that such a failure is clear and unambiguous.

19.7 A redundant station computer is recommended in order to provide the following facilities:

(a) sum totals from each flowing stream;

(b) logging CO_2 Rich Stream mass flow in near real-time;

(c) logging CO_2 Rich Stream mass flow every thirty (30) minutes;

(d) calculating and logging mass of carbon dioxide flow (not including impurities) every thirty (30) minutes based on carbon dioxide concentration output from carbon dioxide composition analysis equipment and measured CO_22 Rich Stream flow;

(e) produce daily export reports that accurately reflect the twenty four (24) hour stream totals for both CO_22 Rich Stream and total carbon dioxide;

(f) provide an interface with the User's process control system and data source for transmission of data to the T&SCo remote terminal unit (RTU) (Note this shall include all fault failure diagnostics); and

(g) log all alarms, events and manually initiated commands.

19.8 For all alarms that may be generated, the User shall ensure an appropriate alarm response is identified, documented and easily available to plant operations personnel.

20. Factory Acceptance Testing

20.1 User shall invite the T&SCo to witness factory acceptance testing of the flow metering and analysis equipment, providing a minimum of ten (10) Business Days notice.

21. Documentation required by T&SCo

21.1 The following documentation is to be sent to the T&SCo for comment:

(a) metering conceptual design summary;

(b) design dossier featuring data sheets, schematics, piping and instrumentation diagrams (P&IDs), piping isometrics, process data, uncertainty calculations, technical specifications, project plan;

(c) functional design specification (FDS) for metering system (including analysers / detectors) and flow computers;

(d) risk identification (e.g. HAZOP) and risk assessment (e.g. LOPA) reports relating to breach of the Entry Provisions requirements;

(e) carbon dioxide sample grab and transportation procedure for laboratory analysis;

(f) Flow Meter calibration dates and procedure;

(g) factory acceptance test dates and procedures;

(h) flow meter calibration and factory acceptance test reports;

(i) commissioning dates and procedures;

(j) start-up date and procedure; and

(k) metering station databook including operating and calibration test/ maintenance procedures, piping instrumentation diagrams (P&IDs), piping isometrics, process data, detailed description of metering system, summarised flow computer functional design specifications (FDS) and uncertainty calculations.

22. Metering Databooks

22.1 The metering databook shall contain full details of the Flow Meter system, analysers and/or detectors and data transmission equipment used and their operating ranges and measurement uncertainty. The operational and validation methods employed shall be included.

22.2 Example contents include:

(a) system schematics with piping and instrumentation diagram (P&ID). Important piping isometrics;

(b) detailed description of the system with list of equipment and operational data;

(c) calibration test and maintenance procedures, tolerances and frequencies for the metering system. List of example calibration certificates;

(d) operating procedures for the metering system;

(e) details of sample probe, pressure let-down, sample line transit time, gas quality analysers / detectors;

(f) list of calculations/ functions performed by the flow computer system and example computer constants where applicable;

(g) list of test equipment with calibration frequencies, operating ranges and tolerances with example certification;

(h) measurement uncertainty calculations;

(i) list of permanent dispensations; and

(j) maintenance log.

22.3 The metering databooks are to be issued to the T&SCo for review. It is recommended that the documentation is provided in electronic form and has a contents list in line with the above.

22.4 The metering databook is a key document that will be reviewed during the metering audit and should contain the latest versions of procedures and drawings. It shall also include a maintenance log to record maintenance undertaken and details of missed maintenance. It is expected that the document should be updated annually.

23. Metering and Analysis Audits

23.1 The T&SCo shall perform metering and analysis audits at the installation as soon as normal operation has been established, and thereafter at T&SCo discretion in accordance with Section F of the Code.

23.2 The audit requirements and method shall be covered in a metering and analysis audit terms of reference document. This will detail access required to User historical data, maintenance records, carbon dioxide component excursion events and other breaches relating to carbon dioxide capture and disposal.

23.3 Any findings shall be recorded, tracked and close out approved by the T&SCo.

24. Dispensations

24.1 The metering and analysis system shall be operated and maintained to an agreed standard and set of procedures. Situations may arise infrequently that result in difficulties in following these procedures, for example due to equipment failure or changes in process conditions. Often these changes are foreseen and may be planned well in advance, though occasionally faults may occur which cannot be resolved quickly.

24.2 In situations where agreed procedures can no longer be followed, a dispensation may be ~~sort~~ sought by the User, subject to such dispensation not contravening Section F of the Code. Dispensation applications to the Teesside pipeline system shall include a summary of steps being taken to minimise the impact on custody transfer metering.

25. Mis-measurements

25.1 The metering and analysis system shall operate automatically and normally create a daily export report for the T&SCo.

25.2 Occasionally daily report quantities may need to be adjusted in order to correct them for an event or fault that has affected the metered figures. This will be covered by an operating procedure developed for the T&S Network.

25.3 Metered quantities may only be corrected when supported by a valid mis-measurement report and subject to Section F of the Code. Flow measurement undertaken in other locations in the pipeline systems shall be used to validate corrected flows.

26. Proposed changes to method of Measurement / Analysis

26.1 The T&SCo shall be notified well in advance of any significant changes to the User's metering/ analysis and the data reporting system.

26.2 Changes may be due to change in emission rates or specification, difficulties in operating the installed system or upgrading due to obsolescence/ adoption of new techniques.

26.3 The T&SCo shall review the proposal with the aim of ensuring consistency throughout all the metering systems.

26.4 Implemented changes pursuant to a Modification of the Code shall be incorporated into the metering databook, sections such as procedures and uncertainty calculations may need to be updated.

27. Metering Meetings

27.1 Regular meetings shall be conducted by the T&SCo; metering specialists of the Users shall participate in the meeting.

27.2 Meetings shall be held at least annually, representatives of the Department for Energy Security and Net Zero (or any successor) may be invited to attend annual meetings for their information/ comment.

27.3 The purpose of the meetings is to review the Users metering and analysis systems. Any problems or proposed changes will be discussed that may impact upon all representatives.

27.4 Typical agenda items include:

(a) safety issues and any safety alerts since the last meeting;

(b) action log status;

(c) any general carbon credit accounting issues;

(d) any general metering/ analysis/ data reporting issues;

(e) status of metering and analysis systems;

(f) metering audit summary;

(g) dispensation summary;

(h) mis-Measurement summary; and

(i) review of each metering and analysis system since last meeting and any proposed changes over the next twelve months.

27.5 An action log will be used to record agreed actions with a responsible party and target date. The action log will also be used to record any technical decisions made. Copies of presentation material from the meeting will be issued to attendees. It is expected that all organisations invited will be represented by the primary contact or deputy. It is anticipated that six (6) weeks' notice will be given for meetings.

Appendix A – Technology Readiness Level Definition

TRL definitions based on ISO 16290.

Phase	TRL	Stage	Description
Operations	TRL 9	Operations	The technology is being operationally used in an active facility
Deployment	TRL 8	Active Commissioning	The technology is undergoing active commissioning
	TRL 7	Inactive Commissioning	The technology is undergoing inactive commissioning. This can include works testing and factory trials but it will be on the final designed equipment, which will be tested using inactive simulants comparable to that expected during operations. Testing at or near full throughput will be expected
Development	TRL 6	Large Scale	The technology is undergoing testing at or near full-scale size. The design will not have been finalised and the equipment will be in the process of modification. It may use a limited range of simulants and not achieve full throughput
	TRL 5	Pilot Scale	The technology is undergoing testing at small to medium scale size in order to demonstrate specific aspects of the design
	TRL 4	Bench Scale	The technology is starting to be developed in a laboratory or research facility.
Research	TRL 3	Proof of Concept	Demonstration, in principle, that the invention has the potential to work
	TRL 2	Invention & Research	A practical application is invented or the investigation of phenomena, acquisition of new knowledge, or correction and integration of previous knowledge
	TRL 1	Basic Principles	The basic properties have been established