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TITLE:

TECHNICAL SPECIFICATIONS FOR THE REVAMPING OF A LIQUID PHASE OLIGOMERIZATION PILOT PLANT OPERATING IN SEMI-BATCH MODE AND EVALUATION CRITERIA OF THE OFFER

Centro Ricerche ENEA di Trisaia

ROTONDELLA (MT)

Luglio 2021

0		Prima emissione			
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REV.	*DESCRIZIONE*	*DATA*	*REDAZIONE*	*CONVALIDA*	*APPROVAZIONE*

This is an English courtesy translation of the original documentation prepared in Italian language.

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1. INTRODUCTION

The supply relates to the revamping of an existing crystallization pilot plant (hereinafter referred to as "crystallization plant" to a liquid phase reaction pilot plant operating in semi-batch mode for the production of oligomers with different viscosity cuts starting from monomers organic (hereinafter referred to as the “oligomerization plant”). The crystallization plant is mounted on a skid and is installed at the ENEA research center in Trisaia, Rotondella (Matera).

The supplier will have to provide for the transfer of the existing skid (equipped with wheels) within the same research center. The transfer requires partial disassembly of the existing skid as discussed below.

The skid-mounted oligomerization plant will be installed outdoors.

ENEA will carry out the civil works necessary for the installation of the skid as well as the useful works to make the utilities available at the limits of the battery.

2. SCOPE OF THE DOCUMENT

The purpose of this document is to provide all the basic technical information useful for the preparation of a technical-economic offer regarding the supply and installation of all the equipment and auxiliary services for the revamping of a crystallization pilot plant to be used as a plant. liquid phase oligomerization pilot, as reported below.

Any changes, additions or improvements must be reported in the technical offer.

The economic offer must report the total price for the entire supply on site.

3. DESCRIPTION OF THE SUPPLY

3.1. General description of the existing crystallization plant

The P&ID of the current crystallization plant, a 3D sketch and some photos are shown in the attachment "**ENEA0120-B5-001-00: P&ID, SKETCH 3D E FOTO IMPIANTO DI CRISTALLIZZAZIONE**".

The existing system consists of the following main components:

• Borosilicate glass additive dosing tanks (S-101, S-102);

• Jacket crystallization reactor (R-104) with internal diameter equal to 700 mm and total height (bottom-lid) equal to 1105 mm;

• Borosilicate glass (E-105) tube bundle head condenser equipped with E-110 condensing coil;

• Condensate collection tank (S-106);

• Thermostat control unit of the electrically heated diathermic oil reactor (E-107);

• Reactor circulation pump (P-109);

• Thermostatic diathermic oil circulation pump (P-108).

• All process lines are in borosilicate glass as reported in the P&ID;

• The system control unit is absent.

ENEA carried out the following actions:

• Disassembly of all borosilicate lines;

• Disassembly and functional check of the existing electro-instrumental components;

• Check operation of component E-107 heating resistors and P-108 pump;

• Disassembly of the agitator of component R-104.

At present, the plant is therefore composed of:

• R-104 reactor without stirrer;

• E-105 head capacitor with E-110 component;

• S-106 condensate collection tank;

• E-107 thermostatic control unit with P108 pump connected to R-104 reactor;

• ATEX electrical cabinet

The crystallization plant is mounted on a skid that has the following dimensions

Length: about 5m

Width: about 2.9m

Height: about 5.4m

3.2. Brief description of the process

The oligomerization plant shall be able to conduct oligomerization reactions in the liquid phase using a jacketed stirred tank reactor operating in semibatch mode and equipped with a recycling line. Once the monomers (C10-C12 olefins) have been loaded into the reactor, they must be brought to the reaction temperature (<200 ° C) by using diathermic oil circulating in the reactor jacket. Once the desired temperature has been reached, the catalyst (di-tert butyl peroxide) is fed into the reactor. Since the oligomerization reaction is exothermic, and with the aim to keep the reactor in isothermal conditions, the heat produced shall be removed by cooling with a plate heat exchanger installed on the reactor recycling line and cooled with coolant. Due to the formation of vapors (mainly organic vapors such as acetone, tert-butanol alcohol) it will be necessary to condense these vapors by

means of a water-cooled shell and tube condenser. The condensate can be returned to the reactor or discharged. Non-condensed vapors and gases produced (mainly methane) must be burned in the flare. Nitrogen will be used as an inert/purge fluid.

3.3. Design of the oligomerization plant and revamping

The P&ID of the oligomerization plant to be built on the basis of the existing crystallization plant and related 3D views are shown in the attachment "**ENEA00120-B5-002-00: P&ID SKETCH 3D - IMPIANTO DI OLIGOMERIZZAZIONE**".

In particular, the main features of the oligomerization plant are here summarized:

- The plant must be able to conduct oligomerization reactions in liquid phase for the production of oligomers at different viscosity cuts as shown in Table 1.
- The plant consists of four units: a reagents supply unit, a liquid catalyst supply unit, a reaction unit with condensate recovery, a vent treatment unit. The characteristics of the reactants, the catalyst and the reaction products are shown in Table 1.
- All lines and main components have already been sized or have technical specifications useful for the supply. The revamping of process lines consists of the replacement of the current glass lines with lines in AISI316 stainless steel.

The following are the main existing and new components that the oligomerization pilot plant must be equipped with:

- The following existing components will need to be maintained:

- R-104 reactor with M-104 stirrer motor and sealing oil cooling system;
- E-104 glass shell and tube condenser;
- E-110 glass cooling coil;
- S-101 and S-102 glass additive dosing tanks;
- S-106 condensate collection tank;
- E-107 diathermic oil heating system with relative P-108 circulation pump;

- The following components shall be supplied:

- Double-blade agitator (ME-104): the supplier will be able to evaluate the modification of the current agitator as will be described later;
- Gear recycling pump (P-109N) for hydrocarbon oligomers operating up to 200°C and 8.5

barg with flow control;

- Condensate dosing pump (P-106);
- 20 kW plate exchanger (E-112), cooling fluid / hydrocarbon oligomer;
- Diathermic fluid equivalent to Essotherm500 (1500 liters);
- P-125 feed pump with flow meter;
- Reagents skid (SKID 1) with 3 tanks (volume: 100L, 200L, 200L) in AISI316, insulated, with head valve and double discharge valve, agitator, load cells, flushing, PSV, electric heater, temperature / pressure indicators, level switch
- Catalyst skid (SKID2) with 100L tank in AISI316 (insulated, internal coil, agitator, flushing, PSV, temperature / pressure indicators, level switches, and so on), double diaphragm dosing pump with overpressure valve, double pipe heat exchanger, oval wheel flow meter bases feeding system for the catalyst, chiller for temperature control of the catalyst tank;
- Knockout drum, hydraulic guard and open flame torch: existing components will be used
- Actuators and flow meters for the control and measurement of the flow rates of all process and auxiliary streams, manual, safety, overpressure, non-return valves as per P&ID;
- Pressure, temperature, level and flow rate meters and transducers necessary for the proper functioning and monitoring of the system as per P&ID;
-Coriolis flow meters on the P-109N, P-106 and P-125 pump deliveries;
- Oval wheels flow meter on the delivery line of the P-130 pump;
- Additional tanks, such as T-140 and T-160 (300 liters);
- Piping and fittings in AISI 316 / AISI316L steel;
- Interface glass tubing;
- Insulation for operator safety and to avoid condensation in cold pipes;
- Electric panel with ATEX module and PLC control system.

The supply must also include:

- Detailed engineering for the construction of the plant, supervision software, procurement, management, etc.
- workshop construction, transport costs, construction site safety costs, on-site assembly, etc.
- cold-commissioning, commissioning, personal training, etc.

- Hazop analysis / User manual / Technical file / Certifications
- Contingencies, deposits, sureties, mark-ups, ect.

3.4. Physico-chemical properties of the process substances

The pilot plant shall be designed and built to be able to treat the following substances:

TABLE 1 – Physico-chemical properties of the process substances	
Reactants	
Typical composition	C10-C16 aliphatic hydrocarbons
Temperature	Room temperature
State	liquid
Load/batch	200 kg
Loading time	<30 minuti
Catalyst	
Typical compostion	Di-tert butyl peroxide
Temperature	Room temperature
State	Liquid
Products	
Temperature	Room temperature
State	liquid
Typical composition	Oligomers with different molecular weight
Density	840-880 kg/m^3 at RT
Viscosity	5-300 cSt, at 40°C
Heat capacity	2-2.5 kJ/KgK
Thermal conductivity	0.10-0.15 W/mK

3.5. Operation conditions of the pilot plant

The pilot plant must be able to operate in the following conditions:

- Maximum temperature of the catalyst storage tank: 20 ° C
- Maximum system pressure: 1.5 absolute bar
- Maximum R-104 reactor temperature: max: 200 ° C
- R-104 reactor capacity: 300 liters

• Maximum temperature of reagent storage tanks: 100 ° C;

• Catalyst flow rate in pump P-130: 0-25 liters / h;

• Reactant loading time: <30 minutes;

• Recycling line flow rate with P-109N pump: norm 3 m^3 / h

3.6. Main features new components to be supplied and installed

3.6.1. Plate heat exchanger E-112

The E-112 exchanger has the purpose of cooling the recycle stream processed by the P-109N pump as reported in the P&ID.

The E-112 exchanger shall be a plate exchanger with an exchange capacity of 20 kW. For sizing, the following data can be considered:

- Hot fluid flow rate to be cooled: about 3 m^3/ h

- Type of hot fluid to be cooled: hydrocarbon mixture of different molecular weight as indicated in the table in paragraph 3.4.

- Hot fluid inlet / outlet temperature: 160 °C/146.5 °C

- Type of cooling fluid: demineralized water or other low fouling liquid;

- Operating pressure: norm 10 bar, max 20 bar

- Operating temperature: min 5 ° C, max 200 ° C

3.6.2. Recycle pump P-109N

The P-109N pump shall be installed on the recycling line of the R-104 reactor. The pump has the function of recycling the reactants/products mixture allowing to cool them in the E-112 exchanger. The basic specifications of the pump are reported in the attachment "ENEA0120-D1-001-00". The pump should have similar or superior characteristics to the ASCO HL4127A model (Supplier: ASCO POMPE).

3.6.3. Catalysts dosing pump P-130

The P-130 pump shall be installed on the catalyst supply line (di-tert butyl peroxide). The pump shall have the following characteristics:

- Dosing pump with PTFE diaphragm;

- Maximum flow rate: 25 liters / h
- Maximum pressure: 12 bar
- Maximum temperature: 40 ° C
- Setting of the nominal flow rate during running or stopping: from 0 to 100%
- Flow accuracy: ± 2% in the operating range from 10 to 100%
- Construction material: compatible with di-tert butyl peroxide.

3.6.4. Reactants dosing pump P-125

The P-125 pump shall be installed on the reagent supply line (SKID 1, C10-C16 aliphatic hydrocarbons). The pump shall have the following characteristics:

- Maximum flow rate: 2 m^3/h
- Maximum pressure: 12 bar
- Maximum temperature of pumped liquids: 40 ° C
- Type of liquid to be pumped: C10-C16 aliphatic hydrocarbons

3.6.5. Condensate dosing pump P-106

The P-106 pump shall be installed on the supply line of the condensate collected in the S-106 tank. The pump shall have the following characteristics:

- Maximum flow rate: 25 liters/h
- Maximum pressure: 12 bar
- Maximum temperature of pumped liquids: 40 ° C
- Type of liquid to be pumped: organic liquids such as acetone / alcohols

3.6.6. Reactor stirrer

A three-blade agitator is currently available as reported in Annex **ENEA0120 B5-001-00**. The supplier must evaluate the possibility of modifying the existing agitator or supplying a new one based on the following specifications set out in the annex "**ENEA0120 D1-002-00**".

3.6.7. Vents treatment

The process and safety vents shall be treated with a torch equipped with a knockout drum

and hydraulic guard. The maximum flow rate to be treated is estimated to be 200 Nm^3/h and consists mainly of hydrocarbons. The torch shallt be of automatic operation, with a partially visible flame (semi-contained) with an insulated combustion chamber, with an LPG multi-nozzle burner. In addition, the torch must be equipped with a stainless steel lattice structure and UV sensor for continuous flame detection. Improvements to existing specifications may be reported in the technical offer.

3.6.8. Vessels

The characteristics of the S-130, S-110, S-115 and S-120 tanks are reported in the attached document "**ENEA0120 B6-001-00: VESSELS DATASHEET**".

4. MATERIALS AND ITEMS DETAILS

The main technical details concerning type and quality of materials to be used may be found in the attached documents, here listed:

- ENEA0120 B5-001-00: P&ID, SKETCH 3D E FOTO - IMPIANTO DI CRISTALLIZZAZIONE;
- ENEA00120-B5-002-00: P&ID SKETCH 3D - IMPIANTO DI OLIGOMERIZZAZIONE;
- ENEA0120 B6-001-00: VESSELS DATASHEET;
- ENEA0120 C3-001-00: PIPING CLASS;
- ENEA0120 C3-002-00: ELENCO MATERIALE PIPING;
- ENEA0120 C3-003-00: ELENCO MATERIALE PIPING DA ISOLARE PER PROTEZIONE E PERSONALE;
- ENEA0120 C3-004-00: ELENCO MATERIALE PIPING DA ISOLARE ANTICONDENSA;
- ENEA0120 C3-005-00: SKETCH PIPING;
- ENEA0120 D1-001-00: P109N TECHNICAL SPECIFICATIONS
- ENEA0120 D1-002-00: ME-104 TECHNICAL SPECIFICATIONS

- ENEA0120 E1-001-00: ELENCO CARICHI E SEGNALI

The design, manufacturing and documentation will be in accordance with the European regulations, such as PED 97/23/CE and ATEX 94/9/CE.

5. INSTRUMENTS AND CONTROL SYSTEM

The pilot plant SHALL be equipped with all the necessary instrumentation in order to monitor and / or control the process and in accordance with the logic as reported in the P&ID and attached documentation.
All necessary safety systems must be installed in case of failure to control the system.
Details on the installation of the equipment to be placed in the hazardous area will be specified during the finalization of the project.
The new hardware and software supplied by the supplier are summarized as follows:
- PLC installed in the field

6. SUPPORT SKID

The existing skid will be used for the revamped pilot plant. The reactants and the catalyst supply systems shall be installed on a transportable skid to ensure a suitable allocation of the system components. The main features of the plant layout are: optimal plant accessibility and operability, easily and safety maintenance, service and training, minimum interconnections between the different process items for easy assembly and disassembly operation.

Currently, the skid with the existing components mentioned above is located in a hall.

The existing skid shall be transferred to the installation site (about 100 meters from the current installation site). The supplier will be responsible for the disassembly / reassembly of the components and the skid required for the transfer.

7. SPARE PARTS

An ample selection of spares and consumables shall be included in the scope of supply, e.g. seals, o-rings, gaskets, fuses and couplings. Moreover, wherever special tools are needed, they will be included as well.

All these parts shall be shipped together with the pilot plant and enable client to use these parts during installation and acceptance tests for replacement in case of damage or malfunctioning.

Furthermore, a detailed list of spare parts necessary during operation stage shall be

provided by the Vendor.

8. DESIGN AND MANUFACTURING CODES AND STANDARDS

All documentation, project communication and implementation shall be in the English language. Units will be in accordance with SI. With respect to manufacturer operating manuals, Vendor will ask to suppliers to provide an Italian documentation. The design, manufacturing and documentation will be in accordance with the European regulations, such as PED 97/23/CE and ATEX 94/9/CE. A EC declaration of conformity shall be delivered and the related CE marking shall be installed on the pilot plant.

The Hazardous electrical area classification of the new pilot unit is the Zone 2 IIA T3.

9. SCOPE OF SUPPLY

The supply shall include the following elements:

• Revamping of the current crystallization plant including:

- Disassembly and transport of the existing skid;
- Supply, assembly, installation and testing of all equipment and components necessary for the proper functioning of the system;
- Eventual Updated P&ID
- Testing of the oligomerization plant
- Technical specifications and executive drawings of machines and equipment
- List of instruments and signals with identification of battery limits between supplier and customer
- Electrical schemes and identification of battery limits between Supplier and customer and list of utilities
- HAZOP / SIL analysis
- System control and monitoring system software.

• Operation, maintenance and safety manuals for the components;

• Assistance for the training of operators and conduct of start-up tests and operation of the test system.

The vendor shall provide all the "as built" construction documentation to correctly describe the supply, for which he will be responsible from a technical and functional point of view.

10. UTILITIES

The following utilities will be available on the installation site:

• Electricity: 50 Hz / 380 V / 400 kW

• Mains water: available at 6 bar

• Cooling water: available at 5 ° C, cooled by 100 kW chiller. The cooling water circuit must be closed, allowing it to return to the chiller. The flow rate delivered by the chiller is about 23 m^3/h.

• Demineralized water: if required, it will be possible to install a tank of at least 1m^3 of demineralized water at the site. If necessary, a plate heat exchanger with a circulation pump can be installed to cool demineralized water using cooling water as a cooling fluid.

• Compressed air: available at a pressure of 6 bar

• Nitrogen: available through cylinders with pressure control system by manometer.

The Vendor shall indicate with its technical proposal the requirement needed for each utility at BL condition (norm/max flow-rate/consumption of the new circulating riser pilot unit.

11. ASSESSMENT PARAMETERS OF TECHNICAL OFFER

The tender will be awarded according to Italian Legislative (*art. 95, comma 3, lett. b-bis del D. Lgs. n. 50/2016 e s.m.i.)* on the basis of the following criteria:

a) Economic offer 30% (30/100)

b) Technical offer 70% (70/100)

The score of economic offer will be assigned according to the tender regulations.

The score of the Technical Offer will be assessed by taking into account the following aspects:

A) Technical details of the supply (max score: 30)

B) Turnover of economic capacity of the vendor (max score: 10);

C) Experiences in the field of process engineering (max score: 20);

D) Human resources (max score: 5);

E) Professional skills (max score: 5);

The technical score will be awarded on the basis of the following criteria. The score value will be will be approximated to the second digit (e.g. 45.763 will be considered as 45.76).

A) Technical details of the supply (max score: 30)

The jury will evaluate:

- General description of the supply;
- Technical details of items, machines, accessories and so on;
- Integrations and Technical and improvement considerations suggested by the Vendor;
- Execution schedule

The jury will assign the score on the basis of the level of detail of the the documentation presented by the Vendor.
Maximum score: 30;
Calculation criteria of the score: arithmetic mean of the score values assigned by each component of the jury.

B) Turnover and economic capacity (maximum score: 10)

The economic operator must declare the economic turnover (expressed in €) concerning executive designs/manufacture/fabbrication/commissioning of process plants (pilot and/or industrial scale) carried out in the 2016-2020 five years, by filling the following table:

Turnover of executive design (€)					
2016	*2017*	*2018*	*2019*	*2020*	*Total*

Calculation formula: (F/Fmax)*10 where:
F= turnover in the 2016-20 five year concerning process plants (pilot and/or industrial scale) of the economic operator;

Fmax= maximum turnover in the 2015-19 five year concerning process plants (pilot and/or industrial scale) among all the economic operators participating to the procedure.

For instance:

Economic operator	*Turnover (€)*						*Score*
	2016	*2017*	*2018*	*2019*	*2020*	*Total*	
EO1	*100.000*	*200.000*	*5.000*	*300.000*	*15.000*	*620.000*	*3,13*
EO2	*800.000*	*60.000*	*100.000*	*1.000.000*	*20.000*	*1.980.000*	*10,00*
EO3	*200.000*	*50.000*	*700.000*	*50.000*	*100.000*	*1.100.000*	*5,56*

C) Experience (max score: 20)

C.1-Experience in executive design of process plants (max score: 10)

The economic operator must declare a list of executive design projects process plants (pilot and/or industrial scale) carried out in the 2016-2020 in the field of chemical engineering. For each project, the scope, a technical description and the customer shall be indicated as reported below. Experiences as constructor manager, plant testing, etc., will be not considered.

N.	***Project Overview***
1	*Scope: ……* *Description: ……..* *Customer: ……*
2	*Scope: ……* *Description: ……..* *Customer: ……*
…	

Calculation criterion:

- A score of 1.00 for each executive design projects of pilot plant for liquid phase reactions

(pilot and/or industrial scale);

- A score of 0.50 for each other executive design projects.

An example is reported below:

N.	***Project Overview***	***Assigned score***
1	**Scope:** Pilot plant for liquid phase reactions **Description:** executive design for the revamping of a pilot plant for the production of oligomers by liquid phase reaction in batch mode. Capacity 200 kg / batch, stirred tank reactor operating at atmospheric pressure and up to 200 ° C. **Customer:** ENEA – Italy	*1.00*
2	**Scope:** Batch distillation pilot plant **Description:** executive design of a batch distillation pilot plant able to distillate a C9-C18 olefin mixture in order to obtain C10 olefin cut at high purity. Capacity: 15 kg/h of distillate and 500 kg of feed per batch. Technical aspects: 30 theoretical plates; operating pressure: 0.2 bara; maximum temperature: 260 °C; pot duty: 20 kW;… **Customer:** ENEA – Italy	*0.50*
…		

C.2 - Experience in engineering/manufacture/commissioning (max score: 10)

The economic operator must declare a list of engineering/manufacturing/ projects of process plants (pilot and/or industrial scale in the field of chemical engineering) carried out in the 2016-2020. For each project, the scope, a technical description and the customer shall be indicated as reported below. Experiences as constructor manager, plant testing, etc., will be not considered.

N.	***Project Overview***
1	*Scope: ……* *Description: ……* *Customer: ……*
2	*Scope: ……* *Description: ……* *Customer: ……*
…	

Calculation criterion:

- A score of 1.00 for engineering, manufacture, fabrication, commissioning of plant for liquid phase reactions (pilot and/or industrial scale);
- A score of 0.50 for engineering, manufacture, fabrication, commissioning

of other projects

An example is reported below:

N.	*Project Overview*	Assigned score
1	*Scope: Oligomerization pilot plant* *Description: Engineering revamping of a pilot plant for the production of oligomers by liquid phase reaction in batch mode.* *Capacity 200 kg / batch, stirred tank reactor operating at atmospheric pressure and up to 200 ° C.* *Customer: ENEA – Italy*	1.00
2	*Scope: Batch distillation pilot plant* *Description: fabrication and commissioning of a batch distillation pilot plant able to distillate a C9-C18 olefin mixture in order to obtain C10 olefin cut at high purity. Capacity: 15 kg/h of distillate and 500 kg of feed per batch. Technical aspects: 30 theoretical plates; operating pressure: 0.2 bara; maximum temperature: 260 °C; pot duty: 20 kW;…* *Customer: ENEA – Italy*	0.50
…		

D) Human resources (max score: 5)

Organization chart and number of permanent and not permanent employees (at the date of application) involved in the activities of design, engineering and fabrication, of process plants (pilot and/or industrial scale).

An example is below reported:

Activity	*Permanent employees (no.)*	*Not permanent employees (no.)*
Design *Manufacture/Fabrication* *Assembly* *Commissioning*	……	……

Maximum score:5

Calculation formula: (Nind+Ndet/2)/ (Nind+Ndet/2)max*5

where:

Nind: number of permanent employees Ndet: number of not-permanent employees

(Nind+Ndet/2)max: maximum value among all the economic operators participating to the

procedure.

E) Professional skills (max score: 5)

Permanent employees (at the date of application) with professional skill and experiences able to perform the contract with a suitable quality standard, as reported in the following table:

Professional resources	**Number**
P1- Project manager, with master degree in engineering science and at least three years of experience in the management of projects with economic value higher or equals to the opening bid.	
P2- Project engineer with masterdegree in Chemical Engineering and with at least three years of experience in process engineering;	
● P3 - Structural engineer with master degree in mechanical or nuclear engineering or equivalent and with at least three years of experience in mechanical design of high-pressure equipments.	
● P4 -Process control engineer with master degree in Chemical Engineering or Electric/Electronic engineering or similar, with at least three years of experience in design and tuning of system controls.	
● P5 -Electronic or Mechanical Experts with at least three- years of experience in maintenance of electrical and mechanical devices	

Maximum score for each professional figure: 1;
Maximum score: 5
Calculation criterion: (nP1+nP2+nP3+nP4+nP5)*0,50
where:
nP1 = Number of human resource with P1 profile;
nP2 = Number of human resource with P2 profile;
etc.