Process Description For Reactor Section

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1. Introduction

Pars Petrochemical Company intends to build a propane Dehydrogenation (PDH) plant to produce 600 KTY propylene polymer grade based on UOP Oleflex technology in Pars south Special economic energy zone (PSEEZ), Asalouyeh , Bushehr Province, Iran.
EPCC contractor for PDH plant: Panah Sanat Part Co., and BINA Co. Consortium.
The plant consists of several main process units, including Feed Treatment, Dehydrogenation reactor CCR, Distillation, Hydrogenation reactor, refrigeration, Merox, utility, tankage, …

1.1. Terms and Definitions

PROJECT:	Propane Dehydrogenation Plant (PDH)
Contract Number:	39-402/685
OWNER:	Pars Petrochemical Company
MC:	Aria Pishro Gharn
CONTRACTOR:	Panah Sanat Part Co. and BINA Co. Consortium
PDP	
BASIC DESIGNER:	Sinowey Engineering Technology Co., Ltd.
Third Party Inspection	-
SITE:	Pars south Special economic energy zone (PSEEZ), Asalouyeh Bushehr Province, Iran.
SUBCONTRACTOR:	Organization/Party that CONTRACTOR hires to do a part of the WORK
GOODS:	Any and all equipment machinery, apparatus, material, and other PROJECT commodity described in the contractor’s contract.
VENDOR:	Any manufacture/supplier selected by OWNER/CONTRACTOR to supply the GOODS
MANUFACTURER:	Any Company selected by OWNER/CONTRACTOR to fabricates GOODS according to the purchase order placed with the CONTRACTOR.

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Shall: Indicates mandatory requirements to be strictly followed.

Should: Indicates that through several possibilities, one is recommended as practically suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required. Other possibilities may be applied subject to OWNER approval.

May: It is used where a provision is completely discretionary

1.2 Scope of Document

The document is to describe the Reactor Section process of the Plant.

2. Description

2.1 3981100-110-01 Process Flow Diagram-Reactors and Heaters Section

The mixed feed from Separation System(81-W-104) first enters into the Hot Combined Feed Exchangers(81-E-101A/B/C/D) to exchange the heat with the Reactor Effluent Product in order to further increase the temperature of combined feed and decrease the temperature of the Reactor Effluent product. The preheated combined feed, injected with a little DMDS, is sent to Charge Heater(81-H-101) to heat and then enters into the lower section of Reactor No.1(81-R-101). The materials in the reactor contact with the catalyst to realize the propane dehydrogenation reaction. The propylene and unreacted propane produced after the reaction enters into Interheater No.1 (81-H-102). Because the dehydrogenation reaction is endothermic, it is necessary to supplement the heat in the process. After heated by the interheater, the materials are sent to Reactor No.2(81-R-102) for the dehydrogenation reaction. Afterwards, the materials sequentially enter the Interheater No.2 (81-H-103), Reactor No.3(81-R-103), Interheater No.3 (81-H-104), Reactor No.4(81-R-104). Therefore, external heat is required to achieve the desired reactor inlet temperature (600-650 ℃), the feed heater is used to heat the incoming combined feed,

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and the three intermediate heaters are used to heat the products of the first three reactors. Finally, in order to recover heat from the reactor section, the Reactor effluent product from Reactor No.4(81-R-104) enters into Hot Combined Feed Exchanger(81-E-101A/B/C/D) and exchanges the heat with the raw material of combined feed from the Separation System(81-W-104), then is sent to Reactor Effluent Contact Cooler(81-T-101) in reactor effluent compression section. The pressure control between Reactor No.4(81-R-104) and Hot Combined Feed Exchanger (81-E-101A/B/C/D) is connected to the anti-surge system of the compressor.

One stream of PSA H_2 from Hydrogen Purification System(81-W-106) is sent to the upper part of Reactor and enters into the center tapered plug tube as the continuous purge gas in order to minimize the residence time of the process gas in the center tapered plug tube to prevent the occurrence of coking or other side reactions.

DMDS from Sulfur Injection Drum(81-V-101) is injected into the raw material of propane before and after Hot Combined Feed Exchanger(81-E-101A/B/C/D), also injected into the stream line of outlet of Reactor No.1 (81-R-101) and Reactor No.2 (81-R-102) by Sulfur Injection Pumps(81-P-101A/B/C/D). A cadmium sulfide layer will form on the surface of stainless steel in the hot combined feed Exchanger, Heater, Reactor and piping to avoid stainless steel carburization and minimize the reaction of propane feed cracking into ethane and methane.

2.2 3981100-110-02 Process Flow Diagram-Reactor Effluent Compression Section

The Reactor Effluent product from Reactor No.4 (81-R-104) be cooled in Hot Combined Feed Exchanger (81-E-101A/B/C/D) with the raw material of propane and then enters the Reactor Effluent Contact Cooler (81-T-101) for further cooling, and then enters first section of the Reactor Effluent Compressor (81-C-101) for compression. The temperature of the product gas increases after compression. After cooling by Reactor Effluent Interstage Contact Cooler (81-T-102), the product gas enters the second section of the Reactor Effluent Compressor (81-C-101) for compression. The compressed product gas is cooled

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by Reactor Effluent Compressor Discharge Cooler (81-AE-102) and Reactor Effluent Compressor Discharge Trim Cooler (81-E-115), then enters Reactor Effluent Compressor Discharge Drum (81-V-102). Finally, the product gas from the top of the Reactor Effluent Compressor Discharge Drum (81-V-102) is sent to Reactor Effluent Drier Section to remove the Chloride, sulfide and to dry the gas.

2.3 3981100-110-03 Process Flow Diagram-Reactor Effluent Drier Section

Since chlorine injection is required in the Catalyst Regeneration Section, the chloridion on the catalyst is carried to downstream by the reactor effluent product. Meanwhile, the sulfide injected to the raw material of propane and the sulfide in the raw material of propane is transferred to hydrogen sulfide, which is also carried to downstream by the reactor effluent product. The hydrogen sulfide can poison the catalyst in the SHP section and pollute the propylene product and the net gas. The catalyst reduction process produces a small amount of water which can freeze in the Separation System (81-W-104) and cause blockage. So, all these impurities need to be treated before Separation System (81-W-104) to protect to following equipment.

Due to the requirement of reactor section, SHP catalyst and product, the content of total chloride should not exceed 1 wt ppm, so Chloride Treater is set up to dechlorate the reactor effluent. The non-renewable alumina adsorbent in the Chloride Treater can effectively remove chlorine from the reactor effluent. The compressed product gas enters the Chloride Treater (81-D-101) which filled with non-regenerative absorbent specially produced by activated alumina at the top and flows out at the bottom. After passing through the Chloride Treater(81-D-101), the product gas flows downwards through Reactor Effluent Driers (81-D-102A/B) to remove the H_2S and water（removed to below 1wt ppm） from the product gas. RED uses two different activated alumina to remove water and hydrogen sulfide from reactor effluent, RED is divided into two layers, the upper mass transfer bed removes a large amount of water and hydrogen sulfide, and the bottom balance bed finally removes the remaining small amount of water and hydrogen sulfide. There are two Reactor Effluent Driers (81-D-102A/B), one of which is for the normal operation and another is for

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regeneration and switchover about every 42 hours. For the normal operation, the product gas enters at the top of the Driers and flows out at the bottom after absorbing the impurities by the adsorbent inside, then is sent to Separation System (81-W-104). For the regeneration, a stream of Net gas from Separation System is sent to Reactor Effluent Driers (81-D-102A/B) after heating by Regenerant Heater (81-E-103). The net gas enters at the bottom of the Driers and flows out at the top and carry out the H_2S and water on the adsorbent. Then, the net gas is sent to Regenerant Knockout Drum (81-V-103) after cooled by the Regenerant discharge cooler (81-AE-103) and the regenerant cooler (81-E-104), then, the gas is sent to Regenerant Gas Scrubber (81-T-103) and the liquid heavy component, joins together with the liquid from the bottom of the Reactor Effluent Interstage Contact Cooler(81-T-102), is sent to Reactor Effluent Contact Cooler (81-T-101) for the use of coolant. After the regenerant heating of the Reactor Effluent Driers (81-D-102A/B), the regeneration cooling work continues. When cooling, also the net gas from the Separation system will be used. At this time, the Regenerant Heater (81-E-103) does not work. The net gas enters the Reactor Effluent Driers (81-D-102A/B) from bottom to top to cool the driers and the gas is sent out of the driers at the top, then go through the Regenerant discharge cooler (81-AE-103) and the regenerant cooler (81-E-104) and Regenerant Knockout Drum (81-V-103). Finally, the gas is sent to Regenerant Gas Scrubber (81-T-103).

The gas from Regenerant Knockout Drum (81-V-103) enters the Regenerant Gas Scrubber (81-T-103) from the bottom. The Regenerant Gas Scrubber (81-T-103) is a packed tower, the lower part of which uses the 10wt% NaOH solution to circulating wash to remove the H_2S and the upper part of which uses steam condensate as washing water cycle using to wash the micro alkali carried by the gas. The scrubbed gas from scrubber upper, the main component of which is hydrogen, is sent to the net gas compressor suction drum. The circulating alkali in the scrubber is analyzed regularly and replaced when the sodium sulfide content generated by absorption is less than 30% of the theoretical value. The spent caustic is discharged from the bottom of the scrubber to Spent Caustic Degassing Drum (81-T-104) to remove the hydrogen and hydrocarbon entering into the gas, and then, is sent

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to Spent Caustic Treatment by Spent Caustic Transfer Pumps (81-P-106A/B). Meanwhile, the 10%wt fresh caustic is added (intermittent flow .Usually, the discharge makes the liquid level not less than 9%, and the fresh lye to scrubber liquid level reaches 60% (China plant operation experience reference). According to the plant operation experience, the optimal sodium hydroxide concentration can be adjusted by controlling the discharge of waste alkali and the injection of fresh lye. Provide approximately 163,000 kilograms of 10 weight percent caustic(NaOH). This quantity is required for the initial filling of the Regenerant Gas Scrubber. Refilling will be required approximately once every week.) and then sent to scrubber through Caustic Circulation Pumps (81-P-104A/B), Caustic-oil Removal Package (81-W-107) and Caustic Heater (81-E-105) for circulating， The Caustic Circulation Pump (81-P-104A/B) draws the alkaline solution from the scrubber and sends it to the Caustic-Oil Removal Package (81-W-107) to remove part of the solvent oil substituted through the Net gas. Then it is sent back into the scrubber again（The functions of 81-W-108 and 81-P-103A/B are the same as above）. The wash water in upper also periodically discharge part of the caustic containing waste water to the Spent Caustic Degassing Drum (81-T-104). The condensate water is injected into the Regenerant Gas Scrubber (81-T-103) through a Wash Water Injection Pumps (81-P-105A/B) for make-up water.

The waste water from Net Gas Compressor Suction Drum (81-V-105/106/107) and Hydrogen Purification System Knockout Drum (81-V-108), Feed Drier Regenerant Coalescer (81-V-201) joint with the spent caustic discharged by Regenerant Gas Scrubber (81-T-103) is sent to Spent Caustic Degassing Drum (81-T-104) to remove the hydrogen hydrocarbon, and then sent to Spent Caustic Treatment by Spent Caustic Transfer Pumps (81-P-106A/B). The Heavy Hydrocarbon Degassing Drum (81-T-105) will collect from the Net gas compressor knockout Drum and Caustic-oil removal The solvent oil and other Heavy hydrocarbons separated from the package were sent out of the boundary area through the Heavy Hydrocarbon Transfer Pump (81-P-107A/B). The function of the Regenerant Heater Desuperheater (81-W-101) is to cool and pressurize the overheated and

A.Hoseingoo:(8/30/2025)
According to discussion with Mrs. Jamshidi, this shown paraghraph should be dleted on next revision due to considering desuperheater on header and omitted on PID.

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overpressurized steam in the pipe network to normal temperature and normal pressure through boiler feedwater.

2.4 3981100-110-04 Process Flow Diagram-Separation System Section

Fuel Gas Preparation System (81-W-105)

Fuel Gas Preparation System (81-W-105) is used to remove solid and liquid particles entrained in fuel gas to assure reliable and efficient operation of low NOx burners. The fuel gas, mainly is hydrogen and hydrocarbon, can be produced by the process unit by side, which is used as the fuel gas of the fired heater. The fuel gas is from tail gas of PSA, gas of Depropanizer Bottoms Stripper (81-T-107) and Off gas of the Deethanizer Off gas Exchanger (81-E-213). After Fuel Gas Preparation System (81-W-105), the fuel gas is sent to Charge heater and Interheaters.

Start-up: "Natural Gas using as a feed singly"

Normal: "Fuel Gas and Natural Gas using as a combined feed"

Separation System (81-W-104)

The Separation System (81-W-104) is used to separate the reactor effluent stream from the Oleflex Process Unit reactors into a hydrogen-rich net gas product stream and a hydrocarbon-rich liquid product stream. The System shall also be designed to take a portion of the hydrogen - rich vapor stream, combine it with the liquid hydrocarbon feed for the reactors and return this stream as combined feed to the reactors.

The System separates the reactor effluent stream by cooling the reactor effluent stream to sufficiently low temperatures to achieve the required separation of the two product streams. Cryogenic temperatures are required to achieve the separation while minimizing the pressure of the reactor effluent stream entering the system by the use of turbo-expansion of the hydrogen-rich streams and by optimal heat exchange of the incoming and outgoing streams.

The reactor effluent product, after pressurizing, purification and filtration to remove the water, HCL and H_2S, is sent to Separation System (81-W-104) through Reaction Effluent Filter (81-S-103A/B). The reactor effluent product exchanges the heat by Cold Combined

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Feed Exchanger with the raw material of propane and partial net gas to decrease the temperature to realize partial condensation, and then the gas and liquid separate in the High Pressure Separator.

The gas in the high pressure separator is sent to HP turbo-expander to expand and work and decrease the temperature（-93℃--109℃） to condensate partially. The expansion work drives the generator to recover energy. Then, the gas and liquid enter intermediate pressure separator. The gas from the intermediate pressure separator is divided into two streams, one is net gas and the other is circulating gas. The circulating gas enters LP turbo-expender for further expand and decrease the temperature（-109℃--126℃） to condensate. The expansion work drives the generator to recover energy. Then, the gas and liquid enter Low Pressure Separator. The net gas from Intermediate and low pressure separator enters net gas cooler to further condensate the remaining propane and heavy hydrocarbons and the gas and liquid is separated in the Net Gas Separator. The liquid from all Separator gathers into the Flash Drum and the gas from the Flash Drum is sent to Reactor Effluent Contact Cooler (81-T-101). The liquid phase from the flash tank is pressurized by liquid product pumps to exchange heat with the fresh propane feed in the feed heat exchanger to ambient temperature and then transported to the Deethanizer Stripper(81-T-202). The cooled propane feed and circulating hydrogen are mixed at the inlet of the cold combined feed heat exchanger and enter the hot combined feed heat exchanger (81-E-101A/B/C/D) in the reaction section.

The cold box may be clogged by the upstream solvent. The cold box vendor should publish special handling measures based on experience.

The Net gas from the Net Gas Separator is divided into two streams, one of which enter the Cold Combined Feed Exchanger to exchange *heat* with the reactor effluent product, other of which enter to Feed Chiller. Then the two streams merged together and sent to downsteam. The pressure of the medium-pressure dispenser tank is determined by regulating the dry gas flow out of the cold box. A portion of the Net gas is sent directly to the CCR Gas Heater (81-E-302) in the CCR section for use as various blowdown streams

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associated with the catalyst collector and lift engagers. The remaining net gas is sent to the regenerant heater and used to regenerate the RED， then is sent to the Recovered Hydrogen and Fuel Preparation System (RHFPS).

2.5 3981100-110-05 Process Flow Diagram-Hydrogen Purification System

The gas from Regenerant Gas Scrubber (81-T-103) is compressed by Net Gas Compressor (81-C-102A/B)（The compressed dry gas enters 81-V-105,106,107 and 108 respectively to separate part of the water and heavy hydrocarbons precipitate after compression. Then it passes through 81-E-106.107 and 108 for cooling and re-enters the compressor for compression）, and then enters Hydrogen Purification System (81-W-106)（Operation of the system is completely automatic. Controls is provided to regulate internal system pressure and flows. In case of a malfunction, a switchover mode of operation will be required in which it shall be possible to automatically bypass the malfunctioning area and continue operation. Hydrogen recovery during switchover mode may be slightly lower than design recovery. The tail gas containing the absorbed impurities is passed through a tail gas delivery system designed to reduce variations in the composition and pressure resulting from the cyclic operation.System includes charcoal adsorber vessel upstream of hydrogen purification bed to protect the hydrogen purification bed adsorbent from lubrication oil mist carryover from upstream compression. With utilizing charcoal adsorber, oil content is equal to below 50 ppb at the outlet streams of 81-W-106）. The high purity hydrogen (a stream in excess of 99.99 mole percent) is produced after adsorption of multiple adsorption towers.

Hydrogen, as the product of the PSA unit, is sent to three destinations. Part of the hydrogen is sent to CCR section as the purge gas, a small part is sent to SHP reaction section, and the rest is sent to hydrogen header out of the boundary.

A part of the tail gas is sent to Striping Hydrogen Heater (81-E-109) and the rest is sent to Fuel Gas Preparation System (81-W-105).

2.6 3981100-110-06 Process Flow Diagram-Solvent Recovery Section

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One of the functions of the solvent is to cool the reaction effluent by direct contact with it. Another function is to partially remove the macromolecular hydrocarbons produced by the side reaction. The main component of this solvent is p-diethylbenzene, which is the recommended solvent for UOP. We believe that the solvent oil is relatively stable in chemical properties at high temperatures and has better compatibility with macromolecular compounds in the reaction effluent. The solvent in the Reactor Effluent Interstage Contact Cooler (81-T-102) is transported to Reactor Effluent Contact Cooler (81-T-101) through Solvent Start-up Circulation Pump (81-P-113). The solvent from the Reactor Effluent Contact Cooler is pressurized by Solvent Circulation Pumps (81-P-102A/B), and then enters the Solvent Circulation Filters (81-S-102A/B) for filtration. After exchange the heat in the Depropanizer Feed Preheater (81-E-207), a portion of the solvent is cooled by the Solvent Circulation Cooler (81-AE-101) and Solvent Circulation Trim Cooler (81-E-102A/B/C) and then circulated with solvent recovered from the solvent recovery tower and replenished fresh solvent into the reaction effluent contact cooler. Other part of solvent enters the Solvent Recovery Column (81-T-106) to separate the solvent with the heavy components by steam stripping at the bottom of the column and the solvent itself washing. The Solvent Recovery Column Reboiler (81-E-112) heats the aromatic solvents, and the high pressure steam in the solvent recovery tower bottom reboiler comes from the high pressure steam main pipe. A portion of the aromatic solvent in the tower is extracted from the sideline and pressurized by the Solvent Recovery Column Overhead Pumps (81-P-109A/B) and cooled by the Solvent Recovery Column Overhead Cooler (81-E-110) and then transported to the Solvent Recovery Column Bottoms Exchanger (81-E-111), where it is exchanged for heat with the solvent recovery tower bottom effluent and then returned to the reaction effluent contact cooler. The light hydrocarbon at the top of the Solvent Recovery Column circulation and join into the reactor effluent product gas, and then, enter the Reactor Effluent Contact Cooler. Solvent from the bottom of the solvent recovery tower is cooled and distill to remove heavy components in the Solvent Recovery Column Bottoms Exchanger (81-E-111). During this period, the solvent is replenished with fresh

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solvent based on aromatic solvent usage, and the spent solvent is cooled by the Spent Solvent Cooler (81-E-114) and sent outside the boundary area.

Partial tail gas of PSA enter to Depropanizer Bottom Stripper (81-T-107) after heated by Stripping Hydrogen Heater (81-E-109) to strip the C4+ gas-liquid from the bottom of Depropanizer (81-T-201) in the Depropanizer Bottoms Stripper (81-T-107). The stripped gas is sent to Fuel Gas Preparation System (81-W-105) and the liquid component is sent to Solvent Recovery Column (81-T-106) together with the spent solvent from the Depropanizer Feed Preheater(81-E-207).

2.7 3981100-110-07 Process Flow Diagram-Steam Generation Section

The fuel gas is sent to heaters to maintain the reaction temperature. In order to make full use of energy, the heater is equipped with the convection chamber, and the heat of the flue gas generated by the radiation chamber is discharged to the convection section of the heater through the collecting pipe, in which several groups of the coils are set up to recover the heat and produce the steam by Steam Generation System.

Boiler Feedwater from out of boundary first enters preheating section of the convection chamber of the Charge Heater (81-H-101), No.1 Interheater (81-H-102), No.2 Interheater (81-H-103), No.3 Interheater (81-H-104), and then, it is mixed with the steam and the water mixture from the steam generation section, then, enters to Steam Disengaging Drum (81-V-109) for vapor-liquid separation. Steam disengaging drum (81-V-109), the continuous sewage discharge volume should be provided to confirm the specific parameters of Steam Disengaging Drum (81-V-109). And the recommended amount of Phosphate to be injected should be given so that the phosphate inject System (81-W-110) vendor confirms the parameters. The liquid phase is sent back to the steam generation section of the convection chamber of each heater through the Circulating Water Pumps (81-P-111A/B) to produce steam and the water mixture is sent to the Steam Disengaging Drum again. The vapor from the Steam Disengaging Drum is sent to Charge Heater (81-H-101) and No.1 Interheater (81-H-102) for further heating in the superheated section of the convection chamber. After

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superheated, the steam enters to HP Steam Header Desuperheater (81-W-103) and its pressure and temperature falls down to High Pressure Steam and then sent to HP steam header.

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