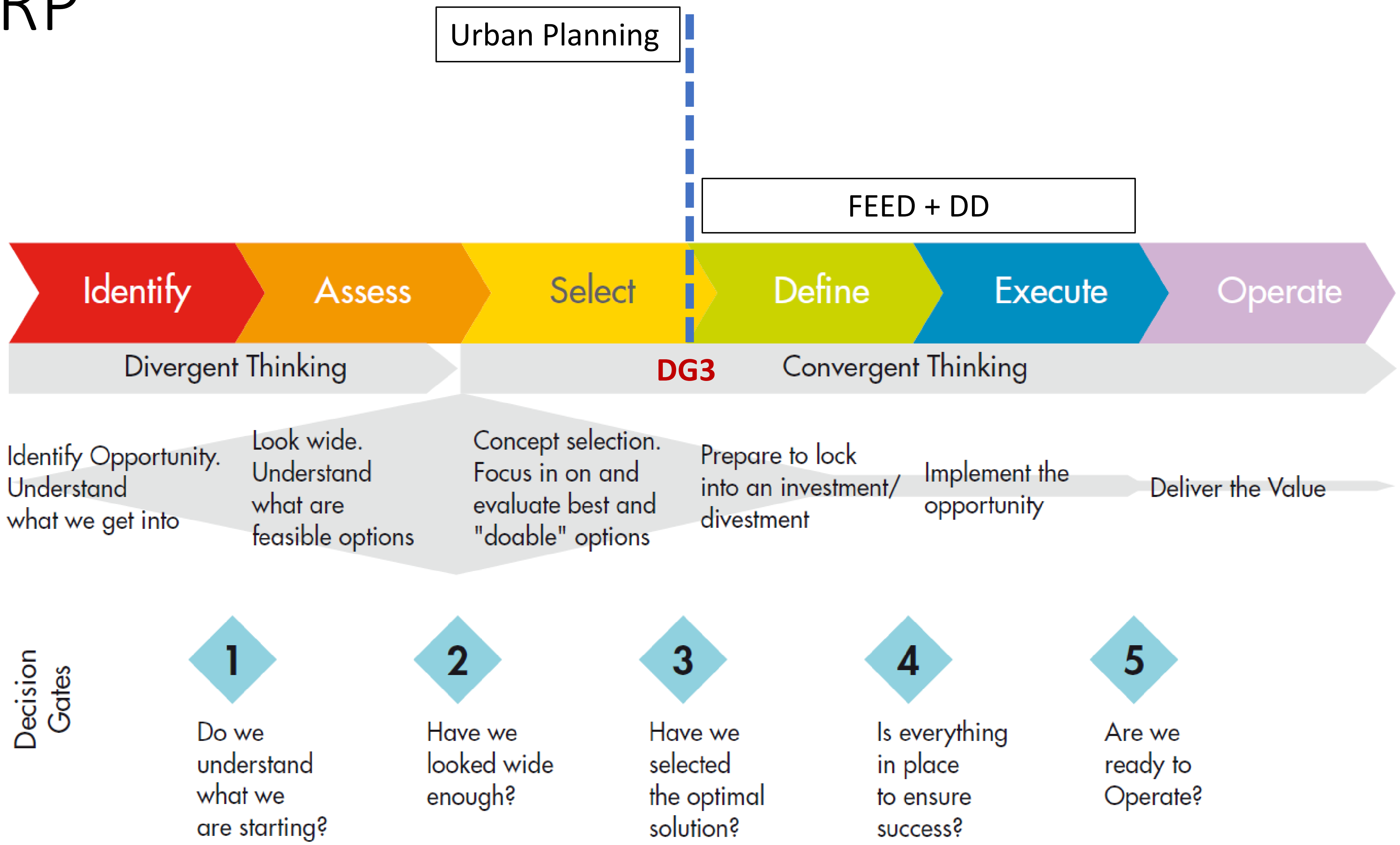
FEED Office FDP

Ahmed Al Fahdi UEMP2X

Mu64956

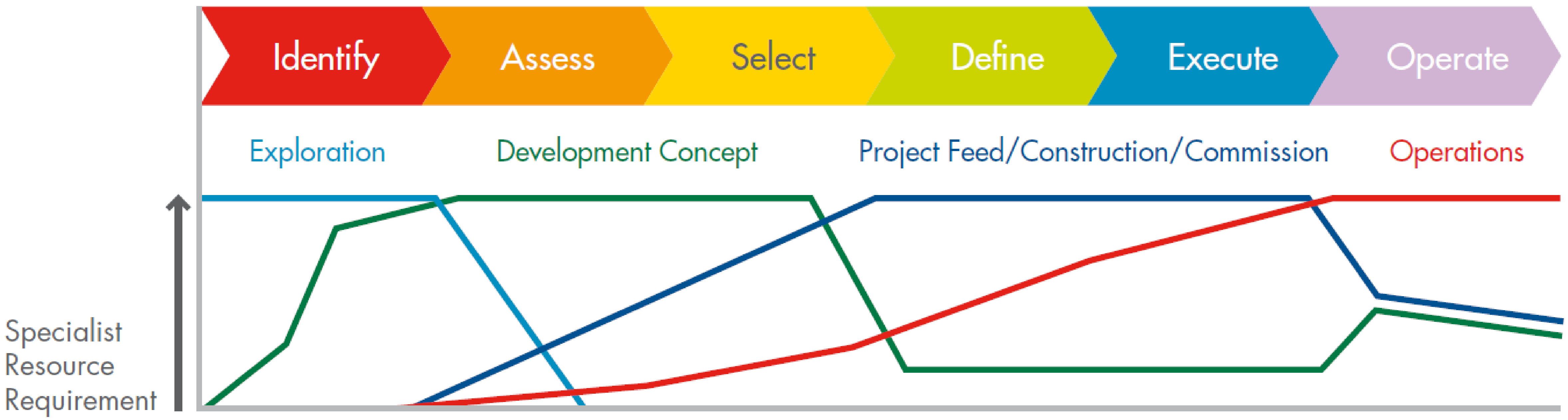
30/06/2022

ORP



Urban Planning
FEED + DD
Identify
Assess
Select
Define
Execute
Operate
Divergent Thinking
DG3
Convergent Thinking
Identify Opportunity. Understand what we get into
Look wide. Understand what are feasible options
Concept selection. Focus in on and evaluate best and "doable" options
Prepare to lock into an investment/ divestment
Implement the opportunity
Deliver the Value
Decision Gates
1
Do we understand what we are starting?
2
Have we looked wide enough?
3
Have we selected the optimal solution?
4
Is everything in place to ensure success?
5
Are we ready to Operate?

Cont.

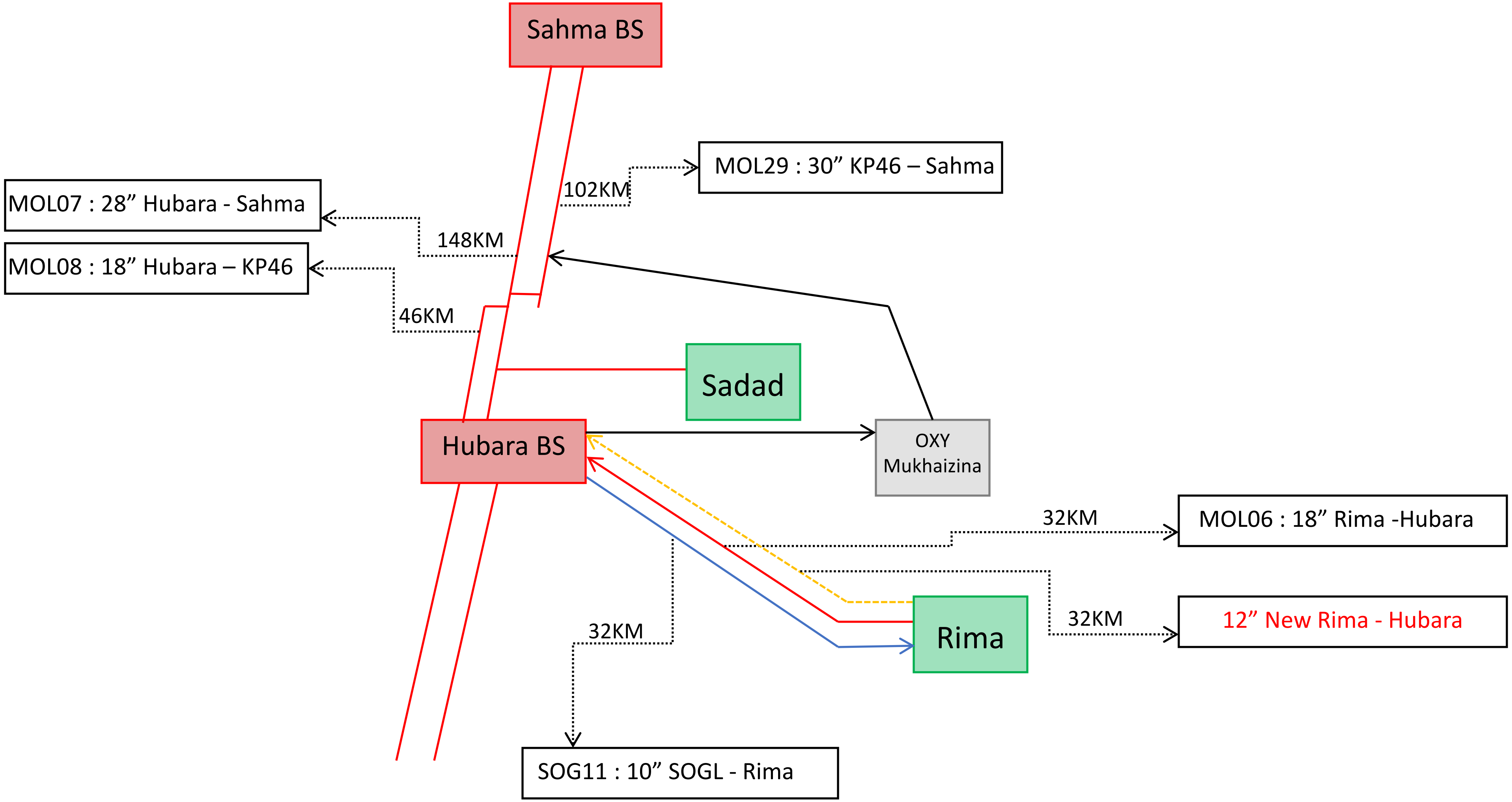


Identify
Assess
Select
Define
Execute
Operate
Exploration
Development Concept
Project Feed/Construction/Commission
Operations
Specialist
Resource
Requirement

CSR

Case Study : REPLACEMENT OF MOL06 RIMA – HUBARA PIPELINE

CSR


Sahma BS
MOL29 : 30” KP46 – Sahma
102KM
MOL07 : 28” Hubara - Sahma
148KM
MOL08 : 18” Hubara – KP46
46KM
Sadad
Hubara BS
OXY Mukhaizina
32KM
MOL06 : 18” Rima -Hubara
32KM
12” New Rima - Hubara
Rima
32KM
SOG11 : 10” SOGL - Rima

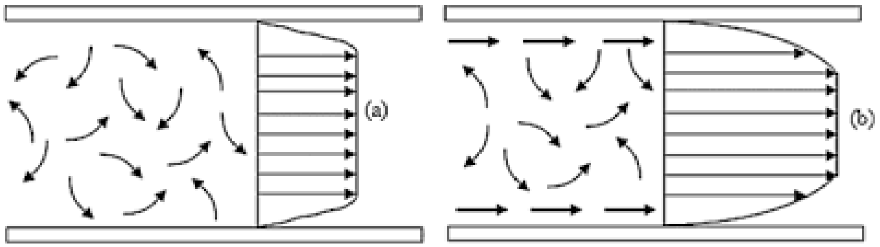
MOL06 Pipeline Data, & Rima Production Profile

Segment No:	MOL06		
Line Description	Rima - Hubara	**Design Pressure**	8200 kPa
Diameter /inch	18	**Current MAOP**	2500 kPa
Wall Thickness /mm	6.35	**Year of Installation**	1982
Length /km	32	**Fluid**	Crude oil
MOC	API 5L X60	**Operational Status**	Operating
External Coating	PE	**Pigging Frequency**	Monthly

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Production (M3/day)	5083	5618	5451	5783	5542	5217	4777	4283	3771	3160

CSR

- Problem Overview.
- About MOL06, and why it’s a troublesome.
- Options:
    1. Do Nothing.
    2. Pipeline Replacement:
        a) 14” Carbon Steel.
        b) 14” GRE.
        c) 10” carbon steel with pumps upgrade.
        d) 12” Carbon Steel with DRA.
    3. Service Swap between SOGL and MOL with new loop line.
- Concept selection criteria.
- Advantages and disadvantages of each option.



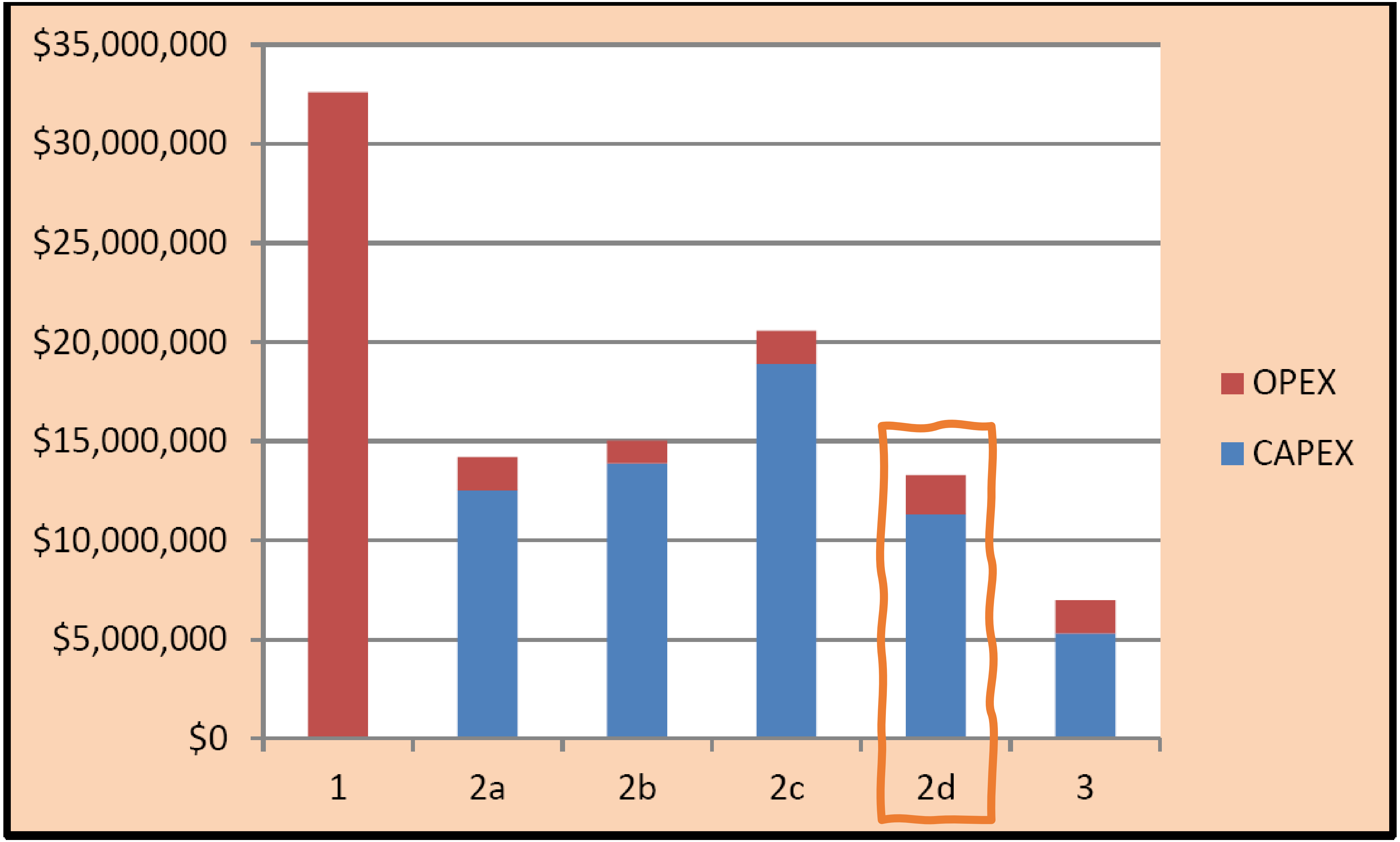


Figure: 3 – Life cycle cost chart

Pipeline Hydraulics

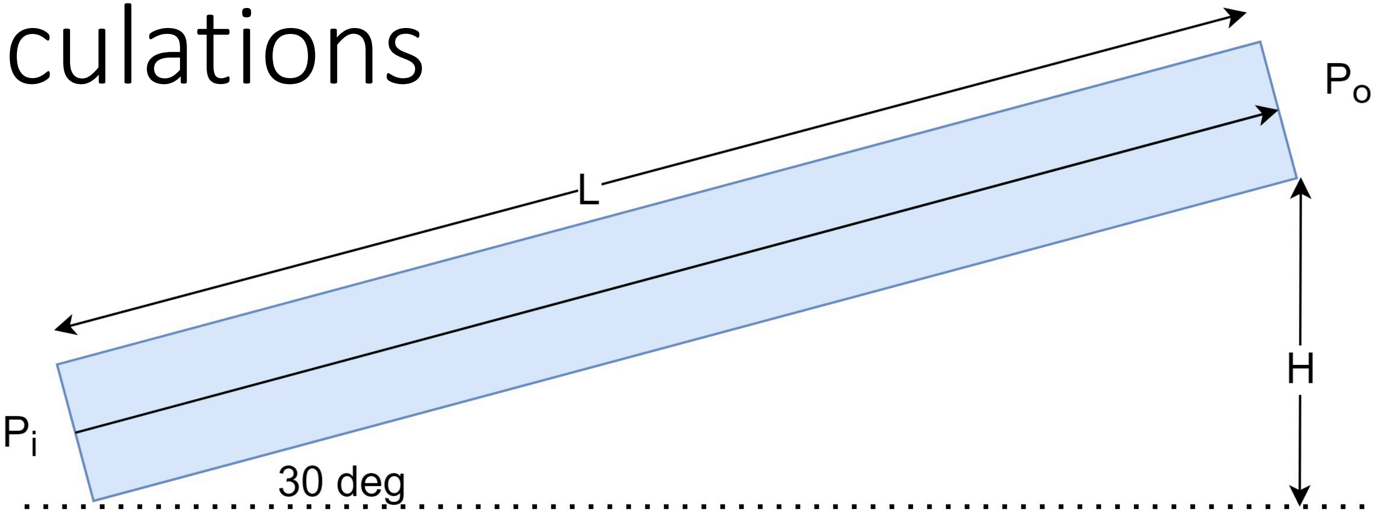
Fluid properties and Hydraulic equations in fluid and gas

Hydraulic analysis

Overview of fluid types

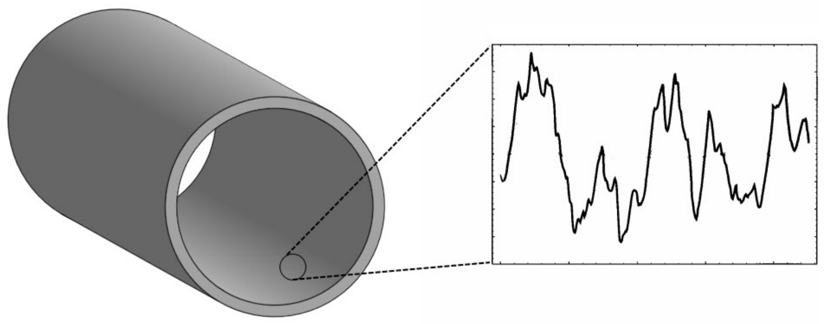
- Liquids
  - Crude oil (waxy, heavy)
  - Condensate
  - Water
- Gases
  - Natural gas (lean, rich, dense phase)
- Two-phase
  - Natural gas & condensate
  - Crude

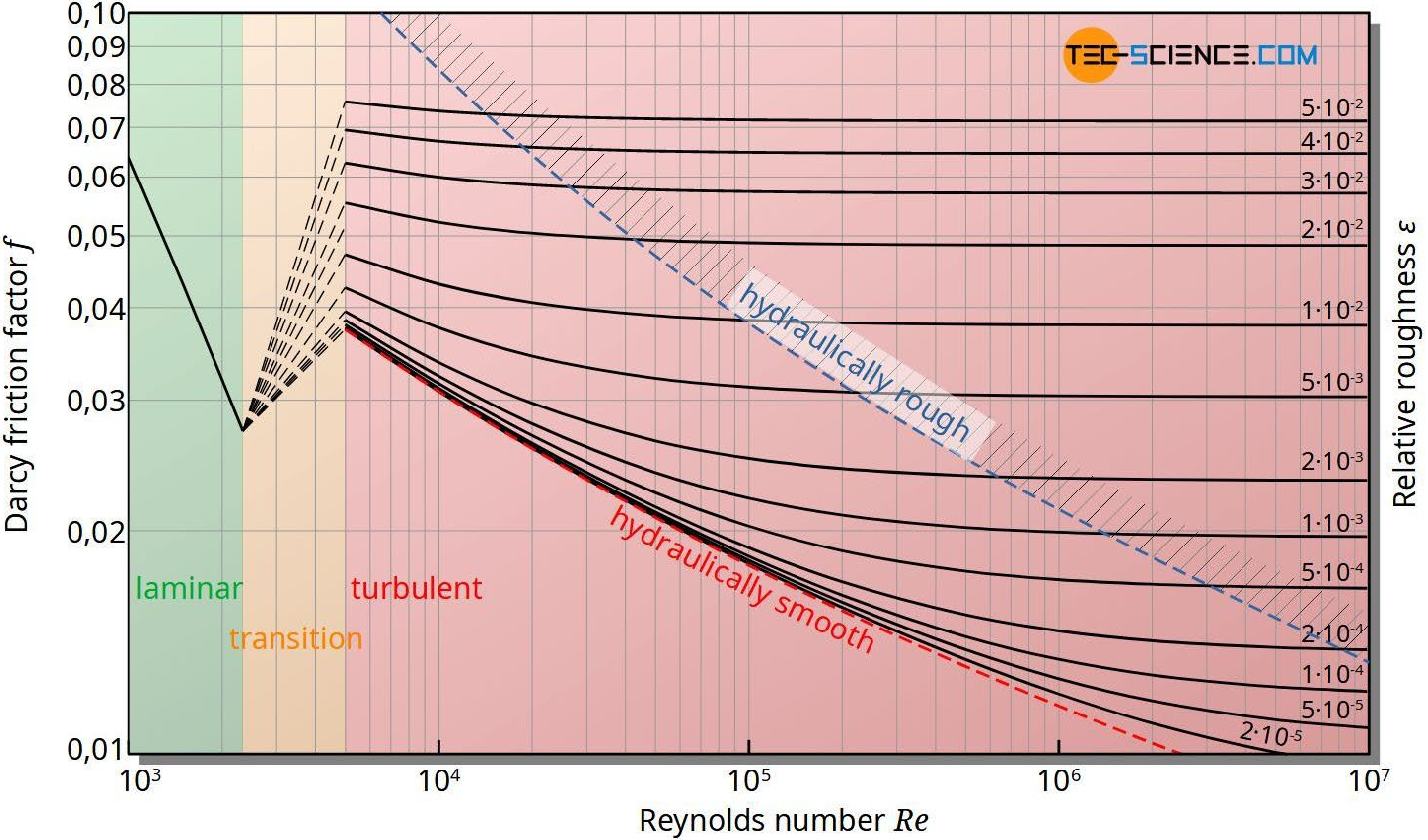
Basics of Fluids Calculations



- $\rho\ \left[\frac{kg}{m^3}\right]$
- $\rho_{rel} = \frac{\rho_{liq}}{\rho_{gas}}$ or S (15 C, 1 atm)
- Liquid $API\ gravity\ = \frac{141.5}{\rho_{rel}} - 131.5$

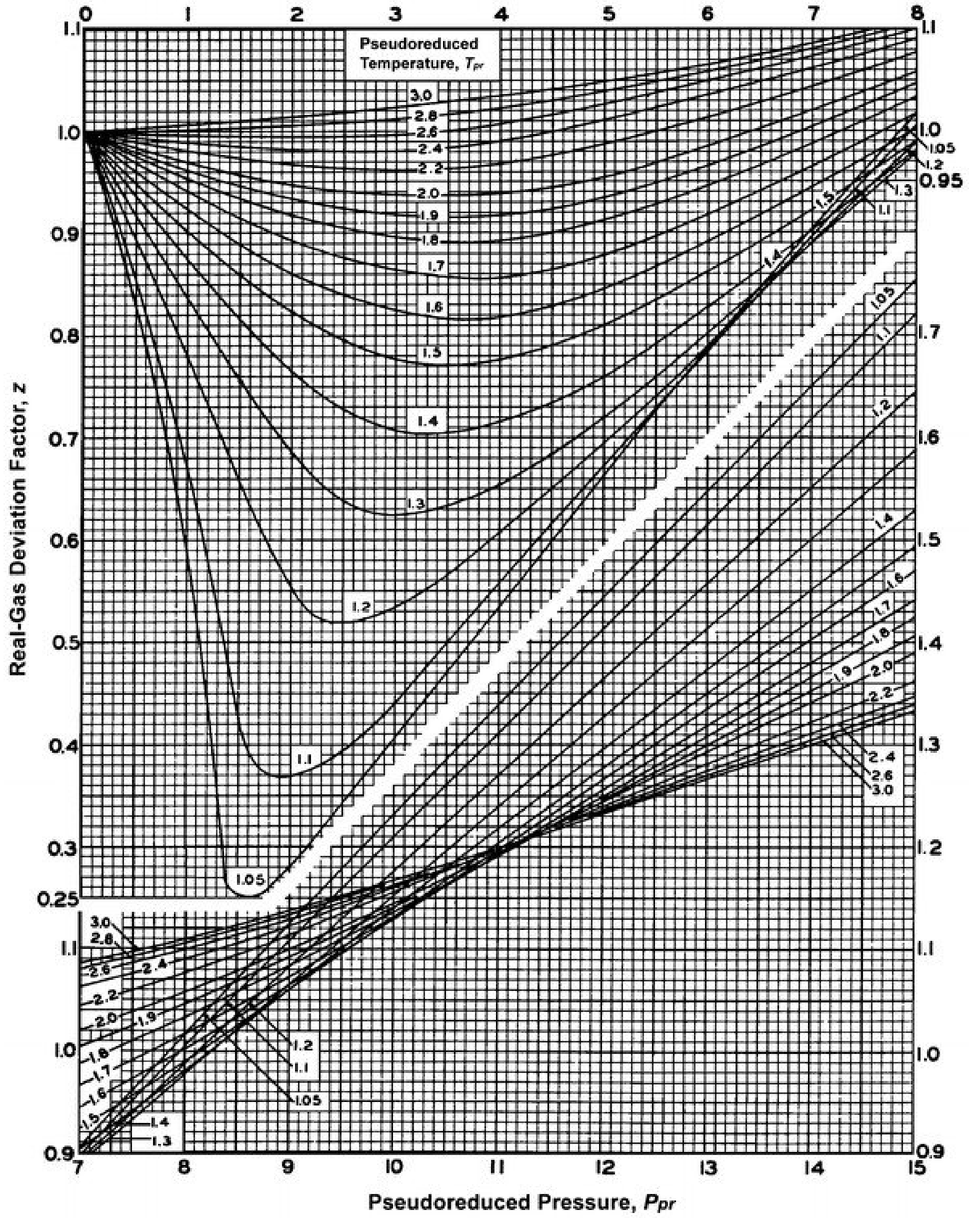
- Friction (Darcy's equation for **liquids only**) ➔ $\Delta P_{fric.} = \frac{1}{2} \cdot \rho \cdot v^2 \cdot \frac{L}{d} \cdot f \ \equiv \frac{8}{\pi^2}\rho\dot{Q}^2\frac{L}{d^5}f, where\ \boldsymbol{f}\left(\mathbf{Re}, \frac{\boldsymbol{\varepsilon}}{\boldsymbol{d}}\right)$
- Elevation ➔ $\Delta P_{elev.} = g \cdot \rho \cdot h$
- Acceleration (=0 if DI=constant) ➔ $\Delta P_{acc.} = \frac{1}{2} \cdot \rho \cdot \Delta v^2$
- $\Delta P_{total} = \Delta P_{fric.} + \Delta P_{elev.} + \Delta P_{acc.}$



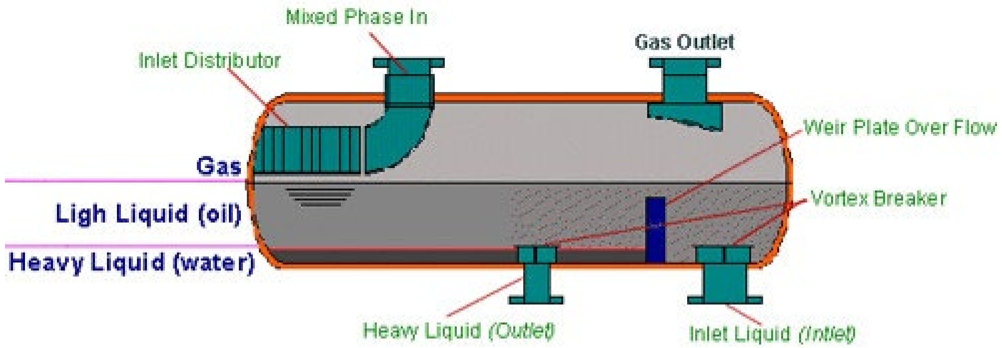


0,10
0,09
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
Darcy friction factor f
TEC-SCIENCE.COM
5·10-2
4·10-2
3·10-2
2·10-2
1·10-2
5·10-3
2·10-3
1·10-3
5·10-4
2·10-4
1·10-4
5·10-5
2·10-5
Relative roughness ε
hydraulically rough
hydraulically smooth
laminar
transition
turbulent
10³
10⁴
10⁵
10⁶
10⁷
Reynolds number Re

- $Pumping\ power = \frac{q \cdot \Delta P}{\eta}$
  - Where:
    - q = throughput m3/s
    - η = Pump efficiency
- Gas Flow Pressure Loss – AGA equation
  - $\frac{\Delta P^2}{L} = C\ f\ z\ T\ \rho\ \frac{q^2}{d^5}$
  - Where:
    - C = $5.7 \cdot 10^{-10}\ \frac{MPa}{K}$
    - z = Additional gas compressibility factor
      - $z = \frac{P\ V}{R\ T}$
    - L pipe length
    - d pipe diameter



Hydraulic Analysis



- Why?
  - Surge pressure during shut-down of a liquid line.
  - Turn-down limitations and inhibition or insulation requirements to prevent wax or hydrates depositions.
  - Effect of flow conditions on the efficiency of corrosion inhibitors, liquid catching and slug control requirements at the downstream end of two-phase lines.
- Limitations
  - $velocity\ ranges \begin{cases} 1\ to\ 2\ {}^{m}/_{s}\ (Liquid), and\ not\ greater\ than\ \mathbf{4}\ {}^{\boldsymbol{m}}/_{\boldsymbol{s}} \\ 5\ to\ 10\ {}^{m}/_{s}\ (Gas), and\ not\ greater\ than\ \mathbf{20}\ {}^{\boldsymbol{m}}/_{\boldsymbol{s}} \end{cases}$
  - (Erosion; Vibration difficulties), (Water dropout if less than 20% water-cut)

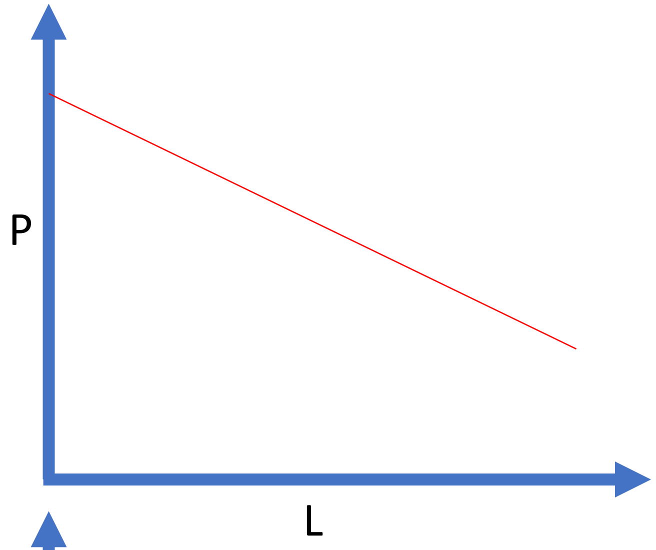
Cont. Gas compression – Power requirement

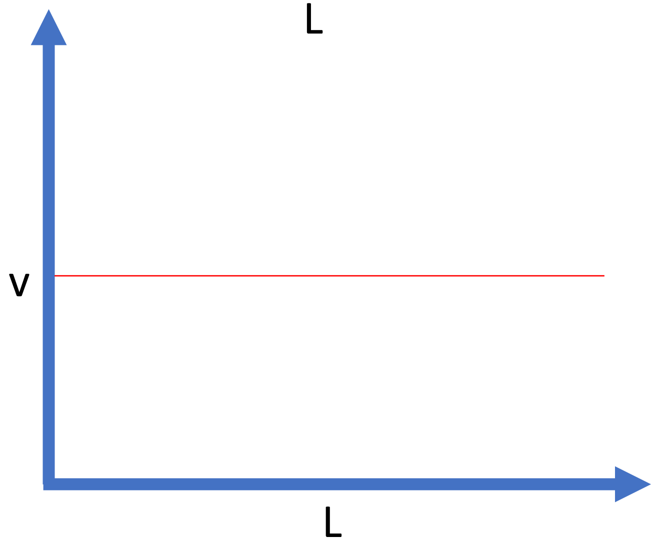
$$P = 0.353 \frac{z\, T_{in}\, q}{\eta} \frac{1}{r} \left(\left(\frac{P_d}{P_s} \right)^r - 1 \right)$$

Variable	Name	Unit
P	Power requirement	kW
z	Additional gas compressibility factor	-
T_{in}	Inlet temperature	K
q	throughput	$m^3/_s$
η	compressor efficiency	-
P_d	Discharge pressure	kPa
P_s	Inlet (suction) pressure	kPa
r	$\frac{k-1}{k}$	-
k	Specific heat ratio	-

Liquid Flow Characteristics

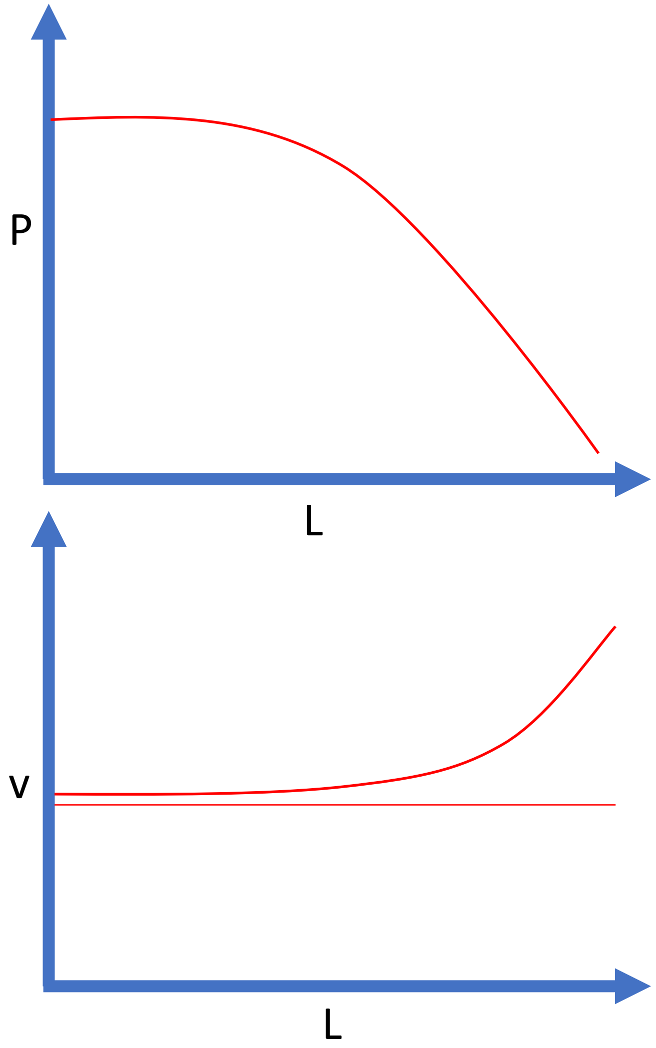
- $\Delta P = f\left(\rho, (\mu \;\; + \;\; \dot{Q}), d, L\right)$
  - $\rho = f(T)$
  - $\mu = f(T)$
- Incompressible
- Linear pressure drop
- If $\frac{\partial T}{\partial t} = 0, \mathit{and}\ \frac{\partial \rho}{\partial t} = 0$, then $\frac{\partial v}{\partial t} = 0$,





Gas Flow Characteristics

- $\Delta P = f\left(\rho, (\mu \;+\; \dot{Q}), d, L\right)$
  - $\rho = f(T, P)$
  - $\mu = f(T, P)$
- Compressible
- If $\frac{\partial T}{\partial t} = 0$, and $\frac{\partial \rho}{\partial t} \neq 0, then\ \frac{\partial v}{\partial x} \neq 0$
- Non-linear pressure drop
- Dependent on pressure level

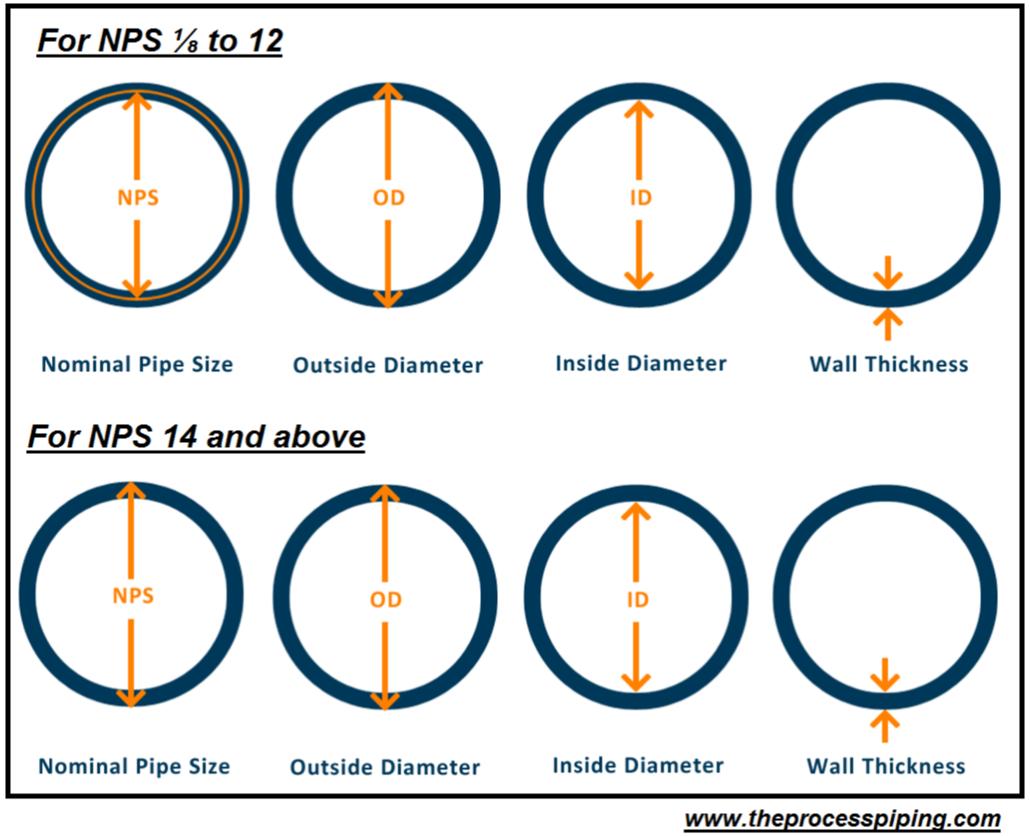


Calculations

- Wall thickness & Vacuum
- Upheaval Buckling
- Road Crossing
- Buoyancy

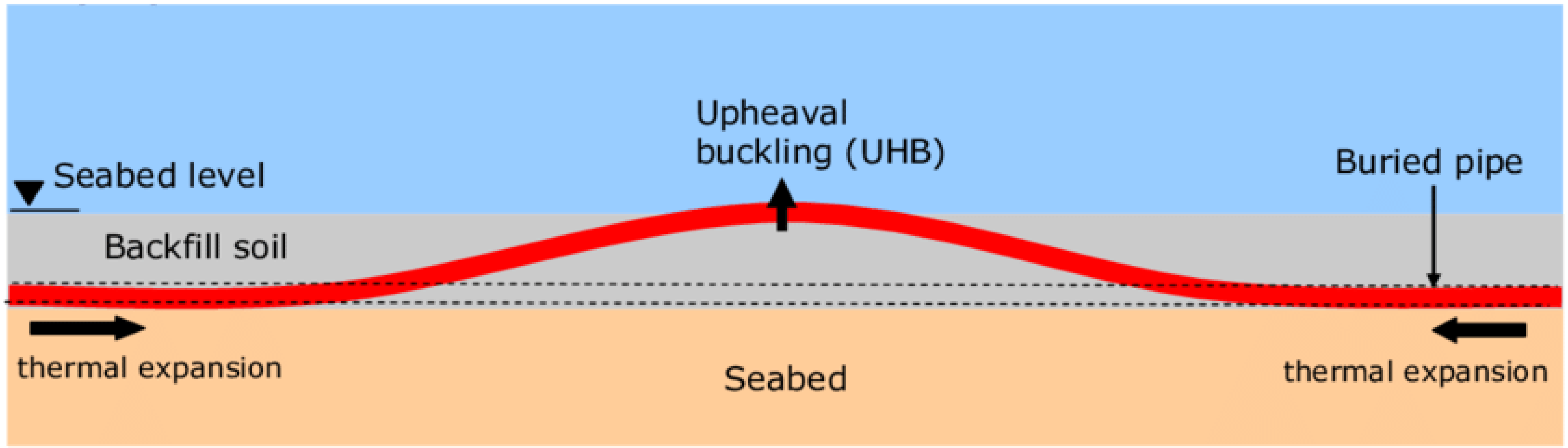
Wall-thickness and Vacuum

- Inputs:
  - NPS, ID, OD.
  - Operating P, T.
  - Material type, and its properties.
- Remarks:
  - Corrosion allowance.
  - Hoop stress.
  - D/t ratio.
  - Equivalent max stress, and 90% SMYS
  - Higher grade ➔ Stronger material

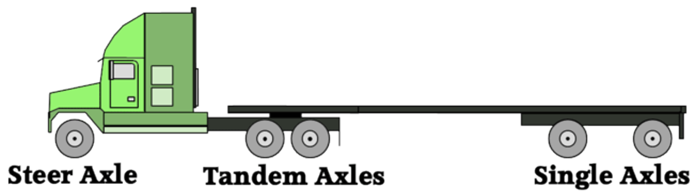


Upheaval Buckling

- Why?
- Inputs:
  - Size, Materials and its properties, Design parameters, Operation parameters.
- Remarks:
  - $w + q > W$ (the resultant force of upwards and downwards)
  - Only on high terampere variations (extremely hot or cold)
    - $DT \geq 82\ °C$; Location imperfections



Road Crossing



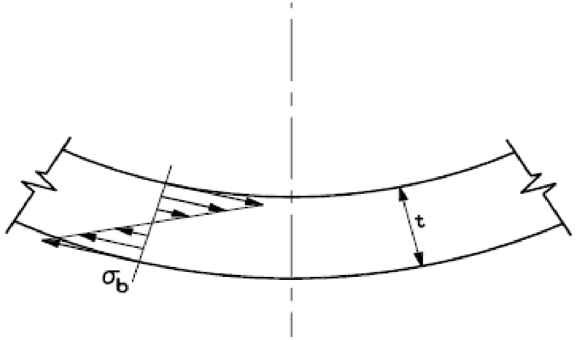


Figure 4.2-2 Through-Wall Bending Stress

- Remarks:
  - Type of soil:
    - Loose sand and gravel.
    - Medium dense sand.
    - Dense to very dense sand.
  - Single axles over tandem axles
  - Cyclic loading/ fatigue

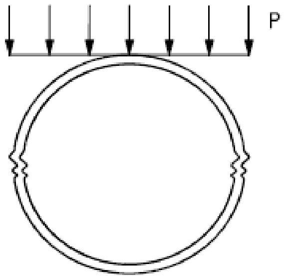
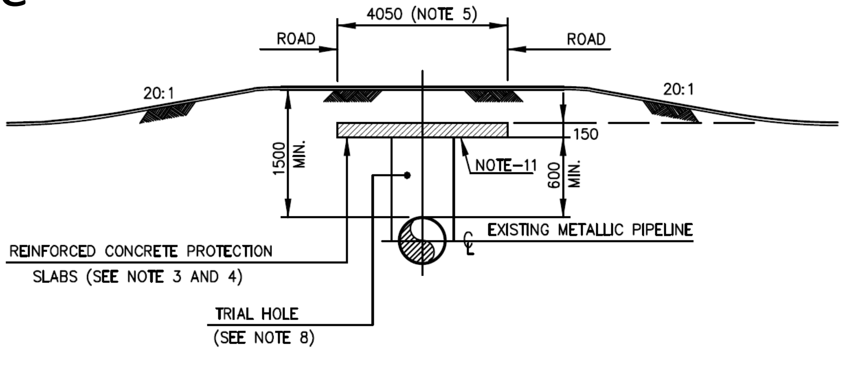


Figure 4.2-3 Crushing of Side Wall



SECTION A–A
(SCALE: N.T.S)

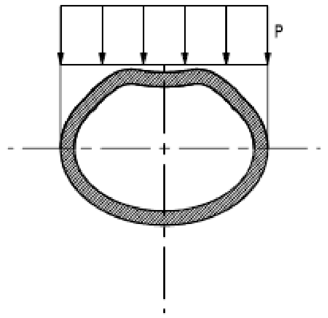
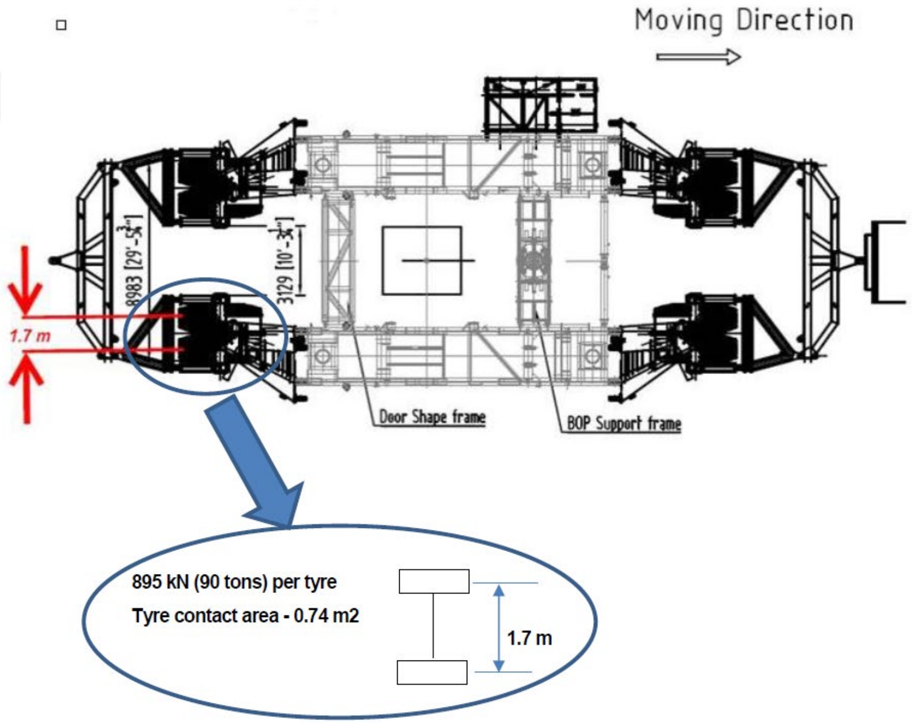


Figure 4.2-4 Ring Buckling of Pipe Cross Section



(Maximum specific pressure over ground of tyre = 1.2 MPa)

(Two tyres – Single axle combination)

Fig C.2: RIG 62/63/64 ABRAJ

Buoyancy

- Why?
- Overcoming the problem
  - Increase cover depth
  - Install concrete slaps

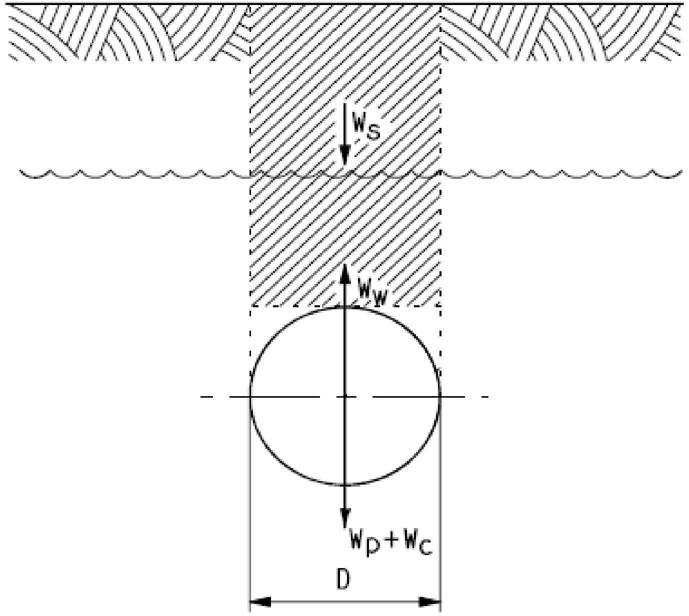


Figure 6.1-1 Resultant Buoyancy Load on Pipe

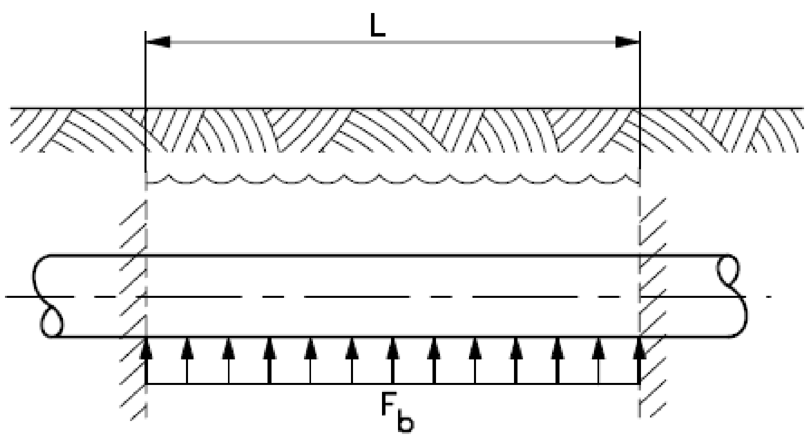


Figure 6.1-2 Distributed Buoyancy Load on Pipe

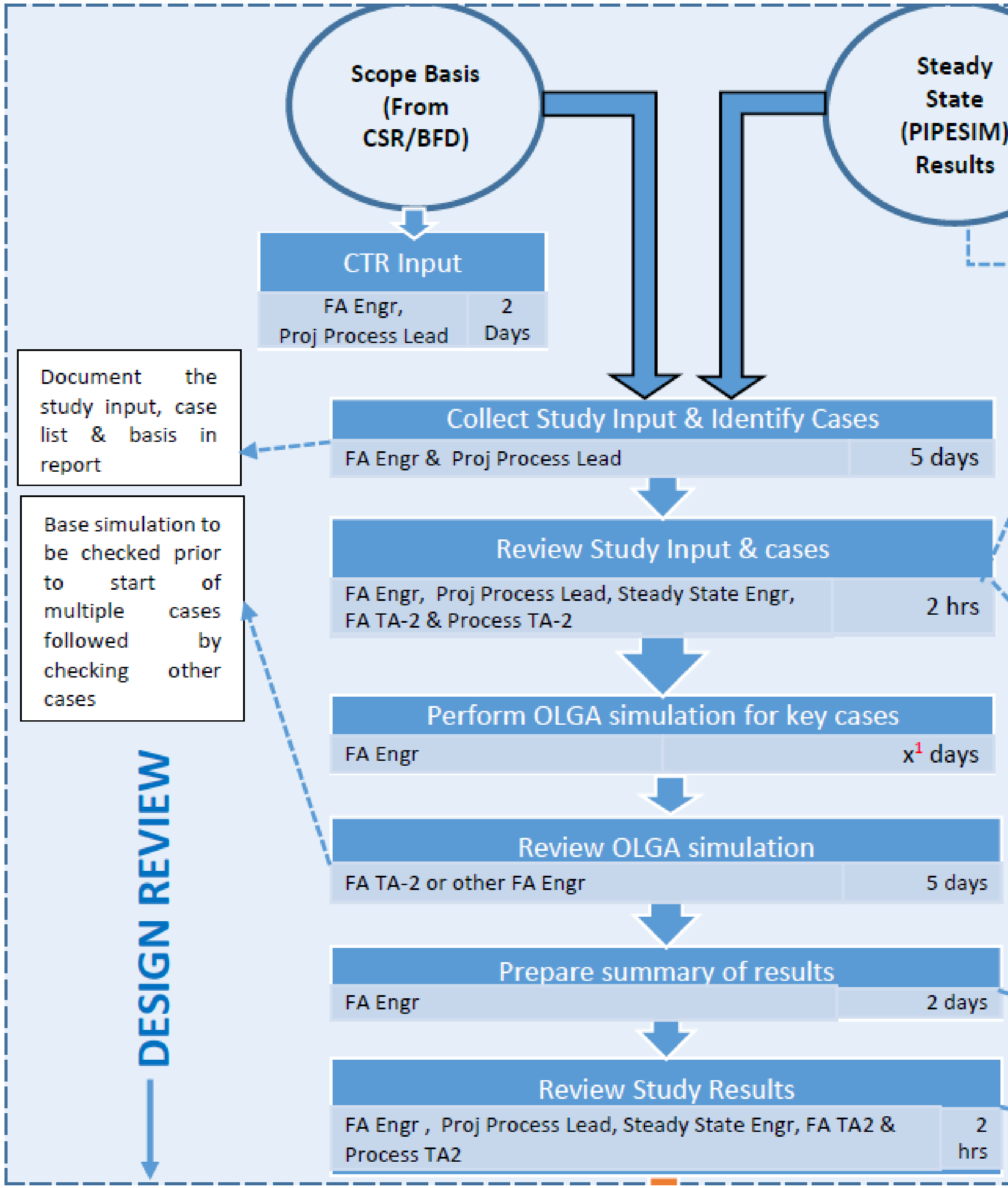
PIPESIM/PIPE STUDIO

- PIPESIM: the recommended application program for hydraulic sizing.
- According to SOP-106:

1. Identify the **purpose of the simulation**. (e.g., maximum Capacity, delivery pressure)
2. Make sure you have the **required input** for the simulation (e.g., operating pressure, delivery end pressure, operating flowrate)
3. Make sure you collected all the data required for the simulation mentioned in the Pre-check and Tools and materials sections at the bottom of this SOP.
4. According to the objective and available data (decide on which simulation is more suitable:
    1. Quick simulation, which requires minimum input. Gives a good estimation of the actual field conditions.
    2. Detailed simulation, which requires PVT report. Gives best estimation of the actual field conditions. (Recommended)

OLGA

- Used for transient analysis of multiphase pipelines.
- Showcase with UEFP18.
- Based on:
    1. Process Engineering Flow Scheme (PEFS)
    2. Heat & Material Balance (HMB)
    3. Basis for Design (BfD)/ Process Design Basis (PDB)
    4. Pipeline elevation profile
    5. Production forecast
    6. Equipment operating envelope/EORD
    7. Equipment data sheet
    8. Pipesim steady state simulation



Pipeline/ flowline sizes are confirmed by PIPESIM study at BFD stage. If BFD information is not sufficient enough, PIPESIM simulation to be performed at early FEED stage to have confirmed line size before starting OLGA study.

Review model boundary, study input & cases by organizing a meeting. Identify the key cases that require before DR & other cases after DR.

List of Typical Flow Assurance Simulation Cases

Case Name	Before DR	After DR
Steady State- Max flow*	√	
Steady State- Min flow*	√	
Minimum stable flow		√
Shutdown & Ramp up		√
Pigging study	√	
Line Depressurization to vent	√	
Line pack release to separator		√
Line black start		√
Pressure surge		√
RV opening study		√
Process Safety Time Estimation		√
Wax Study		√
Hydrate Study		√
Others (Project specific)	√	
Others (Project Specific)		√

*Mandatory for all FA study, other cases as applicable.

-Summary of results should list study input, case list, study results. This should be a word document or a presentation file.

-The summary results to be discussed in a meeting & used in DR workshop if required.

FA Eng.
Flow Assurance Engineer

DR
Design Review

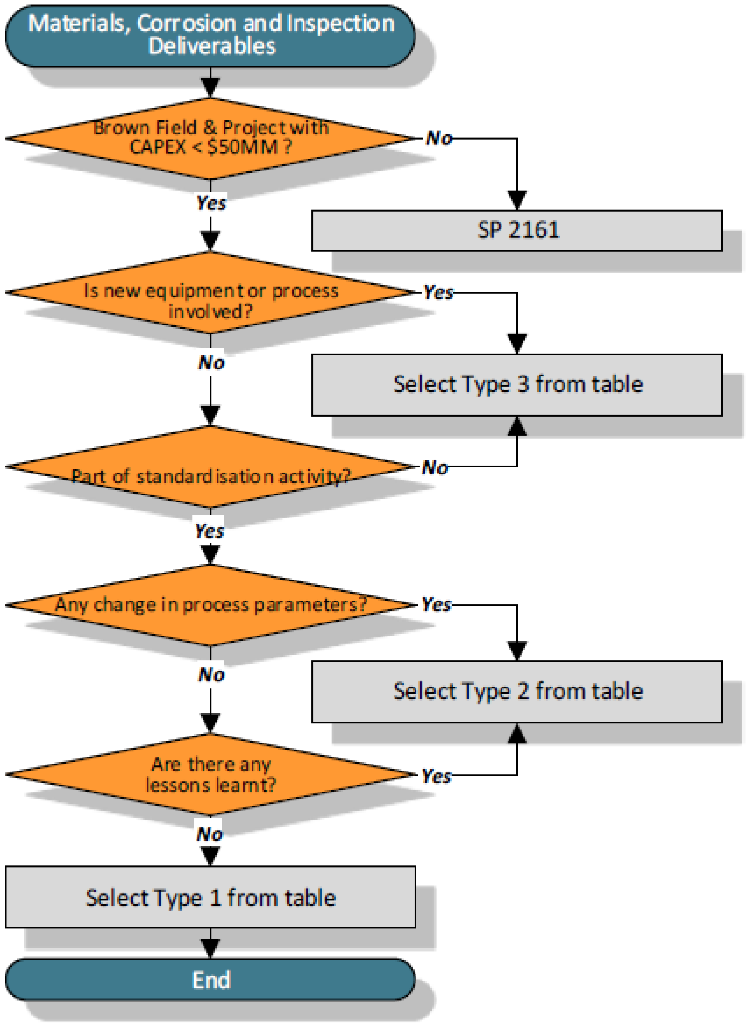
SS
Steady State

Material Selection

- Basics
  - Overview
  - Overcoming shortcomings
- Simulation (Case-study)

Material Selection Basis

- Short listing : feasibility
- Cost effective
    1. Carbon steel
    2. Stainless steel
    3. Duplex
    4. Super duplex
    5. Ni-alloys
- HSE



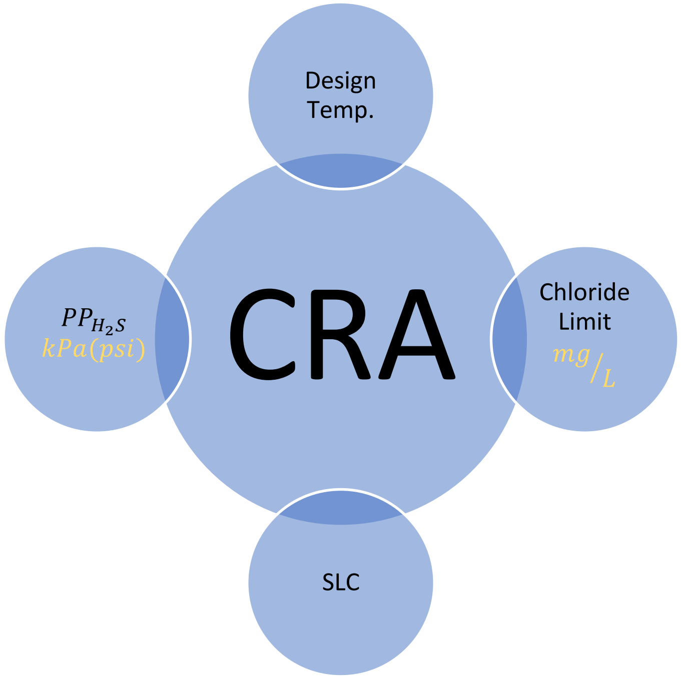
Overcoming Shortcomings

A. Chemical injection:
   1. Corrosion inhibitor
   2. Biocide

B. Non-corrosive materials
   i. Non-metallic
      1. GRE (Glass reinforced epoxy)
      2. HDPE (High density polyethylene)
      3. Internal Fusion Bonded Epoxy (FBE) coating
      4. RTP (reinforced thermoplastic pipe)
   ii. CRA
      1. SS 316 L
      2. DSS
      3. SDSS
      4. Alloy 28
      5. Alloy 825
      6. Alloy 625

CRA

- Alloying:
  - Cr ➔ $12\ to\ 13\ Cr\% \Rightarrow Passive\ film$
  - Ni
  - Mo
  - Mm
  - Si
  - N
  - Ti
  - Cu
  - W



Materials type/ Individual alloy UNS Number	Temperature max. °C (°F)	Partial pressure H_2S, pH_2S max. kPa (psi)	Chloride conc. max. mg/L	pH	Sulphur-resistant?	Remarks
Austenitic stainless steel from materials type described in (A.2)	60 (140)	1.5 (0.22)	60 000	≥3.5	No	Cold working (bending) of instrument tubing up to 9.5 % total deformation is acceptable even if the maximum hardness of 22 HRC is exceeded.
S31603	90 (194)	1000 (145)	1000	≥3.5	NDS	To be applied only for glycol system
	90 (194)	1 (0.145)	50 000	≥ 4.5	NDS	Not applicable for wet gas service
	93 (200)	10.2 (1.5)	5 000	≥ 5.0	No	Not applicable for wet gas service
	120 (248)	100 (14.5)	1 000	≥ 3.5	NDS	
	120 (248)	0.8 (0.12)	60 000	≥ 3.5	No	
	120	0.35 (0.05)	120000	≥ 3.5		This limit from PDO experience
	149 (300)	10.2 (1.5)	1 000	≥4.0	No	
	155 (311)	1.5 (0.22)	38 000	≥3.8	No	
S20910	66 (150)	100 (15)	See remarks	See remarks	No	Any combinations of chloride concentration and in situ pH occurring in production environments are acceptable.

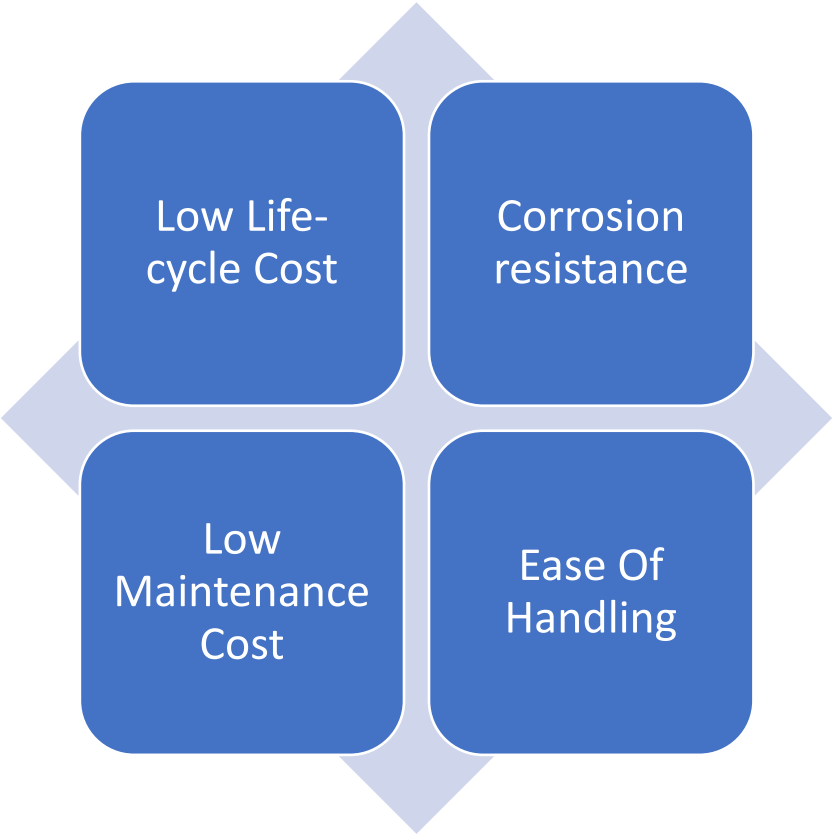
NOTES:
1. Austenitic stainless steels used for any equipment or components, shall comply with all of the following:
   a. be in the solution-annealed and quenched, or annealed and thermally stabilized heat- treatment condition;
   b. be free of cold work;
   c. have a maximum hardness of 22 HRC for base metal and 250 HV10 for weld and HAZ.

2 UNS S20910 is acceptable for environments inside the limits imposed for the material type and for this alloy, specifically, in the annealed or hot-rolled (hot/cold-worked) condition at a maximum hardness of 35 HRC.

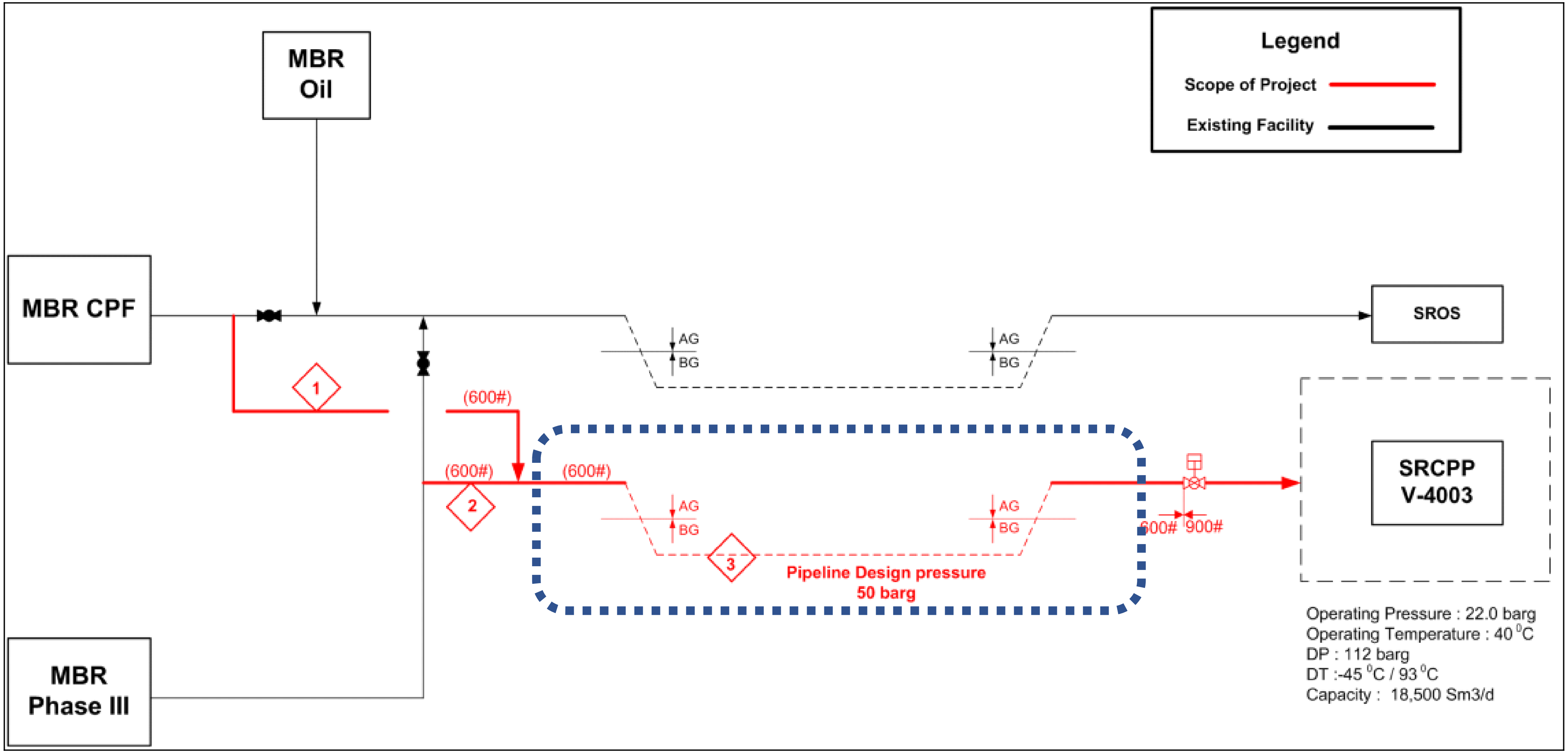
Table A.3 — Environmental and materials limits for austenitic stainless steels used as valve stems, pins and shafts

NMM

- **Material selection strategy** –No corrosion at minimum life cycle cost & No compromise on process safety.



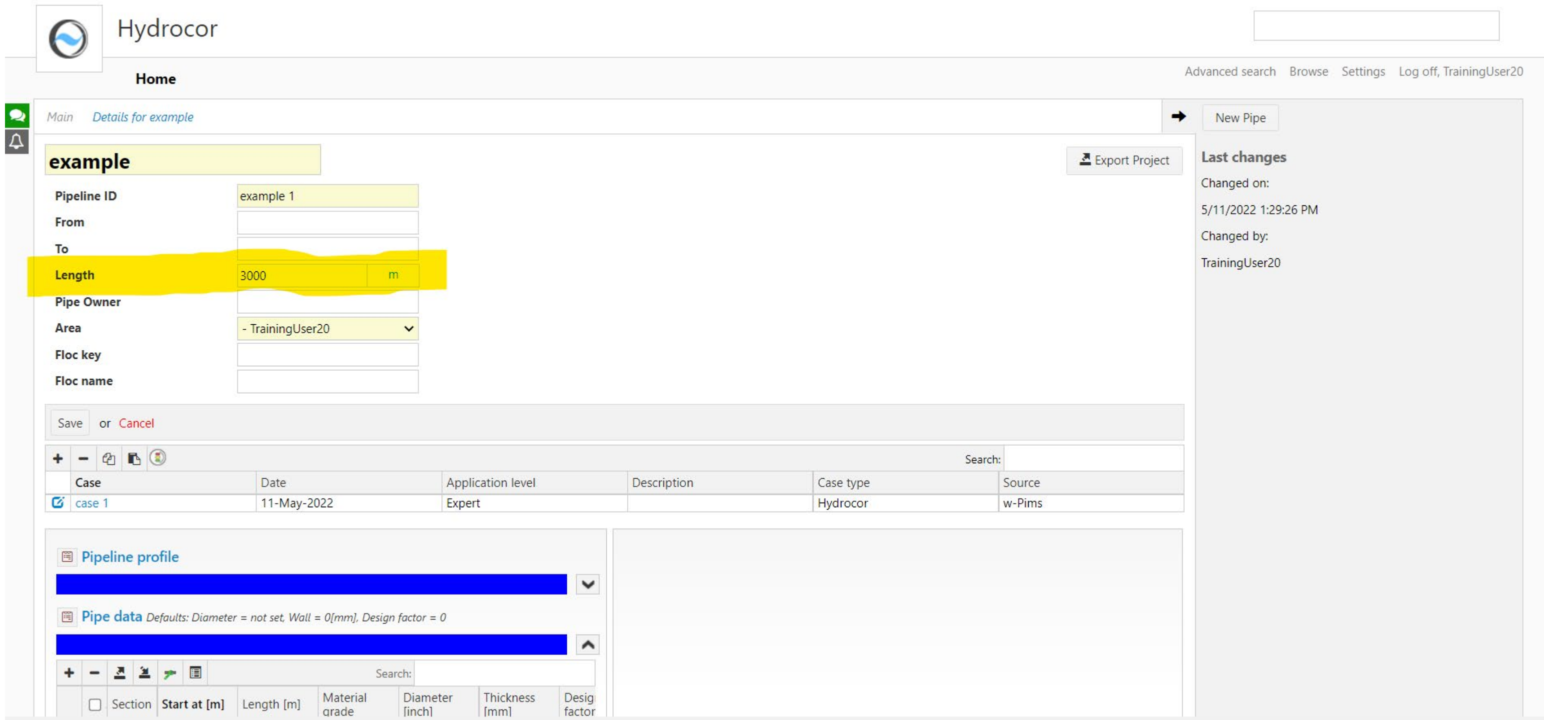
Hydrocor (Case Study)



Hydrocor (Case Study)

Table 4 Process data parameters

Process Parameters	Unit	Condensate from CPF-Steam 1	Condensate from Phase-Stream 2	Condensate to SRCPP-Stream 3	Flash Gas Ejector Outlet-Stream 4	Motive Gas to Ejector-Stream 5	Inlet to Flash Separator-Stream 6	Flash Gas to Ejector-Stream 7
CO_2 content of Gas	mol%	0.91	1.55	1.46	0.8	0.77414	0.796	0.796
H_2S content of Gas	ppm	20	20	20	20	20	20	20
ppH_2S	mbar	1.22	2.42	1.02	1.9	1.9	1.22	1.22
Maximum Operating Pressure	Bara	40	65	33	35	90	40	40
Design Temperature Min/Max	°C	-10 / 82	-46 / 100	70	-50 / 82	-50 / 82	-10 / 82	-10 / 82
Design Pressure	Bara	61.14	121	51	95	95	61.14	61.14
Maximum Operating Temperature	°C	60	65	60	80	80	60	60
Minimum Operating Temperture	°C	45	50	40	44	65	45	45
Gas flow Rate	Sm3/d	3957	48378	54058	3816	2904	912	912
Condensate Flow rate	m3/d	742.8	1234	1976 - 2200	0	0	742.8	0
Water flow rate in upset condition	m3/d	7.428	12.34	20	0	0	7.428	0
Water flow rate	m3/d	180	563	743	Note 1	Note 1	180	Note 1
Debris or sand present	yes/No	No	No	No	No	No	No	No
Design life	Year	25	25	25	25	25	25	25
Diameter	Inch	8	8	10	2	2	6	2
Chloride	ppm	159999	159999	159999	159999	159999	159999	159999
Bicarbonate	ppm	80	80	80	80	80	80	80


Hydrocor
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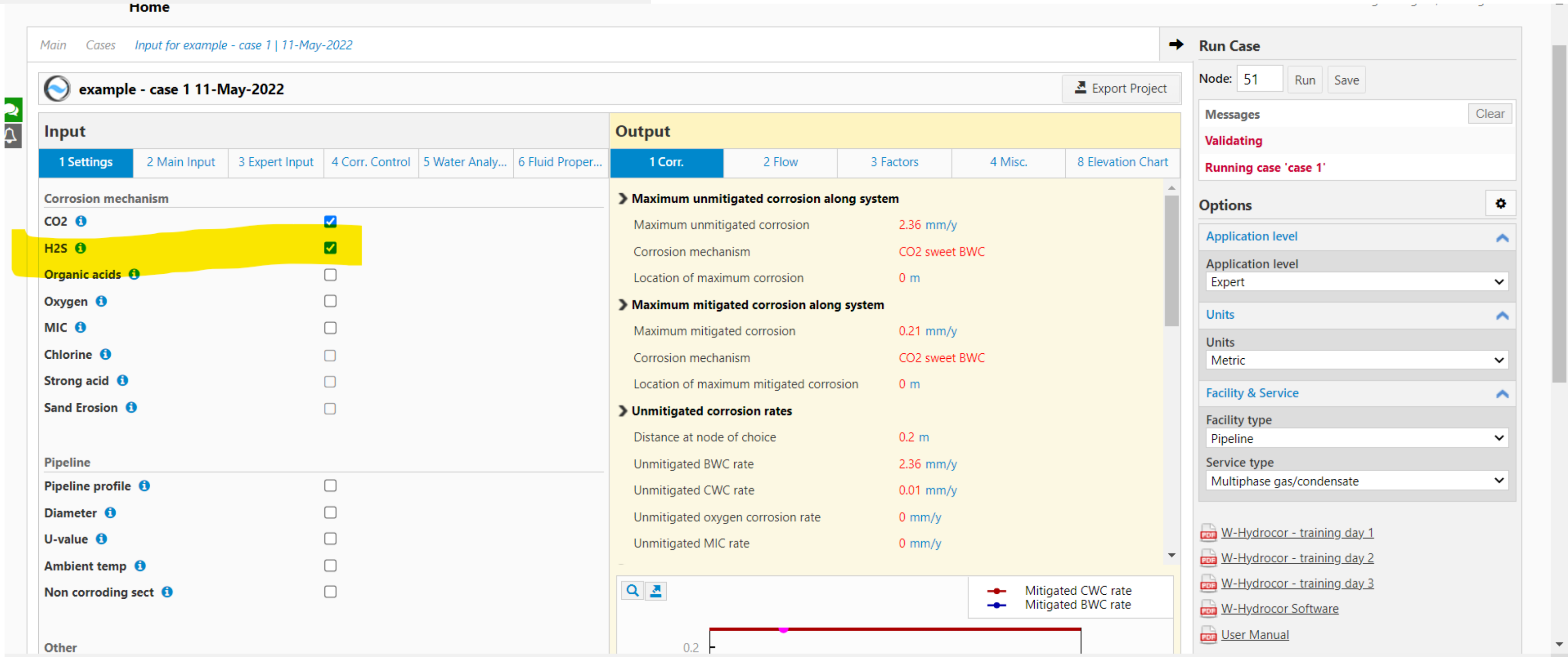
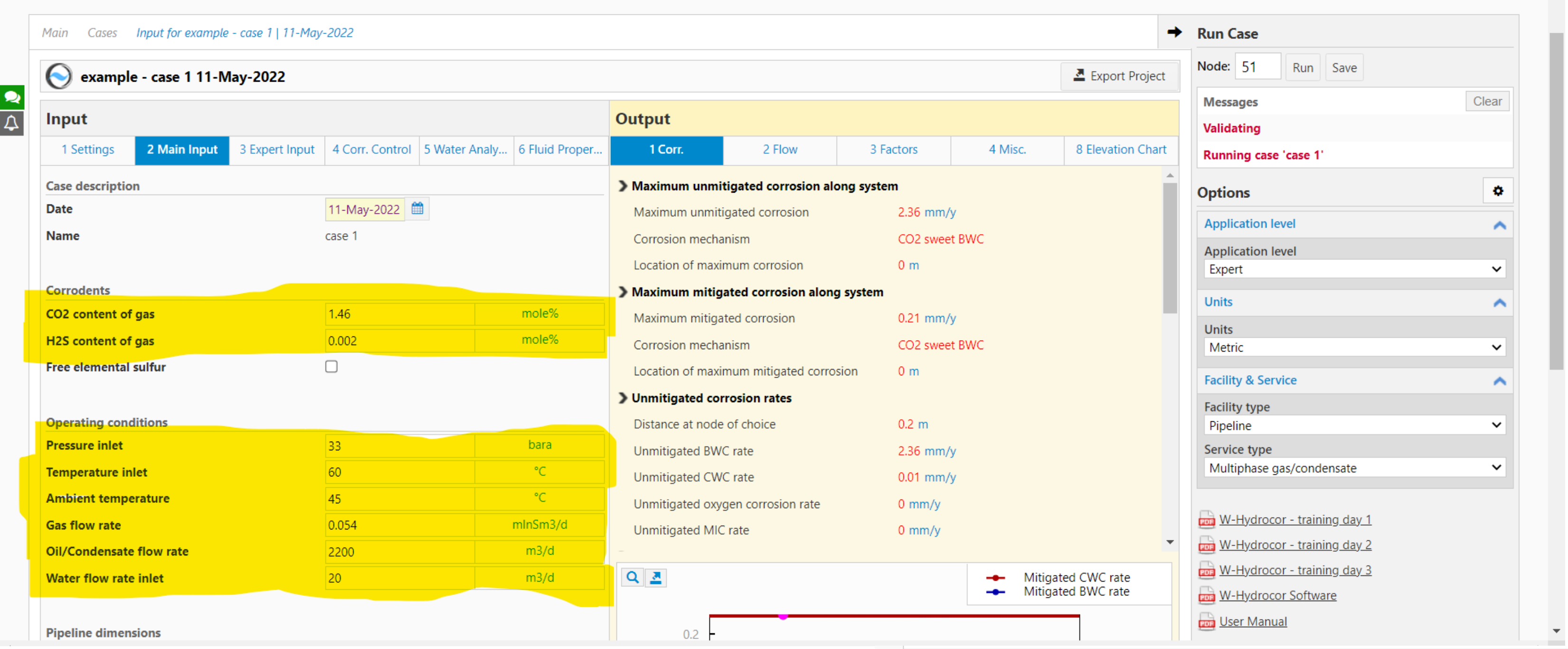
Browse
Settings
Log off, TrainingUser20
Main
Details for example
New Pipe
example
Export Project
Pipeline ID
example 1
From
To
Length
3000
m
Pipe Owner
Area
- TrainingUser20
Floc key
Floc name
Save
or
Cancel
Last changes
Changed on:
5/11/2022 1:29:26 PM
Changed by:
TrainingUser20
Search:
Case
Date
Application level
Description
Case type
Source
case 1
11-May-2022
Expert
Hydrocor
w-Pims
Pipeline profile
Pipe data Defaults: Diameter = not set, Wall = 0[mm], Design factor = 0
Search:
Section
Start at [m]
Length [m]
Material grade
Diameter [inch]
Thickness [mm]
Desig factor


Home
Main
Cases
Input for example - case 1 | 11-May-2022
Run Case
Node:
51
Run
Save
example - case 1 11-May-2022
Export Project
Input
Output
1 Settings
2 Main Input
3 Expert Input
4 Corr. Control
5 Water Analy...
6 Fluid Proper...
1 Corr.
2 Flow
3 Factors
4 Misc.
8 Elevation Chart
Messages
Clear
Validating
Running case 'case 1'
Corrosion mechanism
CO2
H2S
Organic acids
Oxygen
MIC
Chlorine
Strong acid
Sand Erosion
Pipeline
Pipeline profile
Diameter
U-value
Ambient temp
Non corroding sect
Other
Maximum unmitigated corrosion along system
Maximum unmitigated corrosion
2.36 mm/y
Corrosion mechanism
CO2 sweet BWC
Location of maximum corrosion
0 m
Maximum mitigated corrosion along system
Maximum mitigated corrosion
0.21 mm/y
Corrosion mechanism
CO2 sweet BWC
Location of maximum mitigated corrosion
0 m
Unmitigated corrosion rates
Distance at node of choice
0.2 m
Unmitigated BWC rate
2.36 mm/y
Unmitigated CWC rate
0.01 mm/y
Unmitigated oxygen corrosion rate
0 mm/y
Unmitigated MIC rate
0 mm/y
Mitigated CWC rate
Mitigated BWC rate
0.2
Options
Application level
Application level
Expert
Units
Units
Metric
Facility & Service
Facility type
Pipeline
Service type
Multiphase gas/condensate
W-Hydrocor - training day 1
W-Hydrocor - training day 2
W-Hydrocor - training day 3
W-Hydrocor Software
User Manual


Main
Cases
Input for example - case 1 | 11-May-2022
Run Case
example - case 1 11-May-2022
Export Project
Node: 51
Run
Save
Messages
Clear
Validating
Running case 'case 1'
Input
1 Settings
2 Main Input
3 Expert Input
4 Corr. Control
5 Water Analy...
6 Fluid Proper...
Case description
Date 11-May-2022
Name case 1
Corrodents
CO2 content of gas 1.46 mole%
H2S content of gas 0.002 mole%
Free elemental sulfur
Operating conditions
Pressure inlet 33 bara
Temperature inlet 60 °C
Ambient temperature 45 °C
Gas flow rate 0.054 mlnSm3/d
Oil/Condensate flow rate 2200 m3/d
Water flow rate inlet 20 m3/d
Pipeline dimensions
Output
1 Corr.
2 Flow
3 Factors
4 Misc.
8 Elevation Chart
Maximum unmitigated corrosion along system
Maximum unmitigated corrosion 2.36 mm/y
Corrosion mechanism CO2 sweet BWC
Location of maximum corrosion 0 m
Maximum mitigated corrosion along system
Maximum mitigated corrosion 0.21 mm/y
Corrosion mechanism CO2 sweet BWC
Location of maximum mitigated corrosion 0 m
Unmitigated corrosion rates
Distance at node of choice 0.2 m
Unmitigated BWC rate 2.36 mm/y
Unmitigated CWC rate 0.01 mm/y
Unmitigated oxygen corrosion rate 0 mm/y
Unmitigated MIC rate 0 mm/y
Mitigated CWC rate
Mitigated BWC rate
0.2
Options
Application level
Application level
Expert
Units
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Facility type
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Service type
Multiphase gas/condensate
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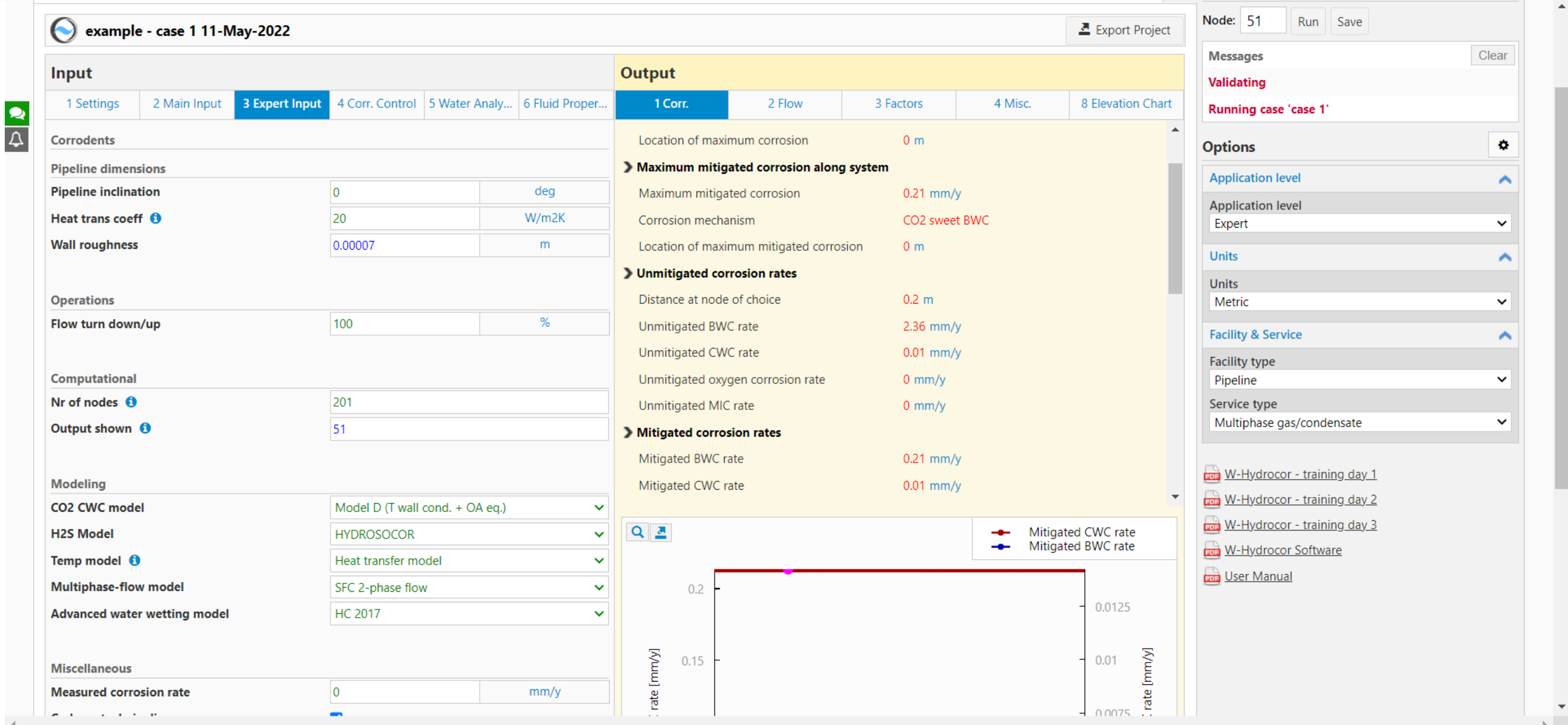
example - case 1 11-May-2022
Export Project
Node: 51
Run
Save
Messages
Clear
Validating
Running case 'case 1'
Input
1 Settings
2 Main Input
3 Expert Input
4 Corr. Control
5 Water Analy...
6 Fluid Proper...
Corrodents
Pipeline dimensions
Pipeline inclination 0 deg
Heat trans coeff 20 W/m2K
Wall roughness 0.00007 m
Operations
Flow turn down/up 100 %
Computational
Nr of nodes 201
Output shown 51
Modeling
CO2 CWC model Model D (T wall cond. + OA eq.)
H2S Model HYDROSOCOR
Temp model Heat transfer model
Multiphase-flow model SFC 2-phase flow
Advanced water wetting model HC 2017
Miscellaneous
Measured corrosion rate 0 mm/y
Output
1 Corr.
2 Flow
3 Factors
4 Misc.
8 Elevation Chart
Location of maximum corrosion 0 m
Maximum mitigated corrosion along system
Maximum mitigated corrosion 0.21 mm/y
Corrosion mechanism CO2 sweet BWC
Location of maximum mitigated corrosion 0 m
Unmitigated corrosion rates
Distance at node of choice 0.2 m
Unmitigated BWC rate 2.36 mm/y
Unmitigated CWC rate 0.01 mm/y
Unmitigated oxygen corrosion rate 0 mm/y
Unmitigated MIC rate 0 mm/y
Mitigated corrosion rates
Mitigated BWC rate 0.21 mm/y
Mitigated CWC rate 0.01 mm/y
Mitigated CWC rate
Mitigated BWC rate
0.2
0.15
0.0125
0.01
Options
Application level
Application level
Expert
Units
Units
Metric
Facility & Service
Facility type
Pipeline
Service type
Multiphase gas/condensate
W-Hydrocor - training day 1
W-Hydrocor - training day 2
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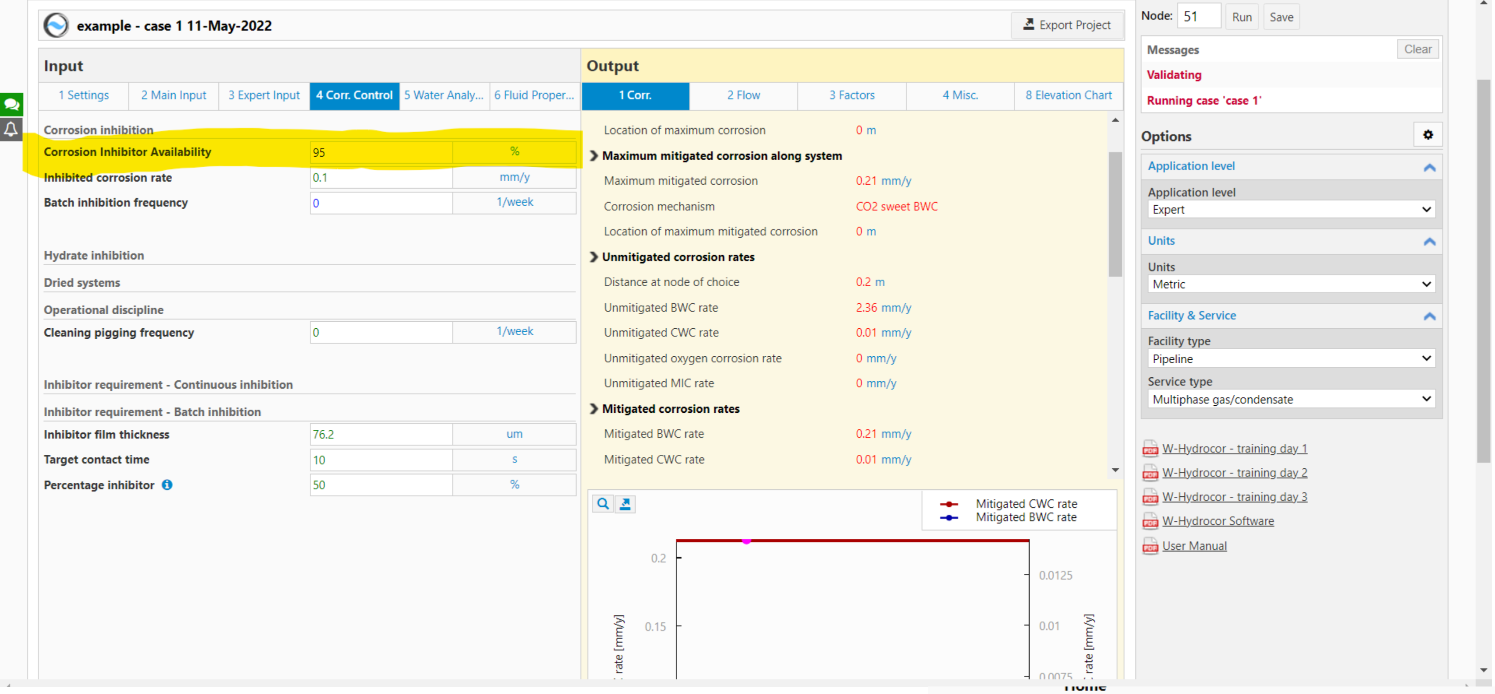
example - case 1 11-May-2022
Export Project
Node: 51
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Save
Messages
Clear
Validating
Running case 'case 1'
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1 Settings
2 Main Input
3 Expert Input
4 Corr. Control
5 Water Analy...
6 Fluid Proper...
Output
1 Corr.
2 Flow
3 Factors
4 Misc.
8 Elevation Chart
Corrosion inhibition
Corrosion Inhibitor Availability 95 %
Inhibited corrosion rate 0.1 mm/y
Batch inhibition frequency 0 1/week
Hydrate inhibition
Dried systems
Operational discipline
Cleaning pigging frequency 0 1/week
Inhibitor requirement - Continuous inhibition
Inhibitor requirement - Batch inhibition
Inhibitor film thickness 76.2 um
Target contact time 10 s
Percentage inhibitor 50 %
Location of maximum corrosion 0 m
Maximum mitigated corrosion along system
Maximum mitigated corrosion 0.21 mm/y
Corrosion mechanism CO2 sweet BWC
Location of maximum mitigated corrosion 0 m
Unmitigated corrosion rates
Distance at node of choice 0.2 m
Unmitigated BWC rate 2.36 mm/y
Unmitigated CWC rate 0.01 mm/y
Unmitigated oxygen corrosion rate 0 mm/y
Unmitigated MIC rate 0 mm/y
Mitigated corrosion rates
Mitigated BWC rate 0.21 mm/y
Mitigated CWC rate 0.01 mm/y
Mitigated CWC rate
Mitigated BWC rate
0.2
0.15
0.0125
0.01
Options
Application level
Application level
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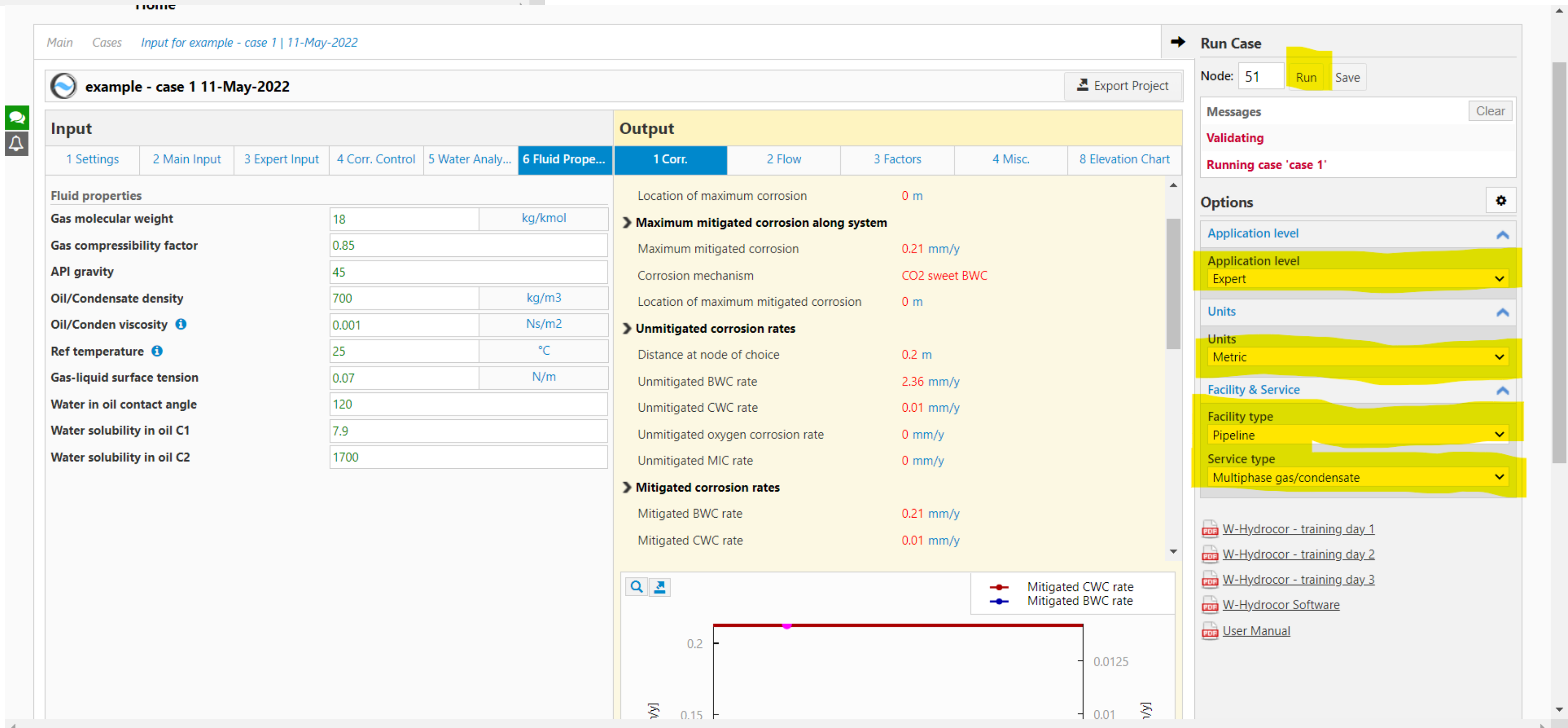
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4 Corr. Control
5 Water Analy...
6 Fluid Prope...
Output
1 Corr.
2 Flow
3 Factors
4 Misc.
8 Elevation Chart
Fluid properties
Gas molecular weight 18 kg/kmol
Gas compressibility factor 0.85
API gravity 45
Oil/Condensate density 700 kg/m3
Oil/Conden viscosity 0.001 Ns/m2
Ref temperature 25 °C
Gas-liquid surface tension 0.07 N/m
Water in oil contact angle 120
Water solubility in oil C1 7.9
Water solubility in oil C2 1700
Location of maximum corrosion 0 m
Maximum mitigated corrosion along system
Maximum mitigated corrosion 0.21 mm/y
Corrosion mechanism CO2 sweet BWC
Location of maximum mitigated corrosion 0 m
Unmitigated corrosion rates
Distance at node of choice 0.2 m
Unmitigated BWC rate 2.36 mm/y
Unmitigated CWC rate 0.01 mm/y
Unmitigated oxygen corrosion rate 0 mm/y
Unmitigated MIC rate 0 mm/y
Mitigated corrosion rates
Mitigated BWC rate 0.21 mm/y
Mitigated CWC rate 0.01 mm/y
Mitigated CWC rate
Mitigated BWC rate
0.2
0.15
0.0125
0.01
Options
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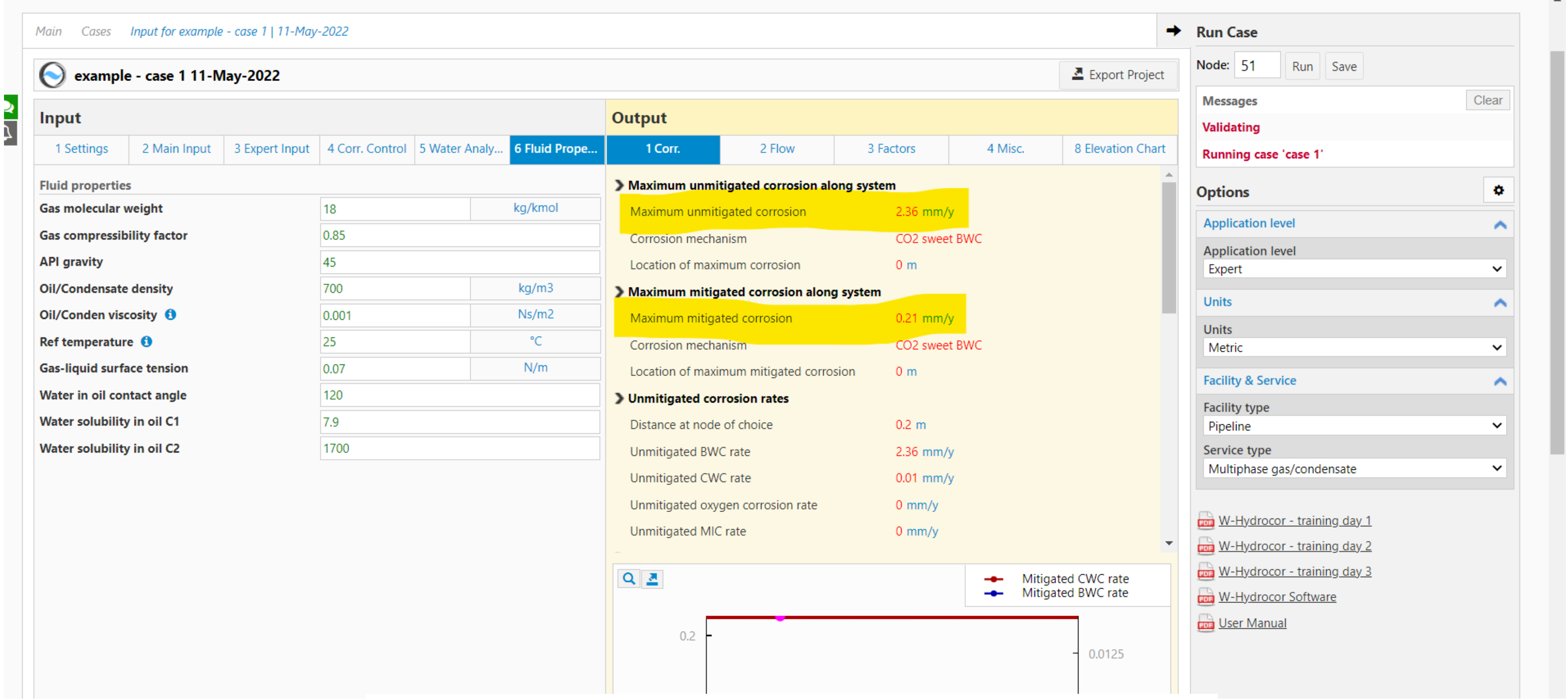


$$C1_{unmitigated} := 2.36\ \frac{mm}{yr} \cdot 25\ yr = 59\ mm$$

$$C1_{unmitigated} \le 6\ mm = 0$$

$$C2_{mitigated} := 0.21\ \frac{mm}{yr} \cdot 25\ yr = 5.25\ mm$$

$$C2_{mitigated} \le 6\ mm = 1$$

Options and Recommendations

Required Parameter	GRE	HDPE lined CS	FBE coated CS Flowlines	FCP pipes
Water	Y	Y	X[1]	Y
Oil	Y[4]	Y	Y	Y
Wet Gas	Y[4]	X	X	♦
Multiphase	Y	Y[3]	Y	♦
H2S	Max 7 mol%[2]	Max 3%[6]	♦	♦
Sand > 10 g/m3	X[5]	X[5]	X[5]	X[5]
Wax and Asphalt	Y[5]	Y[5]	♦	Y
Fluid velocity	Up to 4 m/s liquid velocity Up to 10 m/s gas velocity	≤ 10m/s liquid velocity	Up to 4 m/s[3]	♦
Design pressure	As per SP-2092	Max 180 bar[8]	♦	♦
Temperature[9]	DT Max 100° C[7]	MOT[9,10] 70°C (Water) 65°C (Oil) 65°C (Roto-lining)	DT 90 °C	DT 65°C. (DT>65°C Consult MCI)

Symbols:

X – Shall not be used.

Y – The material may be considered within the boundaries specified in the above table

♦ - Consult with the PDO materials function TA2 authority.

Non-feasible:

- Carbon Steel + 6 mm Corrosion Allowance
- CS + FBE coating
- HDPE lined CS
- SS316L

Feasible:

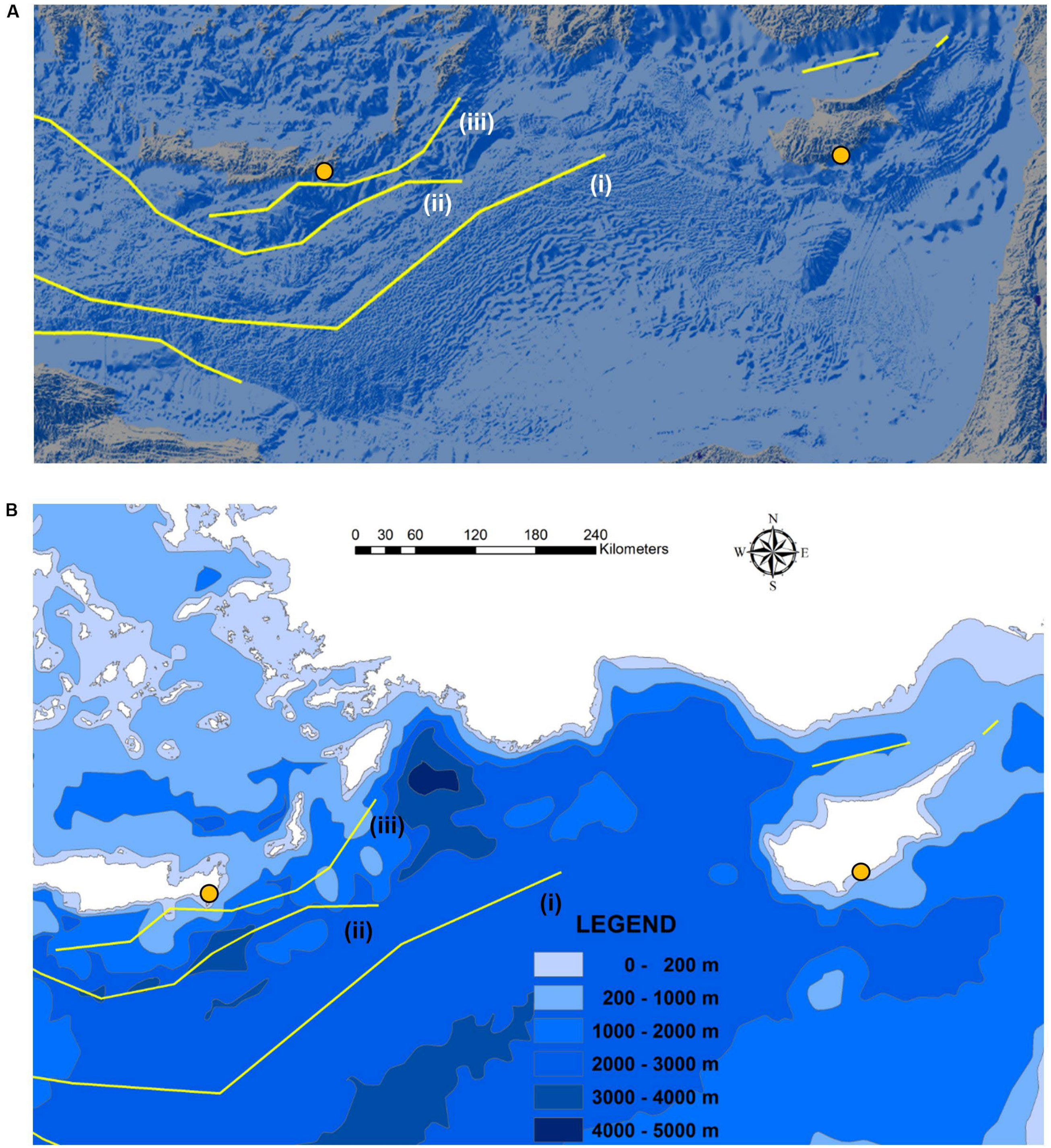
- Carbon Steel + 6mm Corrosion Allowance + 99% Corrosion inhibition + Pigging + Inspection
- GRE
- 22 Cr DSS + 3LPE + ICCP

1. **Recommended option 1:** GRE
2. **Recommended Option 2:** CS+ 6mm CA + 99% CI + Pigging + Inspection
3. **Recommended option 3:** DSS

Valves Body: DSS **Trim:** DSS

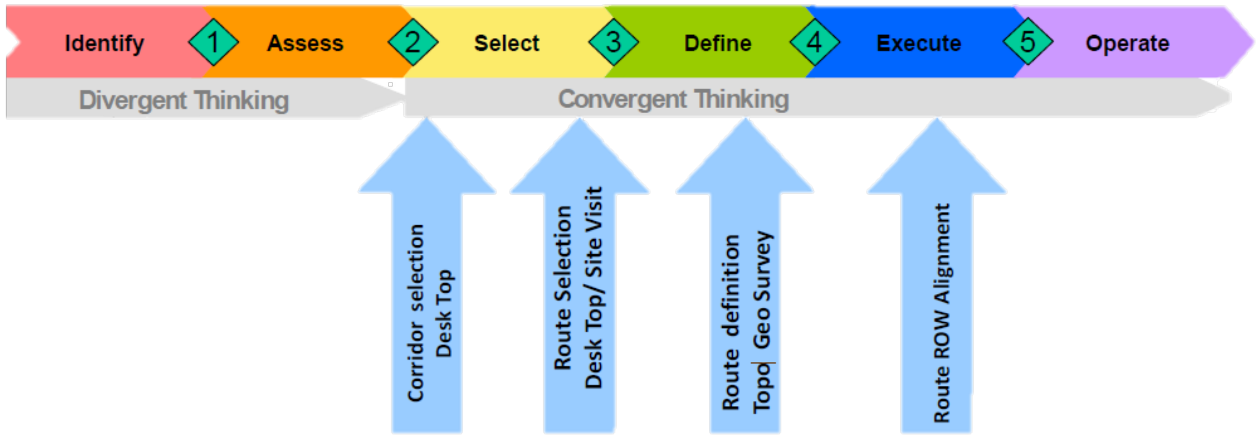
Route Selection

Theoretical Overview

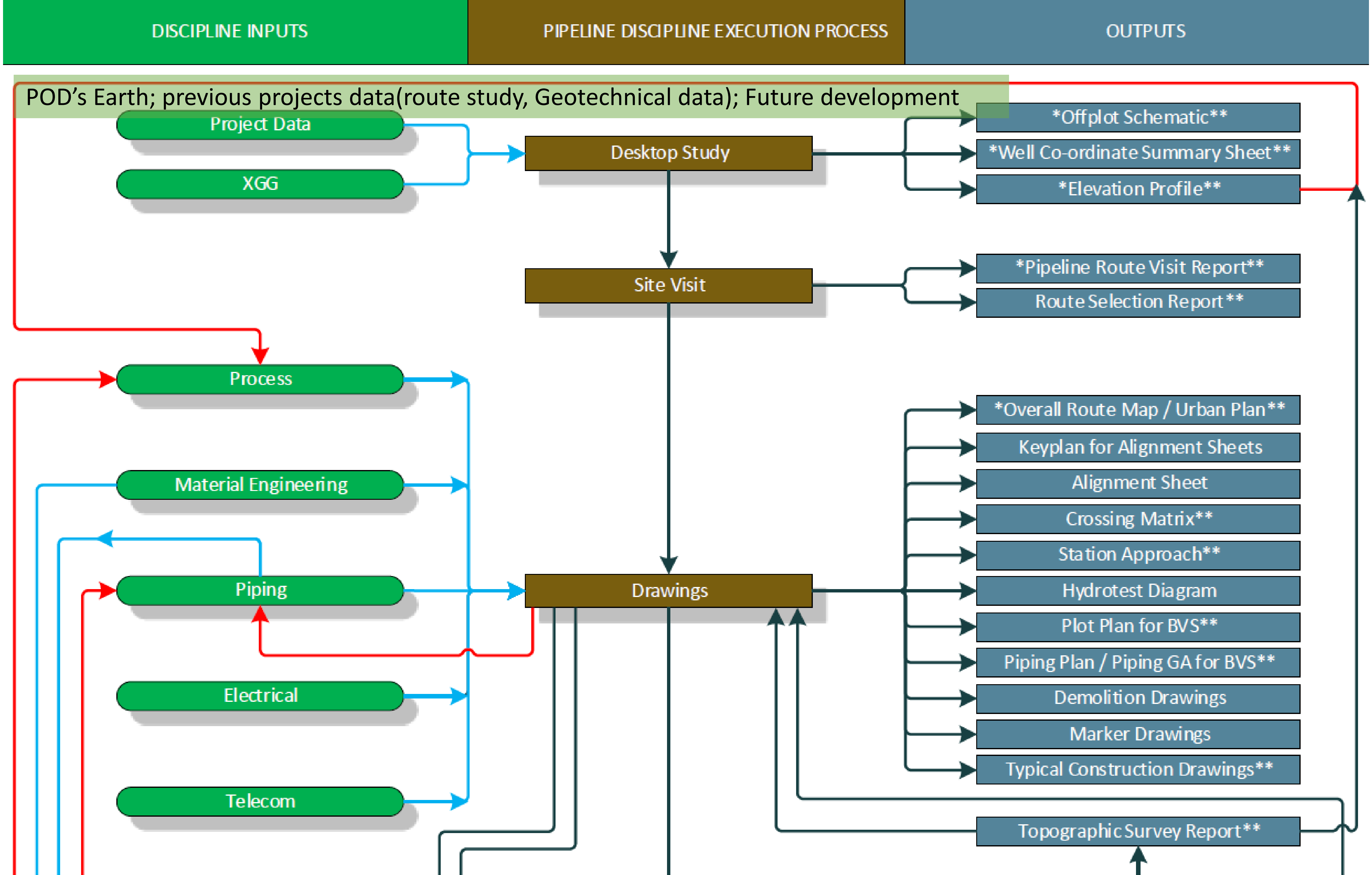


Optimization of Pipeline Route from Concept until Construction

- Corridor selection at Concept / Desktop study /Overall Route Map for Routing Options
- Route refinement at BFD study ~500mt Width / Desktop study & Site Visit / Preliminarily Route Selection /Route Maps
- Route definition; survey 100mt width at FEED / Route Selection finalization / Topographical Geotechnical Survey /Preliminarily Alignment sheets
- Route ROW Alignment i.e. ~30mt at AFC Route Alignment Sheet



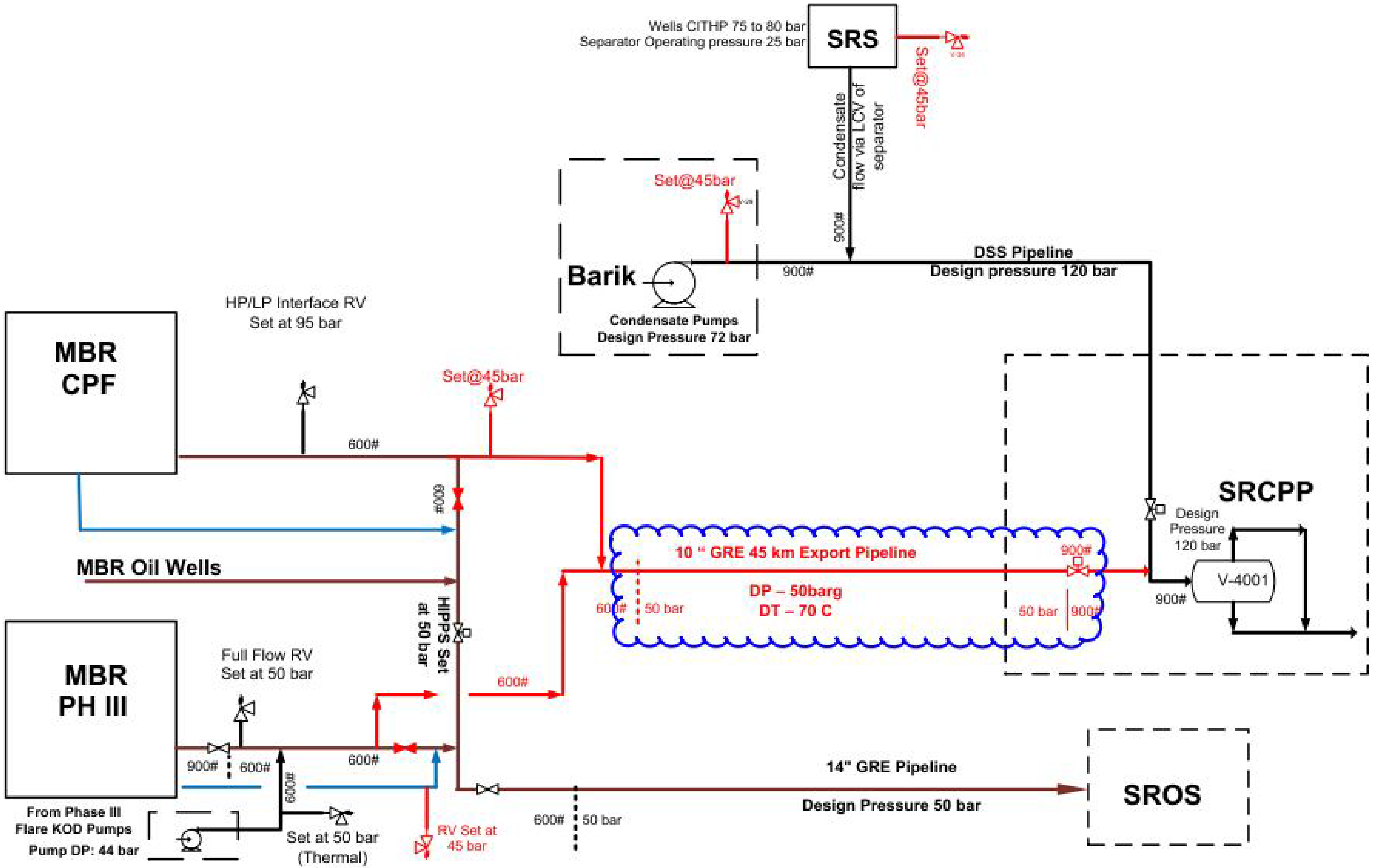
NOTE
1) * BFD
2) **FEED
3) GRE stress analysis by GRE vendor.
4) PE design & procurement by installation contractor.



Route Selection Case Study

10” GRE buried condensate pipeline approximately 44 km from MBR to SRCPP

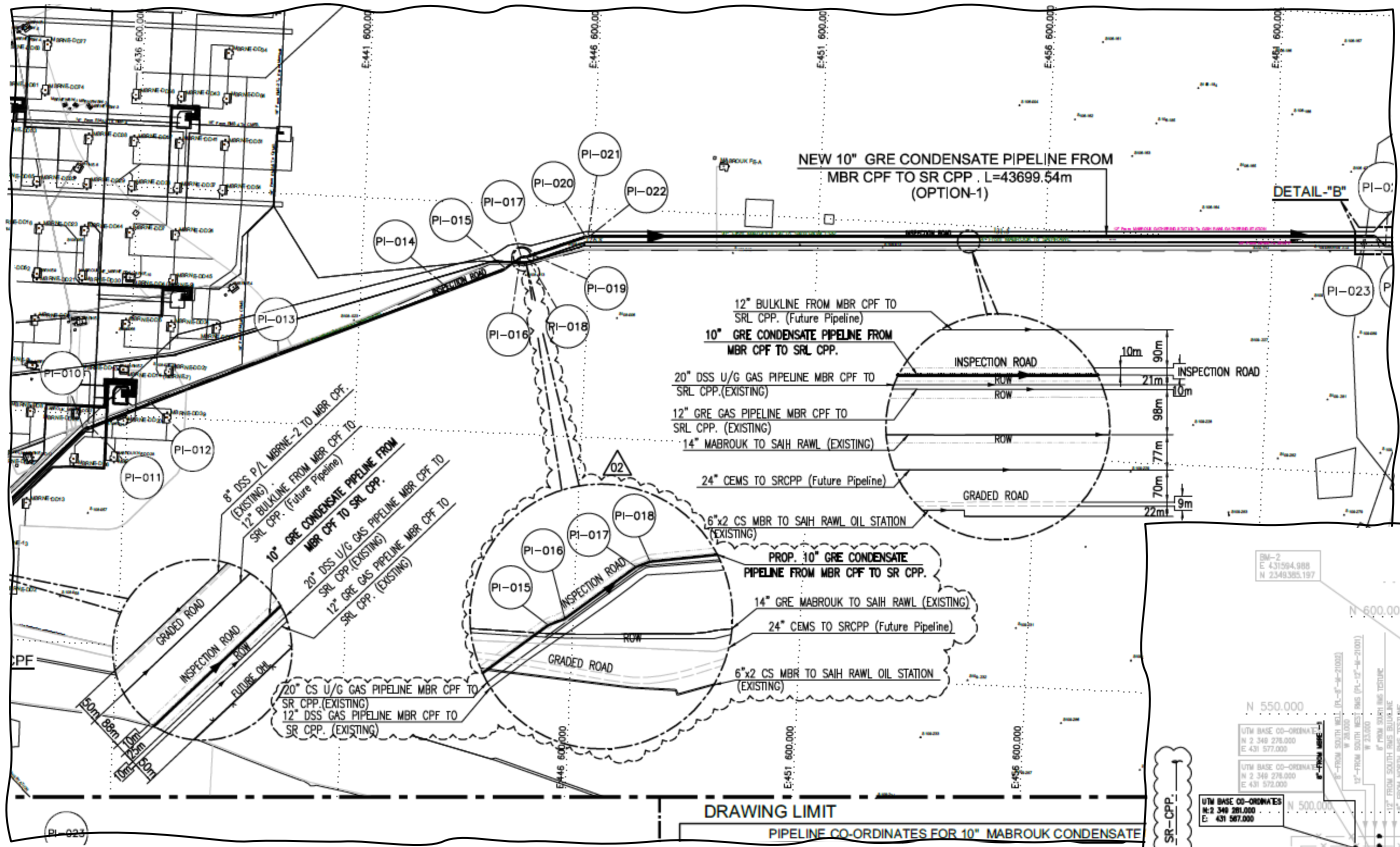
Reference: CRS# MBR-00-101983-LA-7880-00004-0000 Rev 01



Wells CITHP 75 to 80 bar
Separator Operating pressure 25 bar
SRS
Set@45bar
Condensate flow via LCV of separator
900#
Set@45bar
Barik
Condensate Pumps
Design Pressure 72 bar
900#
DSS Pipeline
Design pressure 120 bar
HP/LP Interface RV
Set at 95 bar
MBR CPF
Set@45bar
600#
600#
SRCPP
Design Pressure 120 bar
10 " GRE 45 km Export Pipeline
900#
MBR Oil Wells
V-4001
DP – 50barg
DT – 70 C
600#
50 bar
50 bar
900#
900#
HIPPS Set at 50 bar
MBR PH III
Full Flow RV
Set at 50 bar
600#
600#
900#
600#
600#
14" GRE Pipeline
Design Pressure 50 bar
SROS
From Phase III
Flare KOD Pumps
Pump DP: 44 bar
Set at 50 bar
(Thermal)
RV Set at 45 bar
600#
50 bar

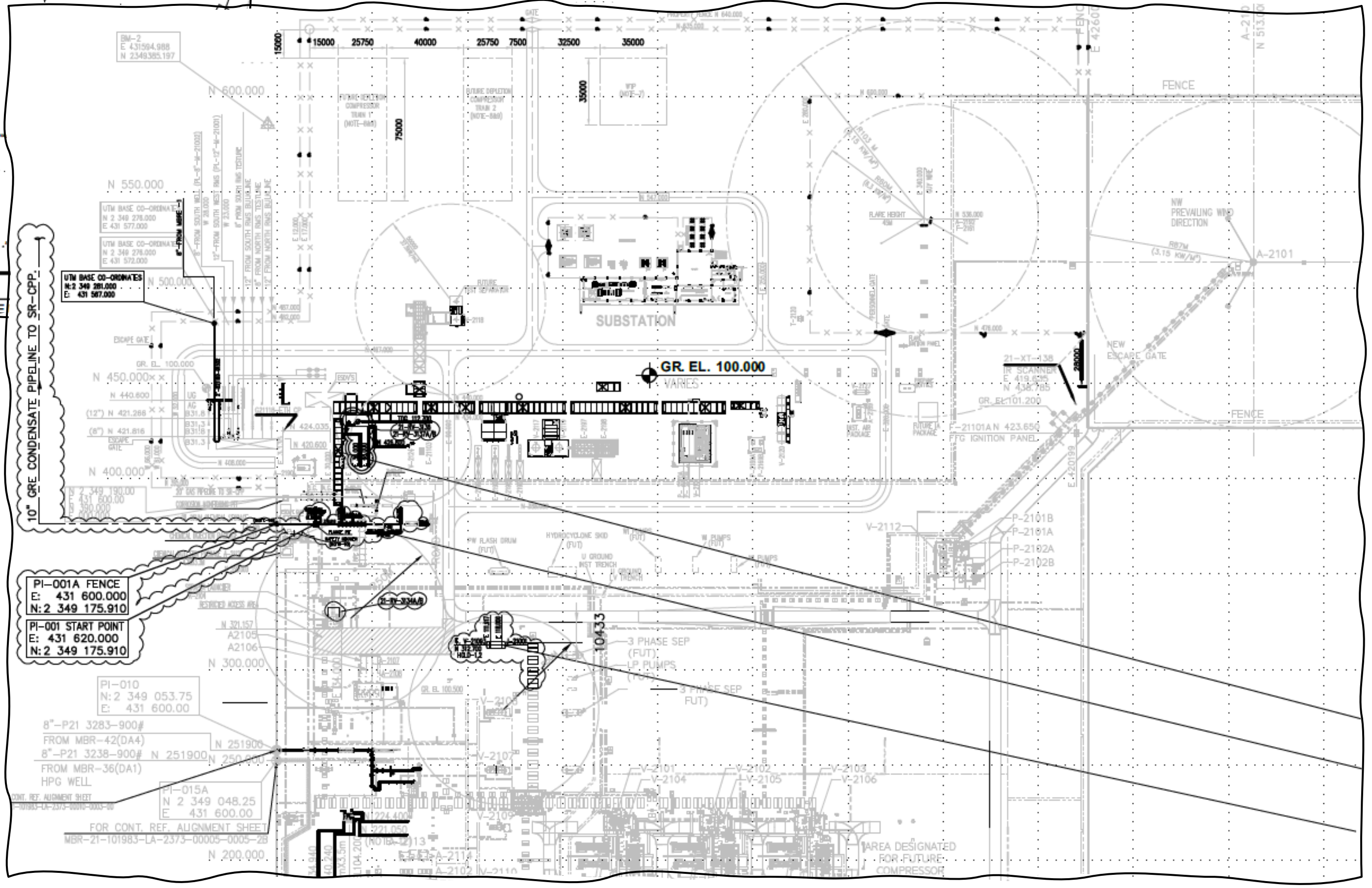
Reference Data And Equipment

- The Preliminary Route Map.
  - based on the latest map provided by PDO.
- GPS equipment (Garmin Montana 650).
  - used for verification during the field reconnaissance survey along the proposed pipeline route.
- Site observations and finding which were verified and recorded.
- FEED
  - pipeline route study
  - CSR
  - BfD



PRELIMINARY PIPELINE ROUTES

PRELIMINARY PLOT PLANS



Route Selection Criteria

The following considerations form the basis for optimal route selection:

a. **Minimize** the total Pipeline **length and bends**.

b. **Minimize** the probability of **physical damage**.

c. **Avoid** the Pipeline route through **sensitive areas** such as University / Schools, Highly populated areas, Residential, Hospital, Market, Defense proximities, etc.

d. **Eliminate critical areas** such as well pads, inhabited locations, third party production facilities and line parallelism with OHL's, etc.

Cont.

e. **Avoid** routing through **difficult construction areas** such as Jebels / Mountains and difficult subsurface conditions such as rock or unstable soil.

f. **Minimize** the number of **crossings** for Wadis, Rivers, Highways/ Tarmac roads, other Pipelines and Utilities, etc. as applicable.

g. The **crossing of existing Pipelines**, Cables, Power lines, Roads, Railways and Waterways should be as close as practicable to **90 degrees angle**.

h. **Maximize routing through an existing corridor(s)** requiring minimum redevelopment.

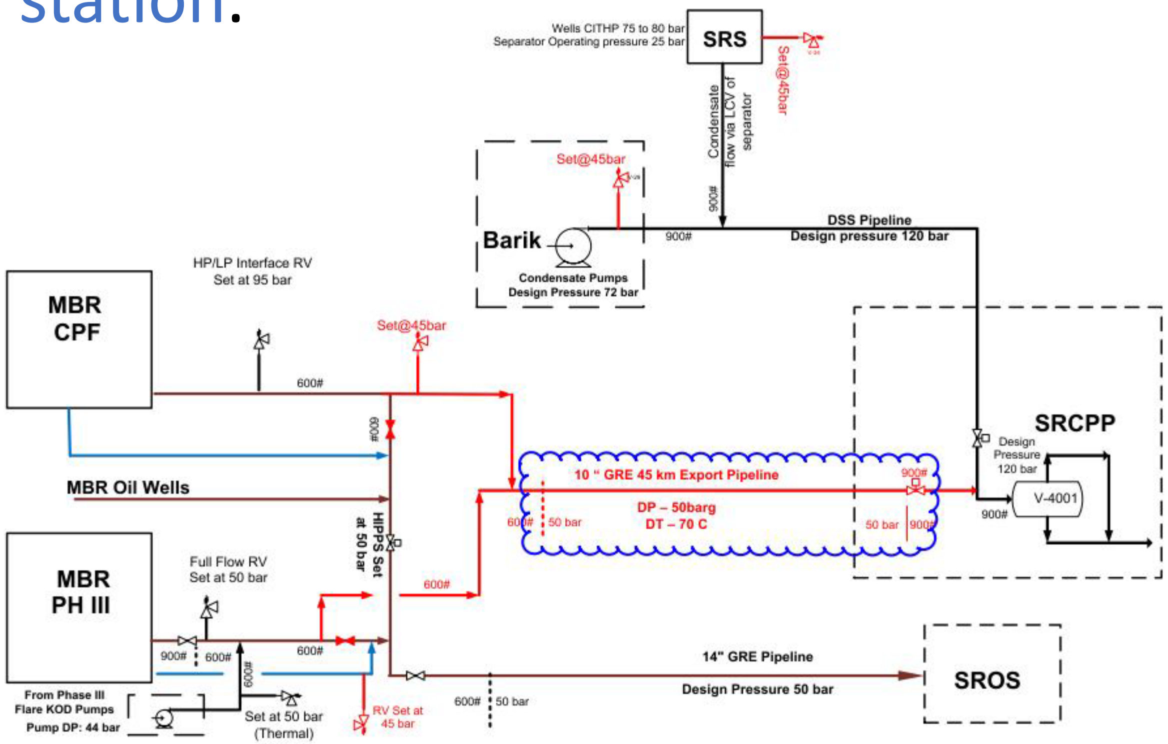
i. **Constructability**, Technical requirements and Cost.

Route Selection Details

- Desktop study
  - 10” GRE, Not feasible.
- Site visit
  - Found 20” Gas line with same route.
  - GRE 10” parallel to 20” gas line.
  - Observations:
    - Existing flowline/pipelines
    - Graded roads
    - Wadis/Jebel areas
    - OHLs

Route Description

The routing of the proposed 10”GRE condensate pipeline starts from spec break flange inside MBR CPF station and ends at spec break flange inside SRCPP station.



Options: At MBR CPF Area

Option-1: From start point at MBR CPF station, the proposed 10" GRE condensate pipeline exits at MBR CPF spec break flange inside fence area and runs towards the southwest direction. The new pipeline turns towards north direction by crossing existing flow lines and buried pipelines & cables and follow parallel route of existing 20" Gas pipeline.

Option-2: From start point at MBR CPF station, the Proposed 10" pipeline will be routed exactly parallel to existing 20" Gas pipeline. The proposed 10" GRE condensate pipeline exits at MBR CPF spec break flange inside fence area and runs towards the southwest direction without crossing any of existing facility.

Options: At SR CPP Area

Option-1: The Proposed 10" GRE pipeline is diverted from chainage 35+252m and will be routed along the proposed 24" CEMS to SR CPP pipeline, till it reaches SRCPP proposed urban planning area. In this section the pipeline crosses right of ways, OHL's, flowlines/ pipelines, Well pads and one black top road.

Option-2: The proposed 10" pipeline will be routed parallel to existing 20" Gas pipeline. The length of the pipeline is same when compared with option-01 route. The number of flowline/pipeline and graded road crossings are less when compared with option-1 route. Additionally, there is ample space available for this option and the route is straight with lesser bends till it approaches SR CPP area. This will ease construction activities like trenching, material handling, etc. and results less impact on project schedule. However existing plot and fence to be extended to accommodate the Pipeline.

Population Density Study For The Proposed Pipeline Route

- Based on site visit observations:
  - New pipeline are installed in remote desert locations within PDO concession area.
  - There is no human occupancy exists.
  - No residential buildings, commercial /shopping location, petrol filling stations, bridges /highways, ROP offices, community area, other public infrastructure locations.
  - Therefor, as per ASME B31.8 and SP-1211 table 1, the location is classified as **location class 1.**

Environmental Considerations

Impact to the environment due to construction and operation of the new pipeline and their associated gathering/piping facilities are considered to be minimal due to the extremely sparse habitat supported at the remote desert location.

Fwd: [External] Plotting project areas on PDO Earth/Topography - MBR Condensate Pipeline Project
1 message

Adil Ahmed Rafi <adil.rafi@galfar.com>
To: Srikanth Gavini <srikanth.gavini@galfar.com>

---------- Forwarded message ---------
From: **Adil Ahmed Rafi** <adil.rafi@galfar.com>
Date: Mon, Sep 7, 2020 at 10:06 AM
Subject: Re: [External] Plotting project areas on PDO Earth/Topography - MBR Condensate Pipeline Project
To: Zadjali, Faisal XTG1 <Faisal.FA.Zadjali@pdo.co.om>
Cc: Harthy, Hamed XTG1 <Hamed.M.Harthy@pdo.co.om>, Mukhtar Murazza <mukhtar.murazza@galfar.com>, Jayakumar Achary <jayakumar.achary@

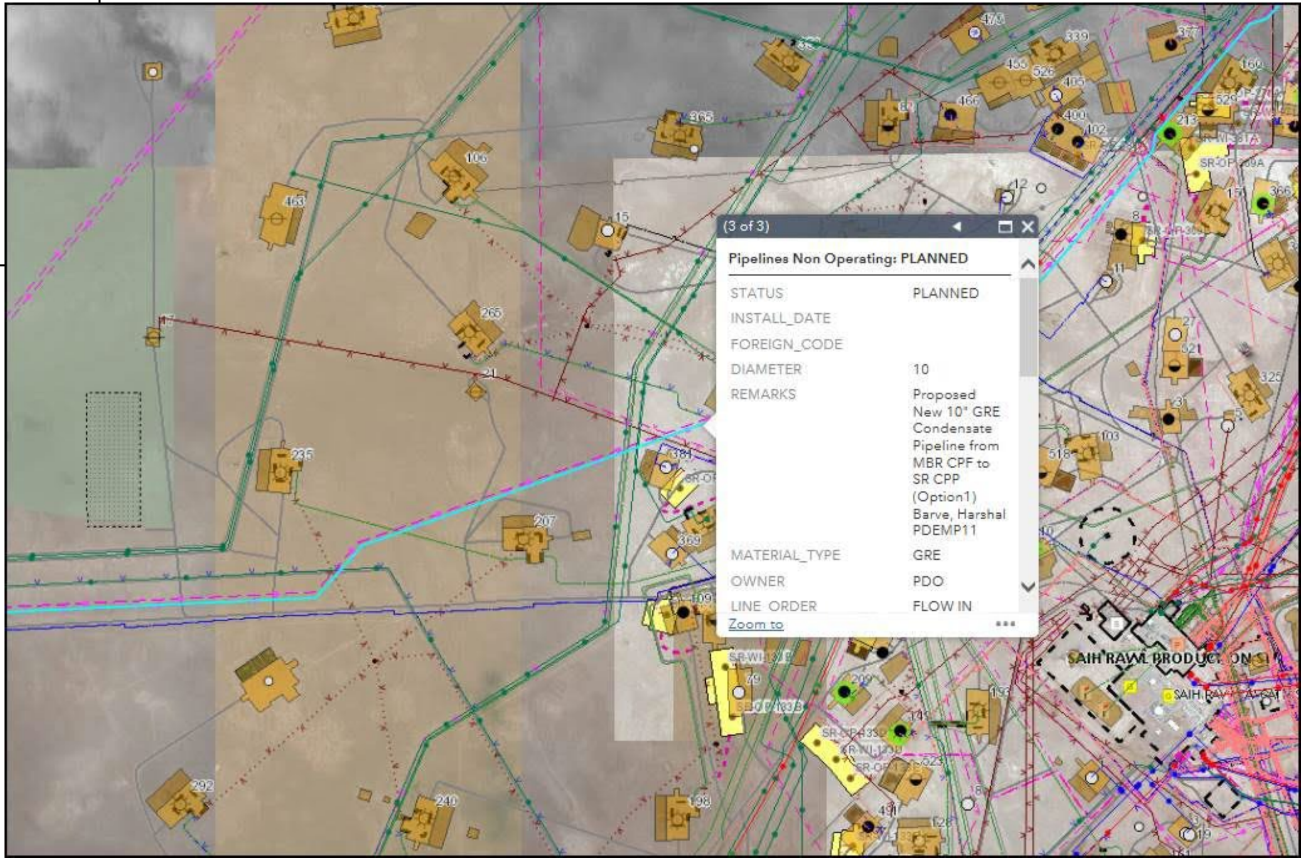
Dear Sir,

Thank you for supporting us with reserving the project scope areas on PDO Earth.

Thanks and regards,
Adil Ahmed.R

On Mon, Sep 7, 2020 at 9:56 AM Zadjali, Faisal XTG1 <Faisal.FA.Zadjali@pdo.co.om> wrote:

> Dear Adil,
>
> The both pipelines are added in GIS data base and are visible in PDO Earth.



PDO XTG MAIL CORRESPONDENCE FOR RESERVING THE PLANNED PIPELINE ROUTE IN XTG MAP

Station Approach Showcase

MBR-00-101983-LA-2580-00156-0002-04

GRE 10”

REV	DATE	ORIGINATOR	CHECKER		APPROVER	DESCRIPTION	TA REF.IND.	SIGN
04	29.08.21	BMS	SKT		JK	AFC-APPROVED FOR CONSTRUCTION	--	--
03	24.08.21	BMS	SKT		JK	IFA-ISSUED FOR APPROVAL	--	--
02	30.06.21	BMS	SIH	SKT	JK	IFA-ISSUED FOR APPROVAL	--	--
01	06.12.20	BMS	JAL	SKT	JK	IFR-ISSUED FOR REVIEW	--	--

P D O APPROVAL

PROJECT DRAWING REVISION — PROJECT ID : GG100MBR0513

IN CASE OF DEVIATIONS A MARKED UP PRINT SHALL BE SENT TO THE PROJECT ENGINEER

galfar engineering & contracting SAOG

Contract No:	Job No:
C-311620	D856/5099

WBS NO / B.I. NO | PROJ.ENG. | SPEC.ENG. | PDO APPROVAL

AL DESIGN OFFICE

AREA: MABROUK

SUB AREA: FIELD — NO: 21

DRWG.TYPE: SCHEMATIC DIAGRAM

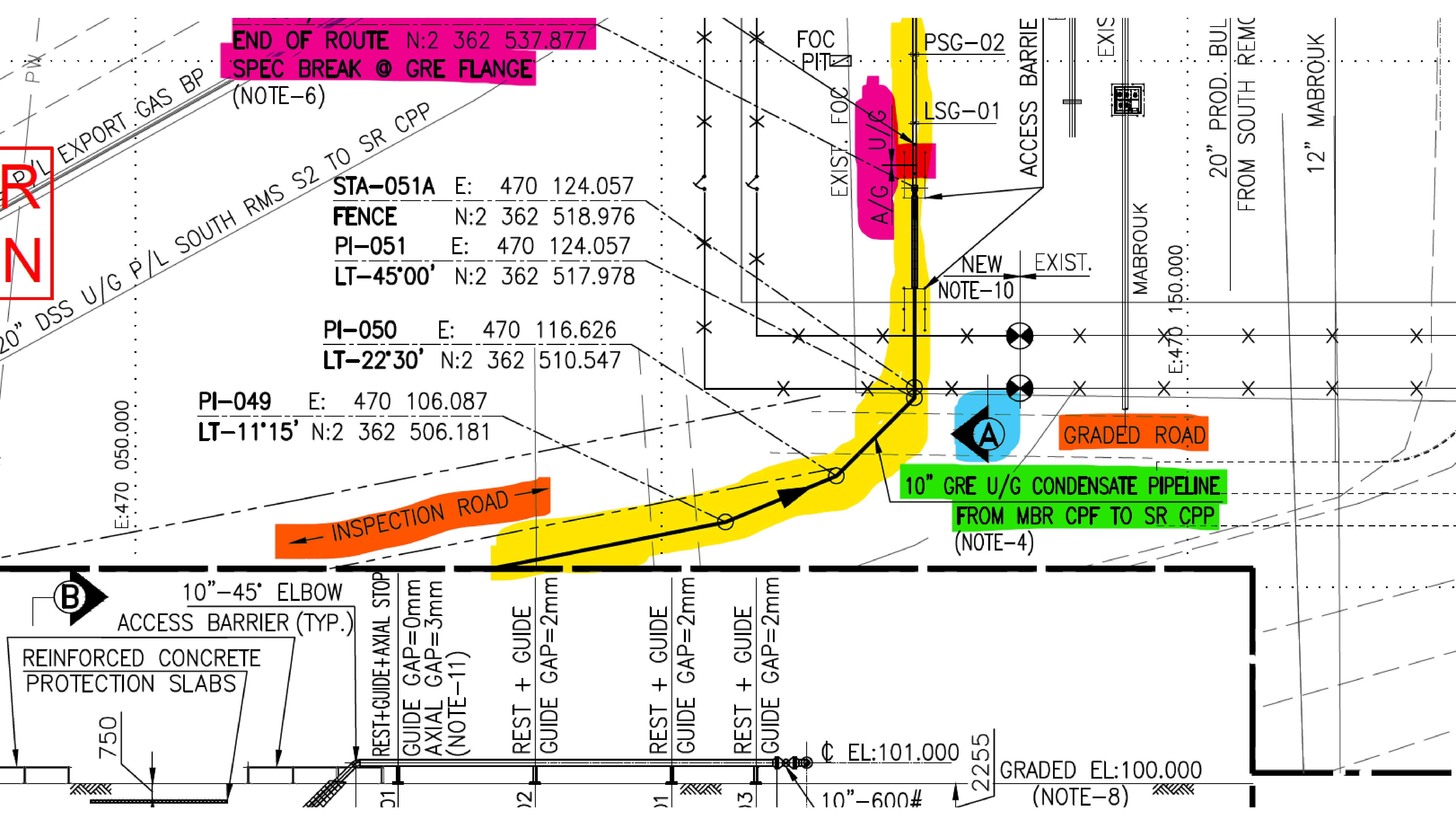
DESCRIPTION: STATION APPROACH FOR 10" GRE CONDENSATE P/L FROM MABROUK CPF TO SAIH RAWL CPP.

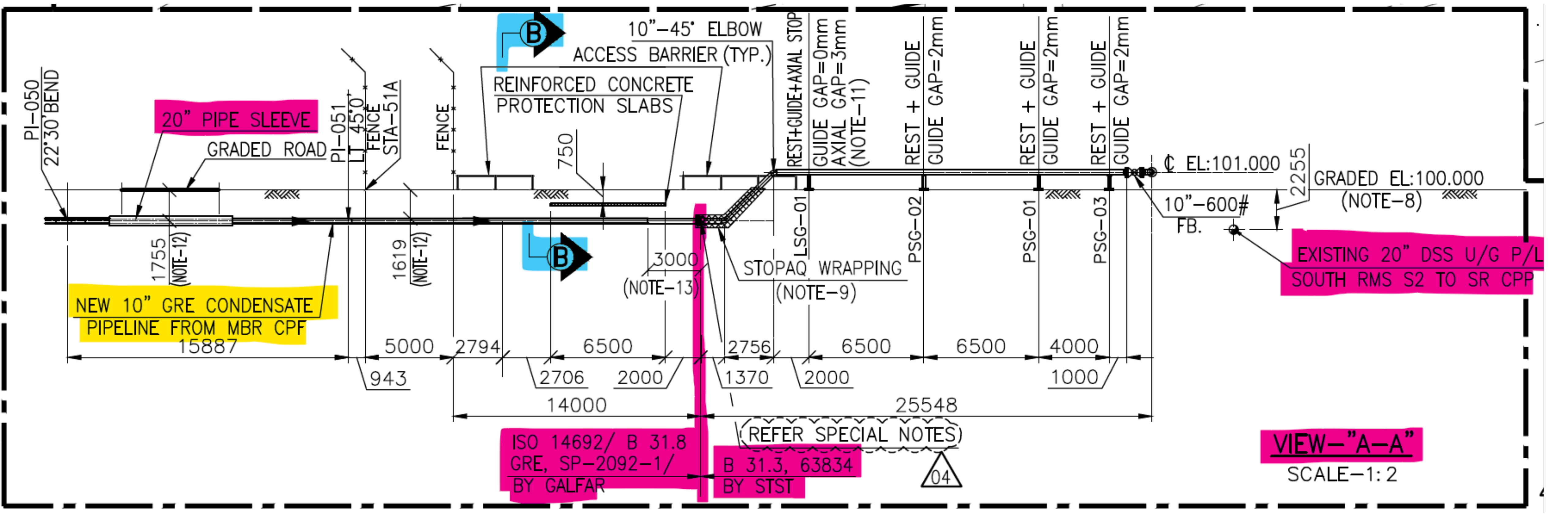
SCALE : 1:750 — CAD DRAWING

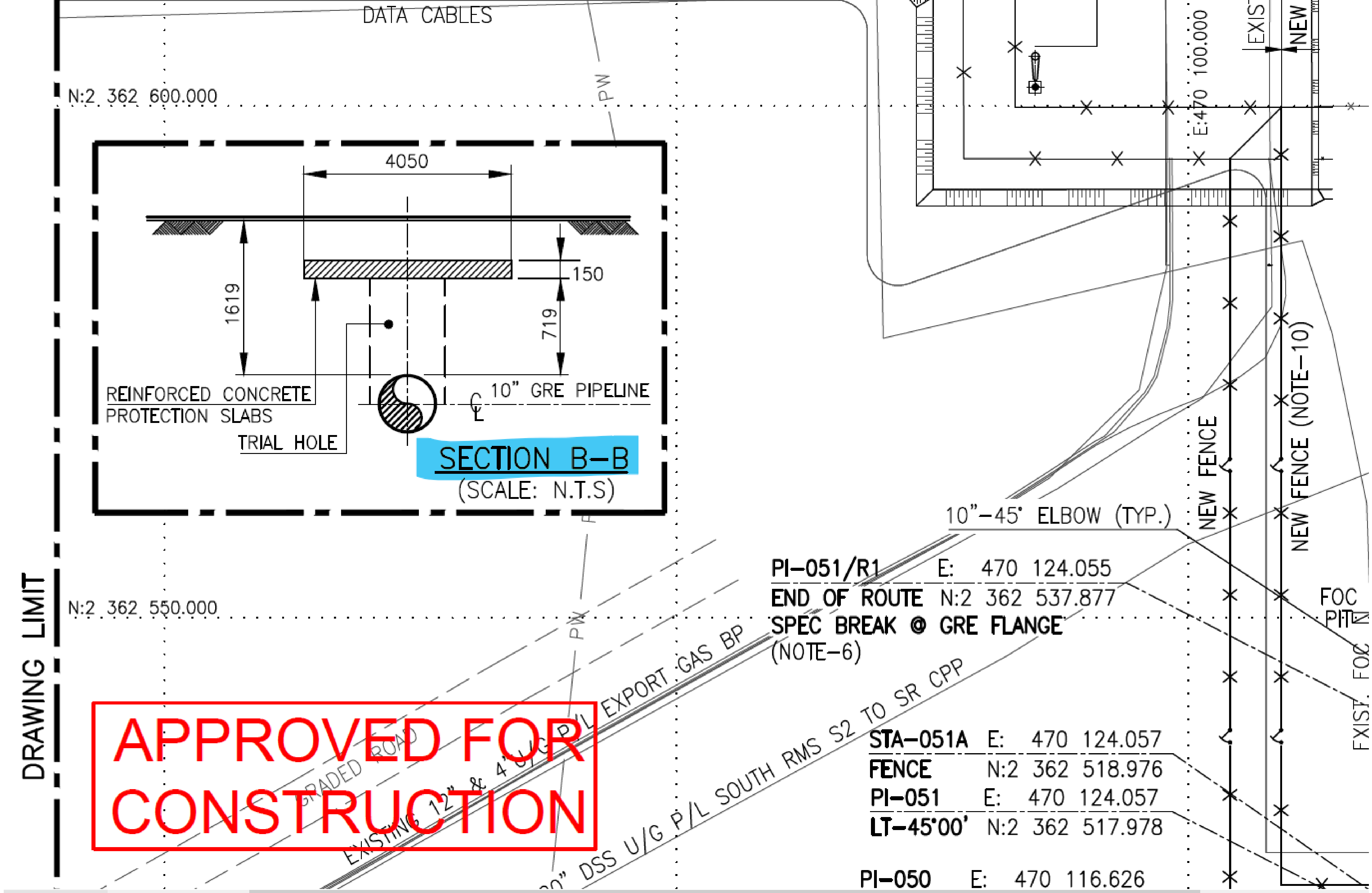
0 1 2 3 4 5 6 7 8 9

شركة تنمية نفط عمان
Petroleum Development Oman

AREA CODE	UNIT CODE	ORIGINATOR CODE	DISC. CODE	DOC. TYPE.	SEQ. NO.	SHT. NO.	REV. NO.
MBR	00	101983	LA	2580	00156	0002	04


END OF ROUTE N:2 362 537.877
SPEC BREAK @ GRE FLANGE
(NOTE-6)
P/L EXPORT GAS BP
20" DSS U/G P/L SOUTH RMS S2 TO SR CPP
STA-051A E: 470 124.057
FENCE N:2 362 518.976
PI-051 E: 470 124.057
LT-45°00' N:2 362 517.978
PI-050 E: 470 116.626
LT-22°30' N:2 362 510.547
PI-049 E: 470 106.087
LT-11°15' N:2 362 506.181
E:470 050.000
INSPECTION ROAD
FOC PIT
EXIST. FOC
A/G U/G
PSG-02
LSG-01
ACCESS BARRIE
NEW
EXIST.
NOTE-10
MABROUK
E:470 150.000
20" PROD. BUL FROM SOUTH REMO
12" MABROUK
A
GRADED ROAD
10" GRE U/G CONDENSATE PIPELINE
FROM MBR CPF TO SR CPP
(NOTE-4)
B
10"-45° ELBOW
ACCESS BARRIER (TYP.)
REINFORCED CONCRETE
PROTECTION SLABS
750
REST+GUIDE+AXIAL STOP
GUIDE GAP=0mm
AXIAL GAP=3mm
(NOTE-11)
REST + GUIDE
GUIDE GAP=2mm
REST + GUIDE
GUIDE GAP=2mm
REST + GUIDE
GUIDE GAP=2mm
℄ EL:101.000
2255
GRADED EL:100.000
(NOTE-8)
10"-600#


PI–050
22°30' BEND
20" PIPE SLEEVE
GRADED ROAD
PI–051
LT 45°0'
FENCE
STA–51A
FENCE
10"–45° ELBOW
ACCESS BARRIER (TYP.)
REINFORCED CONCRETE
PROTECTION SLABS
750
REST+GUIDE+AXIAL STOP
GUIDE GAP=0mm
AXIAL GAP=3mm
(NOTE–11)
REST + GUIDE
GUIDE GAP=2mm
REST + GUIDE
GUIDE GAP=2mm
REST + GUIDE
GUIDE GAP=2mm
℄ EL:101.000
2255
GRADED EL:100.000
(NOTE–8)
10"–600#
FB.
LSG–01
PSG–02
PSG–01
PSG–03
EXISTING 20" DSS U/G P/L
SOUTH RMS S2 TO SR CPP
1755
(NOTE–12)
1619
(NOTE–12)
3000
(NOTE–13)
STOPAQ WRAPPING
(NOTE–9)
NEW 10" GRE CONDENSATE
PIPELINE FROM MBR CPF
15887
5000
2794
6500
2756
6500
6500
4000
943
2706
2000
1370
2000
1000
14000
25548
REFER SPECIAL NOTES
04
ISO 14692/ B 31.8
GRE, SP–2092–1/
BY GALFAR
B 31.3, 63834
BY STST
VIEW–"A–A"
SCALE–1: 2


DATA CABLES
N:2 362 600.000
PW
4050
150
1619
719
REINFORCED CONCRETE
PROTECTION SLABS
TRIAL HOLE
10" GRE PIPELINE
SECTION B–B
(SCALE: N.T.S)
N:2 362 550.000
DRAWING LIMIT
E:470 100.000
EXIST
NEW
NEW FENCE
NEW FENCE (NOTE–10)
10"–45˚ ELBOW (TYP.)
PI–051/R1 E: 470 124.055
END OF ROUTE N:2 362 537.877
SPEC BREAK @ GRE FLANGE
(NOTE–6)
FOC
PIT
EXIST. FOC
EXPORT GAS BP
EXISTING 12" & 4" U/G P/L
GRADED ROAD
DSS U/G P/L SOUTH RMS S2 TO SR CPP
STA–051A E: 470 124.057
FENCE N:2 362 518.976
PI–051 E: 470 124.057
LT–45˚00' N:2 362 517.978
PI–050 E: 470 116.626
APPROVED FOR
CONSTRUCTION

Wadi Classification

Legacy/Current Methodology

Wadi Classification methodology

- As per SP-1208 Sec. 2.9.3.3 :

Wadis may be classified based on judgement and careful evaluation of the crossing location with due consideration to wadi's width, bed slope, past discharge history and erosion potential at the crossing location.

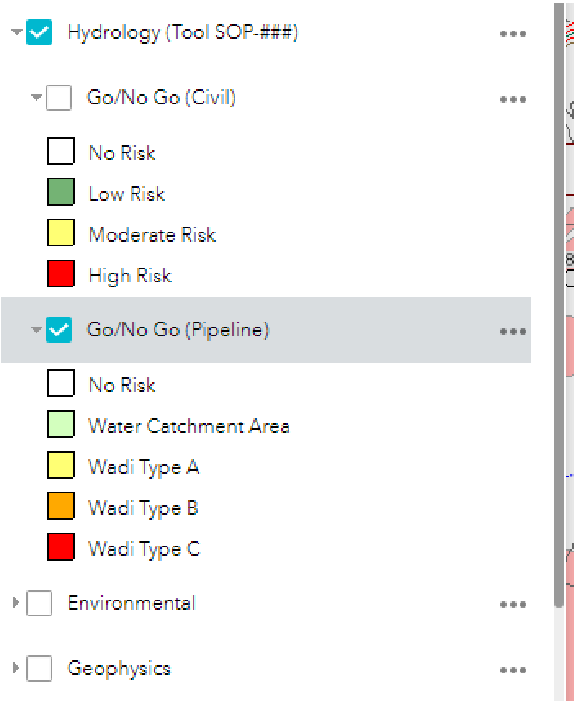
1. **Type 'A'** wadis are those where **low velocity** flow is expected after heavy rains.
2. **Type 'B'** wadis are those where erosion due to **high velocity** flow is expected after heavy rains.
3. **Type 'C'** wadis are those where **heavy erosion** due to **high velocity flow** is expected after heavy rains combined with the existence of **large stones and boulders**.
4. **Type 'D'** wadis – for Type 'C' wadis, in case of **high H2S levels** (critical sour asper SP-1190) and MOL (Main Oil Line) / SOGL(South Oman Gas line) pipelines

Summery

Wadi Type	Rock (R) or Soil (S)	Cover from top of GRE/ GRE casing pipe to bed of localized erosion (mm)	Concrete Weight Coating on GRE casing pipe	Gabions	Remarks
A	S	1500 minimum to top of GRE pipe	No	No	-
B	R/S	1500 minimum to top of GRE casing pipe	Yes	Yes	Gabions shall be installed both end of the pipeline to prevent washout
C	R/S	1500 minimum to top of GRE casing pipe	Yes	Yes	Gabions shall be placed over full length of trench to prevent washout

Wadi Classification Methodology

- Does not depend primarily on the engineers' judgment.
- Utilizing Go/No Go PDO earth.



Wadi Crossing Design Factor

TABLE 1 DESIGN FACTORS FOR ONSHORE STEEL PIPELINES

FLUID CATEGORY	A and B	C, D and E			
APPLICABLE CODE	B31.4 (Note 1)	B31.8			
LOCATION CLASSES		1 Div. 2	2	3	4
Pipelines	0.72	0.72	0.60	0.50	0.40
Crossings (Note 2 , 7)					
Temporary crossings over existing pipeline (used < 2 weeks)	0.72	0.72	0.72	0.72	0.72
Wadi type A, livestock	0.72	0.72	0.60	0.50	0.50
Private roads	0.60	0.60	0.60	0.50	0.40
Unimproved public roads	0.60	0.60	0.60	0.50	0.40
Roads, highways, streets, wadi (Type B and C)	0.60	0.60	0.60	0.50	0.40
Rivers and beaches	0.60	0.60	0.60	0.50	0.40

Wadi Crossing Cover Depth

TABLE 3 RECOMMENDED MINIMUM COVER FOR ONSHORE PIPELINES

LOCATION CLASS (as defined in ASME B 31.8)	MINIMUM COVER (M) (Note 1)	
	IN NORMAL GROUND	IN ROCK, REQUIRING BLASTING OR ROCK CUTTING (note 4)
Location Class 1	0.6	0.50
Location Class 2	0.90	0.60
Location Class 3, 4 and Flood Plain	1.2	0.90
Public and private roads, Wadi, live stock passage crossings	1.50	1.50

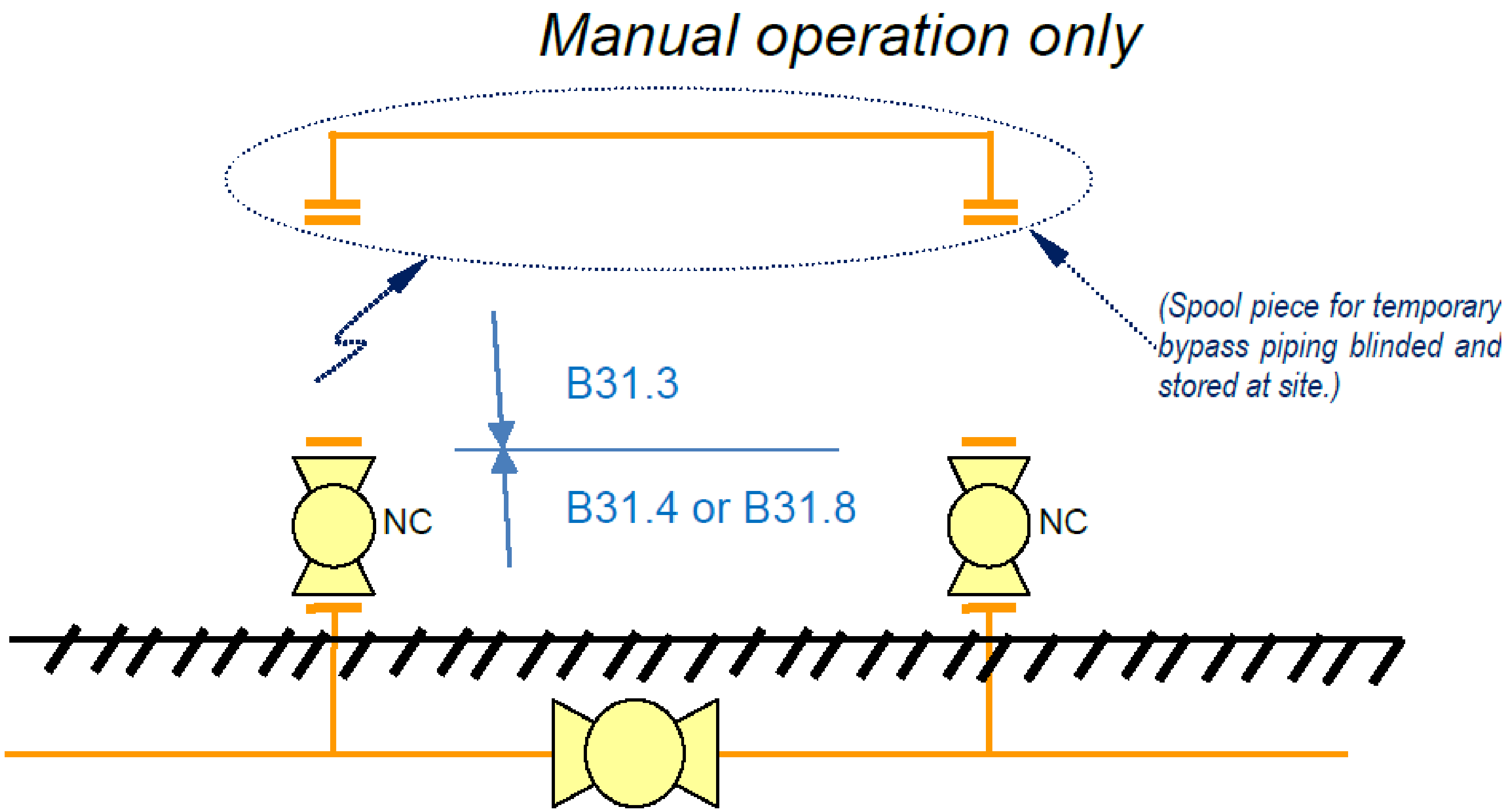
BVS

- Why?
  - Minimize loss of product in the event of a pipeline failure
  - To facilitate repairs.
- Design
  - Same design code as the pipeline as per fluid category.
  - Bypass designed as per ASME B31.3.
  - If $DF_{Pipeline} \geq 0.6$ then BVS $DF_{BVS} = 0.6$.
  - $DP_{Pipeline} = DP_{BVS}$
  - $DT_{BVS} \begin{cases} AG, T_{Max} T_{Min} = \ DT_{pipeline} \\ BG, = DT_{pipeline/pigtrap} \end{cases}$

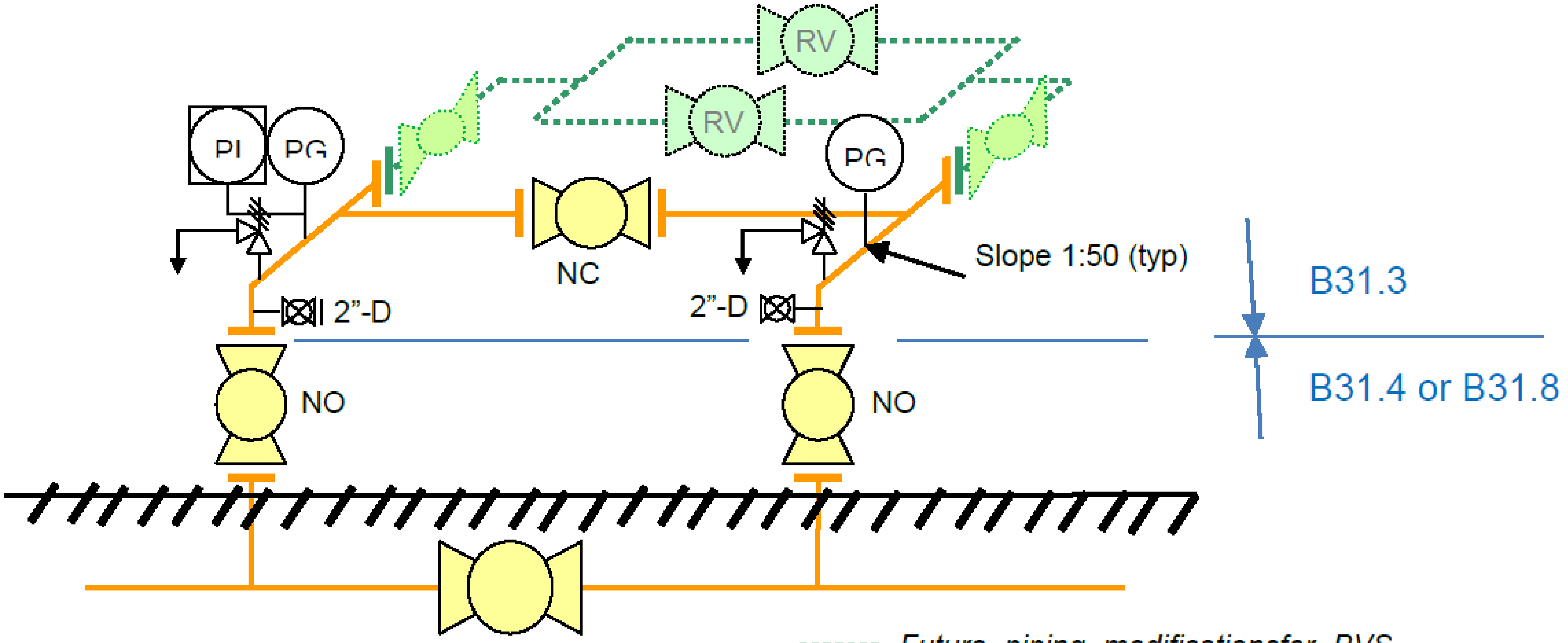
Cont. BVS

- $Dv \begin{cases} Oil, \leq 8\ m/s \\ Gas, \leq 40\ m/s \end{cases}$

Liquid Pipelines Block valve station configuration Manual operation only

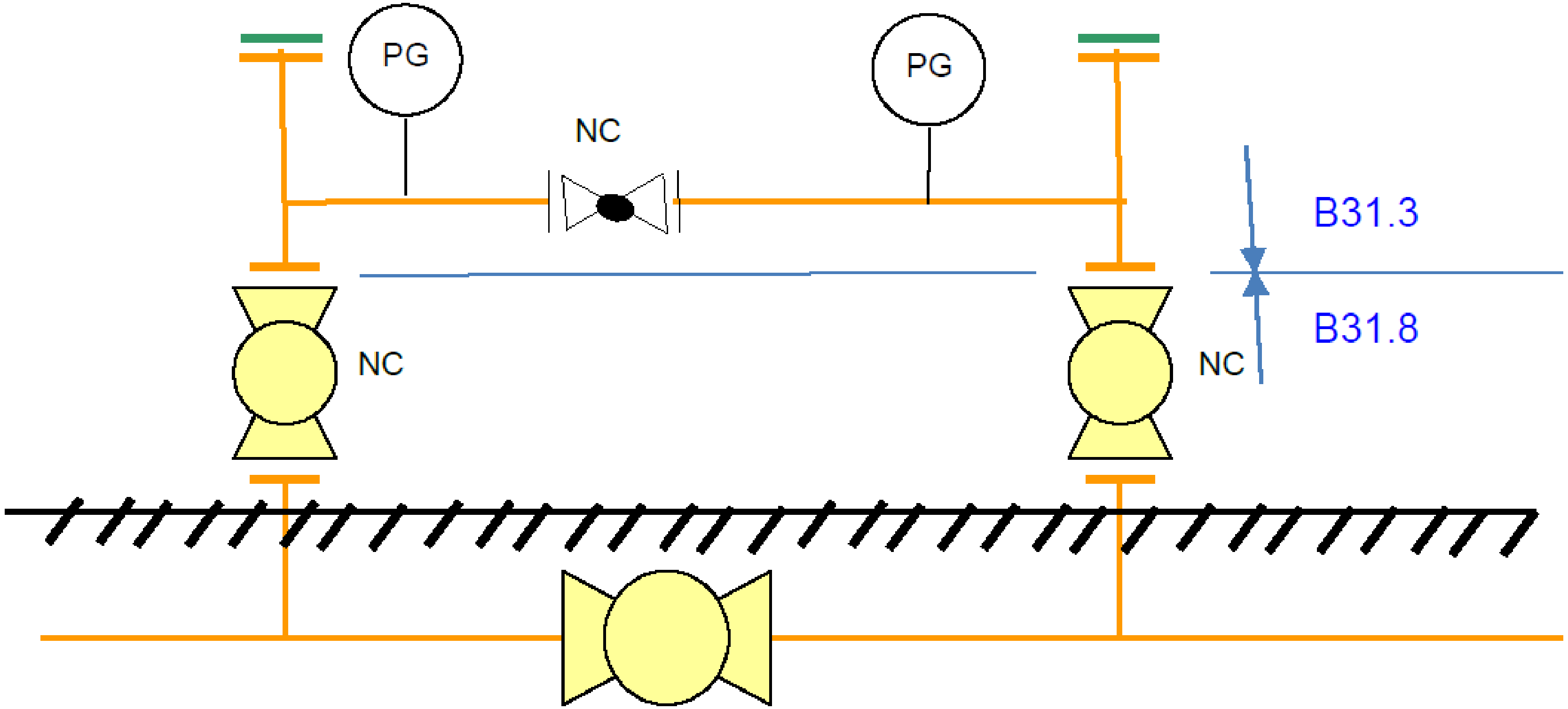


Liquid Pipelines Block valve station configuration Suitable for remote operation



Future piping modificationsfor BVS

Gas Pipelines Block valve station configuration



MTO and Scope of Work

Overview

- Urban Planning
- Overall route map
- Alignment sheets and AFC
- Procurement/ MTO
    - AFT ➔ Process team ➔ TBE (Technical Bid evaluation)

MTO (Material Take-Off)

شركة تنمية نفط عمان
Petroleum Development Oman
UED ENGINEERING DIRECTORATE

(Restricted)

BULK BILL OF MATERIAL-SUMMARY													
Sl No	Item Code	MESC Number	SAP NO.	AVME NO.	Size 1(inch)	Size 2(inch)	Size 3(inch)	ITEM DESCRIPTION	MATERIAL DESCRIPTION	UOM	Total Actual Quantity Required For Project	Total Quantity with Contingency	Remarks
1		7662786021	1001263289	6.2.5.1	0.5			FLANGE ;WN, RF, 300# SCH 80	ASTM A105	PCS	246	258	
2		8541364041	1001264744	6.3.6.1	0.5			GASKET;SPIRAL WOUND, 4.5mm THK	AISI 316, Graphite CS centring-/SS inner ring	PCS	288	346	
3		7430030181	1001299965	6.1	0.5			PIPE;SEAMLESS, BARE,	ASTM A106-B	MTR	72	85	
4		7630661471	1001281511	6.3.1	1	0.5		REDUCER- ;CONCENTRIC, BW ENDS Sch 80	ASTM A234-WPB	PCS	102	107	
5		7630661961	1001281585	6.3.1	2	1		REDUCER- ;CONCENTRIC, BW END Sch 40X Sch 80	ASTM A234-WPB	PCS	30	33	
6		8138661551	1000063457	6.3.5.2				STUDBOLT WITH 2 NUTS 1/2 inch x 70 mm	ASTM A193-B7M/A194-2HM	SET	1152	1267	
7		7720040531	1001246194	6.7.5	0.5			VALVE;GATE,FLANGED , RF , 300#	Body :ASTM A105 TRIM: AISI 316, STELLITE	PCS	144	158	

Technical Bid

Petroleum Development Oman — UED Engineering Directorate

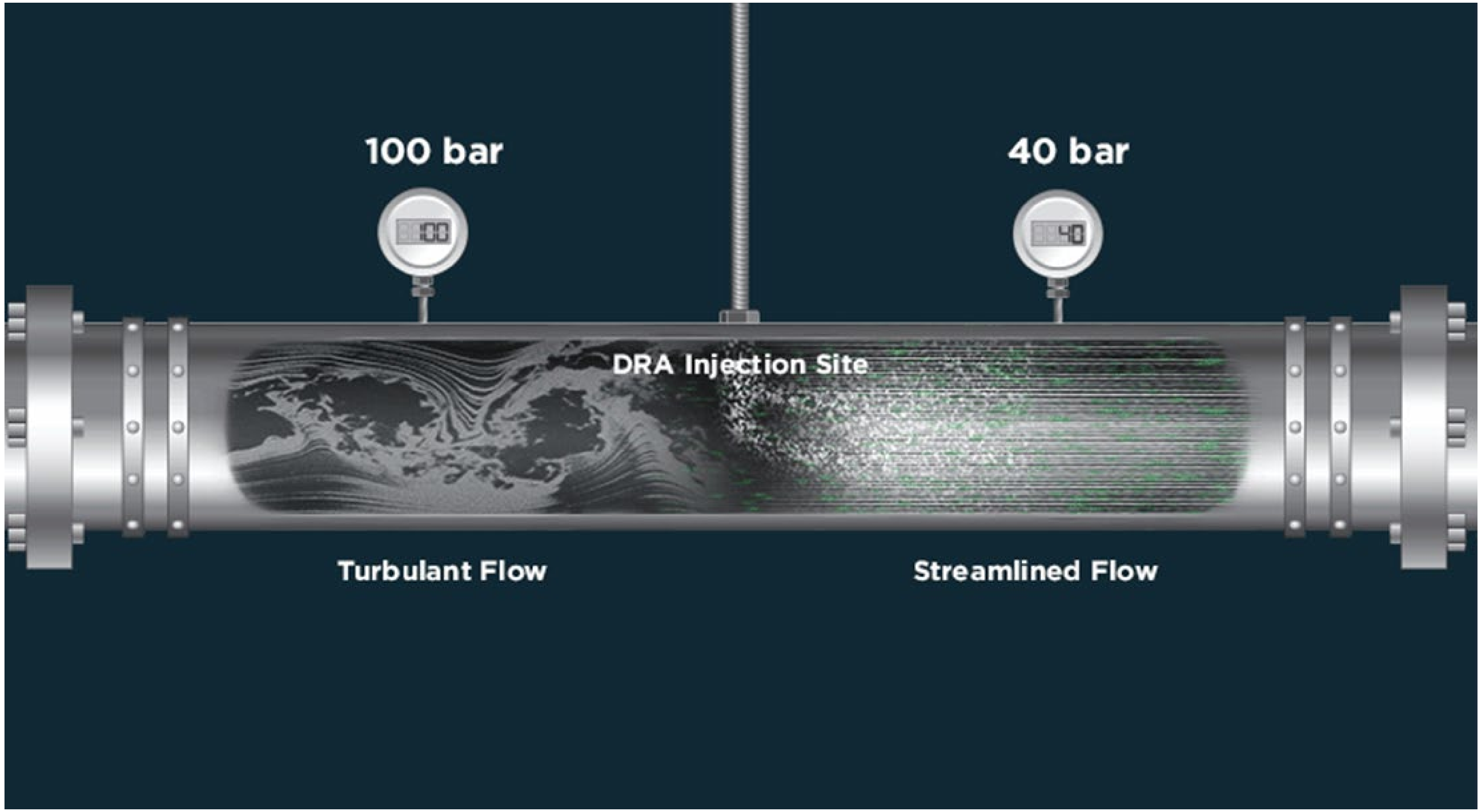
Technical Bid Evaluation

Project ID:		SOM000MM0454	Document No:	MAR-10-PDFEED-LA-6999-00001-0000				
Project Name:		MARMUL GSR DEVELOPMENT PROJECT PHASE-01 FEED+DD	SOW / MR Doc No:	MAR-10-PDFEED-LA-7303-00001-0000				
Equipment:		CS Line Pipe	SAP NO **					
ITEM NO	DESCRIPTION	Specified / Required	(Note 2)	Vendor - 1	Compliance	Vendor - 2	Compliance	Vendor - 3
				NAME: M/s TMK GULF INTERNATIONAL PIPE INDUSTRY LLC, OMAN	Y/N	NAME: M/s.ARAB DESERT LLC, OMAN	Y/N	NAME: M/s.DESERT PIPING L
1	GENERAL INFO							
1.1	Local Agent/Supplier			M/s TMK GULF INTERNATIONAL PIPE INDUSTRY LLC, OMAN		M/s.ARAB DESERT LLC, OMAN		DESERT PIPING L.L
1.2	Line Pipe Manufacturer	As per AVME 6.1		M/s TMK GULF INTERNATIONAL PIPE INDUSTRY LLC, OMAN		WELLSPUN INDIA (HFW / LSAW) TIANJIN PIPE COORPORATION, CHINA (SMLS)		TIANJIN PIPE COORPORATI
1.3	Steel Supplier (PLATES, COILS & INGOTS)	As per AVME 17.1.2		Confirmed	Y	Confirmed	Y	Confirmed
1.4	Coating Plant (PDO approved)	As per AVME 50.1.2		M/s.TMK GIPI, Sohar, Oman	Y	Confirmed ,Wellspun for 3LPE GIPI for 3LPP	Y	Confirmed ,Will be taken car agents BREDERO SH INTERNATIONAL
1.5	Technical Queries Reference			Refer Combined TBE:FEED-LA-TBE-001		Refer Combined TBE:FEED-LA-TBE-001		Refer Combined TBE:FEED-L
1.6	TQ response			Refer Combined TBE:FEED-LA-TBE-001		Refer Combined TBE:FEED-LA-TBE-001		Refer Combined TBE:FEED-L
1.7	Quote Reference No & Date			2021-1-20. TMK GIPI PDO/Tech		1034516885		5000317902
1.8	Qualification (as per AVME List)	Max dia/Min Dia. (Inch)		24 / 6	Y	Min - 2 & Max- 14	Y	4 to 28"
		Max/Min Thickness (mm)		Min 4.8mm for less than 12 inch and max 20 mm for 12" and above	Y	Min 4.8mm & max - 30mm	Y	4 to 30 mm
		Manufacturing Process		HFW	Y	HFW / SMLS / LSAW	Y	SMLS
		Max Grade Qualified		Sweet-L450(X65) & Sour- L450(X65)	Y	Sour X60 (HFW) Sour X65 (LSAW/ SMLS)	Y	Sour X65
2	SCOPE OF WORK							
2.1	SCOPE OF SUPPLY	SAP Form		Refer Combined TBE:FEED-LA-TBE-001	Y	Refer Combined TBE:FEED-LA-TBE-001	Y	Refer Combined TBE:FEED-L

Pipeline Drawings

PFS (Process Flow Schemes)
PEFS (Process Engineering Flow Schemes)
UFS (Utilities Flow Schemes)
UEFS (Utility Engineering Flow Schemes)
PSFS (Process Safeguarding Flow Schemes)
USFS (Utility Safeguarding Flow Schemes)
Plot Plans
Isometric Drawings

Backup Slides


100 bar
40 bar
DRA Injection Site
Turbulant Flow
Streamlined Flow

GRP/GRE Temperature and Pressure Limitations

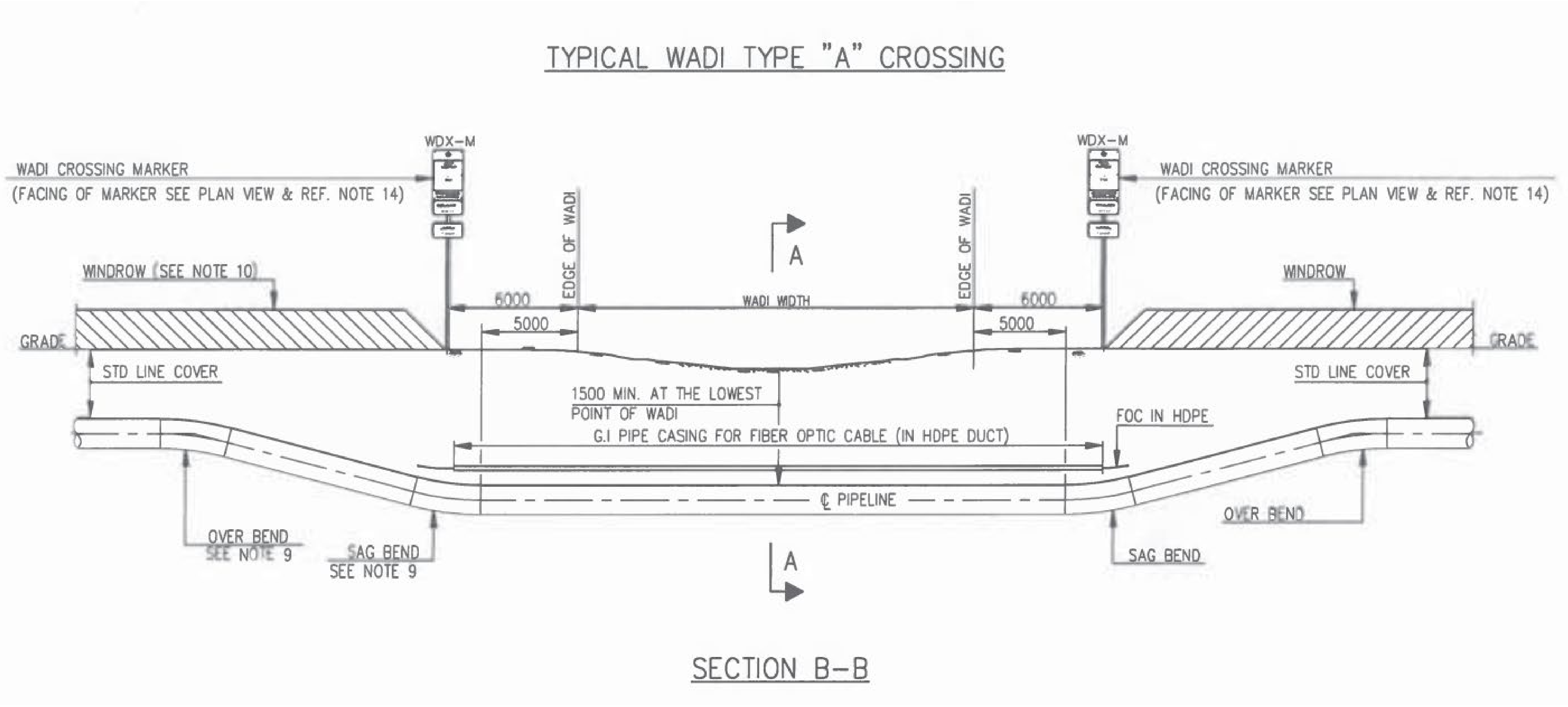
Table 2 Temperature limitations for GRP

Type GRP	Maximum Design temperature
Glass-fibre/epoxy (GRE) - Aromatic-amine cured (MDA) - Cyclo-aliphatic cured (IPD) - Aliphatic-amine cured - Anhydride cured	 100 °C 100 °C 85 °C 65 °C
Glass-fibre/vinyl ester (GRVE) - Bisphenol A - Novolac	 90 °C 100 °C
Glass-fibre/polyester (GRUP) - Isophthalic	60 °C

Type of joint	Above ground application (on plot piping)		Under ground application (off plot)	
	Size (mm)	**Design Pressure (bar)**	**Size (mm)**	**Pressure (bar)**
Threaded Connections	Up to 150mm	Max 70 bar	Up to 150mm	120 bar
Adhesive bonded Connections	25 to 150mm	Max 70 bar	Up to 150	70 bar
	200 to 300mm	Max 45 bar.	250 to 300mm	70 bar
	350 to 450mm	Max 35 bar.	350 to 450mm	60 bar
	500 to 600mm.	Max. 30 bar	500 to 600mm	50bar
Lamination joints	650 to 800mm.	Max 15bar.	650 to 800mm	15 bar
	850 to 1200mm	Max 10bar.	850 to 1200mm	10 bar
Note: The maximum application temperatures based on the resin system used and shall be as per the table 2 of this specification.				

Table 1 – Size and pressure limitations to apply GRE materials in PDO facilities.

Type A (GRE)



TYPICAL WADI TYPE "A" CROSSING
WDX-M
WDX-M
WADI CROSSING MARKER
(FACING OF MARKER SEE PLAN VIEW & REF. NOTE 14)
WADI CROSSING MARKER
(FACING OF MARKER SEE PLAN VIEW & REF. NOTE 14)
EDGE OF WADI
EDGE OF WADI
A
WINDROW (SEE NOTE 10)
WINDROW
6000
WADI WIDTH
6000
5000
5000
GRADE
GRADE
STD LINE COVER
STD LINE COVER
1500 MIN. AT THE LOWEST
POINT OF WADI
FOC IN HDPE
G.I PIPE CASING FOR FIBER OPTIC CABLE (IN HDPE DUCT)
℄ PIPELINE
OVER BEND
SEE NOTE 9
SAG BEND
SEE NOTE 9
OVER BEND
SAG BEND
A
SECTION B-B

Stress Analysis For 16"Production Header (PL5)

A showcase

Overview

- The objective is to perform preliminary stress analysis of the 16" Production Header (PL5) to ensure stresses are within acceptable limit and to report restraints/support reactions and displacements to facilitate structural design of supports and to provide input for piping stress analysis.

Cont. Remarks

- Caesar-II Ver.7.0.
- Covers the entire length of the new pipeline.
- Nodes are created at pipeline point of intersection and other points of interest.
- Buried model of the pipeline system.
- The pipeline system is analyzed for various load case scenarios complying with the Pipeline Design Code ASME B31.8.

Table 1: Load Cases

S. NO	CASE	LOAD	TYPE	DESCRIPTION
1.	L1	WW+HP	HYD	Hydro test condition
2.	L2	W+T1+P1	OPE	Max. Operating Load Condition
3.	L3	W+T2+P1	OPE	Normal Operating Load Condition
4.	L4	W+T3+P1	OPE	Min. Operating Load Condition
5.	L5	W+P1	SUS	Sustain case
6.	L6	W	SUS	Sustain case
7.	L7	L2-L5	EXP	Expansion case
8.	L8	L3-L5	EXP	Expansion case
9.	L9	L4-L5	EXP	Expansion case

LEGEND :

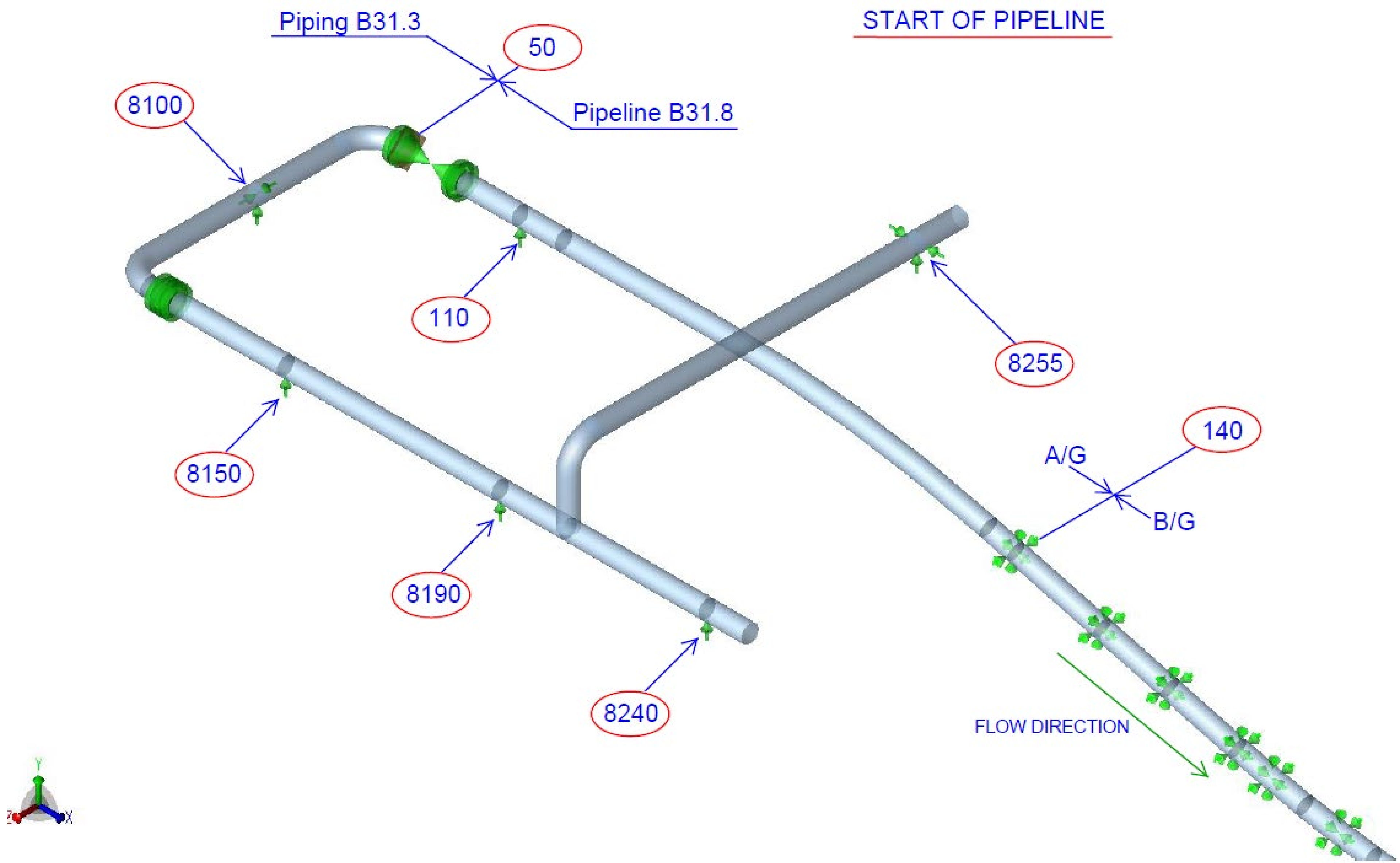
L1 to L9	Load Cases
Dx	Displacement at X Direction
Dy	Displacement at Y Direction
Dz	Displacement at Z Direction
HP	Hydro test pressure
P1	Design pressure of the Pipeline
T1	Max. Operating Temperature of the Pipeline
T2	Normal Operating Temperature of the Pipeline
T3	Min. Operating Temperature of the Pipeline
W	Pipeline with Fluid weight

Table 2: Design Parameters

1	Design Data	Refer Pipeline Design Data Summary Sheet presented in **Appendix 2**.
2	Fluid Density	0.001 Kg/cm^3
3	Bend Radius	
	Cold bend minimum radius	60D,80D and 100D
	Swan neck cold bends	60D
4	Frictional coefficient for the steel-to-steel interface	0.4
5	Ambient temperature	26 Deg. C
6	Operating Temperature	107 Deg. C

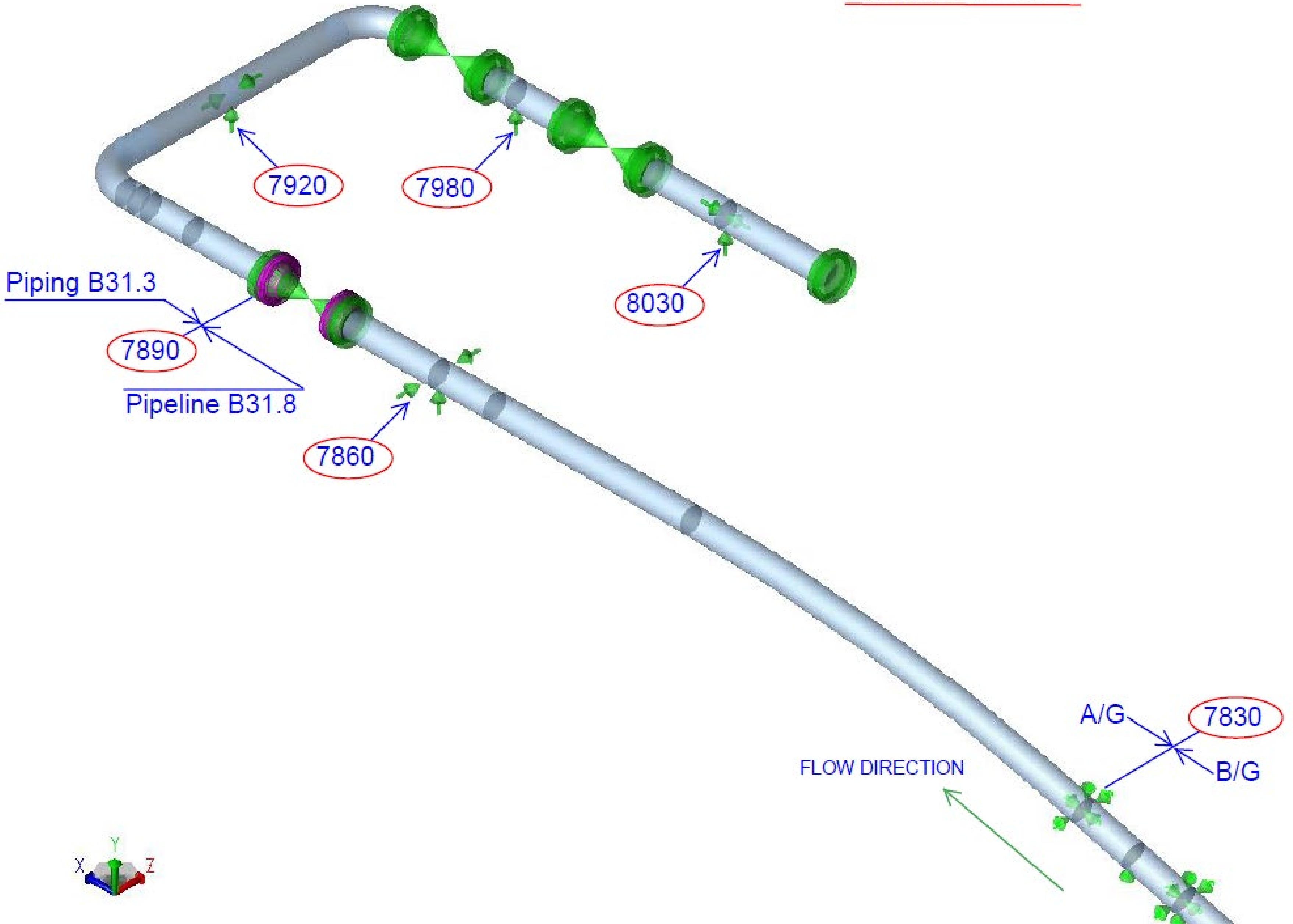
- Soil model type of American Lifelines Alliance details and geotechnical investigation details are applied in the analysis. Loose soil type has been considered in the analysis conservatively. Soil model data presented in Table 3.

- This analysis has been carried out at design pressure, maximum and minimum operating temperature provided in the design data summary sheet and process design basis.



16"-PL5 PRODUCTION HEADER STARTS FROM RMS-5

END OF PIPELINE



16"-PL5 PRODUCTION HEADER ENDS AT EXPORT MANIFOLD

Pump/Compressor Sizing

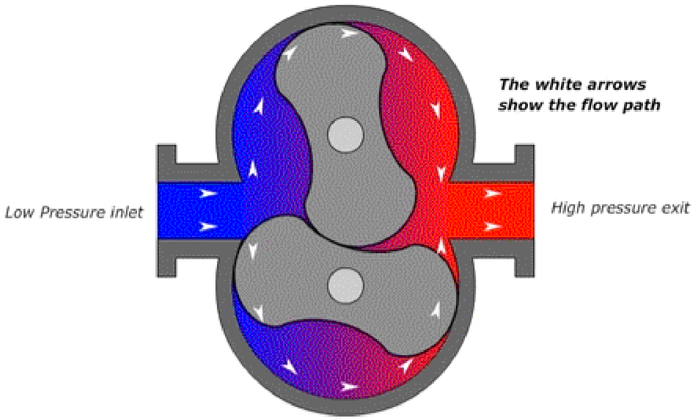
Pumping

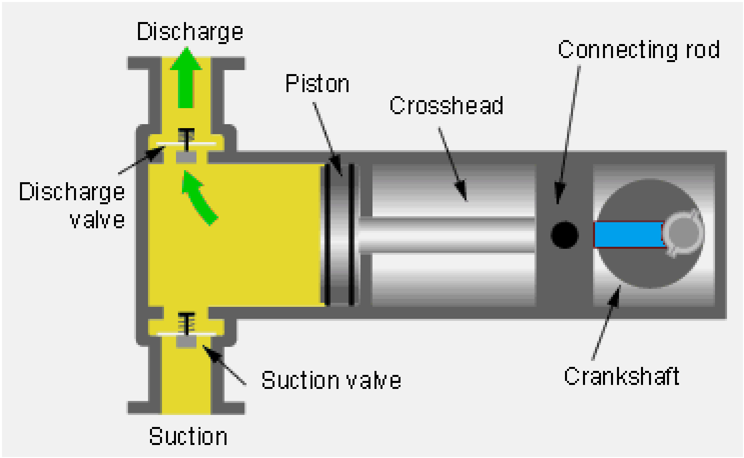
- Definition of pumping: the force to move in a specified direction by means of pump.
- Types of pumps

1. Positive displacement pumps .
    - Discharge of the fluid from a vessel by partially or completely displacing its internal volume with a second fluid or by mechanical means.
2. Centrifugal pumps.
    - Produce kinetic energy by the action of centrifugal force and to convert this energy into pressure by efficiently reducing the velocity of the fluid as per Bernoulli equation.

Types of Positive Displacement Pump

- Rotary Pumps
  - Movement of the fluid is achieved by mechanically displacing the liquid produced by rotation of a sealed arrangement of intermeshing rotating parts within the pump casting.
- Piston Pumps
  - A volume of liquid is drawn into the cylinder through the suction valve on the intake stroke.





Pump Selection

- Pump selection parameters:
  - Capacity
  - Differential head/pressure
  - Viscosity range max/min temperature
  - Net Positive Suction Head Available (NPSHA)
- Done by whom?
  - Rotating engineering team

Cont. Pump Selection

- Centrifugal pump is selected when:
  1. The pump fluid velocity is **less than** 800 cSt.
  2. The pumped fluid viscosity < 1200 cSt, and the efficiency correction factor (CE) > 0.45
     - Where centistokes (cSt) is equivalent to (1 cSt = 0.01 St = 1 mm2/s)

- Positive displacement pump is selected when pumped fluid viscosity is more than 1200 cSt

Compressors

- Definition: fluid machines that handle gases and vapors which are:
  1. Compressible
  2. $T \propto P$
  3. Less dense than liquid
- Remarks:
  - Liquids in a compressor can case:
    1. Major damage like loss of containment
    2. High power requirement, which may damage the driver or transition components
    3. Damage impellers and internal seals

Compressors Applications and Types

- Applications

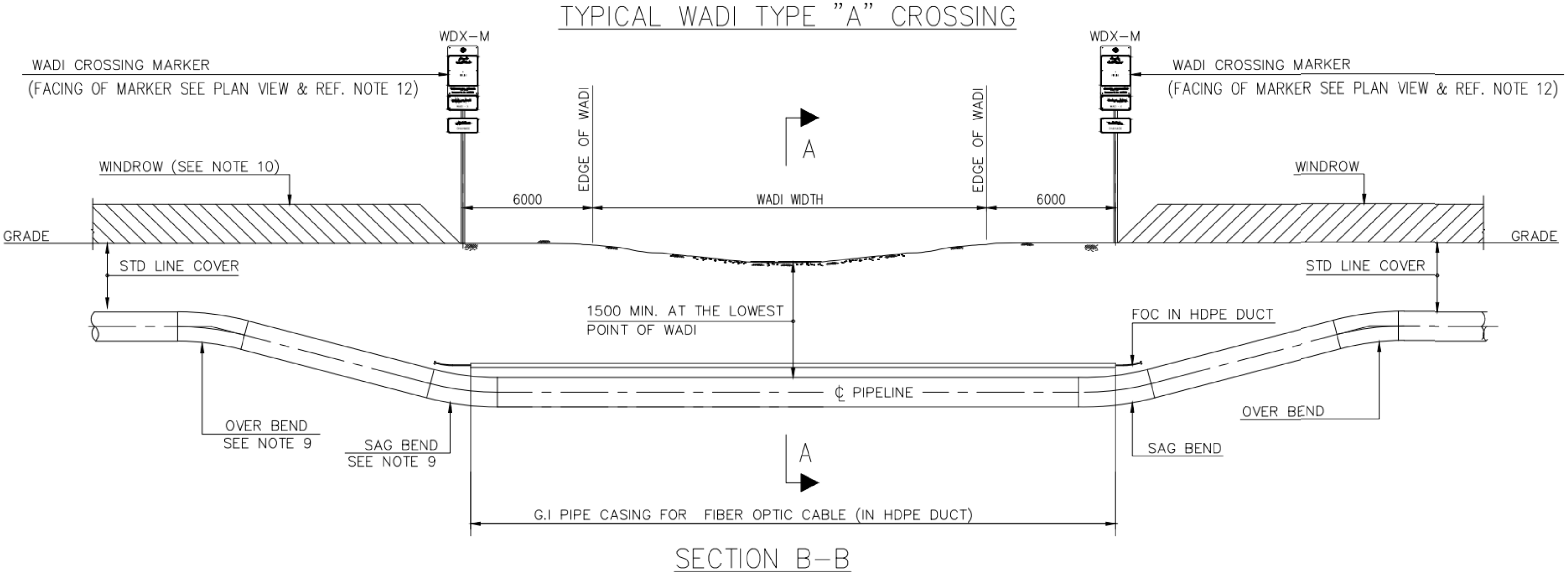
1. Gas gathering
2. Gas injection
3. Gas transmission
4. Refrigeration
5. Plant and instrument air

Cont.

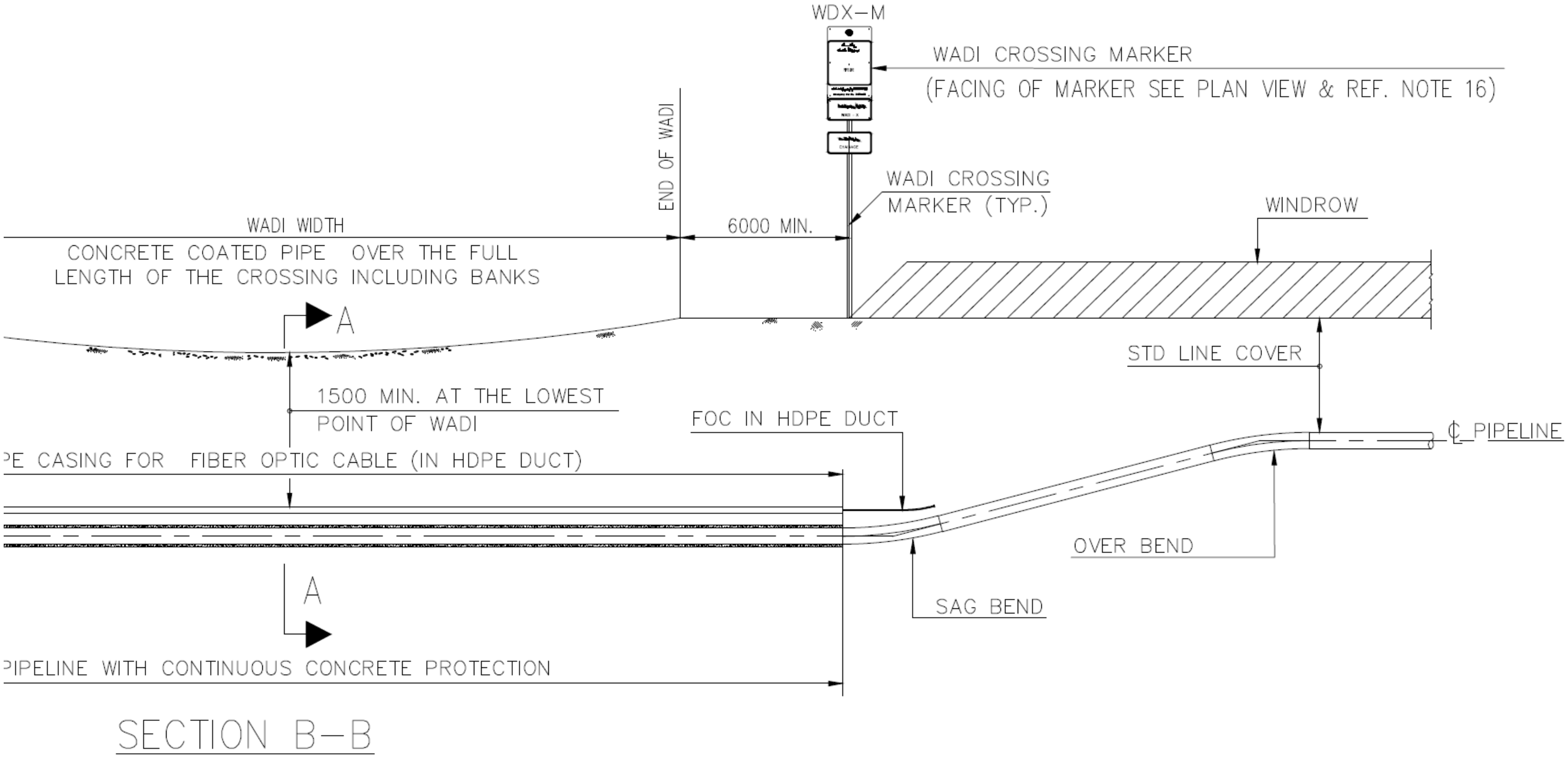
- The compressor type is determined by process operating conditions:
  - Gas Data: composition, corrosivity, Molecular weight, ratio of specific heat, etc.
  - Operating temperature and pressure ranges
  - Volumetric and mass flows at the inlets and outlets

- Types
  - Centrifugal Compressors
  - Piston Compressors
  - Screw Compressors

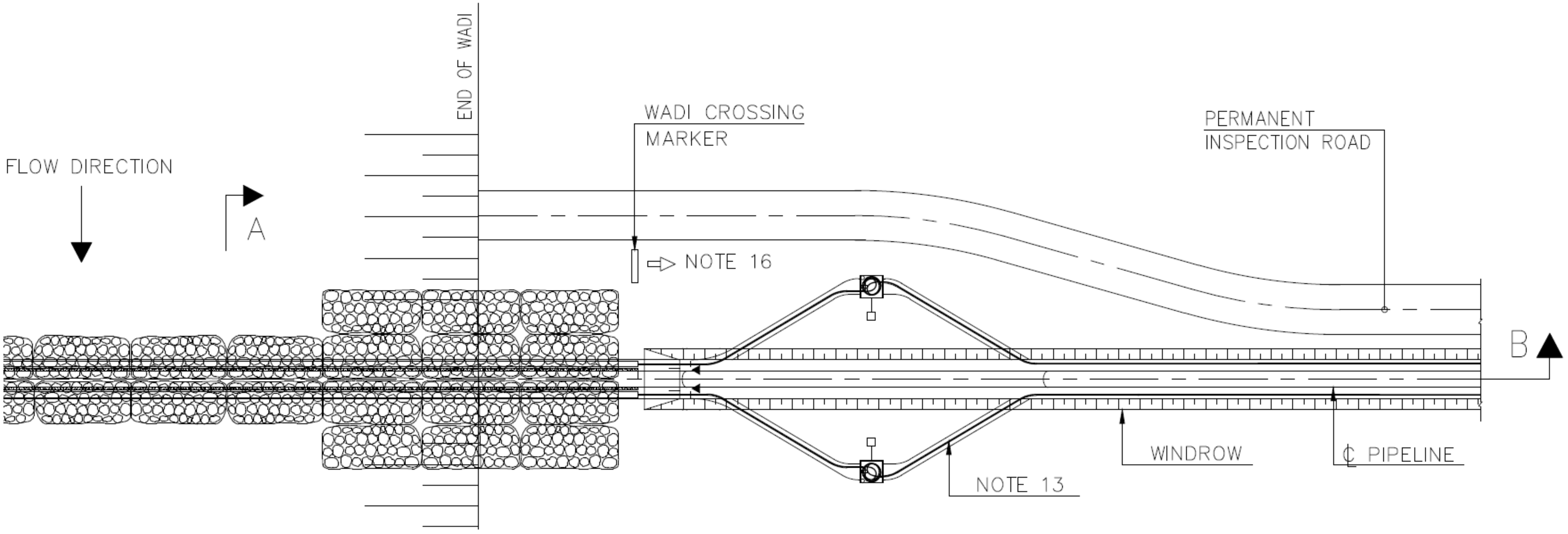
Type A (Metallic)



Type C (Metallic)

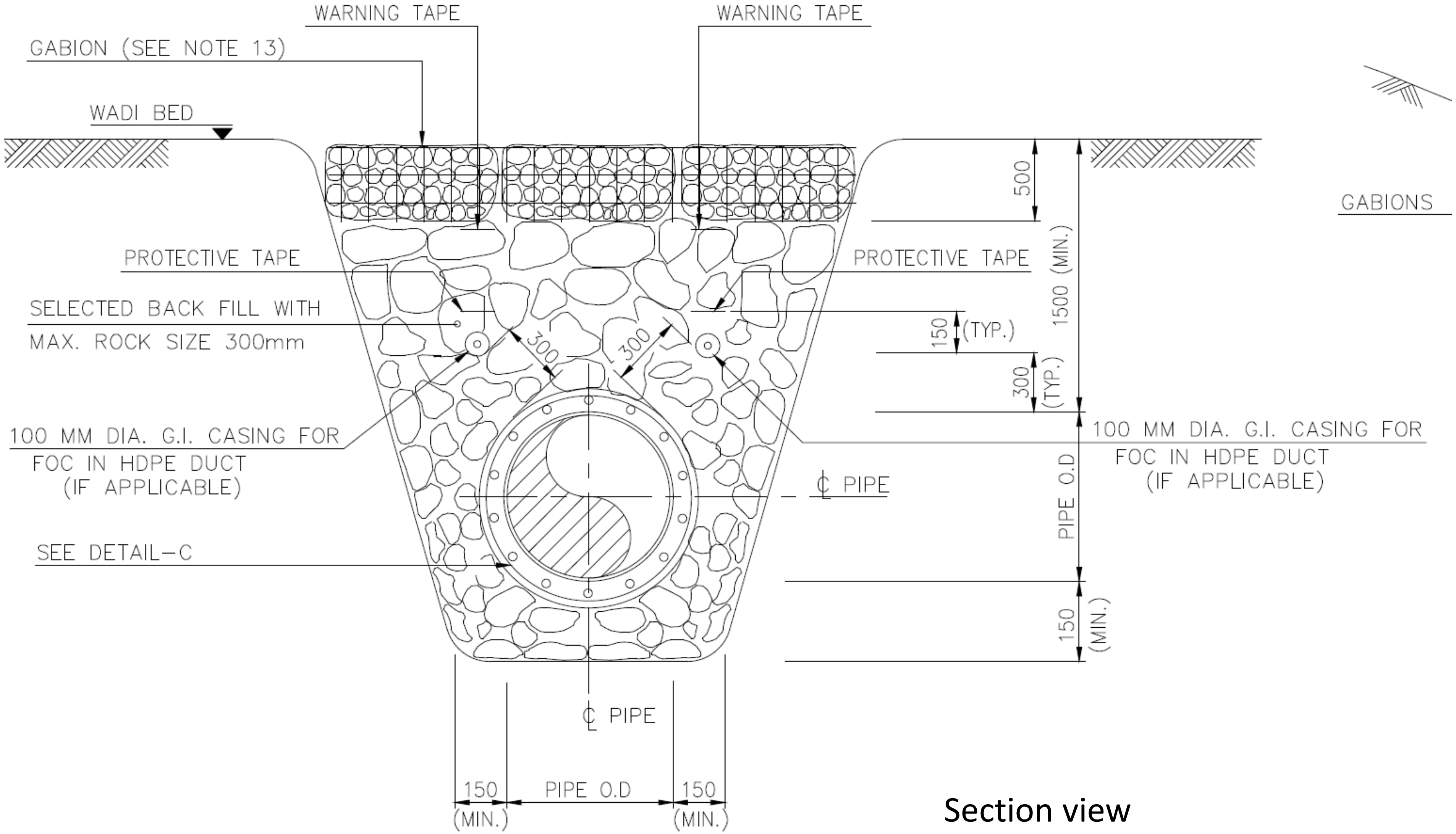


Type C (Metallic)



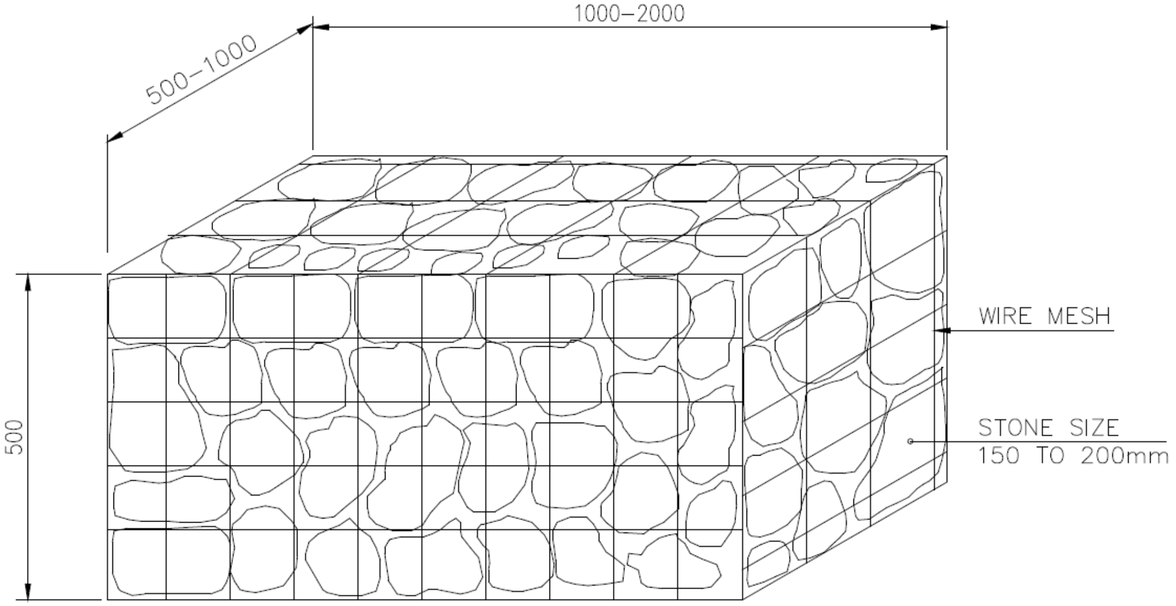
Top View

Type C (Metallic)

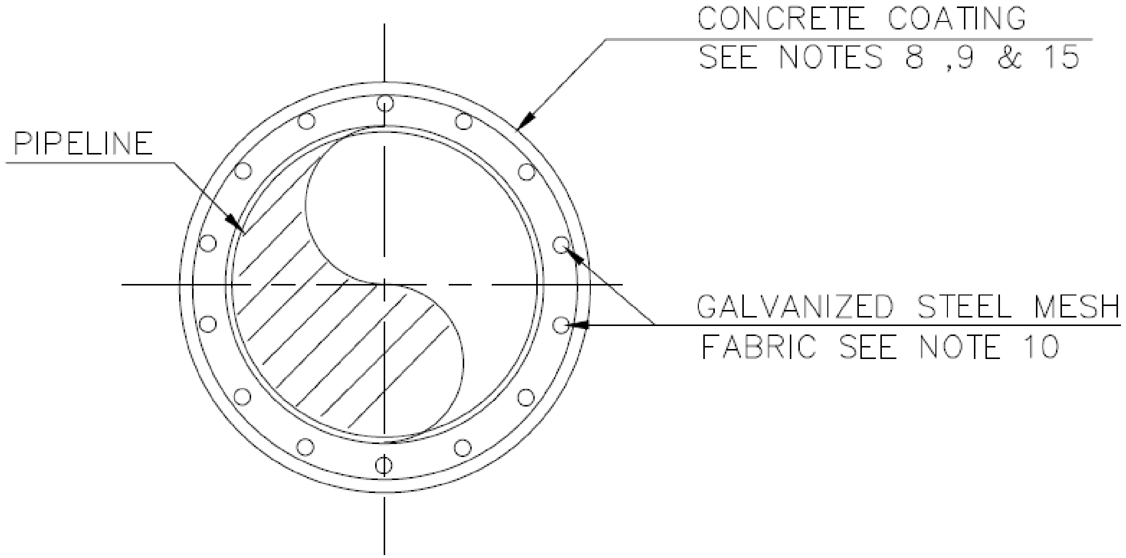


Section view

Type D (Metallic)



GABION DETAIL (TYPICAL)



DETAIL–C

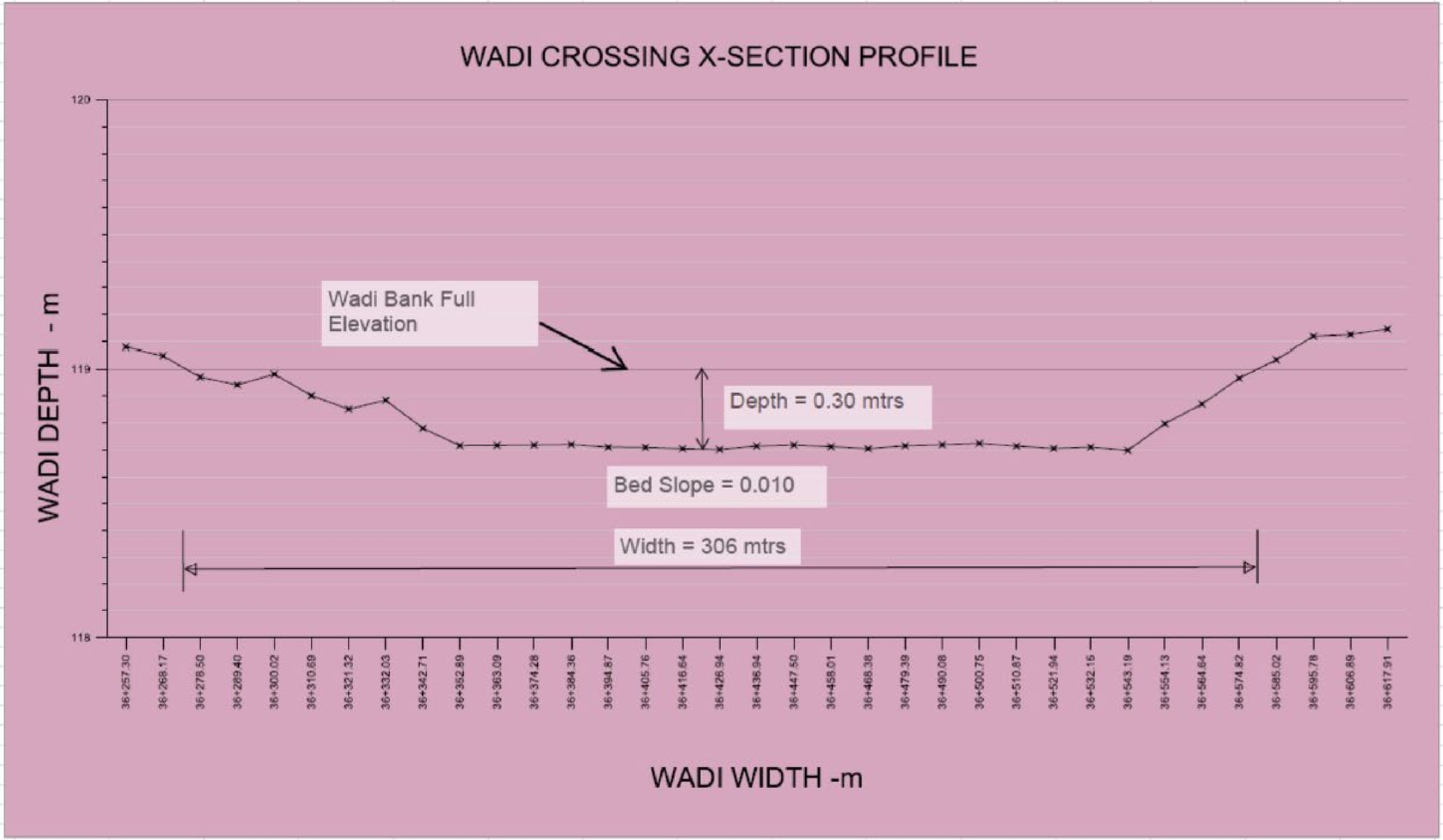
Wadi Crossing Showcase

Type A wadi from

WADI CLASSIFICATION LIST

Sl. NO	Alignment Sheet No.	ChainageStart	Chainage End	Wadi			Remarks
				Width (m)	Depth (m)	Type	
1	MBR-00-101983-LA-2373-00154-0001	3667.07	3854.85	187.78	0.21	TYPE-A	
2	MBR-00-101983-LA-2373-00154-0001	5353.78	5430.31	76.53	0.3	TYPE-A	
3	MBR-00-101983-LA-2373-00154-0001	30341.35	30412.42	71.07	0.3	TYPE-A	
4	MBR-00-101983-LA-2373-00154-0001	30743.63	30772.75	29.12	0.23	TYPE-A	
5	MBR-00-101983-LA-2373-00154-0001	31158.41	31227.18	68.77	0.3	TYPE-A	
6	MBR-00-101983-LA-2373-00154-0001	31883.98	31904.15	20.17	0.22	TYPE-A	
7	MBR-00-101983-LA-2373-00154-0001	32933.28	32969.37	36.09	0.3	TYPE-A	
8	MBR-00-101983-LA-2373-00154-0001	33130.41	33155.42	25.01	0.28	TYPE-A	
9	MBR-00-101983-LA-2373-00154-0001	33457.55	33509.97	52.42	0.3	TYPE-A	
10	MBR-00-101983-LA-2373-00154-0001	33674.38	33721.09	46.71	0.3	TYPE-A	
11	MBR-00-101983-LA-2373-00154-0001	34432.63	34472.99	40.36	0.3	TYPE-A	
12	MBR-00-101983-LA-2373-00154-0001	34554.88	34587.65	32.77	0.24	TYPE-A	

19	MBR-00-101983-LA-2373-00154-0001	36195.08	36694.56	499.48	0.3	TYPE-A	Refer Typical wadi X-section profile



Site condition of major wadi X-section