Detailed Specification for 100 L reactor cum vacuum distillation setup with reflux provision:

I. Introduction:

System shall consist of sub-systems such as
1. Jacketed Reactor of 100 litre gross capacities along with feed charging vessel of 50 litre capacity.
2. Mechanical stirrer with suitable magnetic seal with (Anchor type stirrer made of SS 316L) & with variable speed controller.
3. Reflux provision with condenser and collection vessel.
4. Horizontal condenser – primary and secondary for vacuum distillation
5. Collection flask (2no.s) – 20 L each
6. Various valves such as ball valves, drain valves, vent valves, angle valves, non-return valves etc.
7. Temperature indicators, Pressure and Vacuum gauges
8. Skid mounted structure made of SS 316 and HDPE lining/ powder coating.
9. Safety device - Pressure relief valve, rupture disc, high temperature alarm, flame proof fittings
10. Electric panels for safe area installation
11. Single fluid heating cooling circulator with PID controller

The complete reactor system shall be designed to operate under the following process conditions.
 a) Duty: Batch process
 b) Jacket temperature: 200°C (max.) / -20°C (min.)
 c) Operating pressure (vacuum) : Full Vacuum (10mm Hg (abs)) (Min.) to 0.5 bar (g). (Max.)

The layout of the proposed system is as follows:
II. System Description:

1. The system shall consist of SS316 L make cylindrical reactor with SS 316L make jacket (for connecting a heating cooling unit) operated in the temperature range -20°C to 200°C.
2. The top dome of the reactor will be made of borosilicate glass of 7 mm thickness for enabling better visibility of the contents in the reactor.
3. The agitator assembly shall consist of SS316L make anchor type stirrer with variable rotation speed control for the stirrer (max. rpm 150). Magnetic seal with cooling/ dry mechanical seal shall be provided for the reactor.
4. Suitable motor and gear box of reputed make shall be provided with the agitator assembly of reputed make.
5. Distillation operation shall be carried out in the proposed system.
   a. The glass shell and tube type primary condenser and vent condenser for vacuum drying. Shell and tube shall be arranged horizontally in order to accommodate the system in low head room areas.
   b. The glass shell and tube type primary condenser should be connected to a 6L collection vessel through an isolation valve for reflux provision.
c. Arrangement shall be made such that the distillate shall be collected directly in the graduated spherical receivers (shall be 2 in No.) or recycled to the reactor.

6. Suitable pressure equalization lines with isolation valves shall be incorporated in the system to maintain the hydraulic integrity.

7. Pressure gauge/indicators (Range: 0-6 bar, Unit: Bar) and temperature indicators (Sensor - RTD type, Range: -20 to 200°C) should be provided at appropriate locations to monitor the process parameters. Flows should be monitored by the liquids collected in the graduated receivers.

8. The vacuum manifold should be designed such that vent / vacuum is applied only at one point for the whole system. Arrangement for N₂ purging into the reactor should also be provided.

9. A manifold with regulators to be provided for connecting chiller unit to the condensers for cooling the distillate. (Chiller unit is in the scope of VSSC).

10. Safety equipment like over pressure relief valve, rupture disc, high temperature alarm and flame proof fittings shall be incorporated in the system.

11. All drains should be routed to ground elevation. The drain valves should be at a height of 1 m from ground.

12. Note: All the MOC coming in contact with process medium (both liquid and vapor) and the operating knobs of the valves including the skid mounted structure of the system shall be only borosilicate glass and SS316L.

13. The overall dimensions of system excluding the single fluid heating cooling unit should not exceed 3 x 3 x 3 m.

14. Dry vacuum pump and chiller for condensers shall be in the scope of VSSC.

III. Features of the sub-systems shall be

1. Reactor
   - Cylindrical reactor of (100 litre capacity) suitable dimensions.
   - Working volume of the reactor is 80 litres.
   - Minimum stirred volume - 6.0 L

   Nozzles to be provided are
   1. Feed Nozzle with isolation valve and glass funnel integrated to feed liquid gradually along with soluble solid ingredient.
   2. Discharge valve in the bottom (flush open bottom)
   3. Vapour outlet to distillation cum drying column
   4. Solid charging hand hole with quick release coupling
   5. Agitator with coupling
   6. Liquid recycle
   7. Temperature of liquid with suitable glass thermo-well -2 no.s (For inserting RTD to measure liquid temperature when filled up to 10% of the working volume i.e, minimum measurable volume for temperature indication should be 6 litres).
8. Pressure relief valve (for relief under positive pressure at 1.5 bar absolute) – Spares to be provided (1 No)
9. Rupture disc of suitable rating
10. Spare Nozzle (with plug or isolation valve)
11. N₂ purging port (with isolation valve).

- Reactor shall consist of provision to feed the contents, discharge the contents, vapour outlet, liquid recycle, nitrogen purging and an additional port for measuring the liquid temperature of the contents.
- The solid feeding port will have a hopper & an isolation valve.
- The top dome of the reactor will be made of borosilicate glass of 7 mm thickness for enabling better visibility of the contents in the reactor.
- All the glass vessels shall be graduated (in 250 ml graduation up to 90% of full volume) on its surface for water volume.
- All glass components shall be made of Borosilicate glass.
- A suitable platform for charging the feed to the reactor to be provided if feed port is at a height greater than 1.5 m from ground. The platform must be made of SS 316L.
- Reactor jacket must be able to withstand up to a pressure of 6 bar (g) minimum.
- The outside jacket of the reactor must be provided with suitable insulation material (non carcinogenic, preferably glass wool) so that the outer surface of the raw material will be at room temperature even when the reactor may be operating at -20°C or 200°C.

Supply of spare dummy flange assembly for closing the Reactor flask:
Party shall supply 2 Nos of additional heavy duty, leak proof dummy flange assembly made out of borosilicate glass for closing the main reactor flask for operating the system after the removal of agitator/ mechanical seal assembly for certain application.

Feed Charging vessel:
- A separate feed charging vessel of 50 litre volume (with proper graduation) to charge the feed into feed flask under vacuum shall be provided. Suitable isolation valves shall be provided for easy loading and transfer under vacuum.
- Shall be made of Borosilicate glass.

2. Mechanical stirrer with suitable magnetic/ dry mechanical seal
- Anchor type agitator of variable speed (VFD) to adjust the speed of the stirrer with features such as double bear housing, seal housing, magnetic seal with cooling system/ dry mechanical seal of reputed make, flame proof motor of reputed make with VFD control (max. rpm 150).
- All metal components used for double bearing housing, seal housing etc., should be of SS 304L/ SS 316L as per suitability.
• Stirrer shall be of SS 316L (anchor type) and should immerse to nearly 10% of the minimum working volume i.e 6.0 lit.
• Suitable Gearbox (Make: Bonfiglioli/ any other reputed make) and motor (Make: Crompton/ABB/Siemens) shall be provided.
• Minimum stirred volume - 6.0 L
• The magnetic seal of the stirrer must come with cooling system.

3. Horizontal condenser for distillation cum drying line
• Suitable horizontal primary condenser shall be provided as per the design with min. H.T area as 2.5 Sq.m.
• Coolant of the condenser is MEG + Water solution/ water.
• The vapour should travel in shell side and coolant in tube side.
• MOC: Boro Silicate glass shell and coil.
• Suitable secondary or vent condenser should be provided with min. 1 sq. m heat transfer area.
• Isolation valve, preferably ball valve, needs to be given in the line connecting the reactor to the first condenser.
• A reflux ratio controller with point of contact made of glass to be provided.
• An isolation valve needs to be provided between primary condenser and reflux collection vessel.
• The liquid for reflux should first be collected in a 6 L graduated cylindrical collection vessel with provision for drain valve.

4. Collection flasks
• A suitable graduated spherical collection flasks of volume 20 litres (2 No’s) shall be provided.
• Collection flasks shall have a drain valve.
• N₂ purging port with isolation valve to release the vacuum.
• Vent provision with isolation valve.
• Vessel should be suitable graduated with visible markings showing water volume in litres.
• Shall be made of Borosilicate glass

5. Temperature, pressure and vacuum gauges with indicators
• Temperature indicators (with RTD sensors) to measure the temperature of the contents in the flask i.e liquid temperature, vapour temperature above the vertical column, vent temperature and the chilled water temperature (to be circulated in the condenser and temperature shall be measured in the chilled water return from the primary condenser) with suitable thermowells made of Borosilicate glass.
• There should be 2 temperature sensors in the reactor. The output of one will go to the single fluid heating cooling unit and other to the main display of reactor parameters.
- A pressure sensor is required in the reactor.
- A vacuum gauge must be provided in the distillation cum drying line/vacuum manifold.
- A temperature sensor is required to measure the vapour temperature in both the primary condensers.
- Temperature sensors are also required for the oil inlet and outlet lines, cooling water inlet and outlet lines.
- RTD’s shall be made with SS sheath material cover and suitable head mounted transmitter.
- The system shall have provision to apply vacuum since the distillation has to be carried under vacuum.
- Entire system shall be provided with suitable provision to apply vacuum and also nitrogen for purging purpose.
- Suitable pressure and vacuum gauges in the vapour line shall be provided.
- Gauges shall be of reputed make ranging 0-6 bar and vacuum in full range.
- Suitable vacuum manifold shall be provided to apply the vacuum.

6. **Single fluid heating cooling circulator with PID controller**
   - Temperature range -20 to 200°C
   - PID controller with accuracy of ±0.5°C
   - Must have provision for measuring reactor temperature and jacket temperature.

**Specification for temperature, Pressure and Vacuum gauges:**

1. RTD for temperature measurement:
   a. Sensor type : Pt-100 (RTD)
   b. Measuring range: -25 to 200°C
   c. Accuracy: 0.1°C
   d. Unit of measurement: Degree Celsius
   e. Indicator: Suitable digital indicator shall be provided in the control panel for indicating the liquid temperature, vapour temperature, vent temperature and the chilled water temperature measured.
   f. Liquid temperature shall be indicated both in the single fluid heating cooling unit controller and in the separate indicator.
   g. All sensors shall be provided with suitable glass thermo well and no sensor should be directly exposed to process media.
   h. Shall be of reputed make.

2. Pressure gauge:
   a. Sensor : Diaphragm type
   b. Measuring range: 0-6 bar
   c. Accuracy: 0.01 bar
   d. Dial size: 100 mm
e. Unit of measurement : bar
f. Connection details: suitable connection with the system
g. Shall be of reputed make
h. MOC : SS with PTFE coated

3. Vacuum gauge :
   a. Sensor : Diaphragm type
   b. Measuring range: 0-760 mm of Hg
c. Accuracy: 1 mm of Hg
d. Dial size: 100 mm
e. Unit of measurement : in mm Hg
f. Connection details: suitable connection with the system
g. MOC : SS with PTFE coated

4. Vacuum gauge (Manual dial gauge):
   a. Measuring range: 0-760 mm of Hg
   b. Accuracy: 1 mm of Hg
c. Dial size: 100 mm
d. Unit of measurement : in mm Hg
e. Connection details: suitable connection with the system

7. Valves

   A. Glass Valves:

   In general, all the valves shall be made of the glass quality SCHOTT standards only. All the inner / contact parts of the valve shall be of PTFE / SS 316L. Valves shall be designed as screw type and robust to ensure easy operation. Shall be fully corrosion resistant and chemically inert. MOC of the valves including the operating knobs shall be strictly of SS 316L only. This needs to be strictly ensured, since in case of any leak or explosion the material should not react with the system components.

   The following valves shall be provided in the system.
   a) Flush bottom outlet valve for the main reactor vessel.
   b) Drain valves for all the other vessels such as feed vessel, receivers, bubblers etc.
   c) Vent valves in the receivers
   d) Non – return valves in the bubbler system
B. Ball valves of SS 316L:
- All the connections such as drain, valve, cooling water inlet, cooling water outlet and water inlet of the hot water bath shall be provided with suitable flanges and ball valves made of SS 316 L.
- Ball valves shall be of reputed make.

8. Skid mounted structure
- The entire system shall be skid mounted with SS 316 tubular supporting structure with structural accessories.
- Structural accessories shall be of powder coated / HDPE coated.
- Entire glass distillation set up shall be mounted on a compact type single structure. However, control panel shall be mounted separately with a self supporting structure made of SS304 at a distance of 1 meter minimum from the skid mounted structure of the set-up.

9. Pressure relief valve
- Pressure relief valve shall be made of Borosilicate Glass with PTFE coating shall be provided.
- It shall be mounted on the body of the reactor.

10. Rupture Disc
- Rupture disc of suitable pressure rating given for safety of the system.

11. Electric panels enclosed in safe area enclosures:
- Self supported safe area control panel shall include the digital temperature indicators (liquid, vapour, and reactor) with chartless recording of all the process parameters having USB read out for the data retrieval, stirrer speed controller (VFD), rpm indicator / controller, pressure and vacuum indication, Agitator ON / OFF indication, Power ON /OFF indication to be installed in safe area near to the reactor.
- Recorder shall be of reputed make.
- The control panel shall be kept at a distance of minimum 1 meter from the distillation setup / skid structure.
- Agitator motor shall be of flame proof and totally enclosed type with that of reputed make.
- A separate digital display with controls for the single fluid heating cooling unit to be provided. This will have reactor temperature, cooling fluid inlet and outlet temperature, indication for heating / cooling mode ON/ OFF, jacket temperature, set temperature inside reactor etc.
12. **Glass Nozzles**
   - All glass process equipment and vessels should be provided with suitable sized nozzles as per process requirements.
   - Spare nozzles should be provided wherever necessary and feasible.
   - All spare nozzles should be coupled with matching glass closures with quick release coupling.
   - Appropriate nozzles should also be provided for the installation of monitoring instruments / sensors.

13. **Couplings (Backing Flanges)**
   - Reinforced plastic coupling Flanges, corrosion resistant for both acidic and basic media, should be provided.
   - The flange standard should be as per SCHOTT *(SCHE / SCHD)*
   - Appropriate and matching standard flanges should be provided for coupling the monitoring instruments (PI, TI etc.) to the glass equipment / pipeline.

14. **Nuts & Bolts**
   - Nuts and bolts shall be of SS 316.
   - Nuts & Bolts should be as per SCHOTT coupling standards (with lengths suitable for installation with compression springs).

15. **Compression Springs (MOC: SS 304L / SS 316L)**
   - The coupling flanges should be tightened using suitably designed compression springs in order to compensate for linear changes due to temperature effects.
   - Compression Springs should be as per SCHOTT *(DFED)*

16. **Gaskets**
   - High quality PTFE ‘O’ ring collar type for glass to glass connections.
   - High quality PTFE envelope type of gasket for glass to non-glass connections.

17. **Glass Flange End form (BUTTRESS ENDS)**
   - End-form ball or socket as applicable as per the SCHOTT engineering design to articulate components by up to 3 degrees.

18. **Interconnecting pipelines and bends**
   - All interconnecting pipelines and bends shall be of appropriate sizing (minimum 25 mm) shall be provided by the party with MOC as BSG or PTFE only.

19. **List of Spares required**
    The following spares shall be supplied
- Dummy flange for main reactor (borosilicate) with connecting assemblies - 2 No's
- Tool kit set - 1 No
- RTD's – 2 No’s
- Vacuum gauge – 2 No’s
- Temperature Indicators – 2 No’s.
- Pressure relief valve – 1 No.
- Condensers of 2.5 m² area – 2no.s
- Spare nozzle for reactor for mounting rupture disc, pressure release valve etc.
- Valves
  a) Flush bottom – 1 No
  b) Angle Valves – 6 No’s
  c) Vent valves – 2 No’s
  d) Drain Valves – 4 No’s
  e) NRV – 2 No’s

**IV. Bill of Materials:**

Party has to quote separately with detailed specifications as provided above for each sub-system with bill of materials as given below.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Item Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01</strong></td>
<td><strong>Glass reactor set up</strong>&lt;br&gt;a. Feed Vessel and accessories</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>b. Reactor vessel and its accessories</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>c. Primary condenser</td>
<td>2 Nos.</td>
</tr>
<tr>
<td></td>
<td>d. Secondary condenser</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>e. Collection flasks of 20 litre capacity</td>
<td>2 No’s</td>
</tr>
<tr>
<td></td>
<td>f. Separation cum drain column for reflux line</td>
<td>1 No.</td>
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<tr>
<td></td>
<td>g. Vacuum manifold</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>h. Interconnecting glass Pipelines</td>
<td>1 Set</td>
</tr>
<tr>
<td></td>
<td>i. Valves</td>
<td>1 Lot</td>
</tr>
<tr>
<td></td>
<td>j. Associated coupling flanges, adaptor flanges, Gaskets, SS Nuts and Bolts, SS compression rings etc required for the assembly of total system</td>
<td>1 Lot</td>
</tr>
<tr>
<td><strong>02</strong></td>
<td>Agitator assembly with accessories</td>
<td>1 No</td>
</tr>
<tr>
<td><strong>03</strong></td>
<td>Safety rupture disc</td>
<td>1 No</td>
</tr>
<tr>
<td><strong>04</strong></td>
<td>High temperature alarm</td>
<td>1 No</td>
</tr>
<tr>
<td><strong>05</strong></td>
<td>Electrical panel for display and control of reactor parameters</td>
<td>1 No</td>
</tr>
<tr>
<td><strong>06</strong></td>
<td>Skid mounted structure</td>
<td>1 No</td>
</tr>
<tr>
<td><strong>07</strong></td>
<td>Safety Pressure relief valve</td>
<td>1 No</td>
</tr>
<tr>
<td><strong>08</strong></td>
<td>Single fluid heating cooling unit with PID controller</td>
<td>1 No</td>
</tr>
<tr>
<td><strong>09</strong></td>
<td>Spares: As per the list enclosed above</td>
<td>1 Lot</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Erection Installation and Commissioning services at our site</td>
<td>1 Lot</td>
</tr>
</tbody>
</table>
V. Safety features:

The following safety features shall be included in the system.
1. Glass Systems shall be made of boro-silicate glass only.
2. MOC of the parts of the reactor coming in contact with the process fluid shall be strictly of SS 304L/316L Boro silicate glass only.
3. MOC of the valves including the operating knobs shall be strictly of SS 304 coated with PTFE/PTFE/ Boro silicate glass only.
4. Safety pressure relief valve shall be incorporated in the system.
5. A rupture disc of suitable rating to be provided.
6. All motors shall be of flame proof nature.
7. A high temperature alarm to be incorporated into the reactor system.
8. All the instrumentation such as indicators, temperature controllers and electrical panels shall be mounted in a safe area enclosure.
9. MOC of reactor will be SS 316L with glass lining and SS 316L jacket.
10. The entire system should be leak proof and must be able to maintain a vacuum of 10 mm Hg inside during operation.
11. Since the outer surface of the jacket of the reactor will experience high temperature, the party must provide insulation, preferably made of glass wool over the jacket such that the outer side of the insulation will be at room temperature even when the reactor is operating at 200°C or -20°C.

VI. General Conditions:

- **Standards:**
  The following standards shall be met:
  - BS EN 1595:1997 General rules for design, manufacturing and testing, compatibility and interchangeability.
  - BS EN 12585:1999 Glass plant, pipeline components and fittings.

- **Glass quality:**
  All the glass process equipment, pipeline and components shall be fabricated from 3.3 expansion borosilicate glass from SCHOTT DURAN.
  - Party has to supply the material certificate of the glass from the manufacturer SCHOTT DURAN.
  - Interconnecting process pipelines and valves of appropriate sizing for the complete system shall be provided.
  - All the inner /contact parts of the valve shall be of PTFE. Valves shall be designed as screw type and robust to ensure easy operation. Shall be fully corrosion resistant and chemically inert. MOC of the valves including the operating knobs shall be strictly of SS 316L coated with PTFE/PTFE/ Boro silicate glass only. This needs to be strictly ensured, since in case of any leak or explosion the material should not react with the system components.
• Reinforced plastic coupling flanges (highly corrosion resistance), adaptor flanges, PTFE gaskets, SS 316L nuts and bolts, and SS compression springs shall be provided for the entire system where ever required.
• All glass process equipments and vessels are provided with suitable sized nozzles as per the process equipments.
• Spare nozzles shall be provided / coupled with matching glass enclosures wherever necessary and feasible.
• Appropriate nozzles shall be provided for the installation of monitoring instruments / sensors.
• The coupling flanges shall be tightened using suitably designed compression springs in order to compensate for linear changes due to the temperature effects.
• Party shall clearly spell out type and size of connection provided in each vessel in their offer including the length of glass thermo well provided for each RTD's.
• All the sensors shall have valid calibration certificates provided from the NABL accredited labs.
• Party shall provide material compliance certificate (BSG / SS 304 etc.) for each of the components.
• Detailed engineering drawing & layout shall be provided to VSSC along with quotation.
• **Drawings approval**: Detailed schematic drawing of the entire setup with exact sizing and dimensions has to be submitted by the party to VSSC for approval before fabrication.
• **Pre-Delivery Inspection**: The entire system shall be inspected at your site, prior to dispatch with hydro tests.
• Site inspection, testing and acceptance – The entire set-up will be accepted after testing at the site for operation of the heating system along with sensors in programmed mode of heating through PID controller with satisfactory performance of entire system.
• Suitable stand made of SS material shall be provided for commissioning of the control panel at a safe distance.
• All the items have to be properly packed during shipment with proper warning labels and loading instructions such that the same is received at the site without breakage.
• Party has to provide labels for identification of individual sub-systems.
• Party has to assemble the entire system at our site and demonstrate the performance once again for final payment. Any broken / damaged items / glass wares during transit has to be replaced without additional payment.
• Party has to bring out the deviations in the specifications as that of the given in the offer, clearly (if any)
• Party has to adhere to the time schedule given in the offer strictly.
• Party has to provide the minimum warranty period of one year from date of the commissioning of the reactor at PFC site.
• Party has to provide the offer for the spares as mentioned in the list, separately along with the offer.
• Party has to agree for AMC for 3 years after completion of warranty period. (A separate indent will be raised for the same at the appropriate point of time)
• Party has to provide the break up cost of the each system / component along with the bill of materials with quantity.
• Party has to quote the item, “FOR VSSC, TRIVANDRUM”. Quote separately for the installation and commissioning at VSSC.
• Party has to duly fill and submit the compliance matrix provided along with the offer, without any fail. Party has to bring out deviations if any, in the compliance matrix strictly.
• Foundation bolts has to be provided for all electrical panels, main skid mounted structure, VFD panel, display panel etc.
• Documents: The following documents shall be submitted along with the supply
  1. P&ID of the process system
  2. General arrangement and dimensional drawings
  3. Detailed parts list and bill of materials.
  4. Itemized spare parts lists for two years of maintenance free operation.
  5. Test and final inspection reports.
  6. Manual and warranty certificates for all the equipments such as motors, VFD, mechanical seal system, controllers, indicators and process set up.

**Installation and commissioning:** Party must come on site to VSSC for installation.

• Party has to ensure to assemble all the systems on a skid mounted structure with least minimum floor area.
• Party must demonstrate the performance of the reactor, distillation setup & heating cooling unit with controller by taking a trial run where the process temperature will be varied as given in the specification of the reactor.
• Vacuum leak proofness of the reactor cum distillation setup to the level given in the specification must also be demonstrated for successful completion of installation. (Vacuum pump will be provided by VSSC)