Limited Tender Document for Laboratory Scale s-CO_2 loop and Test Section

Overall facility description:

The proposed facility will generate, control, measure and safely handle super-critical CO_2 flow, with conditions specified in Table 1. The s-CO_2 flow thus generated will then be fed into an optically accessible mm sized channel to be called test section, from here onwards.

The gaseous CO_2 from commercially available high purity CO_2 cylinders (minimum pressure 20 bar, maximum pressure 140 bar) must be first fed into a condenser in a controlled manner. The line should have a pressure transducer and appropriate needle valve to control the flow of CO_2 (alternatively a remote-controlled ball valve may be used as an ON/OFF valve). The line from cylinder to condenser should be heated to ensure CO_2 does not freeze/condense on expansion before reaching the condenser. This pressurised gas should then be fed to a condenser which should bring down the temperature of CO_2 and convert it into liquid state.

The liquefied CO_2 will then be fed to a reciprocating/gear pump to increase the pressure. The line from the condenser to the pump should be insulated in order to avoid inflow of heat into the CO_2 from the ambient. The pump will raise the pressure of the liquefied CO_2 to a maximum of 150 bar. A damper (a 5 litre or bigger tank with pressure sensors, rapture disk and safety relief valve) at the outlet of the pump is required so that the oscillations and the unsteadiness in the flow dies out in the downstream. This liquefied CO_2 will then be fed to a heater which will raise the temperature of the CO_2 as required by the user (see Table 1 below) and the heater will convert the state of CO_2 from liquid state to supercritical state before being fed to the test section. The heater should have a computerized feedback loop (possibly through the use of PID controller) so that the CO_2 can be raised to any temperature in the range mentioned in Table 1, as required for the user for the experiments.

The facility must be able to create the following flow and thermodynamic properties of supercritical CO_2 at the inlet of the test section.

Table 1: Required flow and fluid properties at the inlet of the test section

Mass flow rate	1kg/hr to 10 kg/hr
Temperature	300K-643K
Pressure	80 bar-150 bar

One or more pressure sensors and thermocouples are required just before the entry of the test section to ascertain the thermodynamic conditions at the inlet to the test section. The test section is a 400 mm long channel with 2mm x 2mm square cross section (inner dimensions). It should have stainless steel on three sides and quartz/sapphire based optical access on one side. The dimensions of the cross section (2mm x 2mm) including surface roughness can have a maximum allowable deviation of +/- 10 microns. Detailed report on surface roughness and cross section geometry after manufacturing is required. Test section must have independent heat sources with uniform heat flux into the channel, placed on

each of the three SS sides, along the length of the channel. Heater on each side should be capable of independently adding 0 to 0.6 kW (in steps of 0.01 kW) thermal energy, into the s-CO2 flow in the test section. The heat flux from each side should be allowed to be independently varied from the computer. Contact IISc (see below) for further details.

Pressure transducers and thermocouples should be present at the exit of the test section as well. The supercritical CO_2 after exit from the test section must be cooled down. Then a high precision metering valve should be placed. This must have NI DAQ based remote control. The pressure of the flow must then be reduced. Next a Coriolis mass flow controller should be placed, which will be used for ensuring that the desired mass flow rate has been achieved. Pressure should be reduced further after which the flow should pass through a non-return valve to be ejected into the atmosphere.

The data from the pressure sensors, mass flow meters and the thermocouples as well as the mass flow rate, pressure and temperature control of the CO_2 should be remotely accessible and operable with a NI base DAQ operated from a computer.

The maximum pressure that will be encountered in the pipes is 150 bar. The maximum velocities will occur when the mass flow rate is highest (10 kg/hr) and at the point of lowest pressure and highest temperature which are 80 bar and 813 K (at the exit of the experimental set up).

Additional requirements:

1. Ensuring the seamless and safe operation of all items and components, individually or collectively, mentioned here, their purchase, integration and control is in the scope of the vendor. Manual, warranty, calibration, certification and invoice details of all individual components must be provided with the end-user being IISc. Hence appropriate GST, IGST and associated rates and concessions must be utilized. Required documentation must be asked for well in advance.
2. The interested vendor must first present a detailed technical document, including but not limited to detailed facility layout diagram, detailed description and rationale for selection of all components to be used.
3. Remote control and data acquisition should be National Instruments CRIO based.
4. Hydrotesting of individual components with certificates must be provided. Leak testing for full assembly should be done by the vendor.
5. Calibration certificates of all instruments with certification from NABL accredited labs should be provided.
6. All fittings, pipings and piping accessories should be by Swagelok. Certificates required.
7. The 5 litre pressure vessel (damper, size could be chosen appropriately to ensure fluctuations less than or equal to 0.1% of the total mass flow rate) should be from Swagelok with design pressure of at least 300 bar. Rapture disk, pressure sensors and safety relief valve should be appropriately installed. ASME approved vendor certification is required.
8. Mass flow meter should be by Emerson (CFM series).

9. Mass flow rates into the mm sized test section must be steady. Fluctuations in mass flow rate at the entry of the test section must be less than 0.1% of average mass flow rate.
10. Copper gaskets for appropriate joints.
11. The loop must always be able to perform uninterruptedly for a test time of minimum one hour. During the test time the test section entry conditions should be held constant or be ramped only at the command of the user.
12. 3 years warranty on all equipment and the facility.
13. Safety relief valve at appropriate points.
14. Emergency shut down option. Remote electronic option along with multiple manual, fail safe emergency shut down options.
15. Detailed safety audit of the entire facility must be performed after its erection in IISc premises and appropriate certification should be provided.
16. Demonstration of safe and satisfactory operation of the facility, achieving the mentioned flow parameters, control, measurement and ejection of cooled CO_2 in the vent is a must for successful completion of the project.

Bid Submission Guidelines:

i. The quotation should contain two sealed envelopes for a) Technical bid b) Commercial bid. The technical bid should only have the complete technical specifications of their system where the technical specs should be clearly written. Any optional accessory can also be included as optional items in the quote. Commercial bid should have only the offered price including discounts. Quotations should adhere to the following format:
ii. The quote should be addressed to "Chairman, ICER, kind attention; Prof. Swetaprovo Chaudhuri"
iii. The name and address of the company in the official letterhead of the company
iv. Couriered To: The Chairman, Interdisciplinary Center for Energy Sciences, Indian Institute of Science. Attention; Prof. Swetaprovo Chaudhuri.
v. Subject: Quotation for lab scale s-CO_2 facility with test section.
vi. Reference: Limited Tender for lab scale s-CO2 loop and test section.

Other Terms and Conditions:

a. Provide a detailed description of where a s-CO_2 loop facility (at an equivalent or larger scale) has been successfully installed in past (and successfully working at present) by your company /your team, at leading academic and/or R&D institutions in India.
b. Three years of warranty with complete technical support. In case of damage due to manufacturing, or faulty parts, there should be total replacement. In case of damage by user there should be provision for covering complete repair activity whatsoever including but not limited to shipping, handling and repair. In case of damage due to negligent use by user the cost of repair will be borne by the user. However, the vendor should be available within the next two business days in person to cater for such repair

issues. After the warranty period there should also be provisions for a separate annual maintenance contract for immediate support.

c. The total price including all discounts, taxes, transport, loading/unloading should be mentioned in the commercial bid with itemized price details for individual components and sub-component. A good discount on the price will be appreciated. Please note that the standard payment term in IISc is: Payment against satisfactory installation, commissioning and testing to show that the requirements mentioned in Table 1 and elsewhere in the document, have been perfectly satisfied.
d. Documentation indicating adherence and compliance to the above mentioned specifications should be submitted.
e. The last date and time for receipt of the bids are March 22nd, 2019, 12pm.
f. For any further queries contact: Prof. S. Chaudhuri, email: schaudhuri@iisc.ac.in, phone 080-22932875.