Technical Proposal

for

GT-Styrene® Styrene Recovery Unit
and
GT-BTX® Benzene/Toluene/Xylenes Recovery Unit

Presented To:

Indian Oil Corporation Ltd.

Panipat, India

by

GTC TECHNOLOGY US, LLC

USA

January 2013

TABLE OF CONTENTS

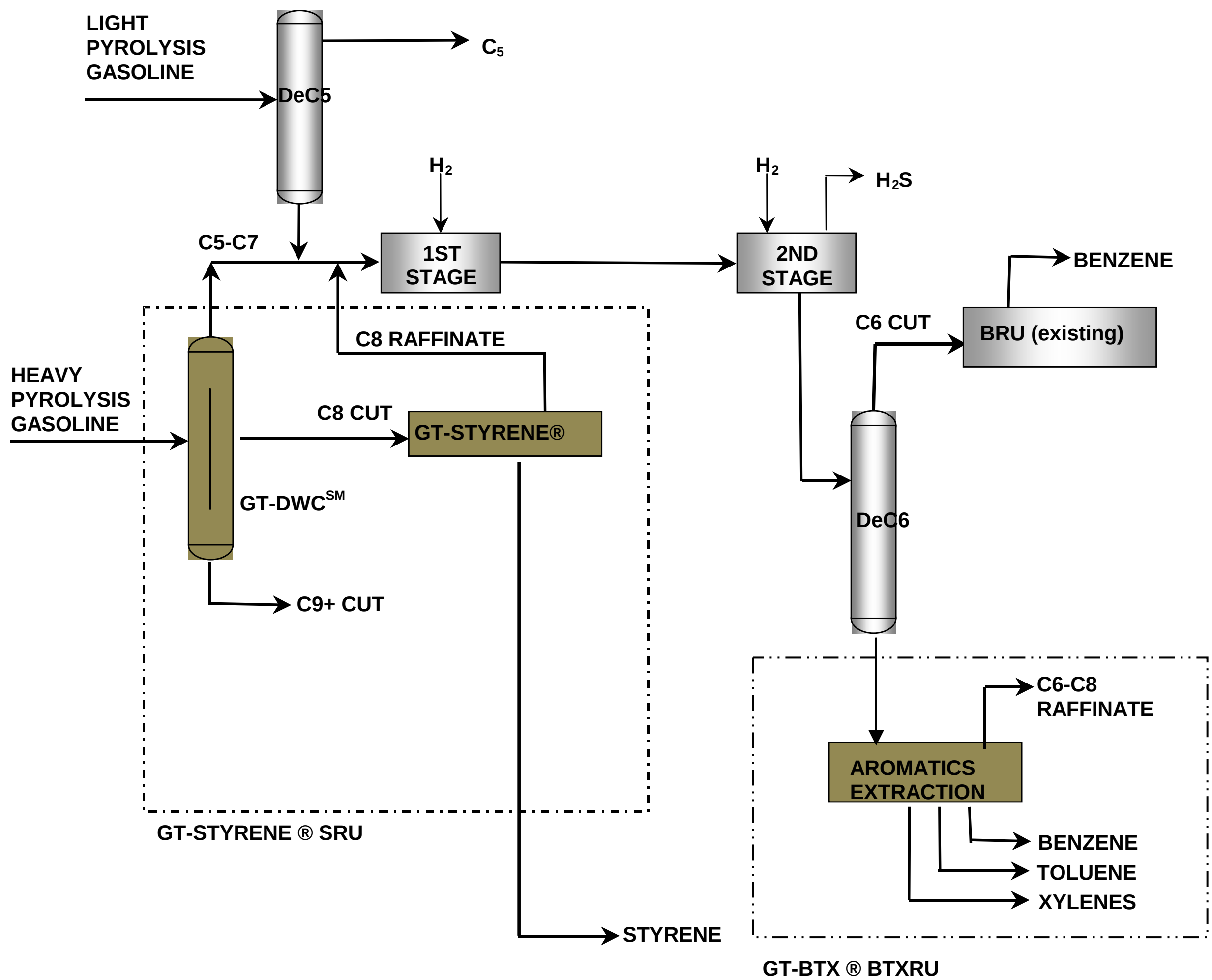
APPENDIX 1 SRU Preliminary Equipment List
APPENDIX 2 BTXRU Preliminary Equipment List

1. EXECUTIVE SUMMARY

Indian Oil Corporation Limited (IOCL) currently operates a Naphtha Cracker Complex (NCC) at Panipat, India which includes a full range pygas hydrogenation unit, followed by Benzene Recovery Unit (BRU) to recover high-purity benzene product. IOCL is evaluating the option of installing a new Styrene Recovery Unit (SRU), upstream of existing pygas hydrogenation unit, to extract high-purity styrene from heavy pyrolysis gasoline stream and a new Benzene/Toluene/Xylenes Recovery Unit (BTXRU) to produce benzene, toluene, and mixed xylenes from the Dehexanizer bottoms stream after hydrogenation, through GT-BTX® aromatics extraction.

In the past, GTC presented several separate proposals to IOCL for the SRU and GT-BTX® Toluene/Xylenes Recovery Unit (TXRU). Now IOCL is having capacity limitation for the existing BRU and would like to send part of the benzene to the new aromatics extraction unit. The existing BRU operates with a benzene concentration much higher (almost double) than original design, thus its capacity is limited and is unable to process the entire C6 cut feed from Dehexanizer. To overcome this situation part of the benzene will be routed to new intended GT-BTX® aromatics extraction converting the new TXRU in a Benzene/Toluene/Xylenes Recovery Unit (BTXRU). The following block flow diagram illustrates the proposed process configuration.

GTC's scope of work includes the new SRU and BTXRU. Here GTC presents a consolidated technical proposal for both Styrene Recovery Unit and Benzene/Toluene/Xylenes Recovery Unit. In this proposal IOCL will find information regarding material balance, utility consumption, catalyst, solvent and chemicals, equipment design information and investment cost estimation for the units. Information for SRU and BTXRU is presented in two sections, with SRU covering first section of the proposal.


LIGHT
PYROLYSIS
GASOLINE
DeC5
C5
H2
H2
H2S
C5-C7
1ST
STAGE
2ND
STAGE
BENZENE
C8 RAFFINATE
C6 CUT
BRU (existing)
HEAVY
PYROLYSIS
GASOLINE
C8 CUT
GT-STYRENE®
GT-DWCSM
DeC6
C9+ CUT
C6-C8
RAFFINATE
AROMATICS
EXTRACTION
GT-STYRENE ® SRU
BENZENE
TOLUENE
XYLENES
STYRENE
GT-BTX ® BTXRU

2. SECTION I: STYRENE RECOVERY UNIT (SRU)

2.1 Design Basis

The SRU presented in this proposal represents an advanced option where the DeC7 and DeC8 columns in the pre-fractionation section are combined into one single column using GT-DWC^{SM} divided wall column technology, reducing substantially the energy consumption in pre-fractionation section. C8 cut resulting from pre-fractionation section is sent to GT-Styrene® extractive distillation to produce high purity styrene.

2.1.1 Plant Capacity

The SRU is designed to process 365,726 MTY of feedstock to produce approximately 20,173 MTY of high purity styrene, based on an on-stream time of 8,000 hr/year. In actual operation, the plant is able to operate at a higher on-stream factor.

2.1.2 Feed Specification

The composition of the feed stream has been provided by IOCL and is presented below.

Stream	Gasoline Stripper Bottoms
Composition (wt %)	
H2	0.000
CO	0.000
CO2	0.000
H2S	0.000
CH4	0.000
ACETYLENE	0.000
ETHYLENE	0.000
ETHANE	0.000
PROPADIENE/METHYLACT	0.000
PROPYLENE	0.000
PROPANE	0.000
BUTADIENE/C4ACETYLEN	0.097
BUTYLENES	0.009
BUTANES	0.004
C5 HCs	1.882
C6 NON AROMATICS	5.473
C7 NON AROMATICS	6.284
C8 NON AROMATICS	3.374
BENZENE	12.566
TOLUENE	26.274

XYLENE/ETHYLBENZENE	17.006
STYRENE	6.000
C9-204 DEGC	21.018
204-288 DEGC - PGO	0.011
288 DEGC PLUS - PFO	0.001
Mass Flow (kg/hr)	**44,505.7**

Detailed feed composition per hydrocarbon species used in simulation and design, including breakdown of C8 aromatic, C9+ heavy component, C6 through C8 non aromatic, and Phenyl Acetylene (PA) concentration in heavy pygas stream are estimated by GTC based on in-house experience. The actual feed composition needs to be provided by IOCL, and it might impact the styrene recovery process.

One additional feed consisting of a recycle stream from SBR needs to be considered, at following composition and flow rate.

Stream	SBR Recycle to EDC
Composition (wt %)	
Butadiene	7.82
Benzene	0.27
Toluene	0.73
Vinyl cyclohexene	16.36
Ethyl benzene	1.51
Styrene	73.22
Cumene	0.09
Mass Flow (kg/hr)	**85**

2.1.3 Product Specification

The SRU will produce high-purity styrene product meeting the following specification.

Item	Specification	Analysis Method
Purity, wt%	99.0 min	ASTM D-1016
Polymer, wppm	10 max	ASTM D-2121
Inhibitor, wppm	10-20	ASTM D-4590
-α-methyl-styrene	500 max	ASTM D-5135
PA content	300 wppm	

2.1.4 Utility Information

Utility information is provided by IOCL, and is presented as follows.

Steam	Min.	Normal	Max.	Thermal Design (1)	Mechanical Design
HP Steam					
Pressure, kg/cm2g	40.0	42.0	44.0	38.0	50.0 / FV
Temperature, C	380	390	400	375	427
MP Steam					
Pressure, kg/cm2g	15.1	16.3	17.7	13.6	20.4 / FV
Temperature, C	270	285	310	265	350
LP Steam					
Pressure, kg/cm2g	3.6	4	4.5	2.7	6.5 / FV
Temperature, C	195	200	225	190	288

Note 1: Steam header condition for equipment design is based on the lowest available pressure, i.e. thermal design pressure condition. For example, MP steam pressure at the inlet of heat exchanger would be 13.6 kg/cm2g and this value is used for utility calculation.

Cooling Water	Normal	Design
Supply pressure, kg/cm2g	5	10
Supply Temperature, C	33 max	65
Return Pressure, kg/cm2g	2.2	
Return Temperature, C	45 max	

Electrical power is assumed to be available for powering pump and air cooler fan motors.

Nitrogen, instrument air and plant air are considered at the normal required parameters for all kinds of usages.

Chilling water is needed for main process and is assumed to be available as follow.

Supply temperature 5 °C
Return temperature 10 °C max.

Dry bulb temperature for air cooler design is assumed to be 40 °C.

2.2 Process Design

2.2.1 Process Description and Preliminary PFDs

The process description is based on the following PFDs.

Pre-fractionation Section

Pygas Feed stream is first sent to DWC Feed Surge Drum D-103, and then pumped by DWC Feed Pump P-104A/b to the pre-fractionation side of DWC C-101. Feed is preheated by exchanging heat with hot lean solvent from extractive distillation section in DWC Feed Preheater E-102.

Divided Wall Column (DWC) C-101 represents a GTC proprietary design. The vertical dividing wall splits the middle portion of the column into equal halves. The feed side of the wall is called the pre-fractionation section. The light components travel up the column while the heavier components travel down the column. The liquid from the top of the column and the vapor from the bottom of the column are split to both sides of the dividing wall. The main fractionator side of the wall contains the concentrated middle-boiling components, mainly C8, where they are removed from the column as a side draw.

Overhead vapor from DWC is condensed in DWC Air Cooler E-101, and collected in DWC Overhead Receiver D-101. A portion of the condensed liquid is returned to the column as reflux and the remainder is sent to battery limit (B.L.) as C5-C7 cut via DWC Reflux Pump P-101A/B.

The concentrated C8 cut is taken as side draw from C-101. The C8 cut is collected in Reactor Feed Surge Drum D-102 and pumped to the hydrogenation reactor via Reactor Feed Pump P-103A/B.

The DWC bottoms product is first cooled by C9+ Cut Cooler E-107, followed by C9+ Cut Trim Cooler E-108, and sent to B.L. by DWC Bottom Pump P-102A/B.

LP Steam is used to reboil DWC Side Reboiler E-104. DWC Reboiler is reboiled by IP steam.

C-101 is operated under vacuum condition.

PA Selective Hydrogenation

The C8 cut contains a small amount of phenyl-acetylene (PA), which is undesirable in the final styrene product. This stream is sent through a selective hydrogenation reactor, upstream of the extractive distillation unit, where the PA is selectively hydrogenated to styrene. A small amount of styrene is saturated to ethyl-benzene at the same time. The overall styrene loss in PA hydrogenation section is controlled within 5 percents. PA selective hydrogenation catalyst can be regenerated.

C8 styrene concentrate cut from C-101 is cooled in Reactor Feed Cooler E-208, and then sent to PA Hydrogenation Reactor R-201A/B. Two PA selective hydrogenation reactors are used, one is in operation and one is spare. The hydrogenated reactor effluent free of PA is cooled in Hydrogenation Product Cooler E-201, and then the cooled effluent is sent to Hydrogenation Product Separator D-201. Offgas from the separator is sent to fuel gas system or flare header. The liquid effluent is split into two streams; one stream is returned to the reaction loop as recycle feed to keep the space velocity and reactor temperature uplift within required limits; the other stream is sent to EDC Feed Drum D-206, as feed to the Extractive Distillation Section. The PA hydrogenation reactors can be also operated in series.

Extractive Distillation Section

The hydrotreated C8 heart-cut and SBR recycle from B.L. is collected in EDC Feed Drum D-206, preheated by hot lean solvent in EDC Feed Preheater E-202, and fed to Extractive Distillation Column (EDC) C-201. In a vapor-liquid operation, the solvent selectively extracts the styrene to the bottoms, while rejecting the other C8 aromatics and non-aromatics components to column overhead as raffinate. Stripping steam is injected at the bottom of column to reduce the bottom temperature at the level when polymer formation is avoided; also to allow the overall operation of the column in such a way that regular recirculation cooling water can be use for overhead main condenser instead of chilled water.

EDC is a packed column and operates under vacuum. Column overhead vapors are condensed in two-stage overhead condensers; cooling water is used as cooling medium for the main condenser EDC Condenser E-203A, while chilled water is used for EDC Trim Condenser E-203B. The condensed liquid is collected in EDC Overhead Receiver D-202. A portion of the condensed liquid is routed back to the column as reflux, while the remaining C8 raffinate is sent to B.L. via EDC Reflux Pump P-202A/B. A small part of raffinate is sent to Polymer Removal System. Water collected in D-202 is removed via water boot on the receiver and sent to Water Surge Drum D-204 via EDC Water Pump P-203A/B. EDC is reboiled using LP steam in EDC Reboiler E-204A/B.

Rich solvent withdrawn from the bottom of EDC is fed to Solvent Recovery Column (SRC) C-202. SRC is also a packed column that operates under vacuum. In SRC, styrene is separated, from the solvent, to the bottoms of column, producing a lean solvent quality required for the extractive distillation operation. Furthermore, stripping steam originating from the system water balance is injected to the base of SRC to assist in the stripping operation. SRC is reboiled using IP steam in SRC Reboiler E-206.

Styrene product, stripped out from the rich solvent, is condensed in SRC Condenser E-205 using cooling water, and then collected in SRC Overhead Receiver D-203. Part of the overhead condensed hydrocarbons is used as reflux while the rest is withdrawn as styrene product via SRC Reflux Pump P-205A/B. After being cooled to storage temperature in Styrene Product Chiller E-213 using chilled water, styrene product is pumped to Styrene Product Daily Tank A/B D-211/212. Water collected in D-203 is removed via the water boot and sent to Water Surge Drum D-204 via SRC Water Pump P-206A/B.

Lean solvent from the bottom of SRC is sent through a series of heat exchangers to recover heat before being routed to the top of EDC. First, the lean solvent is used as heating medium to preheat the feed to DWC in E-102, then to preheat the feed to EDC in E-202. Finally, the lean solvent is cooled down to the required temperature in Lean Solvent Cooler E-210 before being introduced to EDC. A small part of the lean solvent which contains some heavy components is directed to Polymer Removal System.

Process water containing traces of light hydrocarbon from EDC Overhead Receiver and SRC Overhead Receiver is collected in Water Surge Drum D-204 and pumped to the top of Water Stripper C-205 by Water Surge Pump P-208A/B. Part of the water is also sent to Polymer Removal System. Solvent and water from Polymer Removal System is fed to the middle section of C-205. In C-205, any trace amount of hydrocarbon contained in the water phase is stripped by the ascending vapor generated in Steam Generator E-207. Water Stripper overhead vapor, including stripped hydrocarbon, is routed to E-203A for hydrocarbon recovery. Steam Generator is a kettle exchanger vaporizing the process water using LP steam as heating medium.

Stripping steam generated in E-207 is used to assist the stripping process in EDC, SRC, and the vaporization of solvent in Solvent Regenerator C-204. The solvent remaining at the bottom of E-207 is split into two directions, one part is sent to Solvent Generator, while the remaining is returned to bottom of SRC.

In Solvent Regenerator, the heavy decomposition products of solvent degradation are removed from the solvent. The heavies are purged periodically, while the regenerated solvent is returned back to SRC. Stripping steam is utilized to assist in the separation of the heavies from the solvent, thus integrating the solvent recovery and regeneration operations and avoiding the use of a separate vacuum system or equipment. IP steam is used as heating medium for C-204.

Polymer Removal System Section

A small amount of cooled solvent from Lean Solvent Cooler is sent to 1st Stage Separator D-208 for removal of possible styrene polymer, in order to keep the solvent at desired quality. The solvent slip stream is mixed with raffinate from EDC overhead to facilitate the removal of polymer from the solvent phase. The organic layer consisting of polymer dissolved in the raffinate stream is further water washed in 2nd Stage Separator D-209 to remove and recover traces of solvent which are carried by the polymer-raffinate stream. Fresh water from Water Surge Drum is sent to D-209 and used as water wash for the organic phase. In D-209, water is mixed with the solvent-raffinate stream, and the solvent-water-raffinate mixture is returned to 1st Stage Separator where the two phases are separated. The water phase dissolving the solvent is separated as the lower liquid layer, and sent to Water Striper. The polymer-raffinate is separated as the organic top layer, and sent to B.L.

Styrene Storage Section

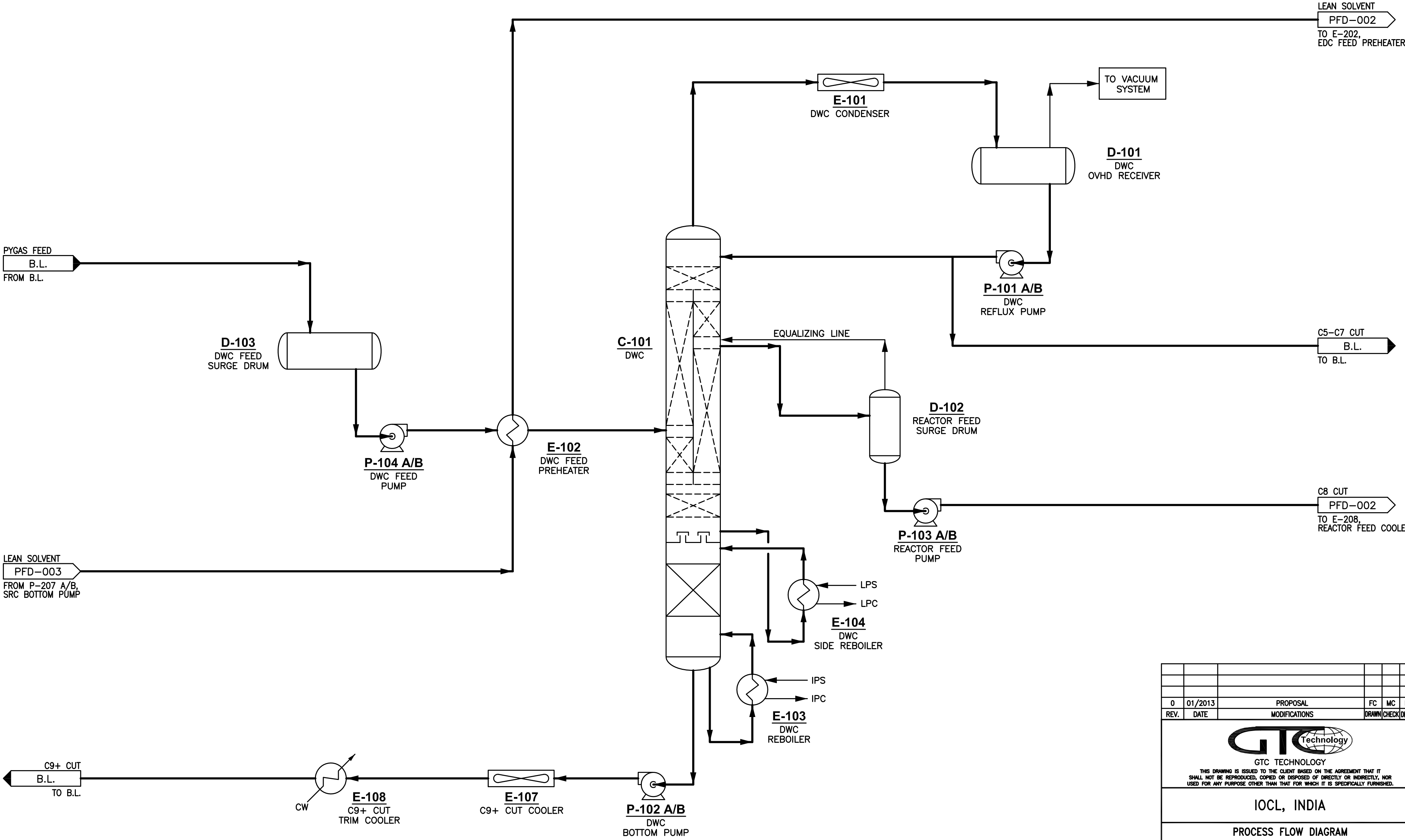
Three storage tanks are designated for the storage of styrene product, Styrene Product Daily Tank A TK-211, Styrene Product Daily Tank B TK-212, and Styrene Tank TK-213.

Aromatic drain from Extraction section is sent to Aromatic Sump D-217 located underground at the lowest point of the plant. Aromatic Sump Cooler E-220 is provided for cooling down the aromatics before being sent to B.L. One additional vessel, D-210, is provided as LP Vent Drum to collect liquids from the extraction unit PSV's where there is a high probability that a release could result in a loss of the valuable liquid aromatics to the flare. From D-216, the liquid can be directed to the aromatics drain, which is collected in Aromatic Sump for eventual recovery.

Solvent Storage Section

The operation of the Solvent Recovery Unit also requires a solvent storage facility consisting of two solvent tanks, one solvent sump tank, one wet solvent cooler and two transfer pumps. The solvent is loaded/ unloaded to/ from the process unit in Plant Solvent Tank TK-214 and Wet Solvent Tank TK-215. Solvent drain from Extraction section is sent to Solvent Sump D-218 located underground at the lowest point of the plant. Wet Solvent Cooler E-220 is provided for cooling down wet solvent before sending it to the storage facilities.

One additional vessel, D-216, is provided as Solvent Vent Drum to collect liquids from the extraction unit PSV's where there is a high probability that a release could result in a loss of the valuable liquid solvent to the flare. From D-216, the liquid can be directed to the solvent drain, which is collected in Solvent Sump for eventual recovery.



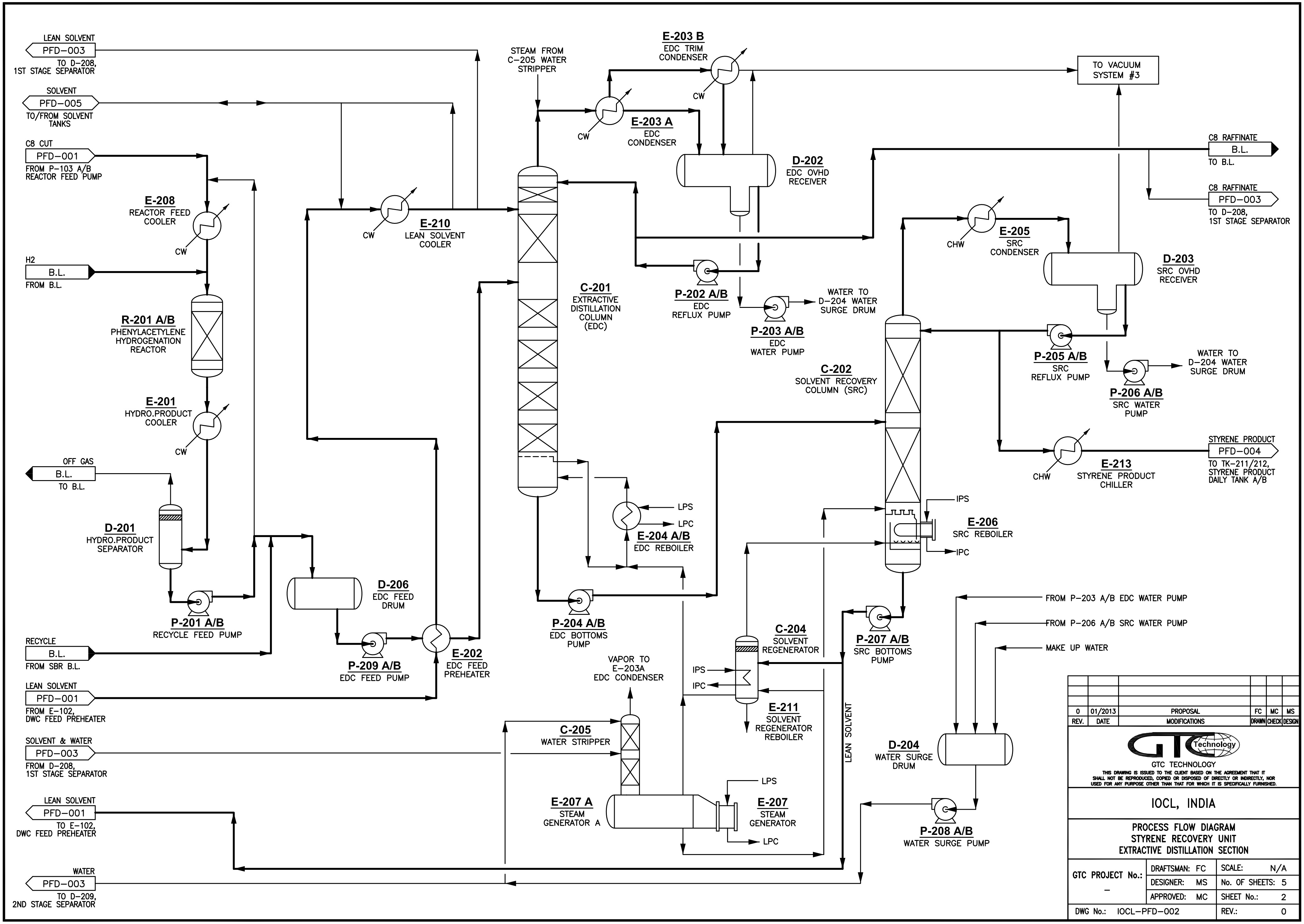
REV.	DATE	MODIFICATIONS	DRAWN	CHECK	DESIGN
0	01/2013	PROPOSAL	FC	MC	MS

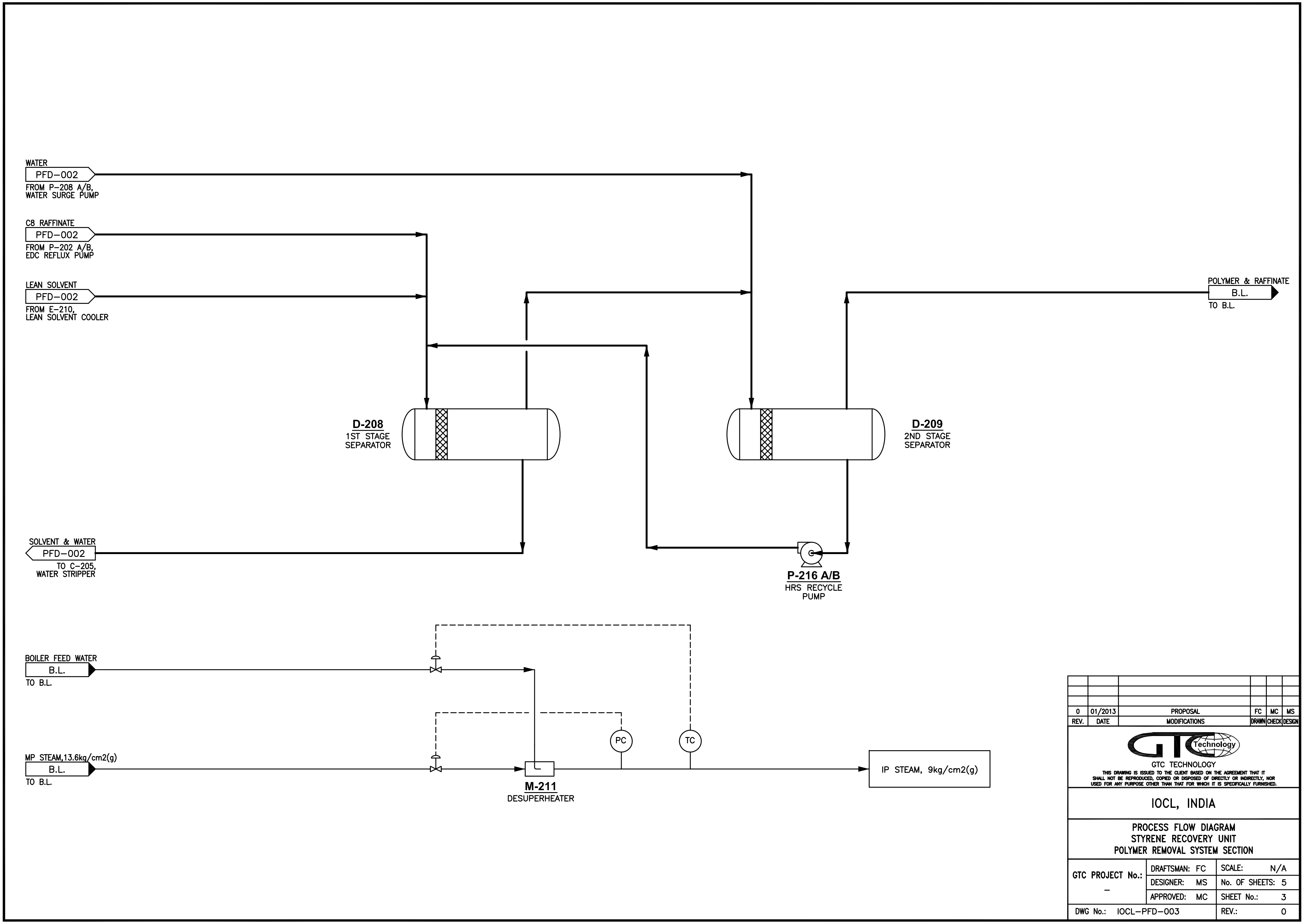
GTC TECHNOLOGY

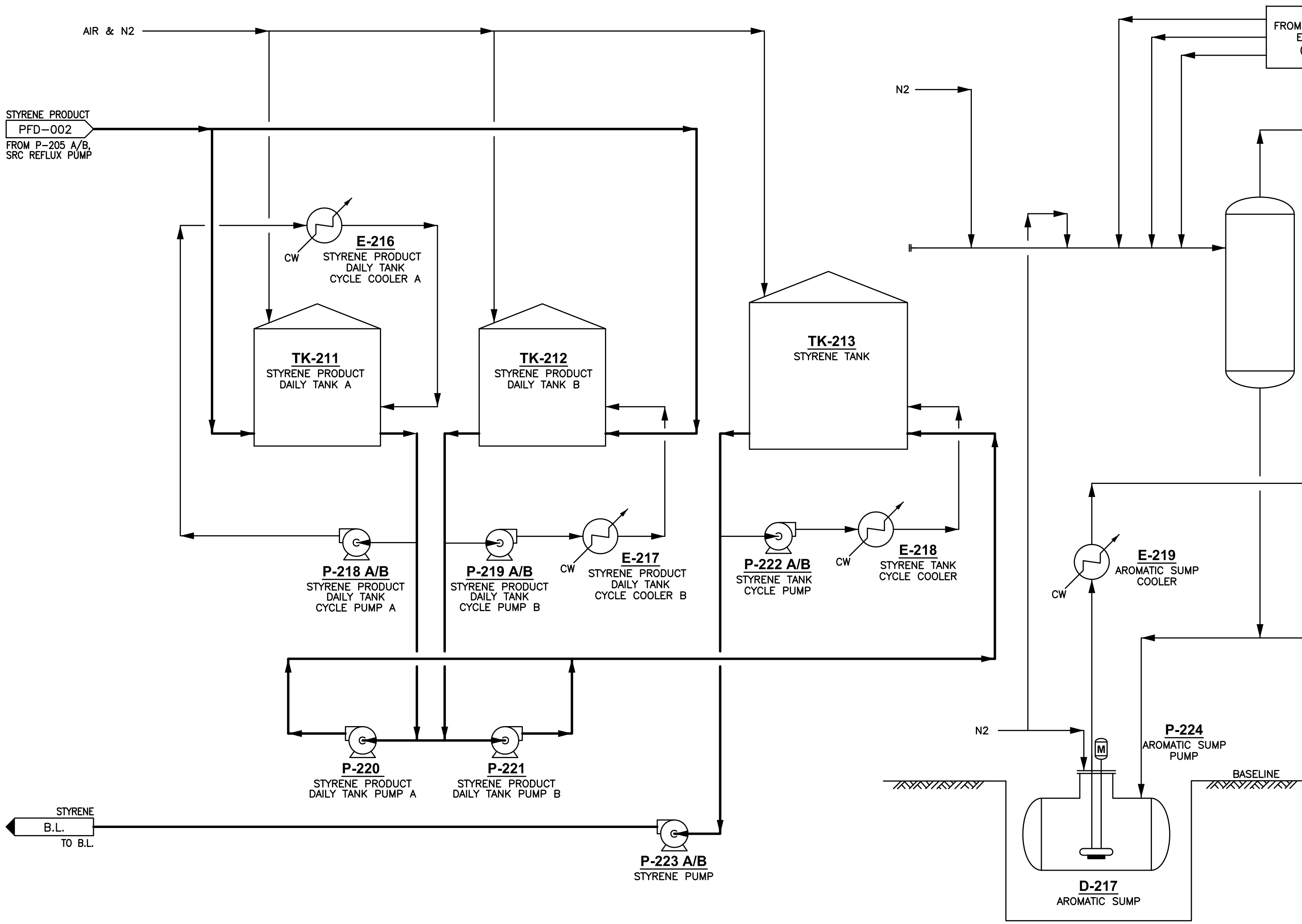
IOCL, INDIA

PROCESS FLOW DIAGRAM
STYRENE RECOVERY UNIT
PREFRACTIONATION SECTION

GTC PROJECT No.: –	DRAFTSMAN: FC	SCALE: N/A
	DESIGNER: MS	No. OF SHEETS: 5
	APPROVED: MC	SHEET No.: 1
DWG No.: IOCL–PFD–001		REV.: 0


LEAN SOLVENT
PFD–003
TO D–208, 1ST STAGE SEPARATOR
SOLVENT
PFD–005
TO/FROM SOLVENT TANKS
C8 CUT
PFD–001
FROM P–103 A/B REACTOR FEED PUMP
E-208
REACTOR FEED COOLER
CW
H2
B.L.
FROM B.L.
R-201 A/B
PHENYLACETYLENE HYDROGENATION REACTOR
E-201
HYDRO.PRODUCT COOLER
OFF GAS
B.L.
TO B.L.
D-201
HYDRO.PRODUCT SEPARATOR
P-201 A/B
RECYCLE FEED PUMP
RECYCLE
B.L.
FROM SBR B.L.
LEAN SOLVENT
PFD–001
FROM E–102, DWC FEED PREHEATER
SOLVENT & WATER
PFD–003
FROM D–208, 1ST STAGE SEPARATOR
LEAN SOLVENT
PFD–001
TO E–102, DWC FEED PREHEATER
WATER
PFD–003
TO D–209, 2ND STAGE SEPARATOR
E-210
LEAN SOLVENT COOLER
D-206
EDC FEED DRUM
P-209 A/B
EDC FEED PUMP
E-202
EDC FEED PREHEATER
STEAM FROM C–205 WATER STRIPPER
C-201
EXTRACTIVE DISTILLATION COLUMN (EDC)
E-203 A
EDC CONDENSER
E-203 B
EDC TRIM CONDENSER
D-202
EDC OVHD RECEIVER
P-202 A/B
EDC REFLUX PUMP
P-203 A/B
EDC WATER PUMP
WATER TO D–204 WATER SURGE DRUM
E-204 A/B
EDC REBOILER
LPS
LPC
P-204 A/B
EDC BOTTOMS PUMP
VAPOR TO E–203A EDC CONDENSER
C-205
WATER STRIPPER
E-207 A
STEAM GENERATOR A
E-207
STEAM GENERATOR
C-204
SOLVENT REGENERATOR
IPS
IPC
E-211
SOLVENT REGENERATOR REBOILER
LEAN SOLVENT
TO VACUUM SYSTEM #3
C8 RAFFINATE
B.L.
TO B.L.
C8 RAFFINATE
PFD–003
TO D–208, 1ST STAGE SEPARATOR
E-205
SRC CONDENSER
CHW
D-203
SRC OVHD RECEIVER
P-205 A/B
SRC REFLUX PUMP
P-206 A/B
SRC WATER PUMP
WATER TO D–204 WATER SURGE DRUM
C-202
SOLVENT RECOVERY COLUMN (SRC)
E-213
STYRENE PRODUCT CHILLER
STYRENE PRODUCT
PFD–004
TO TK–211/212, STYRENE PRODUCT DAILY TANK A/B
E-206
SRC REBOILER
P-207 A/B
SRC BOTTOMS PUMP
FROM P–203 A/B EDC WATER PUMP
FROM P–206 A/B SRC WATER PUMP
MAKE UP WATER
D-204
WATER SURGE DRUM
P-208 A/B
WATER SURGE PUMP
0 | 01/2013 | PROPOSAL | FC | MC | MS
REV. | DATE | MODIFICATIONS | DRAWN | CHECK | DESIGN
GTC Technology
GTC TECHNOLOGY
THIS DRAWING IS ISSUED TO THE CLIENT BASED ON THE AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED OR DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED.
IOCL, INDIA
PROCESS FLOW DIAGRAM
STYRENE RECOVERY UNIT
EXTRACTIVE DISTILLATION SECTION
GTC PROJECT No.: –
DRAFTSMAN: FC
DESIGNER: MS
APPROVED: MC
SCALE: N/A
No. OF SHEETS: 5
SHEET No.: 2
DWG No.: IOCL–PFD–002
REV.: 0


WATER
PFD–002
FROM P–208 A/B,
WATER SURGE PUMP
C8 RAFFINATE
PFD–002
FROM P–202 A/B,
EDC REFLUX PUMP
LEAN SOLVENT
PFD–002
FROM E–210,
LEAN SOLVENT COOLER
POLYMER & RAFFINATE
B.L.
TO B.L.
D-208
1ST STAGE
SEPARATOR
D-209
2ND STAGE
SEPARATOR
SOLVENT & WATER
PFD–002
TO C–205,
WATER STRIPPER
P-216 A/B
HRS RECYCLE
PUMP
BOILER FEED WATER
B.L.
TO B.L.
MP STEAM,13.6kg/cm2(g)
B.L.
TO B.L.
PC
TC
M-211
DESUPERHEATER
IP STEAM, 9kg/cm2(g)
0
01/2013
PROPOSAL
FC
MC
MS
REV.
DATE
MODIFICATIONS
DRAWN
CHECK
DESIGN
Technology
GTC TECHNOLOGY
THIS DRAWING IS ISSUED TO THE CLIENT BASED ON THE AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED OR DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED.
IOCL, INDIA
PROCESS FLOW DIAGRAM
STYRENE RECOVERY UNIT
POLYMER REMOVAL SYSTEM SECTION
GTC PROJECT No.:
–
DRAFTSMAN: FC
DESIGNER: MS
APPROVED: MC
SCALE: N/A
No. OF SHEETS: 5
SHEET No.: 3
DWG No.: IOCL–PFD–003
REV.: 0



0	01/2013	PROPOSAL	FC	MC	MS
REV.	DATE	MODIFICATIONS	DRAWN	CHECK	DESIGN

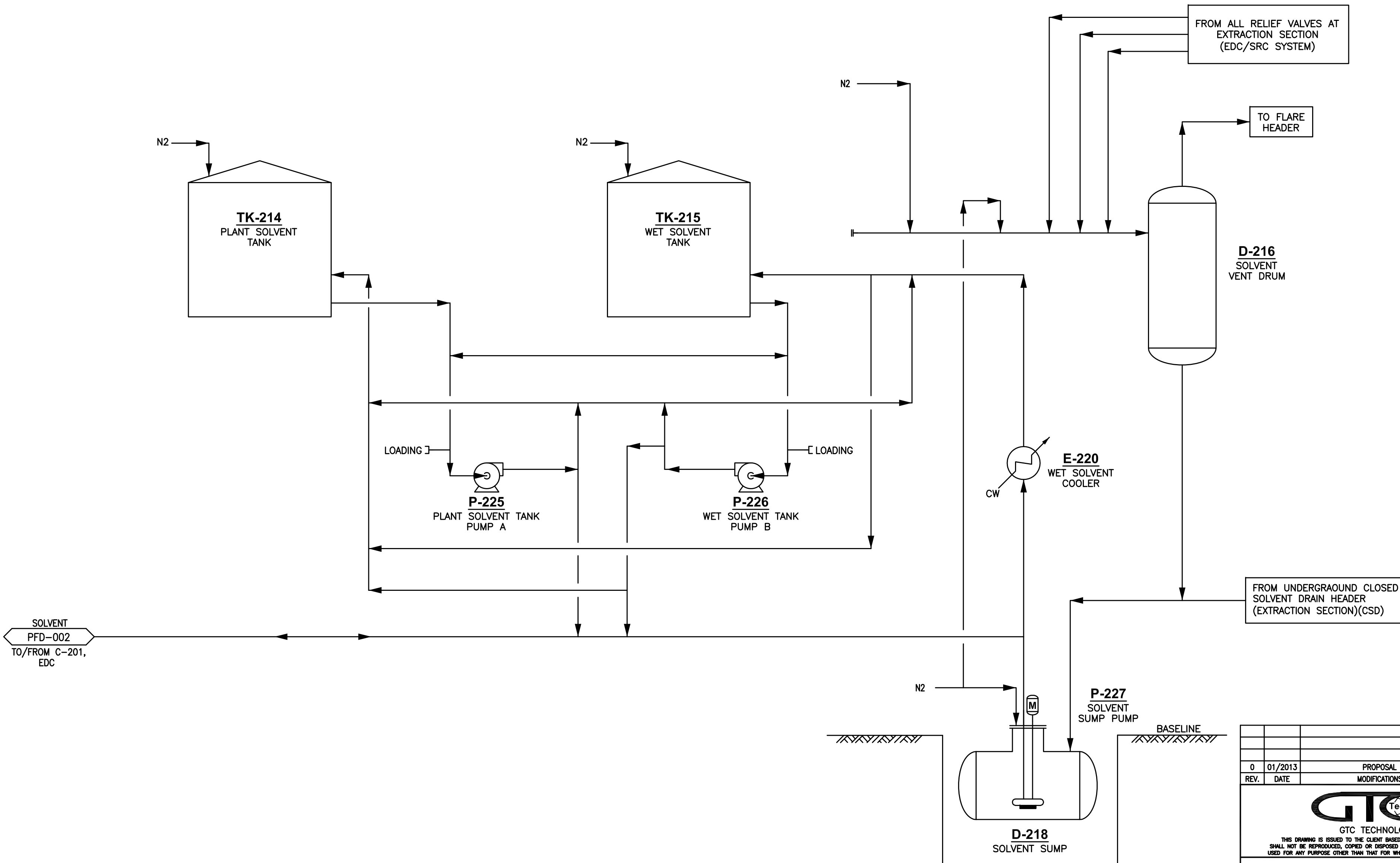
GTC Technology

GTC TECHNOLOGY

IOCL, INDIA

PROCESS FLOW DIAGRAM
STYRENE RECOVERY UNIT
STYRENE STORAGE SECTION

GTC PROJECT No.: –	DRAFTSMAN: FC	SCALE: N/A
	DESIGNER: MS	No. OF SHEETS: 5
	APPROVED: MC	SHEET No.: 4
DWG No.: IOCL–PFD–004		REV.: 0



REV.	DATE	MODIFICATIONS	DRAWN	CHECK	DESIGN
0	01/2013	PROPOSAL	FC	MC	MS

GTC TECHNOLOGY

IOCL, INDIA

PROCESS FLOW DIAGRAM
BENZENE/TOLUENE/XYLENE RECOVERY UNIT
SOLVENT STORAGE SECTION

GTC PROJECT No.: –	DRAFTSMAN: FC	SCALE: N/A
	DESIGNER: MS	No. OF SHEETS: 5
	APPROVED: MC	SHEET No.: 5
DWG No.: IOCL–PFD–005		REV.: 0

2.2.2 Material Balance

The overall material balance for SRU is presented below.

Feeds	MTY	Products	MTY
Pygas Feed	356,046	Styrene Product	20,173
Hydrogen	38	C5-C7 Cut	194,493
SBR Recycle	680	C9+ Cut	74,528
		Raffinate	65,592
		Off Gas	58
		Heavies	1,916
Total	**356,763**	**Total**	**356,763**

The compositional material balance for SRU is presented below.

Component	Pygas Feed		C5-C7 Cut		C9+ Cut		SBR RECYCLE		Hydrogen		Off Gas		Raffinate		Styrene Product		Heavies	
	kg/hr	wt%	kg/hr	wt%	kg/hr	wt%	kg/hr	wt%	kg/hr	wt%	kg/hr	wt%	kg/hr	wt%	kg/hr	wt%	kg/hr	wt%
HYDROGEN	0	0	0	0	0	0	0	0	3.3	70.48	0.5	6.46	0	0	0	0	0	0
METHANE	0	0	0	0	0	0	0	0	1.4	29.52	1.4	18.77	0	0	0	0	0	0
C4 (P,O,N)	49.3	0.11	49.3	0.2	0	0	6.6	7.82	0	0	2	27.86	4.5	0.05	0	0	0.1	0.05
C5 (P,O,N)	836.5	1.88	836.5	3.44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6 (P,O,N)	2436.1	5.47	2436.1	10.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7 (P,O,N)	2796.5	6.28	2791.8	11.48	0	0	0	0	0	0	0	0.18	4.5	0.05	0	0	0.1	0.05
C8 (P,O,N)	1511.4	3.4	838.6	3.45	0	0	13.9	16.4	0	0	0.8	10.41	668.6	8.15	0	0	17.4	7.27
C9 (P,O,N)	32.9	0.07	0.1	0	0.8	0.01	0	0	0	0	0	0.06	31.2	0.38	0	0	0.8	0.34
C10+ (P,O,N)	943.9	2.12	0	0	943.9	10.13	0	0	0	0	0	0	0	0	0	0	0	0
BENZENE	5588.5	12.56	5588.5	22.99	0	0	0.2	0.27	0	0	0	0.06	0.2	0	0	0	0	0
TOLUENE	11679.7	26.24	11477.8	47.21	0	0	0.6	0.73	0	0	0.5	7.31	196.9	2.4	0	0	5.1	2.14
EBENZENE	2816.5	6.33	177	0.73	0.2	0	1.3	1.51	0	0	1	13.37	2665.9	32.5	0	0	69.4	28.97
MXYLENE	2313.7	5.2	46.7	0.19	2	0.02	0	0	0	0	0.6	7.79	2207	26.9	0	0	57.4	23.97
PXYLENE	996.7	2.24	29.8	0.12	0.4	0	0	0	0	0	0.3	3.71	941.8	11.5	0	0	24.5	10.23
OXYLENE	1410.5	3.17	4	0.02	68	0.73	0	0	0	0	0.2	3.25	1302.6	15.9	1.8	0.07	33.9	14.15
STYRENE	2669.6	6	34.3	0.14	22.7	0.24	62.2	73.2	0	0	0	0.65	102.9	1.25	2502.1	99.23	2.8	1.17
A9+	8370.7	18.81	0.1	0	8278.1	88.86	0.1	0.09	0	0	0	0.1	72.9	0.89	17.6	0.7	1.9	0.79
PHACETYL	53.4	0.12	1.3	0.01	0.1	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Poly-styrene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	10.86
Total	**44505.7**	**100**	**24311.7**	**100**	**9316**	**100**	**85**	**100**	**4.7**	**100**	**7.3**	**100**	**8198.9**	**100**	**2521.6**	**100**	**239.5**	**100**

2.2.3 Product Quality

The styrene product will comply with the product specifications listed in section 2.1.3. The expected styrene purity is as follows.

Styrene Product Purity: 99.2wt %

2.2.4 Utility Consumption

Based on the preliminary design, the following utility consumption is estimated for SRU.

Utility	UOM	Pre-fractionation	Extraction	Total
IP Steam, 9 Kg/cm^2 (G) (1)	t/hr	5.1	1.9	7.0
LP Steam, 2.7 Kg/cm^2 (G)	t/hr	7.9	8.2	16.1
Cooling Water (2)	m3/hr	8	884	892
Chilled Water	m3/hr	-	8	8
Electricity	kW	167	144	311

Note:
1. IP Steam is prepared by letting down MP steam from 13.6 kg/cm2 (g) to 9.0 kg/cm2 (g).
2. Cooling Water consumption is based on 5 ^oC temperature rise; supply and return temperatures at 33 ^oC and 38 ^oC respectively. This is due to the requirement to cool down product streams to final storage temperature of 40 ^oC.

2.2.5 Investment Cost Estimation

The preliminary investment cost estimation has been developed on a USGC 2012 price basis and is estimated based on sized equipment list and typical installation factors for each type of equipment. The total investment cost is estimated at **40 MM USD (+/- 50%)**.

The estimated investment cost does not include:
- license, PDP and DEP engineering fees,
- proprietary equipment cost,
- solvent, catalyst, and chemicals cost,
- tower internals cost.

2.2.6 Equipment List

The list of ISBL equipment required for SRU is summarized in Appendix 1. The information of the equipment includes equipment description, main characteristics, and material of construction, design temperature/pressure, and number of pieces. Equipment overdesign margin is 110% of the design case capacity. For equipment in solvent loop the overdesign margin is 120% for added flexibility in operation.

2.2.7 Chemicals and Catalyst Specifications and Consumption

PA Selective Hydrogenation Catalyst

Form	sphere
Normal Size	2-4mm
Bulk Density	650 +/- 50 kg/m3
Active Ingredients	Palladium on Alumina
Operating Temperature Range, ^{o}C	50-100
Regeneration Method and Temperature, ^{o}C	Oxidation with air at 400-550 ^{o}C in presence of steam, atmospheric pressure.
Initial Regeneration Cycle	6 months

Techtiv® 200

Form	colorless liquid
Techtiv® 200 Content	>96%
Water Content	<3%
Distillation Range	282°C-288 ^{o}C
Flash point,COC	177 ^{o}C
Materials to Avoid	None

True Inhibitor GE S310

Composition	Hydroxypropyl hydroxylamine
Sp. Gr. @ 20 ^{o}C	1.039
Freeze Point,	-8
Viscosity, cps@ 21 ^{o}C	10
Solubility	100% soluble in water
Appearance	Colorless to yellow
Physical State	Liquid
Flash Point, ^{o}C	> 93

Material to Avoid	React with metals (iron, copper, brass), alkali and oxidizers
Storage Conditions	Closed, away from oxidizers and bases. Storage between 5-38 °C

Monoethanolamine (MEA) - H2NCH2CH2OH

Composition	Monoethanolamine≥99.5%
Physical State	Liquid
Relative Density@25 °C	1.0113
Freeze Point, °C	10
Surface Tension, dynes/cm@25 °C	48.3
Viscosity, cp@20 °C	24.1
Flash Point, CC	96
Materials to Avoid	Strong oxidizing agents. strong bases. Strong acids. Aldehydes. Ketones. crylates. Organic anhydrides. Organic halides. Formates. Lactones. Oxalates

Antifoam

Relative Density@25 °C	0.97
Freeze Point, °C	-
Viscosity, cp@25 °C	1,500
Flash Point, CC	>101
Stability	Stable
Materials to Avoid	oxidizing agent

Non-sulfure Inhibitor DNBP

Appearance	Yellow to brown, liquid, EB odor
Boiling Point	Unknown
Melting Point	Unknown
Sp. Gr	1.14
Stability	Stable under ordinary conditions
Materials to Avoid	Strong alkalis and oxidzers

TBC Inhibitor

Composition	Solution of 4-tert-butylcatechol in methanol
Relative Density@20 °C	1.037
Freeze Point, °C	9
Viscosity, cps@21 °C	10
Solubility	Slightly soluble in water, miscible in all proportions with methanol
Appearance	Amber

Physical State	Liquid
Flash Point, CC	32
Stability	Stable under normal conditions of use
Materials to Avoid	Strong oxidizing agent

Consumption of Chemicals and Catalyst

Chemicals/ Catalyst	Unit	Initial charge	Estimated Annual Consumption and life
PA catalyst (GTC-203B)	M3	10	5 years life, with 3-4 regenerations
Techtiv-200 Solvent	Ton	90	0.65/ year
Retarding agent DNBP	Ton	0.0225	4.5/ year
GE 20Y3	Ton	0.9	23.6/ year
GE S310	Ton	0.15	7.2/ year
TBC	Ton	By vendor	0.48/ year
Anti-foam	Ton	By vendor	0.035-0.05/year*
MEA	Ton	By vendor	1 -2/year

2.2.8 Effluent Summary

PA Selective Hydrogenation Reactor Regeneration Off-gas

Prior to regeneration, hydrocarbons are purged by nitrogen and steam, and then cooled and sent to the flare. During steam/air regeneration, off-gas is sent to the atmosphere at the safe location. There will be one regeneration per 1-2 years for 3 days duration.
Temperature: 450 °C max

Water Purge from Water Surge Drum

Quantity: normally no flow. Maximum instantaneous flow expected to be 200 kg/hr. Disposition: OSBL waste water treatment unit. Temperature: 40 degree ^{o}C.

Composition	
Techtiv® 200 solvent	5 wppm
Styrene & C8 Aromatics	0.08%
Water	Balance

Solvent Regenerator Dump-out

Quantity: 20 kg/week; drained once per week to collection drum. Disposition: viscous liquid to be disposed in fuel oil or waste incineration.

Composition	**Wt%**
Polymerized viscous material (35% sulfur; 65% aromatic hydrocarbon)	20-30%
Styrene dimer/trimer	35-45%
Styrene polymer	30-40%

Spent Catalyst from PA Selective Hydrogenation Reactors

When the catalyst can no longer be satisfactorily regenerated, since it contains the noble metal, it may be returned to the manufacturer for recovery.

3. SECTION II: BENZENE/ TOLUENE/ XYLENES RECOVERY UNIT (BTXRU)

3.1 Design Basis

BTXRU to be presented in the following segment includes a pre-fractionation column, GT-BTX® extractive distillation section, post-fractionation section, and solvent storage.

3.1.1 Plant capacity

The BTXRU is designed to process 239,352 MTY of C6 – C8 feed (from Dehexanizer bottoms) to produce approximately 65,640 MTY of high purity benzene, 78,894 MTY of high purity toluene, and 40,483 MTY of mixed xylenes. Annual production is based on an on-stream time of 8,000 hr/year. In actual operation, the plant is able to operate at a higher on-stream factor.

3.1.2 Feed Specification

The following feed composition is used for the design of BTXRU. The feed composition was determined based on re-simulating the dehexanizer column of the existing BRU in such a way to bring the specification of the feed going to the existing BRU to the conditions of the original design. This was realized by dropping part of the benzene from the raw pygas to the bottom of the De-C6 column, and leaving to be recovered in the new BTXRU.

	C6+ Feed
Component	**wt%**
N-hexane	0.00
3-methylpentane	0.00
Methylcyclopentane	0.53
Cyclohexane	0.88
Benzene	27.50
2,2-dimethylpentane	0.00
2,4-dimethylpentane	0.02
3-methylhexane	1.77
2,3-dimethylpentane	0.11
3-metylhexane	1.49
N-heptane	1.50
1,1-dimethylcyclopentane	0.38
cis-1,3-dimethylcyclopentane	1.28
trans-1,3-dimethylcyclopentane	1.08
cis-1,2-dimethylcyclopentane	0.40
trans-1,2-dimethylcyclopentane	1.40

Methylcyclohexane	4.41
Ethylcyclopentane	1.49
Toluene	32.95
N-octane	2.42
1,1-dimethylcyclohexane	0.40
Ethylcyclohexane	0.06
Propylcyclopentane	0.85
Ethylbenzene	11.01
P-xylene	6.27
C9 Aromatics	0.30
1,1,3-trimethylcyclopentane	1.51
Solvent	0.00
Mass flow, kg/hr	**29919**

3.1.3 Product Specification

The following product specification for benzene, toluene and mixed xylenes are considered for the design of BTXRU.

Benzene Product

Property	Unit	Limit(s)
Benzene	wt%	99.9 min
Toluene	ppm wt	500 max
Non-Aromatics	ppm wt	1000 max
Appearance	Clear liquid free of sediment & haze at 20 ^{o}C	
Water	ppm wt	500 max
Colour Pt/Co scale		10 max
Sulfur	ppm wt	1 max
Nitrogen	ppm wt	1 max
Bromine Index	mg Br/100g	20 max
Chlorine	ppt wt	3 max

Toluene Product

Property	Unit	Limit(s)
Purity	wt. %	99.7 min
Non-Aromatics	wt. %	0.2 max
Benzene	wt. %	0.05 max
C8 Aromatics	wt. %	0.05 max.
Acid Wash Color		2
Appearance		Clear Liquid, Free of Sediment or Haze
Color, APHA		20
Specific Gravity at 15.56 ^{o}C		0.865 ~ 0.868
Sulfur content	wppm	2.0 max.

Mixed Xylenes Product

Property	Unit	Limit(s)
Purity,	wt. %	98.0 min
Toluene	wt. %	0.5 max
Non-Aromatics	wt. %	0.5 max
C9+ Aromatics	wt. %	0.5 max

3.1.4 Utility Information

Utility information considered for BTXRU is the same as for SRU, as described in section 2.1.4.

3.2 Process Design

3.2.1 Process Description and Preliminary PFDs

The process description is based on the following PFDs.

Pre-fractionation Section

The C6+ feed from Dehexanizer bottoms is first preheated with BTX cut from overhead of C8/C9+ prefractionator in C8/C9+ Prefractionator Feed Preheater E-101 A/B and then fed to the middle of C8/C9+ Prefractionator C-101, where BTX cut is separated from C9+ heavies. The column overhead vapor is condensed in an C8/ C9+ Prefractionator Overhead Condenser E-102 and collected in C8/C9+ Overhead Receiver D-101. The condensed liquid is partly returned to column as reflux and the remaining is withdrawn as BTX cut by C8/C9+ Prefractionator Reflux Pump P-101 A/B. The BTX cut is further sent to GT-BTX® extractive distillation unit for separating aromatics after exchanging heat with feed in E-101 A/B. C-101 is reboiled using MP steam in C8/C9+ Prefractionator Reboiler E-103. C-101 bottoms consisting mainly of C9+ heavies is pumped by C8/C9+ Prefractionator Bottoms Pump P-102 A/B to storage after being cooled down to storage temperature in C9+ Heavies Cooler E-106 and sent to battery limit (B.L.).

GT-BTX® Extractive Distillation Section

BTX cut from the overhead of C-101 is preheated by exchanging heat with circulating hot lean solvent in EDC Feed Preheater E-209. EDC Feed Surge Drum D-206 is installed to protect downstream extraction unit from fluctuations in upstream pre-fractionation unit. The heated hydrocarbon feed is introduced at the middle of the Extractive Distillation Column (EDC) C-201, while the lean solvent is introduced close to the top of the column. In a vapor-liquid operation the solvent extracts the aromatics to the bottom of the column, while rejecting the non-aromatics to the top as raffinate. The raffinate vapors are condensed in EDC Condenser E-202 and collected in EDC Overhead Receiver D-201. A portion of the liquid is sent back to EDC as reflux, and the remaining stream is cooled to storage temperature in Raffinate Cooler E-211 and sent to B.L. as raffinate product by EDC Reflux Pump P-201 A/B. EDC is reboiled by EDC Side Reboiler E-212 using hot lean solvent as heating medium, and by EDC Steam Reboiler E-203 using MP steam as heating medium.

The rich solvent containing solvent and aromatics is withdrawn from the bottom of EDC by EDC Bottoms Pump P-202 A/B and fed to Solvent Recovery Column (SRC) C-202. Aromatic hydrocarbons are separated from the solvent and recovered at the top of the column. Overhead vapors are condensed in SRC Condenser E-204 and further cooled in SRC Overhead Trim Cooler E-205, and then collected in SRC Overhead Receiver D-202. A portion of hydrocarbon liquid from the receiver is sent back to SRC as reflux, while the remaining is sent to post-fractionation section as the extract product from extractive distillation unit. SRC is reboiled by

MP steam in stab-in type reboiler E-206A/B. Lean solvent from bottom of SRC is pumped back to EDC by SRC Bottoms Pump P-205 A/B. SRC operates under moderate vacuum condition to minimize the boiling point at the base of the column. Furthermore, stripping steam, originating from the water balance of the system, is injected into the base of the column to assist in the stripping operation.

The hot lean solvent from the bottom of SRC passes through several heat exchangers for exchanging heat with different streams, thereby significantly reducing the energy consumption of the process. The lean solvent is used first as heating medium for EDC Side Reboiler. The lean solvent heat integration continues with stripping steam generation in Steam Generator E-207 followed by feed preheating in E-209, process water preheating in Water Preheater E-210, and extract preheating in Extract Preheater E-301. Finally the lean solvent is cooled down to the required solvent feed temperature in Lean Solvent Cooler E-201.

The water collected from the boots of EDC Overhead Receiver and SRC Overhead Receiver is pumped to Water Surge Drum D-203. From there the water is pumped by Decant Water Pump P-207 A/B to Water Preheater first and then to Steam Generator for stripping steam generation. A part of the process water from Water Preheater is directed to bottom of EDC to strip off any heavy boiling non-aromatics to the overhead of the column. The stripping steam generated in Steam Generator is directed to Solvent Regenerator C-203 and then continues to SRC as steam-solvent mixture. The steam is used for stripping the aromatics in SRC, and thus maintains a closed loop for the system water.

Post-fractionation Section

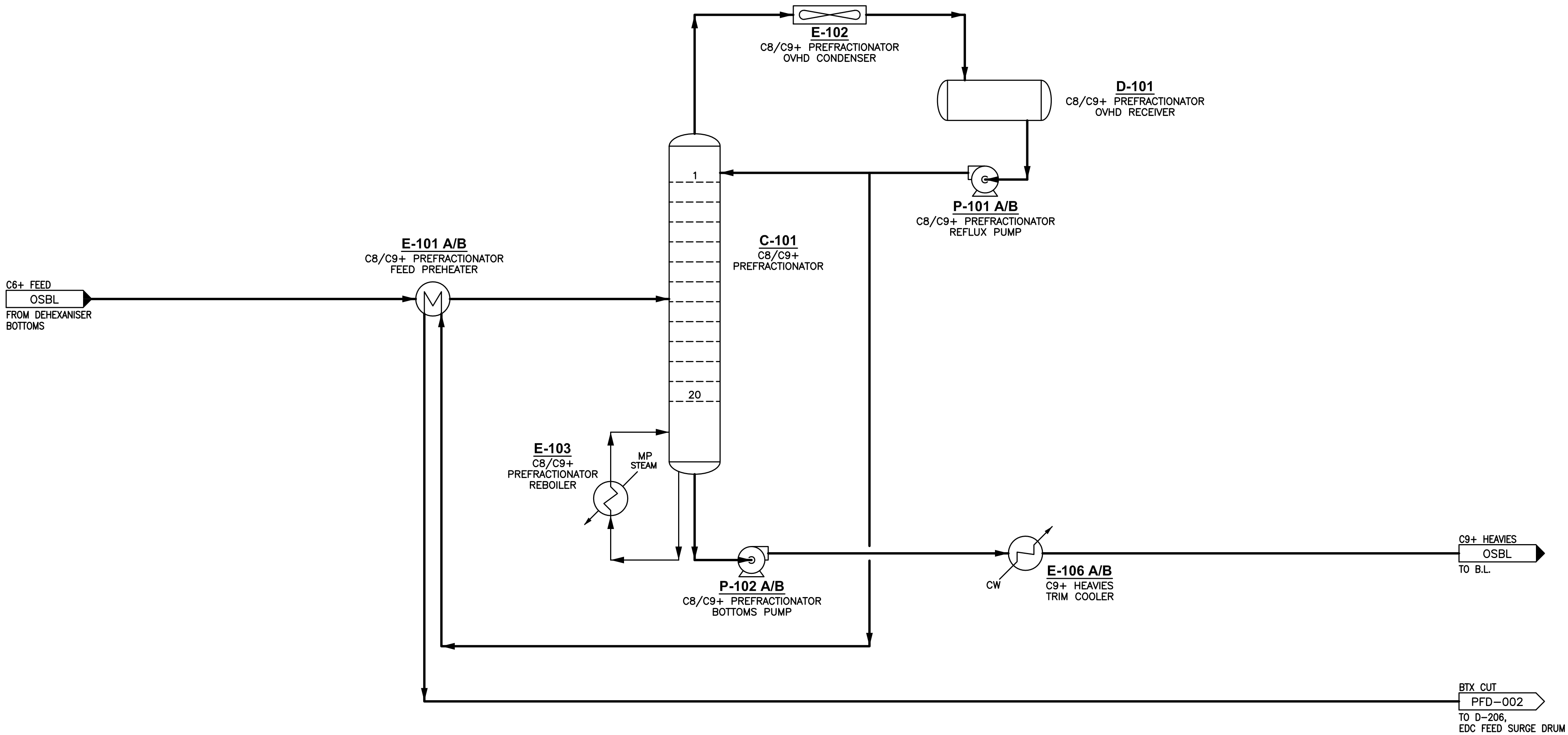
The aromatics extract from SRC is first preheated in Extract Preheater E-301 using hot lean solvent. The aromatics extract is fed to the middle of Benzene Column C-301 where high purity benzene is produced. The small amount of water that is saturated in the extract is removed at the top of Benzene Column as benzene-water azeotrope. Overhead vapors are condensed in Benzene Column Condenser E-303 and collected in Benzene Column Overhead Receiver D-301. The water is separated at the water boot of the receiver and is returned to Water Surge Drum. The condensed liquid stream is returned to the top of C-301 as reflux via Benzene Column Reflux Pump P-303A/B. The dry benzene product is withdrawn as a side draw stream a few trays below the top of the column. The product is cooled in Benzene Product Cooler E-302, and pumped to B.L. as final benzene product by Benzene Product Pump P-302A/B. The benzene column bottoms product is withdrawn by Benzene Column Bottom Pump P-301A/B and sent to Toluene Column C-302 for toluene fractionation. Benzene Column is reboiled by Benzene Column Reboiler E-304 utilizing MP steam as heating medium.

C7+ aromatics from Benzene Column bottom is fed directly to Toluene Column C-302. Overhead vapors from C-302 are condensed in Toluene Column Condenser E-306, and collected in Toluene Column Overhead Receiver D-302. Part of the condensed liquid stream is returned to the top of column as reflux, while the remaining is withdrawn as toluene product. Toluene product is cooled in Toluene Product Cooler E-305, and then pumped to B.L. by Toluene Column Reflux Pump P-304A/B. Mixed xylenes product is withdrawn from Toluene Column bottoms by Toluene Column Bottoms Pump P-305A/B and sent to B.L. after being cooled to storage temperature in Toluene Column Bottoms Cooler E-309 and Toluene Column Bottoms Trim Cooler E-308. Toluene Column is reboiled by Toluene Column Reboiler E-307 using MP steam as heating medium.

Solvent Storage Section

The operation of the extractive distillation unit also requires a solvent storage facility consisting of two solvent tanks, one solvent sump tank, one wet solvent cooler and two transfer pumps. The solvent is loaded/ unloaded to/ from the process unit in Plant Solvent Tank TK-201 and Wet Solvent Tank TK-202. Drains from Extraction section are sent to Solvent Sump D-205 located underground at the lowest point of the plant. Wet Solvent Cooler E-213 is also provided for cooling down wet solvent before sending it to the storage facilities.

One additional vessel, D-204, is provided as Solvent Vent Drum to collect liquids from the extraction unit PSV's where there is a high probability that a release could result in a loss of the valuable liquid solvent to the flare. From D-204, the liquid can be directed to the solvent drain, which is collected in the solvent sump, D-205, for eventual recovery.



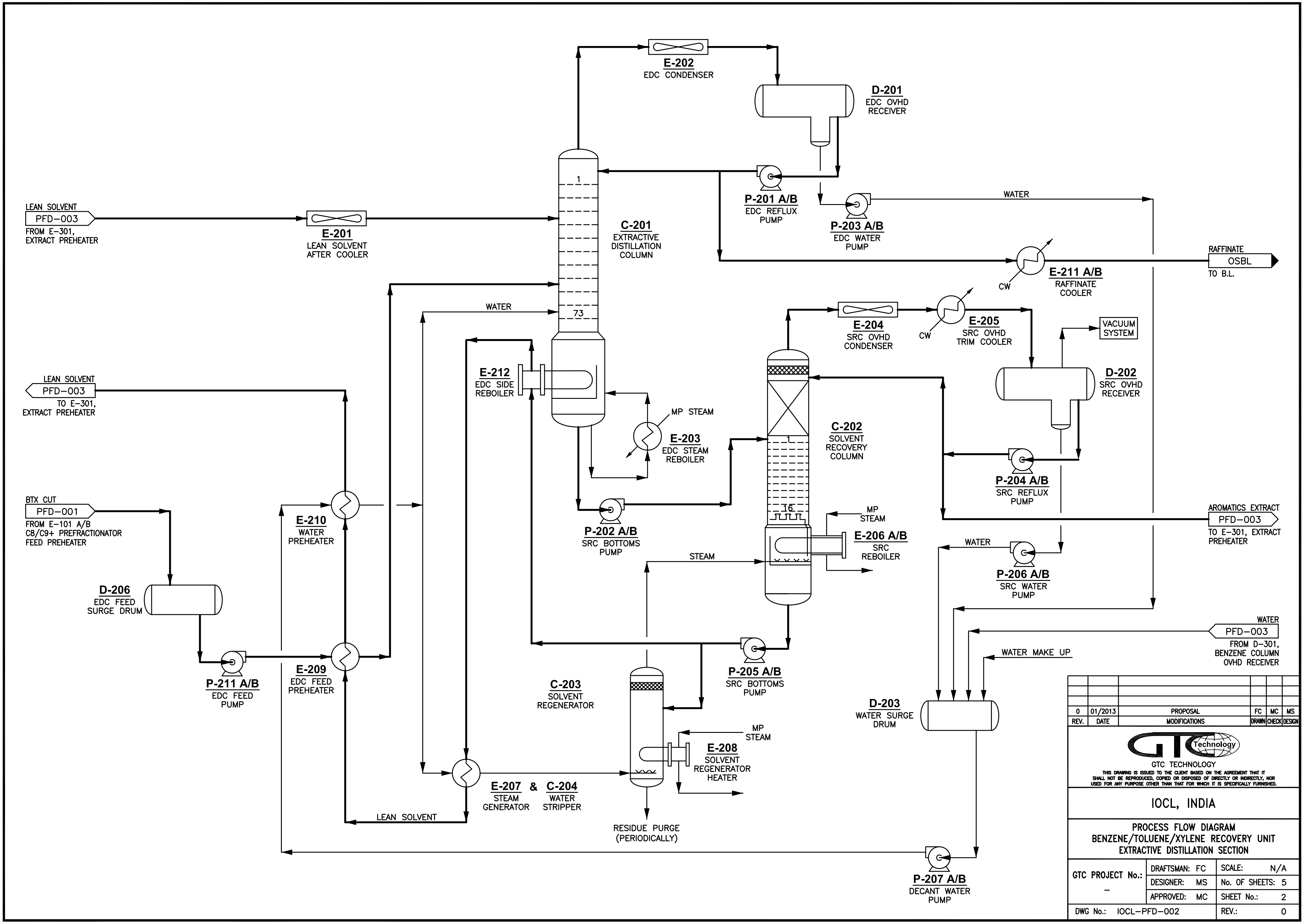
0	01/2013	PROPOSAL	FC	MC	MS
REV.	DATE	MODIFICATIONS	DRAWN	CHECK	DESIGN

GTC TECHNOLOGY

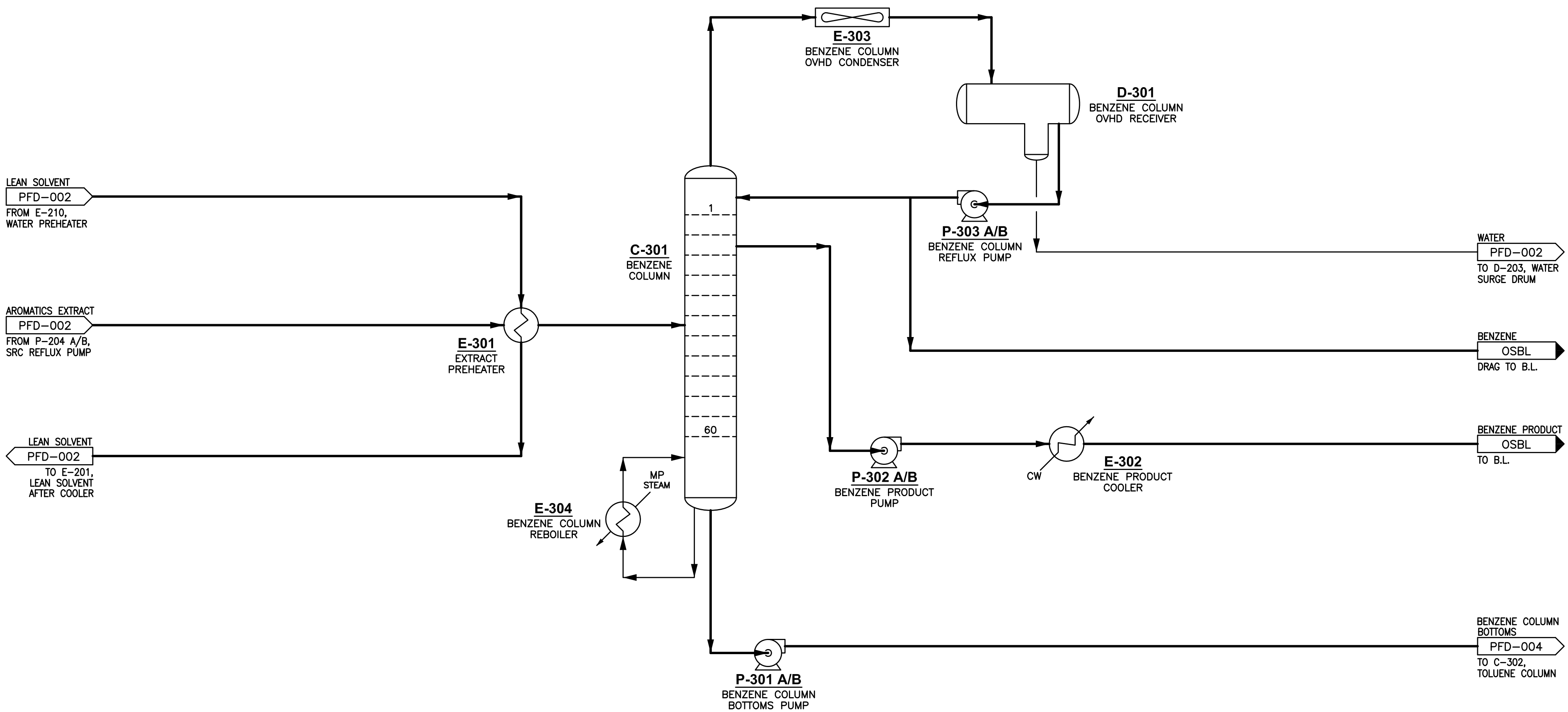
IOCL, INDIA

PROCESS FLOW DIAGRAM
BENZENE/TOLUENE/XYLENE RECOVERY UNIT
PRE FRACTIONATION SECTION

GTC PROJECT No.: –	DRAFTSMAN: FC	SCALE: N/A
	DESIGNER: MS	No. OF SHEETS: 5
	APPROVED: MC	SHEET No.: 1
DWG No.: IOCL–PFD–001		REV.: 0



E-202
EDC CONDENSER
D-201
EDC OVHD RECEIVER
LEAN SOLVENT
PFD-003
FROM E-301, EXTRACT PREHEATER
E-201
LEAN SOLVENT AFTER COOLER
1
73
C-201
EXTRACTIVE DISTILLATION COLUMN
P-201 A/B
EDC REFLUX PUMP
WATER
P-203 A/B
EDC WATER PUMP
RAFFINATE
OSBL
TO B.L.
CW
E-211 A/B
RAFFINATE COOLER
WATER
E-204
SRC OVHD CONDENSER
CW
E-205
SRC OVHD TRIM COOLER
VACUUM SYSTEM
D-202
SRC OVHD RECEIVER
LEAN SOLVENT
PFD-003
TO E-301, EXTRACT PREHEATER
E-212
EDC SIDE REBOILER
MP STEAM
E-203
EDC STEAM REBOILER
C-202
SOLVENT RECOVERY COLUMN
1
16
P-204 A/B
SRC REFLUX PUMP
BTX CUT
PFD-001
FROM E-101 A/B C8/C9+ PREFRACTIONATOR FEED PREHEATER
E-210
WATER PREHEATER
P-202 A/B
SRC BOTTOMS PUMP
MP STEAM
E-206 A/B
SRC REBOILER
AROMATICS EXTRACT
PFD-003
TO E-301, EXTRACT PREHEATER
STEAM
WATER
P-206 A/B
SRC WATER PUMP
D-206
EDC FEED SURGE DRUM
WATER
PFD-003
FROM D-301, BENZENE COLUMN OVHD RECEIVER
WATER MAKE UP
P-211 A/B
EDC FEED PUMP
E-209
EDC FEED PREHEATER
C-203
SOLVENT REGENERATOR
P-205 A/B
SRC BOTTOMS PUMP
D-203
WATER SURGE DRUM
MP STEAM
E-208
SOLVENT REGENERATOR HEATER
E-207 & C-204
STEAM GENERATOR
WATER STRIPPER
LEAN SOLVENT
RESIDUE PURGE (PERIODICALLY)
P-207 A/B
DECANT WATER PUMP
0
01/2013
PROPOSAL
FC
MC
MS
REV.
DATE
MODIFICATIONS
DRAWN
CHECK
DESIGN
GTC Technology
GTC TECHNOLOGY
THIS DRAWING IS ISSUED TO THE CLIENT BASED ON THE AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED OR DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED.
IOCL, INDIA
PROCESS FLOW DIAGRAM
BENZENE/TOLUENE/XYLENE RECOVERY UNIT
EXTRACTIVE DISTILLATION SECTION
GTC PROJECT No.: –
DRAFTSMAN: FC
DESIGNER: MS
APPROVED: MC
SCALE: N/A
No. OF SHEETS: 5
SHEET No.: 2
DWG No.: IOCL–PFD–002
REV.: 0



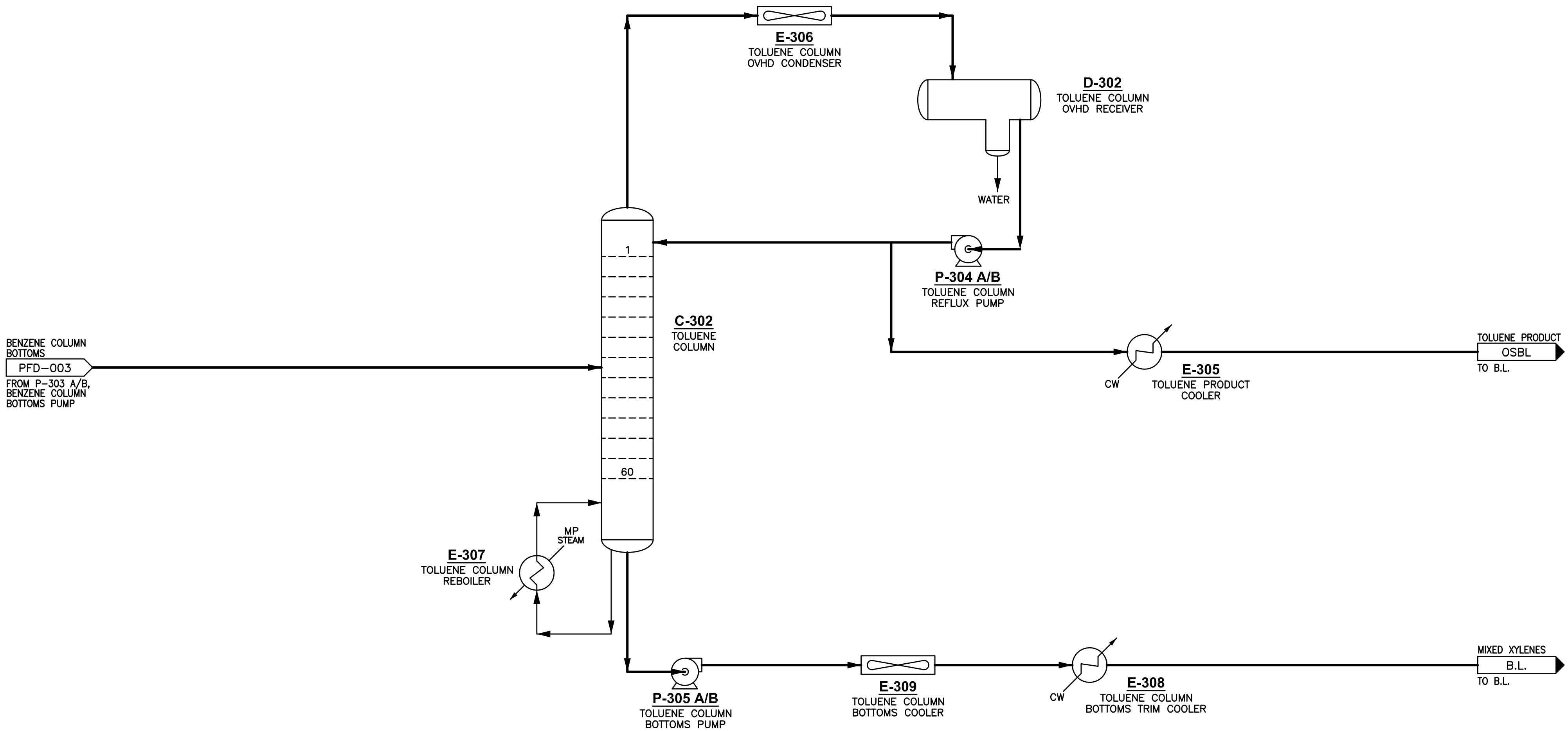
REV.	DATE	MODIFICATIONS	DRAWN	CHECK	DESIGN
0	01/2013	PROPOSAL	FC	MC	MS

GTC TECHNOLOGY

IOCL, INDIA

PROCESS FLOW DIAGRAM
BENZENE/TOLUENE/XYLENE RECOVERY UNIT
POST FRACTIONATION SECTION

GTC PROJECT No.: –	DRAFTSMAN: FC	SCALE: N/A
	DESIGNER: MS	No. OF SHEETS: 5
	APPROVED: MC	SHEET No.: 3
DWG No.: IOCL–PFD–003		REV.: 0



REV.	DATE	MODIFICATIONS	DRAWN	CHECK	DESIGN
0	01/2013	PROPOSAL	FC	MC	MS

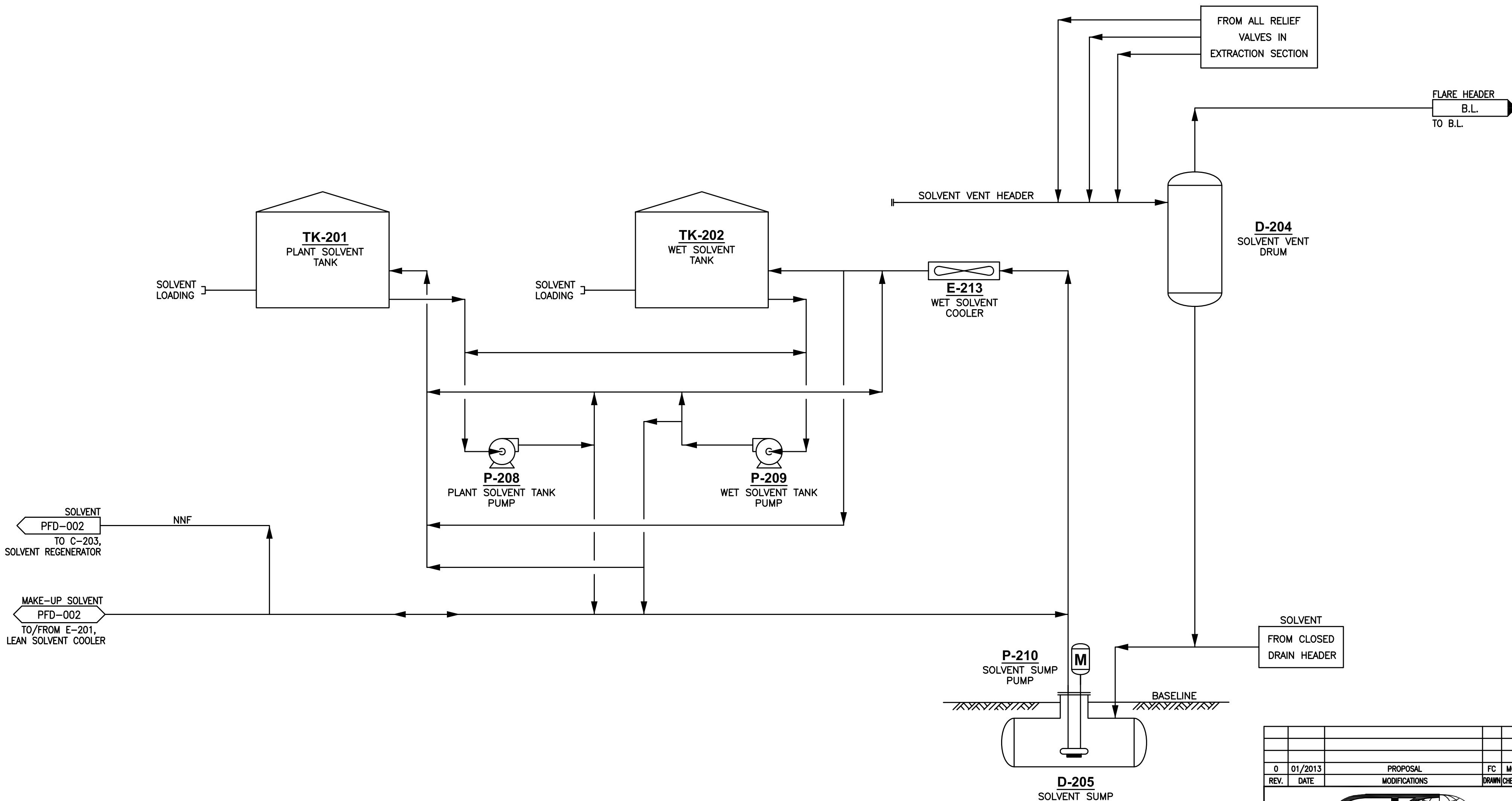
GTC TECHNOLOGY

THIS DRAWING IS ISSUED TO THE CLIENT BASED ON THE AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED OR DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED.

IOCL, INDIA

PROCESS FLOW DIAGRAM
BENZENE/TOLUENE/XYLENE RECOVERY UNIT
POST FRACTIONATION SECTION

GTC PROJECT No.: –	DRAFTSMAN: FC	SCALE: N/A
	DESIGNER: MS	No. OF SHEETS: 5
	APPROVED: MC	SHEET No.: 4
DWG No.: IOCL–PFD–004		REV.: 0



REV.	DATE	MODIFICATIONS	DRAWN	CHECK	DESIGN
0	01/2013	PROPOSAL	FC	MC	MS

GTC TECHNOLOGY

THIS DRAWING IS ISSUED TO THE CLIENT BASED ON THE AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED OR DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED.

IOCL, INDIA

PROCESS FLOW DIAGRAM
BENZENE/TOLUENE/XYLENE RECOVERY UNIT
SOLVENT STORAGE SECTION

GTC PROJECT No.: –	DRAFTSMAN: FC	SCALE: N/A
	DESIGNER: MS	No. OF SHEETS: 5
	APPROVED: MC	SHEET No.: 5
DWG No.: IOCL–PFD–005		REV.: 0

3.2.2 Material Balance

The overall material balance for BTXRU is shown below.

Feeds	MTY	Products	MTY
C6+ Feed	239,352	Benzene Product	65,640
		Toluene Product	78,894
		Mixed Xylenes	40,483
		C9+ Cut	1,749
		Raffinate	52,586
Total	**239,352**	**Total**	**239,352**

The detailed compositional material balance of BTXRU is presented below:

	C6+ Feed		C9+ Cut		Raffinate		Benzene Product		Toluene Product		Mixed Xylenes	
Component	**wt%**	**kg/hr**	**wt%**	**kg/hr**	**wt%**	**kg/hr**	**wt%**	**kg/hr**	**wt%**	**kg/hr**	**wt%**	**kg/hr**
N-hexane	0.00	0.12	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
3-methylpentane	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Methylcyclopentane	0.53	157.22	0.00	0.00	2.39	157.22	0.00	0.00	0.00	0.00	0.00	0.00
Cyclohexane	0.88	263.32	0.00	0.00	4.01	263.32	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	27.50	8227.71	0.00	0.00	0.34	22.02	99.99	8204.32	0.01	0.99	0.00	0.00
2,2-dimethylpentane	0.00	0.70	0.00	0.00	0.01	0.70	0.00	0.00	0.00	0.00	0.00	0.00
2,4-dimethylpentane	0.02	4.61	0.00	0.00	0.07	4.61	0.00	0.00	0.00	0.00	0.00	0.00
3-methylhexane	1.77	529.36	0.00	0.00	8.05	529.36	0.00	0.00	0.00	0.00	0.00	0.00
2,3-dimethylpentane	0.11	33.21	0.00	0.00	0.51	33.21	0.00	0.00	0.00	0.00	0.00	0.00
3-metylhexane	1.49	445.01	0.00	0.00	6.77	445.01	0.00	0.00	0.00	0.00	0.00	0.00
N-heptane	1.50	449.44	0.00	0.00	6.84	449.44	0.00	0.00	0.00	0.00	0.00	0.00
1,1-dimethylcyclopentane	0.38	113.84	0.00	0.00	1.73	113.84	0.00	0.00	0.00	0.00	0.00	0.00
cis-1,3-dimethylcyclopentane	1.28	382.90	0.00	0.00	5.83	382.90	0.00	0.00	0.00	0.00	0.00	0.00
trans-1,3-dimethylcyclopentane	1.08	321.78	0.00	0.00	4.90	321.78	0.00	0.00	0.00	0.00	0.00	0.00
cis-1,2-dimethylcyclopentane	0.40	119.50	0.00	0.00	1.82	119.50	0.00	0.00	0.00	0.00	0.00	0.00
trans-1,2-dimethylcyclopentane	1.40	420.24	0.00	0.00	6.39	420.20	0.00	0.04	0.00	0.00	0.00	0.00
Methylcyclohexane	4.41	1319.46	0.00	0.00	20.07	1319.45	0.00	0.00	0.00	0.00	0.00	0.00
Ethylcyclopentane	1.49	445.79	0.00	0.00	6.76	444.39	0.00	0.01	0.01	1.40	0.00	0.00
Toluene	32.95	9857.51	0.11	0.24	0.00	0.01	0.01	0.66	99.80	9842.04	0.30	15.18
N-octane	2.42	723.95	0.05	0.11	11.00	723.38	0.00	0.00	0.00	0.45	0.00	0.00
1,1-dimethylcyclohexane	0.40	120.66	0.01	0.03	1.84	120.63	0.00	0.00	0.00	0.00	0.00	0.00
Ethylcyclohexane	0.06	18.10	0.04	0.09	0.19	12.73	0.00	0.00	0.00	0.21	0.10	5.07
Propylcyclopentane	0.85	253.38	0.37	0.80	3.63	238.87	0.00	0.00	0.02	1.77	0.24	11.95
Ethylbenzene	11.01	3293.93	32.38	70.79	0.00	0.01	0.00	0.00	0.13	12.54	63.44	3210.47
P-xylene	6.27	1876.22	32.74	71.57	0.00	0.00	0.00	0.00	0.02	2.36	35.61	1802.24
C9 Aromatics	0.30	90.50	34.30	74.99	0.00	0.00	0.00	0.00	0.00	0.00	0.31	15.45
1,1,3-trimethylcyclopentane	1.51	450.52	0.00	0.00	6.85	450.52	0.00	0.00	0.00	0.00	0.00	0.00
Solvent	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**100**	**29919**	**100**	**219**	**100**	**6573**	**100**	**8205**	**100**	**9862**	**100**	**5060**

3.2.3 Product Quality

The benzene, toluene, and mixed xylene products will comply with the product specifications as outlined in section 3.1.3. The expected benzene, toluene, and mixed xylene products will have the following quality.

Benzene Product

Property	Expected quality
Benzene, wt %	99.9+ min.
Toluene, wppm	500 max.
Non Aromatics, wppm	1000 max.

Toluene Product

Property	Expected quality
Toluene, wt %	99.8 min.
Non Aromatics, wt %	0.2 max.
Benzene, wt %	0.05 max.
C8 Aromatics, wt%	0.05 max.

Mixed Xylenes Product

Property	Expected quality
Mixed Xylenes, wt %	99.0 min.
Toluene, wt %	0.5 max.
Non-aromatics, wt %	0.5 max.
C9 Aromatics, wt %	0.5 max.

3.2.4 Utility Consumption

Based on the preliminary design, the following utility consumption is estimated for BTXRU.

Utility	UOM	Pre-fractionation	Extraction	Post-fractionation	Total
MP Steam, 13.6 Kg/cm^2 (G)	t/hr	8.4	16.2	5.6	30.2
Cooling Water (1)	m3/hr	30.0	44.0(2)	58.0	132.0
Electricity	kW	28.0	283.0	91.0	402.0

Note:
1. Cooling Water consumption is based on 5 ^{o}C temperature rise; supply and return temperatures at 33 ^{o}C and 38 ^{o}C respectively. This is due to the requirement to cool down product streams to final storage temperature of 40 ^{o}C.
2. Additional 110 kW electricity consumption is required for Wet Solvent Cooler E-213 in Solvent Storage Section.

3.2.5 Investment Cost Estimation

The preliminary investment cost estimation has been developed on a USGC 2012 price basis and is estimated based on sized equipment list and typical installation factors for each type of equipment. The total investment cost is estimated at **23 MM USD (+/- 50%)**.

The estimated investment cost does not include:
- license, PDP and DEP engineering fees,
- proprietary equipment cost,
- solvent, catalyst, and chemicals cost,
- tower internals cost.

3.2.6 Equipment List

The list of ISBL equipment required for BTXRU is summarized in Appendix 2. The information of the equipment includes equipment description, main characteristics, and material of construction, design temperature/pressure, and number of pieces. Equipment overdesign margin is 110% of the design case capacity. For equipment in solvent loop the overdesign margin is 120% for added flexibility in operation.

3.2.7 Chemicals and Solvent Specifications and Consumption

Mono-ethanol-amine (MEA)

Mono-ethanol-amine (MEA) consumption is estimated at the level of maximum 3200 liters/year. MEA injection is recommended 1 time / shift maximum, at the level of 1-2 liters. In normal operation the injection can be at much lower level for good operating conditions.

Antifoam

Antifoam is typically added to reduce and minimize any tendency for foaming in a solvent based system. The antifoam recommended is DOW CORNING Antifoam A Compound or an equivalent. It is a silicone foam control agent that is 100 percent active. Effective in both aqueous and non-aqueous systems, it can be used in concentrations as low as one part per million. The initial charge will be pre-blended to the solvent inventory. Antifoam is injected as required if the EDC indicates a foaming tendency. The antifoam compound must be injected while mixing with raffinate in an approximate ratio of 20:1, as the compounds are viscous. The antifoam injection is recommended at the level of 0.1 (max. 0.2) wt. ppm antifoam, diluted with toluene, based on solvent rate as continuous injection.

Techtiv® 500 Solvent

The unit requires Techtiv® 500 solvent for extractive distillation. An initial inventory of **200 tons** is estimated. Solvent losses are typically <1 wppm in each of the raffinate and extract streams.

The components in the solvent system used for the GT-BTX® process are completely accepted by the refining and the petrochemical industry. The solvent blend will contain stabilization agents, and water, composition-adjusted to provide optimum extractive distillation performance. GTC provides means to control the quality of the Techtiv® 500 solvent by minor quantities of chemical treatment via injection pump.

The preliminary solvent inventory is based on the information available at the proposal level and needs to be revised during next stage of design including by Detail Engineering Contractor (DEC) based on final construction of the unit.

GTC will supply the proprietary Techtiv® 500 solvent for the GT-BTX® aromatics extraction unit. This solvent is essential to the proper functioning of the unit design, and is required for validating the process guarantees.

3.2.8 Waste Streams

GT-BTX® process produces no special waste streams. During normal operation the waste streams are minimized and their treatment is as summarized below:

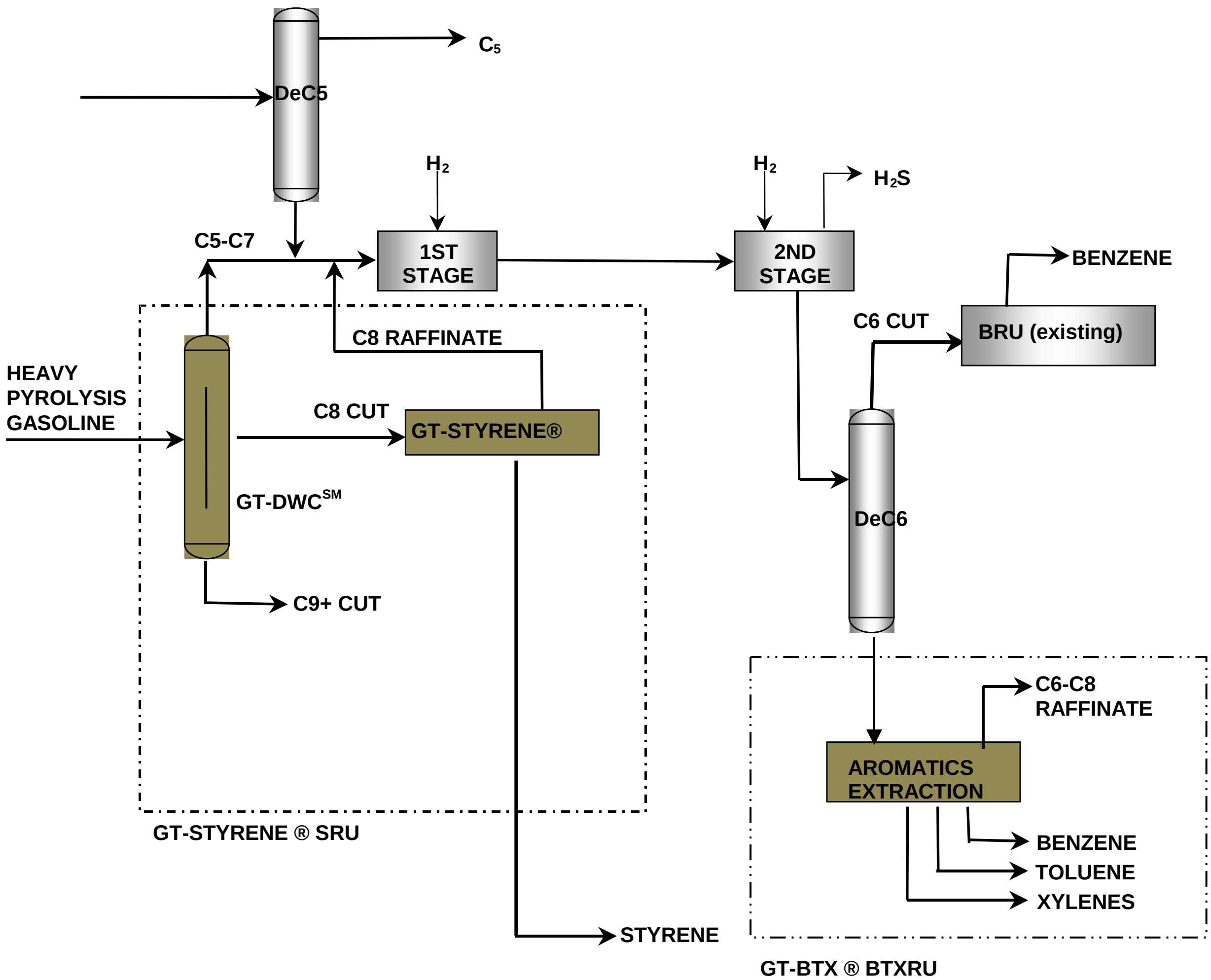
Point Source	Waste	Discharge Conditions	Destination	Notes
Water purge from the vacuum system	Water and hydrocarbon	Water with HC at solubility level	Waste water system	Note 1
Solvent Regenerator dump out	Residue, high molecular weight components	-	Waste incineration system or waste field	Periodic purge dependent on solvent quality
Vacuum system discharge off gas	Non-condensable & hydrocarbons	90 mol% Air and 10 mol% organics @ 40°C (Note 1)	Heater fire box or alternate safe location	Quantity and duration depends on the tightness of the vacuum system

Note 1: After initial evacuation, the unit operates normally with the vacuum system shut down, so no emissions (vacuum discharge off gas or water purge) are purged in normal operation.

No other waste is produced from GT-BTX® unit.

4. SECTION III: SRU AND BTXRU IN SUMMARY

4.1 Process Configuration



4.2 Material Balance

SRU

Feeds	MTY	Products	MTY
Pygas Feed	356,046	Styrene Product	20,173
Hydrogen	38	C5-C7 Cut	194,493
SBR Recycle	680	C9+ Cut	74,528
		Raffinate	65,592
		Off Gas	58
		Heavies	1,916
Total	**356,763**	**Total**	**356,763**

BTXRU

Feeds	MTY	Products	MTY
C6+ Feed	239,352	Benzene Product	65,640
		Toluene Product	78,894
		Mixed Xylenes	40,483
		C9+ Cut	1,749
		Raffinate	52,586
Total	**239,352**	**Total**	**239,352**

4.3 Utility Consumption

Utility	UOM	SRU		BTXRU			Total
		Pre-frac	Extraction	Pre-frac	Extraction	Post-frac	
MP Steam, 13.6 Kg/cm^2 (G)	t/hr			8.4	16.2	5.6	30.2
IP Steam, 9 Kg/cm^2 (G)	t/hr	5.1	1.9				7.0
LP Steam, 2.7 Kg/cm^2 (G)	t/hr	7.9	8.2				16.1
Cooling Water	m3/hr	8	884	30	44	58	1024
Chilled Water	m3/hr	-	7.7				7.7
Electricity	kW	167	144	28	283	91	713

4.4 Estimated Total Investment Cost

The preliminary investment cost estimation developed on USGC 2012 price basis and based on sized equipment list and typical installation factors for each type of equipment is presented below:

SRU **40 MM USD (+/- 50%)**.
BTXRU **23 MM USD (+/- 50%)**.
Total project; **63 MM USD (+/- 50%)**.

The estimated investment cost does not include:
- License, PDP and DEP engineering fees,
- Proprietary equipment cost,
- Solvent, catalyst, and chemicals cost,
- Tower internals cost.

4.5 Solvent, Chemicals, Catalysts

Chemicals/ Catalyst	Unit	Initial charge	Estimated Annual Consumption and life
Catalysts			
PA catalyst (GTC-203B)	M3	10	5 years life, with 3-4 regenerations
Solvents			
Techtiv-200	Tons	90	0.65/ year
Techtiv-500	Tons	200	2-3/year
Chemicals			
Retarding agent DNBP	Tons	0.0225	4.5/ year
GE 20Y3	Tons	0.9	23.6/ year
GE S310	Tons	0.15	7.2/ year
TBC	Tons	By vendor	0.48/ year
Anti-foam	Tons	By vendor	0.035-0.05/year*
MEA	Tons	By vendor	1 -2/year

APPENDIX 1 SRU Preliminary Equipment List

PRELIMINARY EQUIPMENT LIST - **COLUMNS**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
LOCATION:	INDIA	PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. Kg/cm2g
1	C - 101	DWC	1	D x H = 4,000 mm x 63,000 mm GTC Proprietary Structure Packing	C.S	200	3.5/ FV
2	C - 201	EDC	1	D x H = 3,200 mm x 62,000 mm GTC Proprietary Structure Packing	C.S	200	3.5/ FV
3	C - 202	SRC	1	D x H = 2,100 mm x 27,000 mm GTC Proprietary Structure Packing	C.S	200	3.5/ FV
4	C - 204	SOLVENT REGENERATOR	1	D x H = 600 mm x 2,500 mm	C.S	220	3.5/ FV
5	C - 205	WATER STRIPPER	1	D x H = 600 mm x 5,600 mm	C.S	150	3.5/ FV

PRELIMINARY EQUIPMENT LIST - **VESSELS & REACTOR**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
LOCATION:	INDIA	PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. Kg/cm2g
1	D - 101	DWC OVERHEAD RECEIVER	1	D x L = 1,800 mm x 4,800 mm	C.S.	150	3.5/ FV
2	D - 102	REACTOR FEED SURGE DRUM	1	D x L = 1,600 mm x 4,000 mm	C.S.	150	3.5/ FV
3	D - 103	DWC FEED SURGE DRUM	1	D x L = 2,900 mm x 7,000 mm	C.S.	100	3.5
4	D - 201	HYDRO. PRODUCT SEPARATOR	1	D x H = 1,500 mm x 4,600 mm	C.S.	100	3.5
5	D - 202	EDC OVHD RECEIVER	1	D x L = 1,700 mm x 4,600 mm	C.S.	100	3.5/ FV
6	D - 203	SRC OVHD RECEIVER	1	D x L = 1,100 mm x 2,700 mm	C.S.	100	3.5/ FV
7	D - 204	WATER SURGE DRUM	1	D x L = 1,600 mm x 3,400 mm	C.S.	100	3.5
8	D - 206	EDC FEED DRUM	1	D x L = 1,900 mm x 4,300 mm	C.S.	150	3.5

PRELIMINARY EQUIPMENT LIST - **VESSELS & REACTOR**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
LOCATION:	INDIA	PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. Kg/cm2g
9	D - 208	1ST STAGE SEPARATOR	1	D x L = 1,000 mm x 2,400 mm	C.S.	150	19.0
10	D - 209	2ND STAGE SEPARATOR	1	D x L = 1,100 mm x 2,600 mm	C.S.	150	19.0
11	D - 210	LP VENT DRUM	1	D x L = 500 mm x 1,500 mm	C.S.	250	3.5/ FV
12	TK - 211	STYRENE PRODUCT DAILY TANK A	1	D x H = 4,000 mm x 8,700 mm	C.S.	-10 / 65	0.02/-0.005
13	TK - 212	STYRENE PRODUCT DAILY TANK B	1	D x H = 4,000 mm x 8,700 mm	C.S.	-10 / 65	0.02/-0.005
14	TK - 213	STYRENE TANK	1	D x H = 5,600 mm x 9,100 mm	C.S.	-10 / 65	0.02/-0.005
15	TK - 214	PLANT SOLVENT TANK	1	D x H = 4,400 mm x 5,300 mm	C.S.	100	0.02/-0.005
16	TK - 215	WET SOLVENT TANK	1	D x H = 4,400 mm x 6,200 mm	C.S.	100	0.02/-0.005

PRELIMINARY EQUIPMENT LIST - **VESSELS & REACTOR**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
LOCATION:	INDIA	PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. Kg/cm2g
17	D - 216	SOLVENT VENT DRUM	1	D x L = 2,300 mm x 5,100 mm	C.S.	250	3.5/ FV
18	D - 217	AROMATICS SUMP	1	D x L = 1,400 mm x 4,300 mm	C.S.	250	3.5/ FV
19	D - 218	SOLVENT SUMP	1	D x L = 2,100 mm x 2,500 mm	C.S.	250	3.5/ FV
REACTOR							
1	R - 201A/B	PA HYDROGENATION REACTOR	2	D x H = 1,900 mm x 9,000 mm	1.25Cr-0.5Mo	400	6.0/ FV

PRELIMINARY EQUIPMENT LIST - **HEAT EXCHANGERS**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
LOCATION:	INDIA	PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQUIRED DESIGN TEMP. C shell	tubes	PRESS. Kg/cm2(g) shell	tubes
1	E - 102	DWC FEED PREHEATER	1	Area = 75 m3	C.S.	150	150	3.5/ FV	2.5
2	E - 103	DWC REBOILER	1	Area = 190 m^2	C.S.	250	200	11.0	3.5/ FV
3	E - 104	DWC SIDE REBOILER	1	Area = 625 m^2	C.S.	250	200	7.0	3.5/ FV
4	E - 108	C9+ CUT COOLER	1	Area = 25 m3	C.S.	100	70	7.5	8.0
5	E - 201	HYDRO. PROD. COOLER	1	Area = 70 m^2	C.S.	100	70	6.5	8.0
6	E - 202	EDC FEED PRE-HEATER	1	Area = 30 m^2	C.S.	150	150	11.0	13.0
7	E - 203A	EDC CONDENSER	1	Area = 385 m^2	C.S.	100	70	3.5/ FV	8.0
8	E - 203B	EDC TRIM CONDENSER	1	Area = 5 m^2	C.S.	100	70	3.5/ FV	8.0
9	E - 204A/B	EDC REBOILER	2	Area = 2 X 130 m^2	Tube:304LSS	250	200	7.0	3.5/ FV

GTC Technology

PRELIMINARY EQUIPMENT LIST - **HEAT EXCHANGERS**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
LOCATION:	INDIA	PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQUIRED DESIGN			
						TEMP. C		PRESS. Kg/cm2(g)	
						shell	tubes	shell	tubes
10	E - 205	SRC CONDENSER	1	Area = 430 m^2	C.S.	100	70	3.5/ FV	8.0
11	E - 206	SRC REBOILER	1	Area = 70 m^2	Tube:304LSS	250	200	11.0	3.5/ FV
12	E - 207	STEAM GENERATOR	1	Area = 130 m^2	C.S.	150	200	3.5/ FV	13.0
13	E - 208	REACTOR FEED COOLER	1	Area = 80 m^2	C.S.	150	200	6.5	11.0
14	E - 210	LEAN SOLVENT COOLER	1	Area = 25 m^2	C.S.	150	70	3.5/ FV	8.0
15	E - 211	SOLVENT REGENERATOR REBOILER	1	Area = 15 m^2	Tube:304LSS	200	250	3.5/ FV	11.0
16	E - 213	STYRENE PRODUCT CHILLER	1	Area = 10 m^2	C.S.	70	70	6.0	8.0
17	E - 216	STYRENE PRODUCT DAILY TANK CYCLE COOLER A	1	Area = 12 m^2	C.S.	100	65	7.0	8.0
18	E - 217	STYRENE PRODUCT DAILY TANK CYCLE COOLER B	1	Area = 12 m^2	C.S.	100	65	7.0	8.0

PRELIMINARY EQUIPMENT LIST - **HEAT EXCHANGERS**

PROJECT: STYRENE RECOVERY UNIT
CUSTOMER : IOCL
LOCATION: INDIA

DATE	Jan-13
REVISION	0
PREP. BY	MS
CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQUIRED DESIGN TEMP. C shell	TEMP. C tubes	PRESS. Kg/cm2(g) shell	PRESS. Kg/cm2(g) tubes
19	E - 218	STYRENE TANK CYCLE COOLER	1	Area = 20 m^2	C.S.	70	70	7.0	8.0
20	E - 219	AROMATIC SUMP COOLER	1	Area = 40 m^2	C.S.	150	65	7.0	8.0
21	E - 220	WET SOLVENT COOLER	1	Area = 90 m^2	C.S.	200	65	8.0	8.0
22									
23									
24									
25									
26									
27									

PRELIMINARY EQUIPMENT LIST - **AIR COOLERS**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
		PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQUIRED DESIGN	
						TEMP. C	PRESS. Kg/cm2(g)
1	E - 102	DWC CONDENSER	1	A (bare tube) = 1080 m^2	Hub: C.S. Blade: Al	150	3.5 & FV
2	E - 107	C9+ CUT COOLER	1	A (bare tube) = 77.8 m^2	Hub: C.S. Blade: Al	150	3.5 & FV

PRELIMINARY EQUIPMENT LIST - **PUMPS**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
		PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQUIRED DESIGN TEMP. °C	REQUIRED DESIGN PRESS. Kg/cm2g
1	P - 101 A/B	DWC REFLUX PUMP	2	Q =100 m^3/h , Diff Head = 90 m	C.S.	150	7.4
2	P - 102 A/B	DWC BOTTOM PUMP	2	Q = 14.4 m^3/h , Diff Head = 85 m	C.S.	200	7.5
3	P - 103 A/B	REACTOR FEED PUMP	2	Q = 16.4 m^3/h , Diff Head = 90 m	C.S.	150	6.5
4	P - 104 A/B	DWC FEED PUMP	2	Q = 64.7 m^3/h , Diff Head = 40 m	C.S.	100	2.1
5	P - 201 A/B	RECYCLE FEED PUMP	2	Q = 33.6 m^3/h , Diff Head = 60 m	C.S.	100	5.2
6	P - 202 A/B	EDC REFLUX PUMP	2	Q = 23.3m^3/h , Diff Head = 85 m	C.S.	150	7.3
7	P - 203 A/B	EDC WATER PUMP	2	Q =4.6m^3/h , Diff Head = 35 m	C.S.	100	3.5
8	P - 204 A/B	EDC BTM PUMP	2	Q = 53.0 m^3/h , Diff Head = 30 m	C.S.	200	3.7
9	P - 205 A/B	SRC REFLUX PUMP	2	Q = 5.8 m^3/h , Diff Head = 55 m	C.S.	150	5

PRELIMINARY EQUIPMENT LIST - **PUMPS**

PROJECT:	STYRENE RECOVERY UNIT	DATE	Jan-13
CUSTOMER :	IOCL	REVISION	0
		PREP. BY	MS
		CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQUIRED DESIGN TEMP. °C	REQUIRED DESIGN PRESS. Kg/cm2g
10	P - 206 A/B	SRC WATER PUMP	2	Q = 1.3 m^3/h , Diff Head = 35 m	C.S.	100	3.5
11	P - 207 A/B	SRC BTM PUMP	2	Q = 50.5 m^3/h , Diff Head = 100 m	C.S.	200	12.7
12	P - 208 A/B	WATER SURGE PUMP	2	Q = 4.8 m^3/h , Diff Head = 45 m	C.S.	100	4.5
13	P - 209 A/B	EDC FEED PUMP	2	Q = 15.7 m^3/h , Diff Head = 50 m	C.S.	100	4.4
14	P - 216 A/B	HRS RECYCLE PUMP	2	Q = 0.7 m^3/h , Diff Head = 25 m	C.S.	150	2.5
15	P - 218 A/B	STYRENE PRODUCT DAILY TANK CYCLE PUMP A	2	Q = 5.0 m^3/h , Diff Head = 50 m	C.S.	65	0.8
16	P - 219 A/B	STYRENE PRODUCT DAILY TANK CYCLE PUMP B	2	Q = 5.0 m^3/h , Diff Head = 50 m	C.S.	65	0.8
17	P - 220	STYRENE PRODUCT DAILY TANK PUMP A	1	Q = 20.1 m^3/h , Diff Head = 150 m	C.S.	65	1.9
18	P - 221	STYRENE PRODUCT DAILY TANK PUMP B	1	Q = 20.1 m^3/h , Diff Head = 150 m	C.S.	65	1.9

PRELIMINARY EQUIPMENT LIST - **PUMPS**

PROJECT: STYRENE RECOVERY UNIT
CUSTOMER : IOCL

DATE	Jan-13
REVISION	0
PREP. BY	MS
CHECK. BY	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC	REQUIRED DESIGN TEMP. °C	PRESS. Kg/cm2g
19	P - 222 A/B	STYRENE TANK CYCLE PUMP	2	Q = 5.0 m^3/h , Diff Head = 50 m	C.S.	65	0.8
20	P - 223 A/B	STYRENE PUMP	2	Q = 36.0 m^3/h , Diff Head = 40 m	C.S.	65	0.7
21	P - 224	AROMATICS SUMP PUMP	1	Q = 10 m^3/h , Diff Head = 90 m	C.S.	250	1.3
22	P - 225	PLANT SOLVENT TANK PUMP	1	Q = 16.5 m^3/h , Diff Head = 120 m	C.S.	100	2.0
23	P - 226	WET SOLVENT TANK PUMP	1	Q = 16.5 m^3/h , Diff Head = 120 m	C.S.	100	2.0
24	P - 227	SOLVENT RECOVERY PUMP	1	Q = 10 m^3/h , Diff Head = 30 m	C.S.	250	0.9

APPENDIX 2 BTXRU Preliminary Equipment List

PRELIMINARY EQUIPMENT LIST - COLUMNS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**100- PRE-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. KG/CM2G
1	C-101	C8/C9+ PREFRACTIONATOR	1	No. of trays= 20 D x H = 2100 mmx 22000 mm	CS	200	3.5

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - VESSELS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**100- PRE-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. KG/CM2G
1	D-101	C8/C9+ PREFRACTIONATOR OVHD RECEIVER	1	D x L = 2400 mmx 5700 mm V = 26 m^3	C.S.	150	3.5

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - HEAT EXCHANGERS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**100- PRE-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	**ITEM NO.**	**EQUIPMENT NAME**	**QTY**	**SPEC & SIZE**	**MOC***	**REQUIRED DESIGN TEMP. °C shell**	**TEMP. °C tubes**	**PRESS. KG/CM2G shell**	**PRESS. KG/CM2G tubes**
1	E-103	C8/C9+ PREFRACTIONATOR REBOILER	1	Area = 295 m2	C.S.	350	200	20.4	3.5
2	E-101A/B	C8/C9+ PREFRACTIONATOR FEED PREHEATER	2	Area = 75 m2	C.S.	100	150	6.2	8.0
3	E-106	C9+ HEAVIES COOLER	1	Area = 20 m2	C.S.	200	65	10.0	10.0

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - AIR COOLERS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**100- PRE-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQUIRED DESIGN TEMP. °C	REQUIRED DESIGN PRESS. KG/CM2G
1	E-102	C8/C9+ PREFRACTIONATOR OVHD CONDENSER	1	A (bare tube) = 181 m2	Hub: C.S. Blade: Al	150	3.5

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - PUMPS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**100- PRE-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	**ITEM NO.**	**EQUIPMENT NAME**	**QTY**	**SPEC & SIZE**	**MOC***	**REQUIRED DESIGN TEMP. °C**	**REQUIRED DESIGN PRESS. KG/CM2G**
1	P-101A/B	C8/C9+ PREFRACTIONATOR REFLUX PUMP	2	SG= 0.769 Q = 11 m^3/hr Diff Head = 70 m	C.S.	150	by vendor
2	P-102A/B	C8/C9+ PREFRACTIONATOR BOTTOMS PUMP	2	SG= 0.739 Q = 3 m^3/hr Diff Head = 90 m	C.S.	200	by vendor

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - COLUMNS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. KG/CM2G
1	C-201	EDC	1	No. of trays= 73 D x H = 2000/3200 mmx 53000 mm	CS Tray- CS Valves- 410SS	250	3.5
2	C-202	SRC	1	No. of trays= 16 + packing D x H = 2200/4000 mmx 34000 mm	CS Tray- CS Packing-410SS Valves- 410SS	250	3.5/ FV
3	C-301	BENZENE COLUMN	1	No. of trays= 60 D x H = 1800 mmx 46000 mm	CS	200	3.5
4	C-302	TOLUENE COLUMN	1	No. of trays= 60 D x H = 2000 mmx 46000 mm	CS	250	3.5
5	C-203	SOLVENT REGENERATOR	1	D x H = 2000 mmx 4000 mm	CS	250	3.5/ FV
6	C-204	WATER STRIPPER	1	D x H = 400 mmx 6000 mm	CS Packing- 304SS	200	3.5

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - VESSELS & TANKS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. KG/CM2G
1	D-201	EDC OVHD RECEIVER	1	D x L = 1400 mmx 3700 mm V = 6 m^3	C.S.	150	3.5
2	D-202	SRC OVHD RECEIVER	1	D x L = 2200 mmx 5300 mm V = 20 m^3	C.S.	100	3.5/ FV
3	D-203	WATER SURGE DRUM	1	D x L = 1400 mmx 3200 mm V = 5 m^3	C.S.	100	3.5
4	D-301	BENZENE COLUMN OVHD RECEIVER	1	D x L = 1800 mmx 4600 mm V = 12 m^3	C.S.	150	3.5
5	D-302	TOLUENE COLUMN OVHD RECEIVER	1	D x L = 1300 mmx 3100 mm V = 4 m^3	C.S.	200	3.5

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - VESSELS & TANKS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQ. DESIGN TEMP. °C	REQ. DESIGN PRESS. KG/CM2G
6	D-206	EDC FEED SURGE DRUM	1	D x L = 2500 mmx 5700 mm V = 28 m^3	C.S.	150	3.5
7	D-204	SOLVENT VENT DRUM	1	D x L = 2000 mmx 4000 mm V = 15 m^3	C.S.	150	3.5
8	D-205	SOLVENT SUMP	1	D x L = 1500 mmx 3000 mm V = 6 m^3	C.S.	150	3.5
9	TK-201	PLANT SOLVENT TANK	1	D x L = 5500 mmx 9800 mm V = 233 m^3	C.S.	100	0.10
10	TK-202	WET SOLVENT TANK	1	D x L = 5500 mmx 9800 mm V = 233 m^3	C.S.	100	0.10

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - HEAT EXCHANGERS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQUIRED DESIGN TEMP. °C shell	TEMP. °C tubes	PRESS. KG/CM2G shell	PRESS. KG/CM2G tubes
1	E-203	EDC STEAM REBOILER	1	Area = 285 m2	C.S. Tube:304L SS	350	250	20.4	3.5
2	E-212	EDC SIDE REBOILER	1	Area = 135 m2	Tube:304L SS		250		18.0
3	E-209	EDC FEED PREHEATER	1	Area = 175 m2	C.S.	150	200	13.8	18.0
4	E-206A/B	SRC REBOILER	2	Area = 2 X 275 m2	Tube:304L SS		350		20.4
5	E-208	SOLVENT REGENERATOR HEATER	1	Area = 50 m2	Tube:304L SS		350		20.4
6	E-207	STEAM GENERATOR	1	Area = 295 m2	C.S.	200	200	13.8	18.0
7	E-210	WATER PREHEATER	1	Area = 35 m2	C.S.	150	200	13.8	18.0
8	E-205	SRC OVHD TRIM COOLER	1	Area = 125 m2	C.S.	100	65	7.7	10.0
9	E-211	RAFFINATE COOLER	1	Area = 15 m2	C.S.	100	65	9.0	10.0
10	E-301	EXTRACT PREHEATER	1	Area = 65 m2	C.S.	150	250	8.0	9.0

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - HEAT EXCHANGERS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQUIRED DESIGN TEMP. °C shell	tubes	PRESS. KG/CM2G shell	tubes
11	E-304	BENZENE COLUMN REBOILER	1	Area = 185 m2	C.S.	350	200	20.4	3.5
12	E-302	BENZENE PRODUCT COOLER	1	Area = 45 m2	C.S.	150	65	9.0	10.0
13	E-307	TOLUENE COLUMN REBOILER	1	Area = 225 m2	C.S.	350	250	20.4	3.5
14	E-305	TOLUENE PRODUCT COOLER	1	Area = 30 m2	C.S.	100	65	10.0	10.0
15	E-308	TOLUENE COLUMN BOTTOMS TRIM COOLER	1	Area = 15 m2	C.S.	100	65	10.0	10.0

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - AIR COOLERS

PROJECT:	**Aromatic Extraction Unit**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE			MOC*	REQUIRED DESIGN TEMP. °C	REQUIRED DESIGN PRESS. KG/CM2G
1	E-202	EDC CONDENSER	1	A (bare tube) =	167	m2	Hub: C.S. Blade: Al	150	3.5
2	E-204	SRC OVHD CONDENSER	1	A (bare tube) =	1220	m2	Hub: C.S. Blade: Al	150	3.5/ FV
3	E-201	LEAN SOLVENT COOLER	1	A (bare tube) =	126	m2	Hub: C.S. Blade: Al	200	18.0
4	E-303	BENZENE COLUMN OVHD CONDENSER	1	A (bare tube) =	244	m2	Hub: C.S. Blade: Al	150	3.5
5	E-306	TOLUENE COLUMN OVHD CONDENSER	1	A (bare tube) =	381	m2	Hub: C.S. Blade: Al	200	3.5
6	E-309	TOLUENE COLUMN BOTTOMS COOLER	1	A (bare tube) =	36	m2	Hub: C.S. Blade: Al	250	3.5
7	E-213	WET SOLVENT COOLER	1	A (bare tube) =	172	m2	Hub: C.S. Blade: Al	200	3.5

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - PUMPS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQUIRED DESIGN TEMP. °C	REQUIRED DESIGN PRESS. KG/CM2G
1	P-201A/B	EDC REFLUX PUMP	2	SG= 0.712 Q = 13 m^3/hr Diff Head = 95 m	C.S.	150	by vendor
2	P-202A/B	EDC BOTTOM PUMP	2	SG= 1.082 Q = 207 m^3/hr Diff Head = 35 m	C.S.	250	by vendor
3	P-203A/B	EDC WATER PUMP	2	SG= 0.9995 Q = 0.5 m^3/hr Diff Head = 45 m	C.S.	100	by vendor
4	P-204A/B	SRC REFLUX PUMP	2	SG= 0.853 Q = 43 m^3/hr Diff Head = 75 m	C.S.	100	by vendor
5	P-205A/B	SRC BOTTOM PUMP	2	SG= 1.132 Q = 174 m^3/hr Diff Head = 125 m	C.S.	250	by vendor
6	P-206A/B	SRC WATER PUMP	2	SG= 0.9992 Q = 3.5 m^3/hr Diff Head = 50 m	C.S.	100	by vendor
7	P-207A/B	DECANT WATER PUMP	2	SG= 0.9994 Q = 4 m^3/hr Diff Head = 50 m	C.S.	100	by vendor
8	P-301A/B	BENZENE COLUMN BTMS PUMP	2	SG= 0.752 Q = 22 m^3/hr Diff Head = 50 m	C.S.	200	by vendor
9	P-302A/B	BENZENE PRODUCT PUMP	2	SG= 0.805 Q = 11 m^3/hr Diff Head = 40 m	C.S.	150	by vendor
10	P-303A/B	BENZENE COLUMN REFLUX PUMP	2	SG= 0.835 Q = 32 m^3/hr Diff Head = 75 m	C.S.	150	by vendor

* Note: Corrosion allowance for carbon steel equipments is 3.0mm

PRELIMINARY EQUIPMENT LIST - PUMPS

PROJECT:	**BTX RECOVERY UNIT**	**DATE**	Jan-13
CUSTOMER :	**IOCL**	**REVISION**	0
LOCATION:	**INDIA**	**PREP. BY**	MS
UNIT:	**200- EXTRACTION & 300- POST-FRACTIONATION**	**CHECK. BY**	MC

SR. NO.	ITEM NO.	EQUIPMENT NAME	QTY	SPEC & SIZE	MOC*	REQUIRED DESIGN TEMP. °C	REQUIRED DESIGN PRESS. KG/CM2G
11	P-211A/B	EDC FEED PUMP	2	SG= 0.769 Q = 43 m^3/hr Diff Head = 80 m	C.S.	150	by vendor
12	P-304A/B	TOLUENE COLUMN REFLUX PUMP	2	SG= 0.839 Q = 33 m^3/hr Diff Head = 85 m	C.S.	100	by vendor
13	P-305A/B	TOLUENE COLUMN BTMS PUMP	2	SG= 0.735 Q = 8 m^3/hr Diff Head = 95 m	C.S.	250	by vendor
14	P-208	PLANT SOLVENT TANK PUMP	1	SG= 1.234 Q = 44 m^3/hr Diff Head = 85 m	C.S.	90	by vendor
15	P-209	WET SOLVENT TANK PUMP	1	SG= 1.234 Q = 44 m^3/hr Diff Head = 85 m	C.S.	90	by vendor
16	P-210	SOLVENT SUMP PUMP	1	SG= 1.234 Q = 22 m^3/hr Diff Head = 40 m	C.S.	200	by vendor

* Note: Corrosion allowance for carbon steel equipments is 3.0mm