



DEPARTMENT OF CHEMICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY MADRAS
CHENNAI – 600036, INDIA

Ref. No. CHE/17-18/CHE/006/GAIM/RAJN

Date: 25 APRIL, 2018

Due date: 9 MAY, 2018

Item: High Pressure Gas Hydrate Exploitation Setup with Injection and Production Wells

1. Two bid quotations (technical and commercial separately) are invited in duplicate for the item shown overleaf (in Annexure I). The quotations duly sealed and superscribed on the envelope with reference no. and due date, should be addressed to the undersigned so as to reach on or before the due date mentioned above
2. Quotations are only invited from firms who have at least five years of experience in fabricating customized lab and bench scale equipment for **gas hydrate studies** and applications.
3. The quotations should be valid for sixty days from the due date and the period of delivery required should also be clearly indicated.
4. The total cost of the equipment in terms of CIP Chennai should be clearly mentioned.
5. Terms of warranty and guarantee should be explicitly mentioned.
6. Packing and delivery charges, customs and clearance duty should be clearly stated.
7. Goods shall not be supplied without an official supply order.
8. Local firms: Quotations should be for free delivery to this institute. If quotations are for ex-godown, delivery charges should be indicated separately.
9. Firms outside Chennai: Quotations should be for F.O.R. Chennai. If quotations are F.O.R. consignor station, freight charges by passenger train / lorry transport must be indicated. If quotation is for ex-godown, packing, forwarding and freight charges must be indicated.
10. The rate of sales / general taxes and the percentage of such other taxes legally leviable and intended to be claimed should be distinctly shown along with the price quoted. Where this is not done, no claim for sales / general taxes will be admitted at any stage and on any ground whatsoever. The taxes leviable should take into consideration that we are entitled to have Concessional GST applicable to non-government educational institutions run with no profit

motive for which a concession sales tax certificate will be issued at the time of final settlement of the bill.

10. Payment: Specify the mode of payment and if advanced payment has to be made. Every attempt will be made to make payment within 30 days from the date of receipt of bill / acceptance of goods, whichever is later.
11. IIT Madras is exempt from payment of excise duty and is eligible for concessional rate of customs duty. Necessary certificate will be issued on demand.
12. IIT Madras has the right to accept the whole or any part of the tender or portion of the quantity offered or reject it in full without assigning any reason.
13. In case of any queries/clarifications, please contact Dr. Rajnish Kumar, Chemical Engineering, IIT Madras, Chennai, E-mail: rajnish@iitm.ac.in.
14. The sealed quotation may be sent to

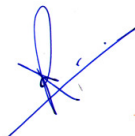
Dr. Rajnish Kumar

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ANNEXURE I

Technical Specifications for High Pressure Gas Hydrate Exploitation Setup with Injection and Production Wells

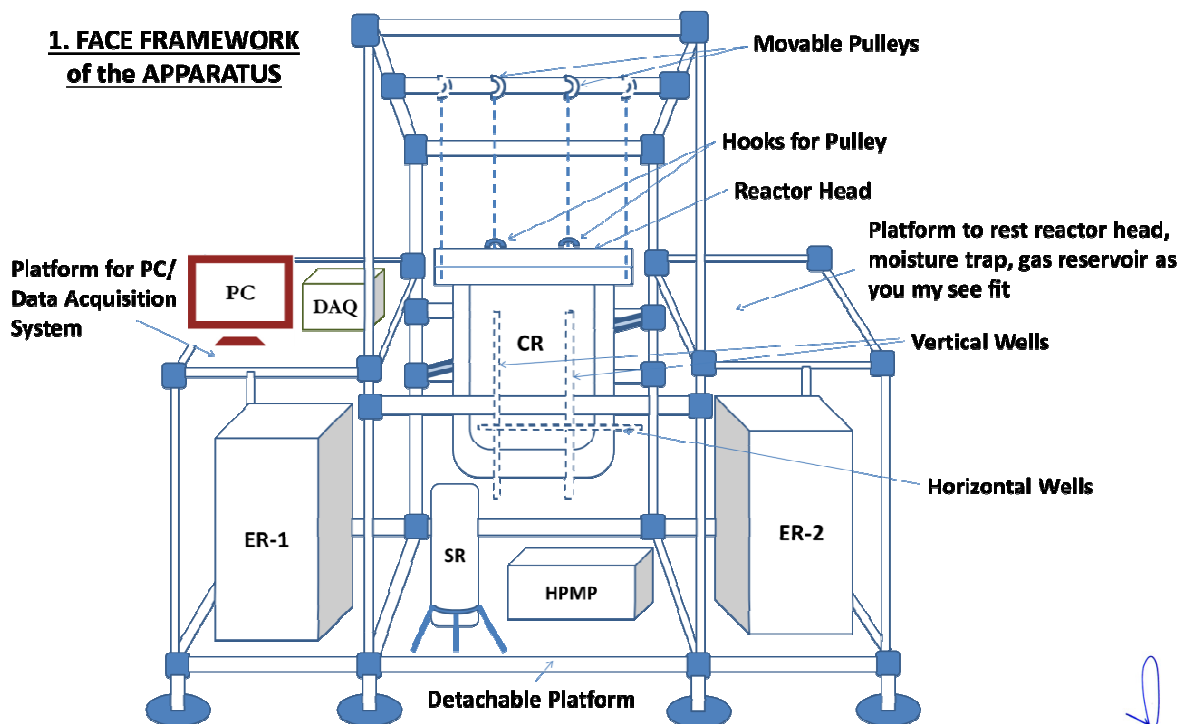
Scope/Application: A highly customized pressure and temperature controlled SS-316 setup is required for gas hydrate studies (please refer the process flow diagram and other details attached with this document). Setup would be operated at sub-zero temperature and up to 200 bar pressure to study synthesis and dissociation of methane hydrate. The temperature and pressure conditions would simulate marine environment. The setup includes high pressure injection well and low pressure production wells to study formation and dissociation kinetics of hydrate growth / decomposition with complete control and real time data acquisition on computer hard drive / flash drive. The study involves exploitation of natural gas hydrate in bench / pilot scale laboratory setup.

Technical Specifications of the Setup:

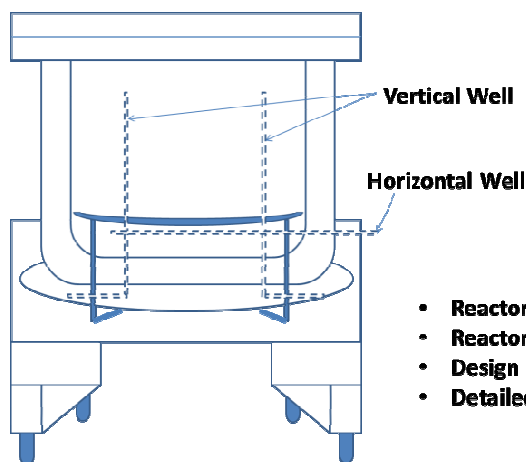
a)	Volume & M.O.C	Approximately 10L net filling capacity with head made from SS-316 Bar stock & body fabricated from SS 316 plates & all wetted parts of SS 316. With fixed head design & pneumatic raising /, lowering and tilting arrangement of the vessel or pulley based raising and lowering arrangement of the vessel. (Note: The internal diameter of the reactor shall be ~240 mm and the length of the reactor shall be ~200 mm)
b)	Design Pressure	200 Bar
c)	Maximum working Temp.	-30 Deg. C to 100 Deg. C
d)	Nozzles & Fittings	i) External Fittings: Pressure gauge, SS316 Pressure Transmitter , vent valve connected to vacuum pump, safety rupture disc, gas inlet- valve, Pressure relief valve of MOC SS- 316, Water inlet valve, 1 nos. spare nozzle with needle valve, vacuum gauge. Note: All valves end connection shall be ½" NPT (M). ii) Internal Fittings: 8 nos. Thermowells from bottom at different levels (with RTD PT-100 temp. sensor), 1no. ½" Injection well & 1no. ½" Vertical production well from bottom, 1 no. ½" horizontal production well from side.
e)	Body & Head Sealing	PTFE Gasket / chemical resistant gasket with split clamp type quick opening system with clamp bolts or C-clamp type opening system.
f)	Heating & Cooling	Through SS 304 jacket with insulation and cladding & M24(M) threads at inlet & outlet.
g)	High pressure metering pump with VFD	For pumping water at a Flowrate of 100ml/min piston pump with a max. discharge pressure of 100 bar, into the reactor through the water inlet valve. Pump should also be capable of working at a back pressure of 100 bar.
h)	Vacuum pump	Oil free pump for 10mbar vacuum inside the reactor.
i)	Detachable Wells	The wells shall be ½" size tubes with perforations to allow flow of solvent. Size of pores: 2mm dia.

		Distance between pores : 1 cm Length of wells: 16 cm for Vertical Wells & 20 cm for horizontal well. MOC: SS 316 (Note: All 3 wells shall be covered with SS mesh of 125 micron & can be detached from the system for cleaning purpose.)
j)	CO2 solvent charging system	It consists of a CO2 gas cylinder mounted on a weighing scale of 0-50kg capacity and accuracy of 1gm. The liquid from the cylinder along with some additives (which shall be added in the line using a small hopper) shall pass through a heat exchanger & SS static mixer of ½" diameter, 100-150mm long and enter the reactor through the injection well.
k)	Moisture Trap	Connected to the outlet of Vertical production well and horizontal production well with inline filter. It consists of 1Ltr SS316 vessel (designed for ~150 bar with L/D of ~10), Pressure gauge, gas / water inlet valve & vent valve. Mounted on a weighing scale of 0-25kg capacity and accuracy of 1 gm. Moisture trap should have some kind of a molecular sieve/packing material to trap the moisture and separate the gas.
l)	Back Pressure Regulator	Pneumatically / electrically operated manual / digital back pressure regulator for 200bar of MOC SS-316 to maintain constant pressure inside the autoclave by venting excess pressure with suitable N2 / O2 gas cylinder, manual regulator and hose pipe
m)	Gas Reservoir/Solvent Reservoir	~1.5 Ltr SS316 vessel designed for ~150 bar with inlet valve, outlet valve, pressure relief valve, pressure transmitter & thermocouple.
n)	Control Panel	SS control Panel with 9 nos. temperature indicator, 5 nos. digital pressure indicator with high pressure alarm.
o)	Data Logger	24 channel data logger capable of storing at least up to 50,00,000 records and records automatically readable in Microsoft Excel.
p)	Piping & Valves	All interconnecting piping & valves.
q)	Mounting	Mounted on Aluminum / SS 304 skid with polishing of complete reactor.
r)	Torque wrench	For uniform tightening, easy operation & ensuring leak tightness.

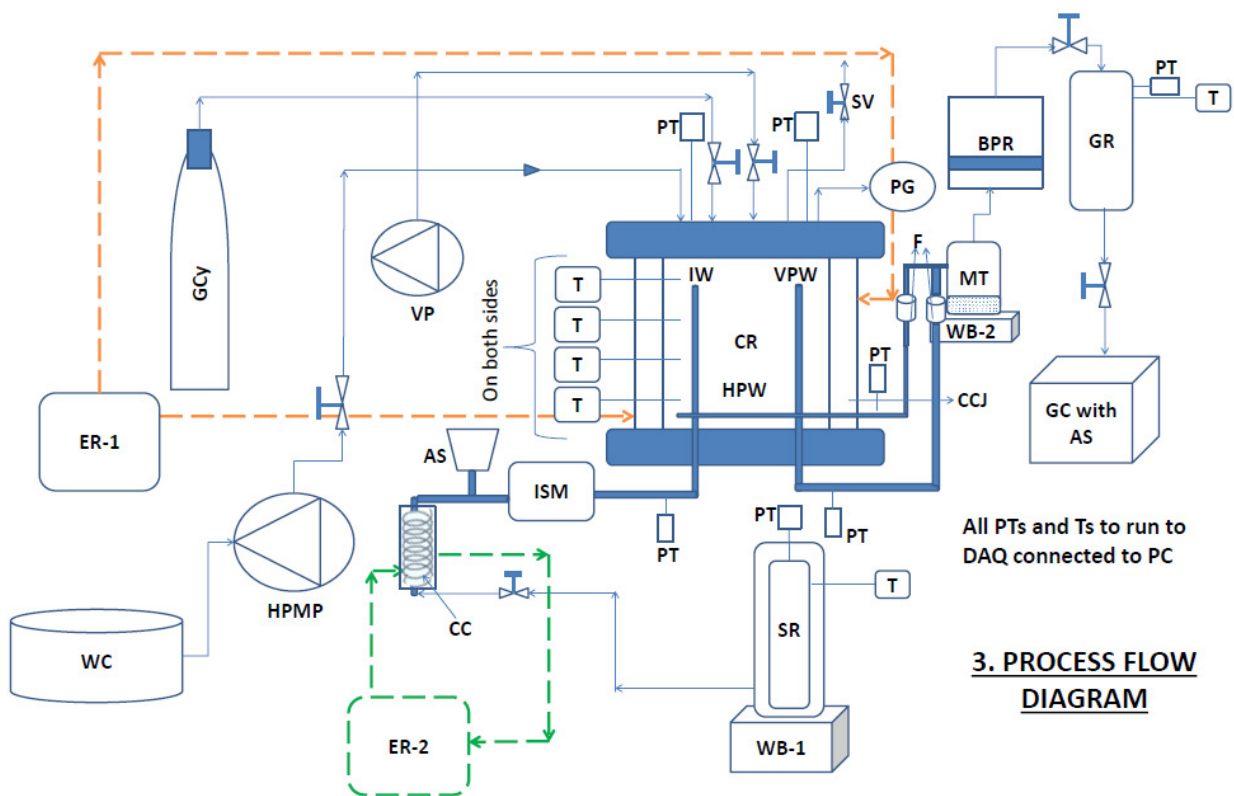
The drawings for this system have been attached below:




2. REACTOR RESTING STATE



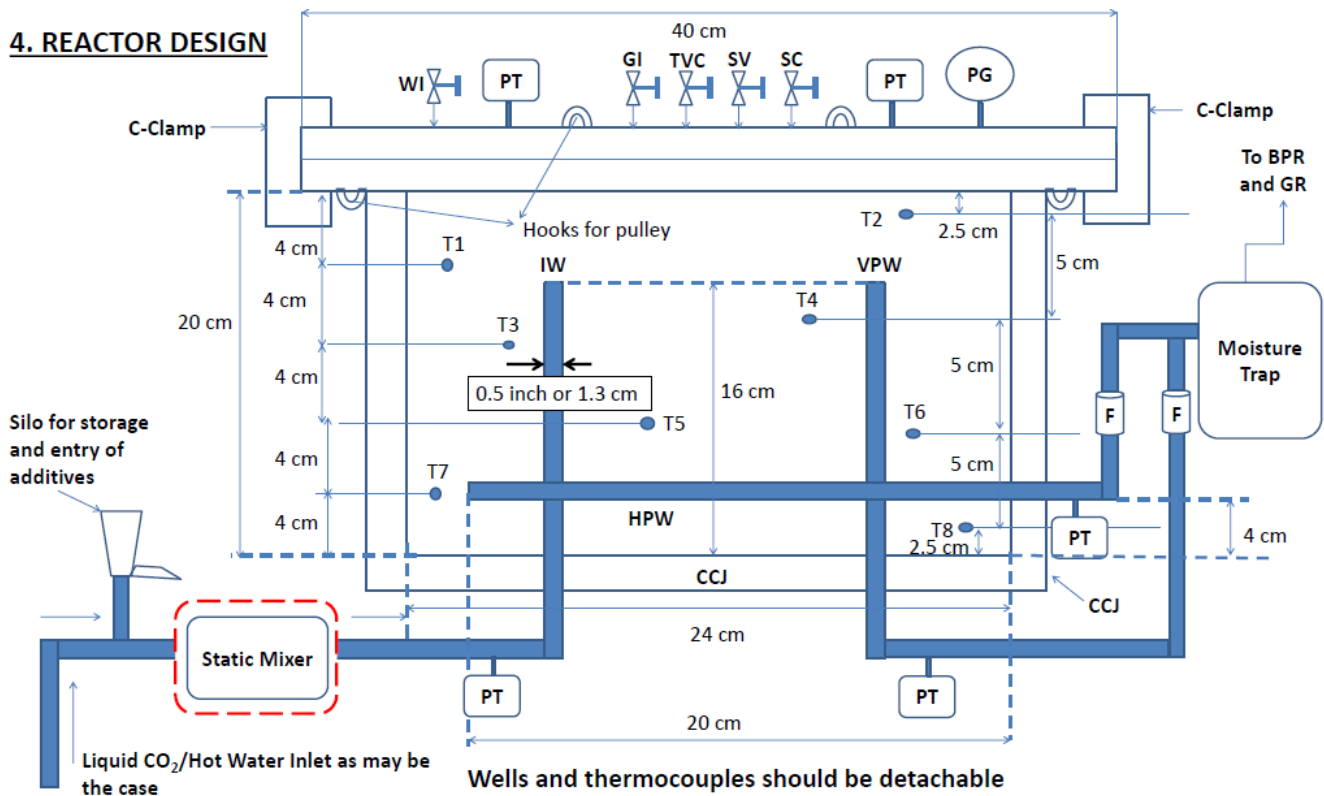
- **Reactor MOC: SS-316**
- **Reactor Volume: 9.04 L**
- **Design Pressure: 250 bar**
- **Detailed reactor design to follow**



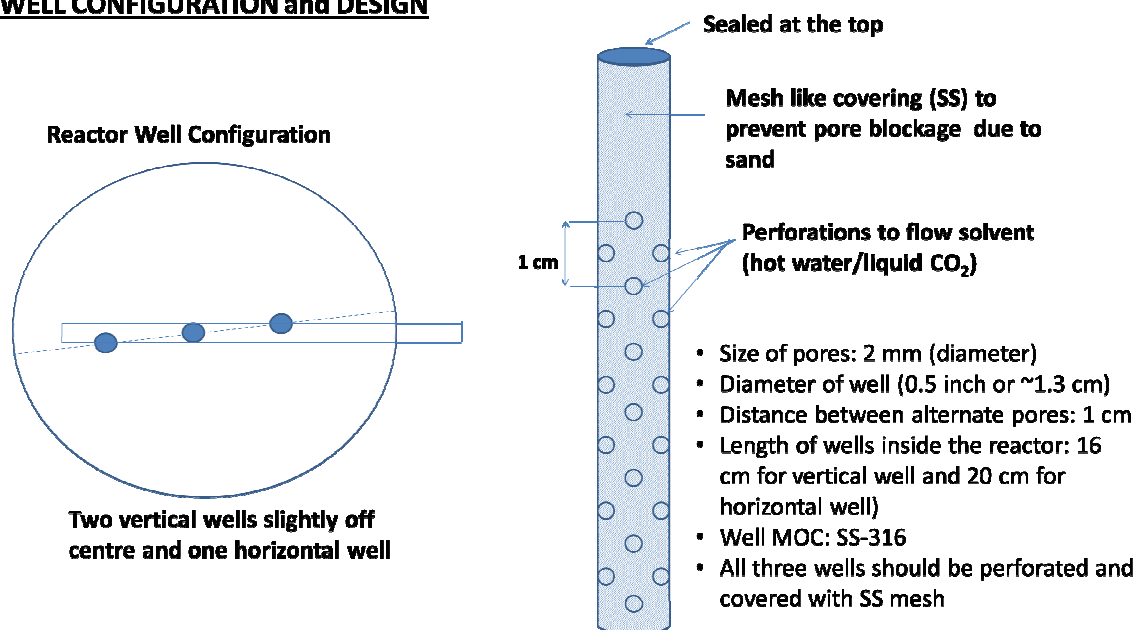
3. PROCESS FLOW DIAGRAM



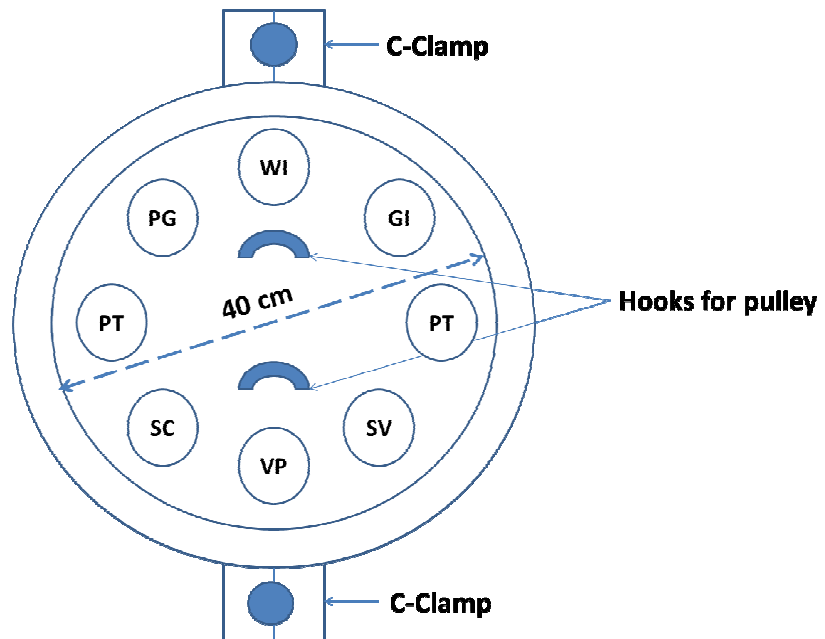
4. REACTOR DESIGN



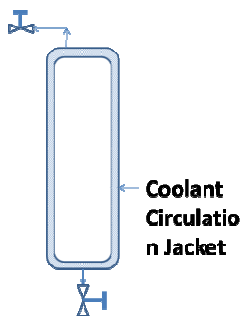
5. WELL CONFIGURATION and DESIGN



6. REACTOR HEAD DESIGN

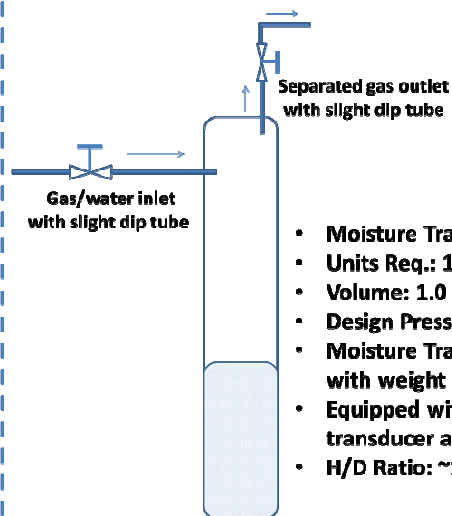


7. SOLVENT RESERVOIR (SR)/ GAS RESERVOIR (GR)



- Reservoirs' MOC: SS-316
- Units Req.: 2 Nos.
- Reservoirs' Volume: 1.5 L
- Design Pressure: 150 bar for SR; 80-100 bar for GR
- Jacket necessary for SR but optional for GR
- SR to be provided with weight balance
- Both reservoirs equipped with one pressure transducer and thermocouple each

8. MOISTURE TRAP (MT)



- Moisture Trap MOC: SS-316
- Units Req.: 1 No.
- Volume: 1.0 L
- Design Pressure: 150 bar
- Moisture Trap to be provided with weight balance
- Equipped with one pressure transducer and thermocouple
- H/D Ratio: ~10

[Handwritten signature]

LIST of ACRONYMS (Exhaustive List for All Figures)

Acronym	Full Form	Acronym	Full Form
ER-1	External Refrigerator – 1	DAQ	Data Acquisition System
G. Cy.	Gas Cylinder	PC	Personal Computer
VP	Vacuum Pump	AS	Additive Storage
T	Thermocouple	ISM	Insulated Static Mixer
PT	Pressure Transducer	BPR	Back Pressure Regulator
SV	Safety Valve	GR	Gas Reservoir
PG	Pressure Gauge	GC with AS	Gas Chromatography with Auto Sampler
CR	Crystallizer	ER-2	External Refrigerator – 2
IW	Injection Well	SR	Solvent Reservoir
VPW	Vertical Production Well	CC	Cooling Coil
HPW	Horizontal Production Well	HPMP	High Pressure Metering Pump
F	Sand Filter/Frit	WC	Water Chamber
MT	Moisture Trap	CCJ	Coolant Circulation Jacket
T1-T8	Thermocouple 1 to Thermocouple 8	WI	Water Inlet
GI	Gas Inlet	TVC	To Vacuum Pump
SC	Spare Connection	WB-1, WB-2	Weight Balance-1 Weight Balance-2

*ER-1 and ER-2 are in customer scope.

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