



Ranhill Worley
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Malaysia LNG Sdn. Bhd. (39964-H)
(A subsidiary of PETRONAS)

CONTRACT TITLE : PROVISION OF ENGINEERING, PROCUREMENT, CONSTRUCTION AND COMMISSIONING FOR GASOLINE AND NATURAL GAS LIQUID (NGL) METERING SKIDS UPGRADE FOR MALAYSIA LNG DUA SDN. BHD.

CONTRACT NUMBER : DTC-BTU/MLNG/2019/31

PROJECT NUMBER : -

CLIENT : MALAYSIA LNG SDN. BHD.

WORK ORDER TITLE : MLNG DUA – GASOLINE SKID (CUSTODY METER) UPGRADE

WORK ORDER NUMBER : PC 20278

DOCUMENT TITLE : HYDRAULIC CALCULATION AND LINE SIZING ADEQUACY CHECK FOR GASOLINE METERING SKID

DOCUMENT REFERENCE NUMBER : 412028-00005-00-PR-CAL-0001

STAGE : DE

A	23.08.19	ISSUED FOR COMMENT	CMC <i>ms</i>	ADW/OH <i>OH</i>	NS	PY <i>ms</i>	AHA
REV	DATE	DESCRIPTION	PREPARED	REVIEWED	APPROVED		
			PRW	PRW	PRW	BWS	MLNG



Customer	Malaysia LNG Sdn Bhd	Proj No	412028-00005
Project Title	Provision of Detailed Design Engineering Services for Gasoline and Natural Gas Liquid (NGL) Metering Skid Upgrade for	Calc No	412028-00005-00-PR-CAL-0001
Calculation Title	Hydraulic Calculation and Line Sizing Adequacy Check for Gasoline Metering Skid	Phase/CTR	Detailed Design
Elec File Location	\\Mymirwpl01\data\Projects\412028-00005 MLNG METER-SKID\04_Process\1_Latest\2_Engineering\5_Calculations\CAL-0001 Hydraulic Cal Gasoline\Rev.A IFC\412028-00005-00-PR-CAL-0001 (Rev.A IFC).xlsx		
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1.0 Calculation Objectives
To perform hydraulic calculation and line sizing adequacy check for Gasoline Metering Skid A-3200.

2.0 Calculation Method
1. Single phase liquid hydraulic calculation is performed for Gasoline Metering Skid A-3200.
2. WorleyParsons Calculation Spreadsheet, 650100-PR-CAL-0302 Rev.0, Liquid Line Hydraulics (Liquid Pressure Drop) is used for Gasoline Metering Skid liquid hydraulic calculation.

3.0 Basis and Assumptions
1. Gasoline Metering Skid is operating at 2 x 100% configuration. [Ref.6]
2. Normal operating temperature and pressure is 35 °C and 5.2 barg respectively. [Ref.3]
3. Gasoline properties used are based on High N₂ Lean Gas case (max. density) and RGLA (Rich Gas Lean Ambient) case (min. density). [Ref.3]
4. Minimum and maximum flowrates are 2088 and 50652 kg/hr respectively. [Ref.3]
5. Pipe material is carbon steel. [Ref.3,4]
6. Pipe roughness factor, e is assumed at 0.05 mm. [Ref.2]
7. Strainer equivalent length is assumed as 250D, as per PTS 12.30.02 [Ref.1].
8. Pipe length and fittings is estimated based on isometric drawings [Appendix C]. 20% margin is included to total pipe length. [Ref.2]
9. Pipe schedule data is obtained from [Ref.4].
10. Assuming there is no elevation difference from S1 to S5 for pressure drop calculation. [Appendix C]
11. Maximum allowable pressure drop of turbine meter, 32-FT-101A/B and 32-FT-102A/B is assumed to be 1 bar. [Ref.3]

4.0 Software Used

Title	Version	Validation (Y / N / N/A)
650100-PR-CAL-0302	Rev. 0	Y

5.0 References
1. PTS 12.30.02, December 2017, Piping General Requirements.
2. 650100-PR-DEG-0003 Rev 2, October 2017, Design Guide Line Sizing and Hydraulics Analysis.
3. PC20278-PDD2-PRO-DES-002 Rev 0, PC20278: Process Instrument Datasheet.
4. S-00-1360-001 Rev. C, Jun 1992, Specification for Piping Systems for MLNG DUA Plant Project.
5. PC 20278-PDD2-PRO-DES-001, Rev.0, PC20278 Basis of Design.

6.0 Conclusion
1. The existing line size of NPS 80 Sch 40 is unable to cater the maximum flowrate of 50,652 kg/hr. A new line size of NPS 150 Sch 40 is proposed.
2. The maximum allowable flow across the existing line size (NPS 80 Sch 40) for High N₂ Lean Gas case and RGLA case is 26,393 kg/h and 26,182 kg/h respectively.
3. Total pressure drop across Gasoline Metering Skid for existing line size (NPS 80 Sch 40) and new line size (NPS 150 Sch 40) is 1.93 bar and 1.06 bar respectively.

Related to a Safety Critical System?	No	Status of Supplier Data used	N/A
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HOLDS
N/A

Rev	Date	Description	By	Checked	Approved
A	23.08.2019	Issued for Comment	CMC <i>helo</i>	ADW/OH <i>oh</i>	-

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Please check boxes for all applicable items checked or mark as "N/A" if not appropriate:

Calculations:

Originator	Checker	
Y	Y	Calculation number assigned and registered. refer to project numbering system or Document Number Standard (DPP-0031-COR-EN) for format.
Y	Y	All required information on Cover Sheet provided.
Y	Y	Revision history box complete and signed. (Typed names (minimum of first initial and last name e.g. A. Wood) of Originator, Checker, Approver; to be initialled beside at sign-off) (Dates in standard format (DD-MM-YY))
Y	Y	Table of Contents.
Y	Y	Appropriate stamp for preliminary issues.
Y	Y	Source of input data stated (with revision number and date if relevant).
Y	Y	Customer's requirements included/addressed.
Y	Y	Approach used is appropriate for problem being solved.
Y	Y	Method clear and easy to follow.
Y	Y	Input data correct.
Y	Y	Calculation arithmetically correct OR software previously verified and reference to verification checked.
Y	Y	Calculation result within expected limits.
N/A	N/A	Calculation tolerances stated if significant.
Y	Y	Units used as required by customer. Unit conversions correctly performed.
Y	Y	Appropriate cross-references.
Y	Y	Sketches included and clearly labelled, where required.
Y	Y	Appendices included and referenced, as required.
N/A	N/A	Considered design reviews, Hazop actions, customer input, safety and environmental issues, etc.
Y	Y	Safety in Design (SID) and Sustainable Design are addressed. Refer relevant SID Discipline Standard.
Y	Y	Conclusions and recommendations are appropriate.

Checking Records:

Y	Y	Checked and annotated copy of calculation filed (use "Doc Check Print" stamp).
Y	Y	Corrections made as required and calculation dated and signed on cover sheet by checker.
N/A	N/A	Alternative method calculation and/or representative check performed and filed, as required.

Revisions:

N/A	N/A	Changes clouded.
Y	Y	Revision history block updated.
Y	Y	Calculation re-checked if required.

A	23.08.2019	Issued for Comment	CMC <i>hww</i>	ADW/OH <i>or</i>	-
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Customer Malaysia LNG Sdn Bhd **Proj No** 412028-00005
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Calculation Title Hydraulic Calculation and Line Sizing Adequacy Check for Gasoline Metering Skid **Phase/CTR** Detailed Design
Elec File Location \\Mymirwpfil01\data\Projects\412028-00005 MLNG METER-SKID\04_Process\1_Latest\2_Engineering\5_Calculations\CAL-0001 Hydraulic Cal Gasoline\Rev.A IFC\412028-00005-00-PR-CAL-0001 (Rev.A IFC).xlsx

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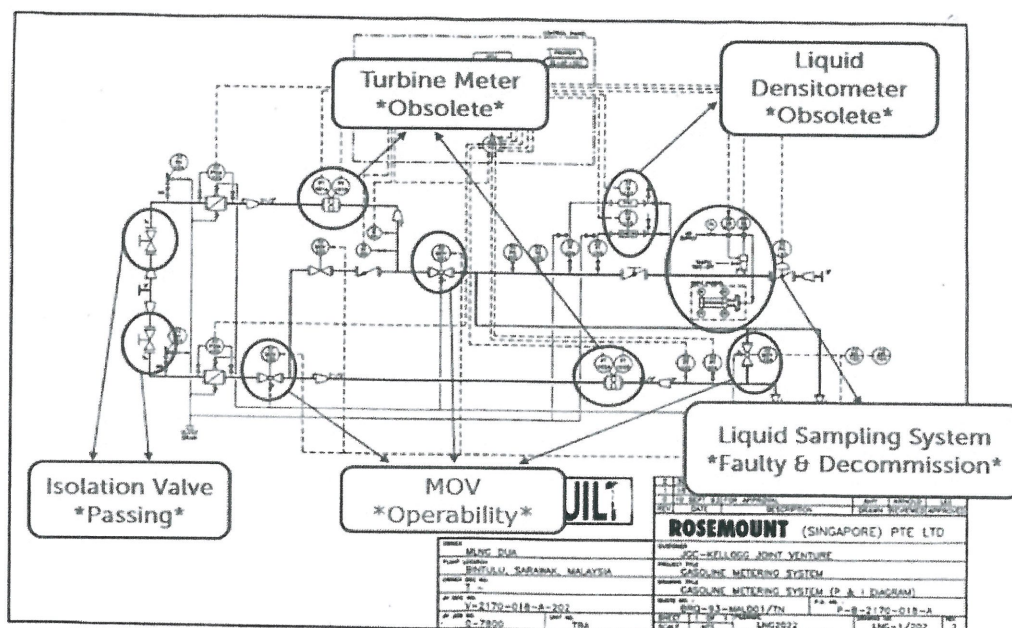
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Phase/CTR Detailed Design

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7.0 Project Background

MLNG DUA Gasoline Metering Skid is a custody meter designed for 2 x 100% operation for gasoline flow to BIF (Bintulu Integrated Facility). The skid consists of two parallel meter runs using turbine meter as primary measurement alongside other instruments (liquid density meter, transmitters, automated valves, gauges, liquid sampling etc.)



Current issues faced are listed below:

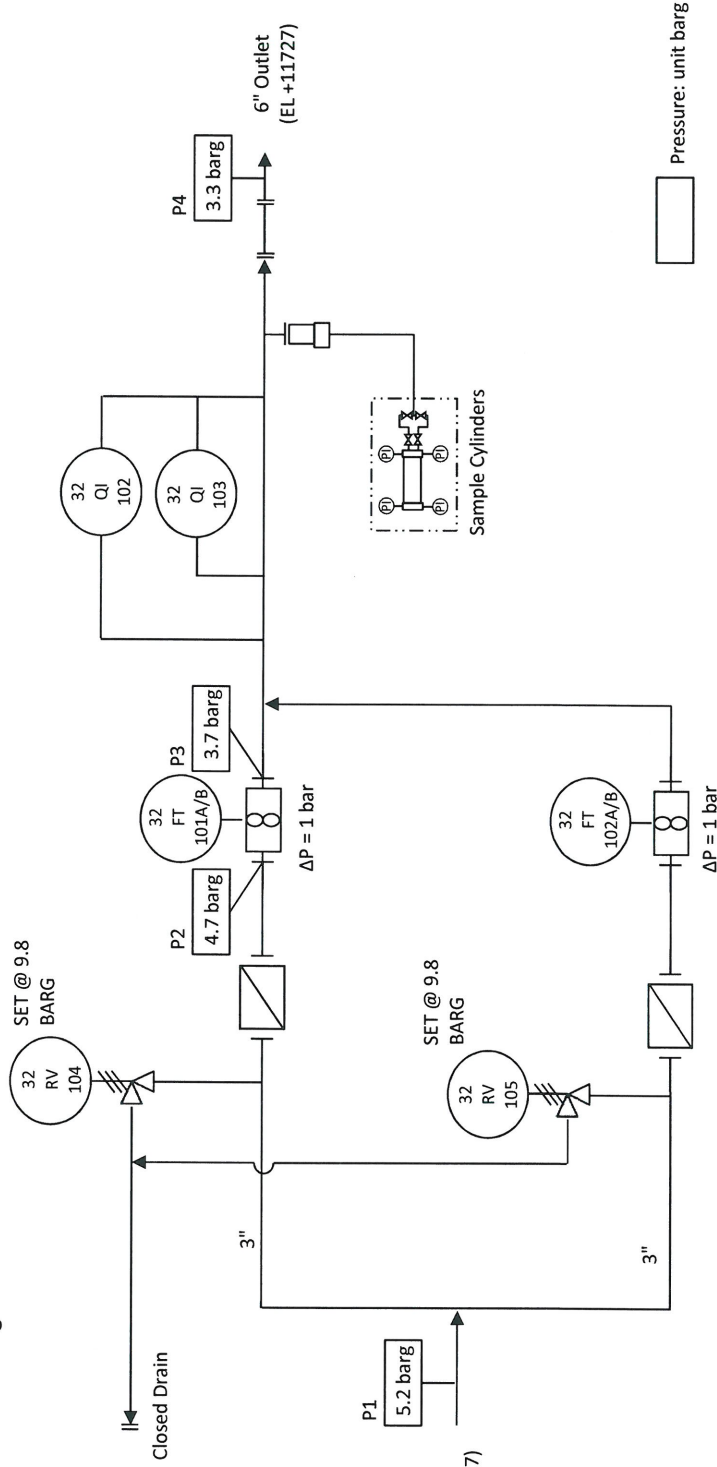
- Obsolescence:** the existing liquid densitometers and turbine meters are already obsolete from the market and spare parts are no longer available. Support of services and repair are only available until 2019.
- Maintainability and Operability:** Current design is difficult to maintain and operate. There are no common line isolation valves, only meter run isolation valves are available. Both isolation valves are currently passing. The MOVs are also difficult to operate and tend to malfunction due to component failure. Existing liquid sampling system is also faulty (have been decommissioned) and currently utilizing manual lab sampling method.
- Incompliance:** As per Gas Sales Agreement (GSA), all custody meter (turbine meter) are required to be validated periodically as per validation schedule (6-monthly). Due to isolation valves passing for both meter runs, the turbine meter cannot be isolated thus cannot be sent for offline validation. This leads to incompliance of validation as per GSA and giving exposure to measurement (meter ticket) for both buyer and seller.

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8.0 Process Sketch - Gasoline Metering Skid



Note: Pressure values based on PC 20278-PDD2-PRO-DES-002 - governing case (Case 3). Refer to Section 10.0 for details.



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9.0 Project Objective

The main objective of the project is to upgrade the existing Gasoline Metering Skid (A-3200) to improve operational, maintenance and Gas Sales Agreement (GSA) validation compliance.

10.0 Calculation & Result

i) Line Sizing Calculation Cases:

Case 1 = High N₂ Lean Gas, maximum flow, existing line size (NPS 80)

Case 2 = High N₂ Lean Gas, maximum flow, new proposed line size (NPS 150)

Case 3 = RGLA, maximum flow, existing line size (NPS 80)

Case 4 = RGLA, maximum flow, new proposed line size (NPS 150)

Line sizing result is summarized below:

Case	Flowrate (kg/h)	Density (kg/m ³)	Line Size (NPS)/ Pipe Schedule	Velocity (m/s)		Pressure Drop (bar/100m)		pV ² (kg/ms ²)		Remarks
				Result [App. A]	Criteria [Ref. 1]	Result [App. A]	Criteria [Ref. 1]	Result [App. A]	Criteria [Ref. 1]	
PC 20278-PDD2-PRO-DES-001, Rev.0, PC20278 Basis of Design.										
1	50,652	625	80 / Sch 40	4.72	2.5 (PTS 2017)	1.62	0.45 (PTS 2017)	13,924	Medium	NOT OK
2	50,652	625	150 / Sch 40	1.21		0.05		915	Negligible	OK
3	50,652	613	80 / Sch 40	4.81		1.65		14,182	Medium	NOT OK
4	50,652	613	150 / Sch 40	1.23		0.05		927	Negligible	OK
Maximum flow using existing 3" line size										
1B	26,393	625	80 / Sch 40	2.46	2.5 (PTS 2017)	0.45	0.45 (PTS 2017)	3,782	Negligible	OK
3B	26,182	613	80 / Sch 40	2.49		0.45		3,801	Negligible	OK

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10.0 Calculation & Result [continued]

ii) Hydraulic Calculation

Pressure drop across Gasoline Metering Skid is summarized below:

Case	Existing 3" Line Size (Case 3)	Proposed 6" Line Size (Case 4)
Node	ΔP (bar)	
P ₁ - P ₂	0.49	0.03
P ₂ - P ₃ (Turbine Meter)	1.00	1.00
P ₃ - P ₄	0.44	0.02
Total Pressure Drop	1.93	1.06
Gasoline Skid:	Pressure (barg)	
Inlet Pressure	5.20	5.20
Outlet Pressure	3.27	4.14

Notes:

1. Refer Process Sketch [Section 8.0] for node location.



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Appendix A

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Appendix A
Hydraulic Calculation Spreadsheet
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		Calculation Name Line Sizing & Hydraulic Calculation (Gasoline) By / Date CMC / 23-Aug-19 Checked / Date 23 / ADW/OH / 23-Aug-19 Malaysia LNG Sdn Bhd / Project No. 412028-0005 Provision of Engineering, Procurement, Construction and Commissioning for Gasoline and Natural Gas Liquid (NGL) Metering Skid Line Sizing & Hydraulic Calculation - Gasoline Case 1: High N ₂ Lean Gas Case, maximum flow, existing line size (NPS 80) Page 1 of 6											
CUSTOMER PROJECT SUBJECT PROJECT FILE LOCATION													
DESCRIPTION		1		2		3		4		5		6	
Pressure Drop Source		PIPING		PIPING		PIPING		PIPING					
From		Notes		Notes		Notes		Notes					
To		S1		S2		S3		S4					
Description		S2		S3		S4		S5					
		6"150# NGBE1		3"150# NGBE1		3"150# NGBE1		3"150# NGBE1					
CONDITIONS													
Inlet Pressure, kPag		520.00		518.20		479.64		471.40					
Temperature, °C		35.0		35.0		35.0		35.0					
Mass Flow Rate, kg/hr		50652		50652		50652		50652					
Design Margin		0%		0%		0%		0%					
Density @ PT, kg/m³		625.0		625.0		625.0		625.0					
Density @ 15 °C, kg/m³													
Viscosity, cP		0.22		0.22		0.22		0.22					
User Specified I.D. mm													
Nominal Pipe Size, mm		150		80		80		80					
Pipe Schedule		40		40		40		40					
VELOCITY													
Std. Volumetric Flow Rate, m³/hr													
Actual Volumetric Flow Rate, m³/hr		81.05		81.05		81.05		81.04					
Specific Gravity @ PT		0.625		0.625		0.625		0.625					
Pipe ID, mm		154.08		77.92		77.92		77.92					
Area, m²		0.0186		0.0048		0.0048		0.0048					
Fluid Velocity, m/s		1.21		4.72		4.72		4.72					
FRICTION FACTOR													
Reynolds Number, Re		528541		1045144		1045144		1045050					
Flow Regime		Turbulent Flow		Turbulent Flow		Turbulent Flow		Turbulent Flow					
Froude number		1.0		5.4		5.4		5.4					
Minimum Liquid Height, m		0.10		0.10		0.10		0.10					
Darcy Friction Factor Constant, α		3.048E+21		1.414E+21		1.414E+21		1.414E+21					
Darcy Friction Factor Constant, β		4.176E-19		7.643E-24		7.643E-24		7.643E-24					
Darcy Friction Factor, f(Darcy)		0.0165		0.0182		0.0182		0.0182					
Line Pressure Drop, kPa/100m		4.88		162.41		162.41		162.38					
Roughness Factor (epsilon), m		0.00005		0.00005		0.00005		0.00005					
Turbulent Friction Factor, f(turbulent)		0.0152		0.0177		0.0177		0.0177					
EQUIVALENT LENGTH													
Straight length, m		0.708		1.414		3.653		5.654					
Complexity Factor Applied													
K-Value Method		Two-K		Two-K		Two-K		Two-K					
Elbow - 90°- Threaded, Standard -r/D = 1		0.000		1		0.531		0.000		1		0.531	
Elbow - 90°- Threaded, Long Radius -r/D = 1.5		0.000				0.000		0.000				0.000	
Elbow - 90°- Flanged, Welded, LR -r/D = 1.5		0.000				0.000		0.000				0.000	
Elbow - 90°- Flanged, Welded, Bend -r/D = 1		0.000				0.000		0.000				0.000	
Elbow - 90°- Flanged, Welded, Bend -r/D = 2		0.000				0.000		0.000				0.000	
Elbow - 90°- Flanged, Welded, Bend -r/D = 4		0.000				0.000		0.000				0.000	
Elbow - 90°- Flanged, Welded, Bend -r/D = 6		0.000				0.000		0.000				0.000	
Elbow - 90°- Mitered, 1 Weld, 90°		0.000				0.000		0.000				0.000	
Elbow - 90°- Mitered, 2 Welds, 45°		0.000				0.000		0.000				0.000	
Elbow - 90°- Mitered, 3 Welds, 30°		0.000				0.000		0.000				0.000	
Elbow - 45°- Threaded, Standard -r/D = 1		0.000				0.000		0.000				0.000	
Elbow - 45°- Long Radius -r/D = 1		0.000				0.000		0.000				0.000	
Elbow - 45°- Long Radius -r/D = 1.5		0.000				0.000		0.000				0.000	
Elbow - 45°- Mitered, 1 Weld, 45°		0.000				0.000		0.000				0.000	
Elbow - 45°- Mitered, 2 Welds, 22.5°		0.000				0.000		0.000				0.000	
Elbows - 180°- Threaded, Closed Return -r/D = 1		0.000				0.000		0.000				0.000	
Elbows - 180°- Flanged -r/D = 1		0.000				0.000		0.000				0.000	
Elbows - 180°- All -r/D = 1.5		0.000				0.000		0.000				0.000	
Tees - Used as elbow		0.000				0.000		0.000				0.000	
Tees - Thru Branch Threaded -r/D = 1		1		0.700		0.000		0.000		3		2.388	
Tees - Thru Branch Threaded -r/D = 1.5				0.000		0.000		0.000				0.000	
Tees - Thru Branch Flanged -r/D = 1				0.000		0.000		0.000				0.000	
Tees - Thru Branch Stub-in Branch				0.000		0.000		0.000				0.000	
Tees - Run Thru Threaded -r/D = 1				0.000		0.000		0.133				0.000	
Tees - Run Thru Flanged -r/D = 1				0.000		0.000		0.000				0.000	
Tees - Run Thru Stub-in Branch				0.000		0.000		0.000				0.000	
Valves - Angle Valve - 45° -Full Line Size, d1=d2				0.000		0.000		0.000				0.000	
Valves - Angle Valve - 90° -Full Line Size, d1=d2				0.000		0.000		0.000				0.000	
Valves - Globe Valve -Standard, d1=d2				0.000		0.000		0.000				0.000	
Valves - Plug Valve -Branch Flow				0.000		0.000		0.000				0.000	
Valves - Plug Valve -Straight Through				0.000		0.000		0.000				0.000	
Valves - Plug Valve -Three-Way (flow through)				0.000		0.000		0.000				0.000	
Valves - Gate Valve -Standard, d1=d2				0.000		1		0.133				0.000	
Valves - Ball Valve -Standard, d1=d2				0.000		0.000		1		0.199		0.199	
Valves - Diaphragm Valve -Dam-Type				0.000		0.000		0.000				0.000	
Valves - Swing Check Valve				0.000		0.000		0.000				0.000	
Valves - Lift Check Valve				0.000		0.000		0.000				0.000	
Valves - Gate/Ball/Plug Valve -Reduced Bore (0.8)				0.000		0.000		0.000				0.000	
Valves - Butterfly Valve				0.000		0.000		0.000		1		0.332	
Spares 1													
Total K Values for Fittings		0.70		0.68		0.33		3.45					
INLET Reducer or Expander?		None		None		None		None					
Number of Reducer/Expander													
Pipe ID, mm													
Reducer/Expander ID, mm													
Angle of Divergence, θ													
INLET REDUCER/EXPANDER, Total K													
OUTLET Reducer or Expander?		Tapered Reducer		None		None		Tapered Expander					
Number of Reducer/Expander		1						1					
Pipe ID, mm		154						78					
Reducer/Expander ID, mm		80						150					
Angle of Divergence, θ		31.7						31.7					
OUTLET REDUCER/EXPANDER, K		2.67						0.38					
Number of Orifice (Thin, Sharp)													
Orifice ID, mm													
Orifice K													
Is there an Entrance?		YES		NO		NO		NO					
Pipe Entrance, K		0.5		0		0		0					
Is there an Exit?		NO		NO		NO		YES					
Pipe Exit, K		0		0		0		1					
Sum of Other K Values													
Sum of Equiv Lengths of Other Equipment, m				19.48									
Age Factor		0%		0%		0%		0%					
Total K Value of System		3.95		5.54		1.18		6.15					
Equivalent Length of System, m		36.84		23.74		5.08		26.39					
PRESSURE LOSSES													
Line Frictional Pressure Drop, kPa		1.80		38.56		6.25		42.86					
Other Equipment P drop, kPa								100					
Control Valve Pressure Drop, kPa													
Or Known Cv Value													
Applied Control Valve Drop, kPa		0.00		0.00		0.00		0.00					
Total Losses (System Resistance), kPa		1.80		38.56		8.25		142.86					
Inlet Elevation, m													
Outlet Elevation, m													
Static Loss, kPa		0.00		0.00		0.00		0.00					
Outlet pressure, kPag		518.20		479.64		471.40		328.54					
TOTAL PRESSURE DROP, kPa		1.80		38.56		8.25		142.86					
Fluid Velocity, m/s		1.21		4.72		4.72		4.72					
Line Pressure Drop, kPa/100m		4.88		162.41		162.41		162.38					
Refer to "NOTES" Worksheet for all note details This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.													

Calculation Name Line Sizing & Hydraulic Calculation (Gasoline) By / Date CMC / 23-Aug-19 Checked / Date ADW/OH / 23-Aug-19																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
CUSTOMER Malaysia LNG Sdn Bhd Project No. 412028-0005 PROJECT SUBJECT Provision of Engineering, Procurement, Construction and Commissioning for Gasoline and Natural Gas Liquid (NGL) Metering Skid PROJECT FILE LOCATION Line Sizing & Hydraulic Calculation - Gasoline Case 2: High N ₂ Lean Gas Case, maximum flow, new proposed line size (NPS 150)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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FRICTION FACTOR	<table border="1"> <tr> <td>Reynolds Number, Re</td> <td>528541</td> <td>528541</td> <td>528541</td> <td>528493</td> <td></td> </tr> <tr> <td>Flow Regime</td> <td>Turbulent Flow</td> <td>Turbulent Flow</td> <td>Turbulent Flow</td> <td>Turbulent Flow</td> <td></td> </tr> <tr> <td>Froude number</td> <td>1.0</td> <td>1.0</td> <td>1.0</td> <td>1.0</td> <td></td> </tr> <tr> <td>Minimum Liquid Height, m</td> <td>0.10</td> <td>0.10</td> <td>0.10</td> <td>0.10</td> <td></td> </tr> <tr> <td>Darcy Friction Factor Constant, α</td> <td>3.048E+21</td> <td>3.048E+21</td> <td>3.048E+21</td> <td>3.048E+21</td> <td></td> </tr> <tr> <td>Darcy Friction Factor Constant, β</td> <td>4.178E-19</td> <td>4.178E-19</td> <td>4.178E-19</td> <td>4.182E-19</td> <td></td> </tr> <tr> <td>Darcy Friction Factor, f(Darcy)</td> <td>0.0165</td> <td>0.0165</td> <td>0.0165</td> <td>0.0165</td> <td></td> </tr> <tr> <td>Line Pressure Drop, kPa/100m</td> <td>4.88</td> <td>4.88</td> <td>4.88</td> <td>4.88</td> <td></td> </tr> <tr> <td>Roughness Factor (epsilon), m</td> <td>0.00005</td> <td>0.00005</td> <td>0.00005</td> <td>0.00005</td> <td></td> </tr> <tr> <td>Turbulent Friction Factor, f(turbulent)</td> <td>0.0152</td> <td>0.0152</td> <td>0.0152</td> <td>0.0152</td> <td></td> </tr> </table>	Reynolds Number, Re	528541	528541	528541	528493		Flow Regime	Turbulent Flow	Turbulent Flow	Turbulent Flow	Turbulent Flow		Froude number	1.0	1.0	1.0	1.0		Minimum Liquid Height, m	0.10	0.10	0.10	0.10		Darcy Friction Factor Constant, α	3.048E+21	3.048E+21	3.048E+21	3.048E+21		Darcy Friction Factor Constant, β	4.178E-19	4.178E-19	4.178E-19	4.182E-19		Darcy Friction Factor, f(Darcy)	0.0165	0.0165	0.0165	0.0165		Line Pressure Drop, kPa/100m	4.88	4.88	4.88	4.88		Roughness Factor (epsilon), m	0.00005	0.00005	0.00005	0.00005		Turbulent Friction Factor, f(turbulent)	0.0152	0.0152	0.0152	0.0152																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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EQUIVALENT LENGTH	<table border="1"> <tr> <td>Straight length, m</td> <td>0.706</td> <td>1.414</td> <td>3.653</td> <td>5.654</td> <td></td> </tr> <tr> <td>Complexity Factor Applied</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>K-Value Method</td> <td>Two-K</td> <td>Two-K</td> <td>Two-K</td> <td>Two-K</td> <td></td> </tr> <tr> <td>Elbow - 90°- Threaded, Standard -r/D = 1</td> <td>0.000</td> <td>1</td> <td>0.467</td> <td>1</td> <td>0.467</td> </tr> <tr> <td>Elbow - 90°- Threaded, Long Radius -r/D = 1.5</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Flanged, Welded, LR -r/D = 1.5</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Flanged, Welded, Bend -r/D = 1</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Flanged, Welded, Bend -r/D = 2</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Flanged, Welded, Bend -r/D = 4</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Flanged, Welded, Bend -r/D = 6</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Mitered, 1 Weld, 90°</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Mitered, 2 Welds, 45°</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 90°- Mitered, 3 Welds, 30°</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 45°- Threaded, Standard -r/D = 1</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 45°- Long Radius -r/D = 1</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 45°- Long Radius -r/D = 1.5</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 45°- Mitered, 1 Weld, 45°</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbow - 45°- Mitered, 2 Welds, 22.5°</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbows - 180°- Threaded, Closed Return -r/D = 1</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbows - 180°- Flanged -r/D = 1</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Elbows - 180°- All -r/D = 1.5</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Tees - Used as elbow</td> <td>0.000</td> <td></td> <td>0.000</td> <td></td> <td>0.000</td> </tr> <tr> <td>Tees - Thru Branch Threaded -r/D = 1</td> <td>1</td> <td>0.700</td> <td>0.000</td> <td>3</td> <td>2.100</td> </tr> <tr> <td>Tees - Thru Branch Threaded -r/D = 1.5</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Tees - Thru Branch Flanged -r/D = 1</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Tees - Thru Branch Stub-in Branch</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Tees - Run Thru Threaded -r/D = 1</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Tees - Run Thru Flanged -r/D = 1</td> <td></td> <td>0.000</td> <td>1</td> <td></td> <td>0.000</td> </tr> <tr> <td>Tees - Run Thru Stub-in Branch</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Angle Valve - 45° -Full Line Size, d1=d2</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Angle Valve - 90° -Full Line Size, d1=d2</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Globe Valve -Standard, d1=d2</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Plug Valve -Branch Flow</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Plug Valve -Straight Through</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Plug Valve -Three-Way (flow through)</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Gate Valve -Standard, d1=d2</td> <td></td> <td>0.000</td> <td>1</td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Ball Valve -Standard, d1=d2</td> <td></td> <td>0.000</td> <td></td> <td>1</td> <td>0.176</td> </tr> <tr> <td>Valves - Diaphragm Valve -Dam-Type</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Swing Check Valve</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Lift Check Valve</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Gate/Ball/Plug Valve -Reduced Bore (0.8)</td> <td></td> <td>0.000</td> <td></td> <td></td> <td>0.000</td> </tr> <tr> <td>Valves - Butterfly Valve</td> <td></td> <td>0.000</td> <td></td> <td>1</td> <td>0.293</td> </tr> <tr> <td>Spares 1</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Total K Values for Fittings</td> <td>0.70</td> <td>0.58</td> <td>0.29</td> <td>3.04</td> <td></td> </tr> <tr> <td>INLET Reducer or Expander?</td> <td>None</td> <td>None</td> <td>None</td> <td>None</td> <td></td> </tr> <tr> <td>Number of Reducer/Expander</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Pipe ID, mm</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Reducer/Expander ID, mm</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Angle of Divergence, θ</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>INLET REDUCER/EXPANDER, Total K</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>OUTLET Reducer or Expander?</td> <td>None</td> <td>None</td> <td>None</td> <td>None</td> <td></td> </tr> <tr> <td>Number of Reducer/Expander</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Pipe ID, mm</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Reducer/Expander ID, mm</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Angle of Divergence, θ</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>OUTLET REDUCER/EXPANDER, K</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Number of Orifice (Thin, Sharp)</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Orifice ID, mm</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Orifice K</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Is there an Entrance?</td> <td>YES</td> <td>NO</td> <td>NO</td> <td>NO</td> <td></td> </tr> <tr> <td>Pipe Entrance, K</td> <td>0.5</td> <td>0</td> <td>0</td> <td>0</td> <td></td> </tr> <tr> <td>Is there an Exit?</td> <td>NO</td> <td>NO</td> <td>NO</td> <td>YES</td> <td></td> </tr> <tr> <td>Pipe Exit, K</td> <td>0</td> <td>0</td> <td>0</td> <td>1</td> <td></td> </tr> <tr> <td>Sum of Other K Values</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Sum of Equiv Lengths of Other Equipment, m</td> <td></td> <td>38.52</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Age Factor</td> <td>0%</td> <td>0%</td> <td>0%</td> <td>0%</td> <td></td> </tr> <tr> <td>Total K Value of System</td> <td>1.28</td> <td>4.86</td> <td>0.68</td> <td>4.64</td> <td></td> </tr> <tr> <td>Equivalent Length of System, m</td> <td>11.91</td> <td>45.39</td> <td>6.38</td> <td>43.33</td> <td></td> </tr> <tr> <td>PRESSURE LOSSES</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Line Frictional Pressure Drop, kPa</td> <td>0.58</td> <td>2.22</td> <td>0.31</td> <td>2.11</td> <td></td> </tr> <tr> <td>Other Equipment P drop, kPa</td> <td></td> <td></td> <td></td> <td>100</td> <td></td> </tr> <tr> <td>Control Valve Pressure Drop, kPa</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Or Known Cv Value</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Applied Control Valve Drop, kPa</td> <td>0.00</td> <td>0.00</td> <td>0.00</td> <td>0.00</td> <td></td> </tr> <tr> <td>Total Losses (System Resistance), kPa</td> <td>0.58</td> <td>2.22</td> <td>0.31</td> <td>102.11</td> <td></td> </tr> <tr> <td>Inlet Elevation, m</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Outlet Elevation, m</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Static Loss, kPa</td> <td>0.00</td> <td>0.00</td> <td>0.00</td> <td>0.00</td> <td></td> </tr> <tr> <td>Outlet pressure, kPag</td> <td>519.42</td> <td>517.20</td> <td>516.89</td> <td>414.78</td> <td></td> </tr> <tr> <td>TOTAL PRESSURE DROP, kPa</td> <td>0.58</td> <td>2.22</td> <td>0.31</td> <td>102.11</td> <td></td> </tr> <tr> <td>Fluid Velocity, m/s</td> <td>1.21</td> <td>1.21</td> <td>1.21</td> <td>1.21</td> <td></td> </tr> <tr> <td>Line Pressure Drop, kPa/100m</td> <td>4.88</td> <td>4.88</td> <td>4.88</td> <td>4.88</td> <td></td> </tr> </table>	Straight length, m	0.706	1.414	3.653	5.654		Complexity Factor Applied						K-Value Method	Two-K	Two-K	Two-K	Two-K		Elbow - 90°- Threaded, Standard -r/D = 1	0.000	1	0.467	1	0.467	Elbow - 90°- Threaded, Long Radius -r/D = 1.5	0.000		0.000		0.000	Elbow - 90°- Flanged, Welded, LR -r/D = 1.5	0.000		0.000		0.000	Elbow - 90°- Flanged, Welded, Bend -r/D = 1	0.000		0.000		0.000	Elbow - 90°- Flanged, Welded, Bend -r/D = 2	0.000		0.000		0.000	Elbow - 90°- Flanged, Welded, Bend -r/D = 4	0.000		0.000		0.000	Elbow - 90°- Flanged, Welded, Bend -r/D = 6	0.000		0.000		0.000	Elbow - 90°- Mitered, 1 Weld, 90°	0.000		0.000		0.000	Elbow - 90°- Mitered, 2 Welds, 45°	0.000		0.000		0.000	Elbow - 90°- Mitered, 3 Welds, 30°	0.000		0.000		0.000	Elbow - 45°- Threaded, Standard -r/D = 1	0.000		0.000		0.000	Elbow - 45°- Long Radius -r/D = 1	0.000		0.000		0.000	Elbow - 45°- Long Radius -r/D = 1.5	0.000		0.000		0.000	Elbow - 45°- Mitered, 1 Weld, 45°	0.000		0.000		0.000	Elbow - 45°- Mitered, 2 Welds, 22.5°	0.000		0.000		0.000	Elbows - 180°- Threaded, Closed Return -r/D = 1	0.000		0.000		0.000	Elbows - 180°- Flanged -r/D = 1	0.000		0.000		0.000	Elbows - 180°- All -r/D = 1.5	0.000		0.000		0.000	Tees - Used as elbow	0.000		0.000		0.000	Tees - Thru Branch Threaded -r/D = 1	1	0.700	0.000	3	2.100	Tees - Thru Branch Threaded -r/D = 1.5		0.000			0.000	Tees - Thru Branch Flanged -r/D = 1		0.000			0.000	Tees - Thru Branch Stub-in Branch		0.000			0.000	Tees - Run Thru Threaded -r/D = 1		0.000			0.000	Tees - Run Thru Flanged -r/D = 1		0.000	1		0.000	Tees - Run Thru Stub-in Branch		0.000			0.000	Valves - Angle Valve - 45° -Full Line Size, d1=d2		0.000			0.000	Valves - Angle Valve - 90° -Full Line Size, d1=d2		0.000			0.000	Valves - Globe Valve -Standard, d1=d2		0.000			0.000	Valves - Plug Valve -Branch Flow		0.000			0.000	Valves - Plug Valve -Straight Through		0.000			0.000	Valves - Plug Valve -Three-Way (flow through)		0.000			0.000	Valves - Gate Valve -Standard, d1=d2		0.000	1		0.000	Valves - Ball Valve -Standard, d1=d2		0.000		1	0.176	Valves - Diaphragm Valve -Dam-Type		0.000			0.000	Valves - Swing Check Valve		0.000			0.000	Valves - Lift Check Valve		0.000			0.000	Valves - Gate/Ball/Plug Valve -Reduced Bore (0.8)		0.000			0.000	Valves - Butterfly Valve		0.000		1	0.293	Spares 1						Total K Values for Fittings	0.70	0.58	0.29	3.04		INLET Reducer or Expander?	None	None	None	None		Number of Reducer/Expander						Pipe ID, mm						Reducer/Expander ID, mm						Angle of Divergence, θ						INLET REDUCER/EXPANDER, Total K						OUTLET Reducer or Expander?	None	None	None	None		Number of Reducer/Expander						Pipe ID, mm						Reducer/Expander ID, mm						Angle of Divergence, θ						OUTLET REDUCER/EXPANDER, K						Number of Orifice (Thin, Sharp)						Orifice ID, mm						Orifice K						Is there an Entrance?	YES	NO	NO	NO		Pipe Entrance, K	0.5	0	0	0		Is there an Exit?	NO	NO	NO	YES		Pipe Exit, K	0	0	0	1		Sum of Other K Values						Sum of Equiv Lengths of Other Equipment, m		38.52				Age Factor	0%	0%	0%	0%		Total K Value of System	1.28	4.86	0.68	4.64		Equivalent Length of System, m	11.91	45.39	6.38	43.33		PRESSURE LOSSES						Line Frictional Pressure Drop, kPa	0.58	2.22	0.31	2.11		Other Equipment P drop, kPa				100		Control Valve Pressure Drop, kPa						Or Known Cv Value						Applied Control Valve Drop, kPa	0.00	0.00	0.00	0.00		Total Losses (System Resistance), kPa	0.58	2.22	0.31	102.11		Inlet Elevation, m						Outlet Elevation, m						Static Loss, kPa	0.00	0.00	0.00	0.00		Outlet pressure, kPag	519.42	517.20	516.89	414.78		TOTAL PRESSURE DROP, kPa	0.58	2.22	0.31	102.11		Fluid Velocity, m/s	1.21	1.21	1.21	1.21		Line Pressure Drop, kPa/100m	4.88	4.88	4.88	4.88	
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Valves - Gate Valve -Standard, d1=d2		0.000	1		0.000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Valves - Ball Valve -Standard, d1=d2		0.000		1	0.176																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Valves - Diaphragm Valve -Dam-Type		0.000			0.000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Valves - Lift Check Valve		0.000			0.000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Valves - Gate/Ball/Plug Valve -Reduced Bore (0.8)		0.000			0.000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Valves - Butterfly Valve		0.000		1	0.293																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Total K Value of System	1.28	4.86	0.68	4.64																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Equivalent Length of System, m	11.91	45.39	6.38	43.33																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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Line Frictional Pressure Drop, kPa	0.58	2.22	0.31	2.11																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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Applied Control Valve Drop, kPa	0.00	0.00	0.00	0.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Total Losses (System Resistance), kPa	0.58	2.22	0.31	102.11																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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Static Loss, kPa	0.00	0.00	0.00	0.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Outlet pressure, kPag	519.42	517.20	516.89	414.78																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
TOTAL PRESSURE DROP, kPa	0.58	2.22	0.31	102.11																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Fluid Velocity, m/s	1.21	1.21	1.21	1.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Line Pressure Drop, kPa/100m	4.88	4.88	4.88	4.88																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Refer to "NOTES" Worksheet for all note details																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

Calculation Name Line Sizing & Hydraulic Calculation (Gasoline) By / Date CMC 18/10/19 / 23-Aug-19 Checked / Date ADW/OH 08/10/19 / 23-Aug-19	
CUSTOMER Malaysia LNG Sdn Bhd Project No. 412028-0005 PROJECT Provision of Engineering, Procurement, Construction and Commissioning for Gasoline and Natural Gas Liquid (NGL) Metering Skid SUBJECT Line Sizing & Hydraulic Calculation - Gasoline Case 3: RGLA Case, maximum flow, existing line size (NPS 80) PROJECT FILE LOCATION Page 3 of 6	

DESCRIPTION	1		2		3		4		5		6	
	PIPING		PIPING		PIPING		PIPING					
	Notes	S1	Notes	S2	Notes	S3	Notes	S4				
From To	S1	S2	S2	S3	S3	S4	S4	S5				
Description	6"150# NGBE1	3"150# NGBE1	3"150# NGBE1	3"150# NGBE1	3"150# NGBE1	3"150# NGBE1	3"150# NGBE1	3"150# NGBE1				
CONDITIONS												
Inlet Pressure, kPa	520.00	518.17	478.93	470.53								
Temperature, °C	35.0	35.0	35.0	35.0								
Mass Flow Rate, kg/hr	50652	50652	50652	50652								
Design Margin	0%	0%	0%	0%								
Density @ PT, kg/m³	613.0	613.0	613.0	613.0								
Density @ 15 °C, kg/m³												
Viscosity, cP	0.20	0.20	0.20	0.20								
User Specified I.D. mm												
Nominal Pipe Size, mm	150	80	80	80								
Pipe Schedule	40	40	40	40								
VELOCITY												
Std. Volumetric Flow Rate, m³/hr												
Actual Volumetric Flow Rate, m³/hr	82.64	82.64	82.64	82.63								
Specific Gravity @ PT	0.613	0.613	0.613	0.613								
Pipe ID, mm	154.08	77.92	77.92	77.92								
Area, m²	0.0186	0.0048	0.0048	0.0048								
Fluid Velocity, m/s	1.23	4.81	4.81	4.81								
FRICTION FACTOR												
Reynolds Number, Re	581395	1149058	1149058	1149555								
Flow Regime	Turbulent Flow	Turbulent Flow	Turbulent Flow	Turbulent Flow								
Froude number	1.0	5.5	5.5	5.5								
Minimum Liquid Height, m	0.10	0.10	0.10	0.10								
Darcy Friction Factor Constant, α	3.195E+21	1.439E+21	1.439E+21	1.439E+21								
Darcy Friction Factor Constant, β	9.089E-20	1.663E-24	1.663E-24	1.669E-24								
Darcy Friction Factor, f(Darcy)	0.0164	0.0181	0.0181	0.0181								
Line Pressure Drop, kPa/100m	4.95	165.23	165.23	165.20								
Roughness Factor (ε/pipe), m	0.00005	0.00005	0.00005	0.00005								
Turbulent Friction Factor, f(turbulent)	0.0152	0.0177	0.0177	0.0177								
EQUIVALENT LENGTH												
Straight length, m	0.706	1.414	3.853	5.654								
Complexity Factor Applied												
K-Value Method	Two-K	Two-K	Two-K	Two-K								
Elbow - 90°- Threaded, Standard -r/D = 1	0.000	1	0.531	0.000	1	0.531						
Elbow - 90°- Threaded, Long Radius -r/D = 1.5	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Flanged, Welded, LR -r/D = 1.5	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 1	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 2	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 4	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 6	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Mitered, 1 Weld, 90°	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Mitered, 2 Welds, 45°	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 90°- Mitered, 3 Welds, 30°	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 45°- Threaded, Standard -r/D = 1	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 45°- Long Radius -r/D = 1	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 45°- Long Radius -r/D = 1.5	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 45°- Mitered, 1 Weld, 45°	0.000	0.000	0.000	0.000	0.000	0.000						
Elbow - 45°- Mitered, 2 Welds, 22.5°	0.000	0.000	0.000	0.000	0.000	0.000						
Elbows - 180°- Threaded, Closed Return -r/D = 1	0.000	0.000	0.000	0.000	0.000	0.000						
Elbows - 180°- Flanged -r/D = 1	0.000	0.000	0.000	0.000	0.000	0.000						
Elbows - 180°- All -r/D = 1.5	0.000	0.000	0.000	0.000	0.000	0.000						
Tees - Used as elbow	0.000	0.000	0.000	0.000	0.000	0.000						
Tees - Thru Branch Threaded -r/D = 1	1	0.700	0.000	0.000	3	2.388						
Tees - Thru Branch Threaded -r/D = 1.5	0.000	0.000	0.000	0.000	0.000	0.000						
Tees - Thru Branch Flanged -r/D = 1	0.000	0.000	0.000	0.000	0.000	0.000						
Tees - Thru Branch Stub-In Branch	0.000	0.000	0.000	0.000	0.000	0.000						
Tees - Run Thru Threaded -r/D = 1	0.000	0.000	1	0.133	0.000	0.000						
Tees - Run Thru Flanged -r/D = 1	0.000	0.000	0.000	0.000	0.000	0.000						
Tees - Run Thru Stub-In Branch	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Angle Valve - 45°- Full Line Size, d1=d2	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Angle Valve - 90°- Full Line Size, d1=d2	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Globe Valve -Standard, d1=d2	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Plug Valve -Branch Flow	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Plug Valve -Straight Through	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Plug Valve -Three-Way (flow through)	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Gate Valve -Standard, d1=d2	0.000	1	0.133	0.000	0.000	0.000						
Valves - Ball Valve -Standard, d1=d2	0.000	0.000	1	0.199	1	0.199						
Valves - Diaphragm Valve -Dam-Type	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Swing Check Valve	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Lift Check Valve	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Gate/Ball/Plug Valve - Reduced Bore (0.8)	0.000	0.000	0.000	0.000	0.000	0.000						
Valves - Butterfly Valve	0.000	0.000	0.000	0.000	1	0.332						
Spare 1												
Total K Values for Fittings	0.70	0.66	0.33	3.45								
INLET Reducer or Expander?	None	None	None	None								
Number of Reducer/Expander												
Pipe ID, mm												
Reducer/Expander ID, mm												
Angle of Divergence, θ												
INLET REDUCER/EXPANDER, Total K												
OUTLET Reducer or Expander?	Tapered Reducer	None	None	Tapered Expander								
Number of Reducer/Expander	1			1								
Pipe ID, mm	154			78								
Reducer/Expander ID, mm	80			150								
Angle of Divergence, θ	31.7			31.7								
OUTLET REDUCER/EXPANDER, K	2.67			0.38								
Number of Orifice (Thin, Sharp)												
Orifice ID, mm												
Orifice K												
Is there an Entrance?	YES	NO	NO	NO								
Pipe Entrance, K	0.5	0	0	0								
Is there an Exit?	NO	NO	NO	YES								
Pipe Exit, K	0	0	0	1								
Sum of Other K Values												
Sum of Equiv Lengths of Other Equipment, m		19.48										
Age Factor	0%	0%	0%	0%								
Total K Value of System	3.94	5.52	1.18	6.15								
Equivalent Length of System, m	37.05	23.75	5.08	26.44								
PRESSURE LOSSES												
Line Frictional Pressure Drop, kPa	1.83	39.24	8.39	43.67								
Other Equipment P drop, kPa				100								
Control Valve Pressure Drop, kPa												
Or Known Cv Value												
Applied Control Valve Drop, kPa	0.00	0.00	0.00	0.00								
Total Losses (System Resistance), kPa	1.83	39.24	8.39	143.67								
Inlet Elevation, m												
Outlet Elevation, m												
Static Loss, kPa	0.00	0.00	0.00	0.00								
Outlet pressure, kPa	518.17	478.93	470.53	326.86								
TOTAL PRESSURE DROP, kPa	1.83	39.24	8.39	143.67								
Fluid Velocity, m/s	1.23	4.81	4.81	4.81								
Line Pressure Drop, kPa/100m	4.95	165.23	165.23	165.20								

Refer to "NOTES" Worksheet for all note details

This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and

CUSTOMER PROJECT SUBJECT PROJECT FILE LOCATION		Calculation Name Line Sizing & Hydraulic Calculation (Gasoline)											
		By / Date CMC 23-Aug-19		Checked / Date ADW/OH 23-Aug-19									
		Malaysia LNG Sdn Bhd		Project No. 412028-0005									
		Provision of Engineering, Procurement, Construction and Commissioning for Gasoline and Natural Gas Liquid (NGL) Metering Skid Line Sizing & Hydraulic Calculation - Gasoline Case 4: RGLA Case, maximum flow, new proposed line size (NPS 150)											
		Page 4 of 6											
DESCRIPTION		1		2		3		4		5		6	
Pressure Drop Source		PIPING		PIPING		PIPING		PIPING					
From		Notes		Notes		Notes		Notes					
To		S1		S2		S3		S4					
Description		S2		S3		S4		S5					
		6"150# NGBE1		6"150# NGBE1		6"150# NGBE1		6"150# NGBE1					
CONDITIONS													
Inlet Pressure, kPag		520.00		519.41		517.16		516.84					
Temperature, °C		35.0		35.0		35.0		35.0					
Mass Flow Rate, kg/hr		50652		50652		50652		50652					
Design Margin		0%		0%		0%		0%					
Density @ PT, kg/m³		613.0		613.0		613.0		613.0					
Density @ 15 °C, kg/m³		613.0		613.0		613.0		613.0					
Viscosity, cP		0.20		0.20		0.20		0.20					
User Specified I.D. mm													
Nominal Pipe Size, mm		150		150		150		150					
Pipe Schedule		40		40		40		40					
VELOCITY													
Std. Volumetric Flow Rate, m³/hr													
Actual Volumetric Flow Rate, m³/hr		82.64		82.64		82.64		82.63					
Specific Gravity @ PT		0.613		0.613		0.613		0.613					
Pipe ID, mm		154.08		154.08		154.08		154.08					
Area, m²		0.0186		0.0186		0.0186		0.0186					
Fluid Velocity, m/s		1.23		1.23		1.23		1.23					
FRICTION FACTOR													
Reynolds Number, Re		581395		581395		581395		581343					
Flow Regime		Turbulent Flow		Turbulent Flow		Turbulent Flow		Turbulent Flow					
Froude number		1.0		1.0		1.0		1.0					
Minimum Liquid Height, m		0.10		0.10		0.10		0.10					
Darcy Friction Factor Constant, α		3.195E+21		3.195E+21		3.195E+21		3.195E+21					
Darcy Friction Factor Constant, β		9.089E-20		9.089E-20		9.089E-20		9.102E-20					
Darcy Friction Factor, f(Darcy)		0.0164		0.0164		0.0164		0.0164					
Line Pressure Drop, kPa/100m		4.95		4.95		4.95		4.95					
Roughness Factor (ε), m		0.00005		0.00005		0.00005		0.00005					
Turbulent Friction Factor, f(turbulent)		0.0152		0.0152		0.0152		0.0152					
EQUIVALENT LENGTH													
Straight length, m		0.706		1.414		3.653		5.654					
Complexity Factor Applied													
K-Value Method		Two-K		Two-K		Two-K		Two-K					
Elbow - 90° - Threaded, Standard -r/D = 1		0.000		1		0.467		0.000		1		0.467	
Elbow - 90° - Threaded, Long Radius -r/D = 1.5		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Flanged, Welded, LR -r/D = 1.5		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Flanged, Welded, Bend -r/D = 1		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Flanged, Welded, Bend -r/D = 2		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Flanged, Welded, Bend -r/D = 4		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Flanged, Welded, Bend -r/D = 8		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Mitered, 1 Weld, 90°		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Mitered, 2 Welds, 45°		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 90° - Mitered, 3 Welds, 30°		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 45° - Threaded, Standard -r/D = 1		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 45° - Long Radius -r/D = 1		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 45° - Long Radius -r/D = 1.5		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 45° - Mitered, 1 Weld, 45°		0.000		0.000		0.000		0.000		0.000		0.000	
Elbow - 45° - Mitered, 2 Welds, 22.5°		0.000		0.000		0.000		0.000		0.000		0.000	
Elbows - 180° - Threaded, Closed Return -r/D = 1		0.000		0.000		0.000		0.000		0.000		0.000	
Elbows - 180° - Flanged -r/D = 1		0.000		0.000		0.000		0.000		0.000		0.000	
Elbows - 180° - All -r/D = 1.5		0.000		0.000		0.000		0.000		0.000		0.000	
Tees - Used as elbow		0.000		0.000		0.000		0.000		0.000		0.000	
Tees - Thru Branch Threaded -r/D = 1		1		0.706		0.000		0.000		3		2.099	
Tees - Thru Branch Threaded -r/D = 1.5		0.000		0.000		0.000		0.000		0.000		0.000	
Tees - Thru Branch Flanged -r/D = 1		0.000		0.000		0.000		0.000		0.000		0.000	
Tees - Thru Branch Stub-in Branch		0.000		0.000		0.000		0.000		0.000		0.000	
Tees - Run Thru Threaded -r/D = 1		0.000		0.000		1		0.117		0.000		0.000	
Tees - Run Thru Flanged -r/D = 1		0.000		0.000		0.000		0.000		0.000		0.000	
Tees - Run Thru Stub-in Branch		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Angle Valve - 45° - Full Line Size, d1=d2		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Angle Valve - 90° - Full Line Size, d1=d2		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Globe Valve - Standard, d1=d2		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Plug Valve - Branch Flow		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Plug Valve - Straight Through		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Plug Valve - Three-Way (flow through)		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Gate Valve - Standard, d1=d2		0.000		1		0.117		0.000		0.000		0.000	
Valves - Ball Valve - Standard, d1=d2		0.000		0.000		1		0.176		1		0.176	
Valves - Diaphragm Valve - Dam-Type		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Swing Check Valve		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Lift Check Valve		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Gate/Ball/Plug Valve - Reduced Bore (0.8)		0.000		0.000		0.000		0.000		0.000		0.000	
Valves - Butterfly Valve		0.000		0.000		0.000		1		0.293		0.293	
Spare 1													
Total K Values for Fittings		0.70		0.58		0.29		3.03					
INLET Reducer or Expander?		None		None		None		None					
Number of Reducer/Expander													
Pipe ID, mm													
Reducer/Expander ID, mm													
Angle of Divergence, θ													
INLET REDUCER/EXPANDER, Total K													
OUTLET Reducer or Expander?		None		None		None		None					
Number of Reducer/Expander													
Pipe ID, mm													
Reducer/Expander ID, mm													
Angle of Divergence, θ													
OUTLET REDUCER/EXPANDER, K													
Number of Orifice (Thin, Sharp)													
Orifice ID, mm													
Orifice K													
Is there an Entrance?		YES		NO		NO		NO					
Pipe Entrance, K		0.5		0		0		0					
Is there an Exit?		NO		NO		NO		YES					
Pipe Exit, K		0		0		0		1					
Sum of Other K Values													
Sum of Equiv Lengths of Other Equipment, m				38.52									
Age Factor		0%		0%		0%		0%					
Total K Value of System		1.27		4.84		0.68		4.64					
Equivalent Length of System, m		11.97		45.42		6.40		43.55					
PRESSURE LOSSES													
Line Frictional Pressure Drop, kPa		0.59		2.25		0.32		2.15					
Other Equipment P drop, kPa								100					
Control Valve Pressure Drop, kPa													
Or Known Cv Value													
Applied Control Valve Drop, kPa		0.00		0.00		0.00		0.00					
Total Losses (System Resistance), kPa		0.59		2.25		0.32		102.15					
Inlet Elevation, m													
Outlet Elevation, m													
Static Loss, kPa		0.00		0.00		0.00		0.00					
Outlet pressure, kPag		519.41		517.16		516.84		414.69					
TOTAL PRESSURE DROP, kPa		0.59		2.25		0.32		102.15					
Fluid Velocity, m/s		1.23		1.23		1.23		1.23					
Line Pressure Drop, kPa/100m		4.95		4.95		4.95		4.95					
Refer to "NOTES" Worksheet for all note details													
<small>This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.</small>													

CUSTOMER PROJECT SUBJECT PROJECT FILE LOCATION		Calculation Name <u>Line Sizing & Hydraulic Calculation (Gasoline)</u>											
		By / Date <u>CMC</u> <u>23-Aug-19</u>		Checked / Date <u>ADW/OH</u> <u>23-Aug-19</u>									
		Malaysia LNG Sdn Bhd		Project No. <u>412028-0005</u>									
		Provision of Engineering, Procurement, Construction and Commissioning for Gasoline and Natural Gas Liquid (NGL) Metering Skid Line Sizing & Hydraulic Calculation - Gasoline Case 1B: High N₂ Lean Gas Case, existing line size (NPS 80), maximum possible flow											
		Page <u>5</u> of <u>6</u>											
DESCRIPTION		1		2		3		4		5		6	
Pressure Drop Source		PIPING		PIPING		PIPING		PIPING					
From		S1		S2		S3		S4					
To		S2		S3		S4		S5					
Description		6"150# NGBE1		3"150# NGBE1		3"150# NGBE1		3"150# NGBE1					
CONDITIONS													
Inlet Pressure, kPag		300.00		305.51		294.85		292.58					
Temperature, °C		35.8		35.8		35.8		35.8					
Mass Flow Rate, kg/hr		26393		26393		26393		26393					
Design Margin		0%		0%		0%		0%					
Density @ PT, kg/m ³		625.0		625.0		625.0		625.0					
Density @ 15 °C, kg/m ³													
Viscosity, cP		0.22		0.22		0.22		0.22					
User Specified I.D. mm													
Nominal Pipe Size, mm		150		80		80		80					
Pipe Schedule		40		40		40		40					
VELOCITY													
Std. Volumetric Flow Rate, m ³ /hr													
Actual Volumetric Flow Rate, m ³ /hr		42.23		42.23		42.23		42.23					
Specific Gravity @ PT		0.625		0.625		0.625		0.625					
Pipe ID, mm		154.08		77.92		77.92		77.92					
Area, m ²		0.0186		0.0048		0.0048		0.0048					
Fluid Velocity, m/s		0.63		2.46		2.46		2.46					
FRICITION FACTOR													
Reynolds Number, Re		275403		544585		544585		544530					
Flow Regime		Turbulent Flow		Turbulent Flow		Turbulent Flow		Turbulent Flow					
Froude number		0.5		2.8		2.8		2.8					
Minimum Liquid Height, m		0.07		0.07		0.07		0.07					
Darcy Friction Factor Constant, α		2.027E+21		1.202E+21		1.202E+21		1.202E+21					
Darcy Friction Factor Constant, β		1.414E-14		2.588E-19		2.588E-19		2.592E-19					
Darcy Friction Factor, f(Darcy)		0.0174		0.0185		0.0185		0.0185					
Line Pressure Drop, kPa/100m		1.39		45.00		45.00		44.99					
Roughness Factor (epsilon), m		0.00005		0.00005		0.00005		0.00005					
Turbulent Friction Factor, f(turbulent)		0.0152		0.0177		0.0177		0.0177					
EQUIVALENT LENGTH													
Straight length, m		0.706		1.414		3.653		5.654					
Complexity Factor Applied		Two-K		Two-K		Two-K		Two-K					
K-Value Method		Two-K		Two-K		Two-K		Two-K					
Elbow - 90° - Threaded, Standard -r/D = 1		0.000		0.532		0.000		0.532					
Elbow - 90° - Threaded, Long Radius -r/D = 1.5		0.000		0.000		0.000		0.000					
Elbow - 90° - Flanged, Welded, LR -r/D = 1.5		0.000		0.000		0.000		0.000					
Elbow - 90° - Flanged, Welded, Bend -r/D = 1		0.000		0.000		0.000		0.000					
Elbow - 90° - Flanged, Welded, Bend -r/D = 2		0.000		0.000		0.000		0.000					
Elbow - 90° - Flanged, Welded, Bend -r/D = 4		0.000		0.000		0.000		0.000					
Elbow - 90° - Flanged, Welded, Bend -r/D = 6		0.000		0.000		0.000		0.000					
Elbow - 90° - Mitered, 1 Weld, 90°		0.000		0.000		0.000		0.000					
Elbow - 90° - Mitered, 2 Welds, 45°		0.000		0.000		0.000		0.000					
Elbow - 90° - Mitered, 3 Welds, 30°		0.000		0.000		0.000		0.000					
Elbow - 45° - Threaded, Standard -r/D = 1		0.000		0.000		0.000		0.000					
Elbow - 45° - Long Radius -r/D = 1		0.000		0.000		0.000		0.000					
Elbow - 45° - Long Radius -r/D = 1.5		0.000		0.000		0.000		0.000					
Elbow - 45° - Mitered, 1 Weld, 45°		0.000		0.000		0.000		0.000					
Elbow - 45° - Mitered, 2 Welds, 22.5°		0.000		0.000		0.000		0.000					
Elbows - 180° - Threaded, Closed Return -r/D = 1		0.000		0.000		0.000		0.000					
Elbows - 180° - Flanged -r/D = 1		0.000		0.000		0.000		0.000					
Elbows - 180° - All -r/D = 1.5		0.000		0.000		0.000		0.000					
Tees - Used as elbow		0.000		0.000		0.000		0.000					
Tees - Thru Branch Threaded -r/D = 1		1		0.701		0.000		0.000		3		2.390	
Tees - Thru Branch Threaded -r/D = 1.5		0.000		0.000		0.000		0.000					
Tees - Thru Branch Flanged -r/D = 1		0.000		0.000		0.000		0.000					
Tees - Thru Branch Stub-in Branch		0.000		0.000		0.000		0.000					
Tees - Run Thru Threaded -r/D = 1		0.000		0.000		1		0.133		0.000			
Tees - Run Thru Flanged -r/D = 1		0.000		0.000		0.000		0.000		0.000			
Tees - Run Thru Stub-in Branch		0.000		0.000		0.000		0.000		0.000			
Valves - Angle Valve - 45° - Full Line Size, d1=d2		0.000		0.000		0.000		0.000		0.000			
Valves - Angle Valve - 90° - Full Line Size, d1=d2		0.000		0.000		0.000		0.000		0.000			
Valves - Globe Valve - Standard, d1=d2		0.000		0.000		0.000		0.000		0.000			
Valves - Plug Valve - Branch Flow		0.000		0.000		0.000		0.000		0.000			
Valves - Plug Valve - Straight Through		0.000		0.000		0.000		0.000		0.000			
Valves - Plug Valve - Three-Way (flow through)		0.000		0.000		0.000		0.000		0.000			
Valves - Gate Valve - Standard, d1=d2		0.000		1		0.133		0.000		0.000			
Valves - Ball Valve - Standard, d1=d2		0.000		0.000		0.000		0.000		0.000			
Valves - Diaphragm Valve - Dam-Type		0.000		0.000		1		0.200		1		0.200	
Valves - Swing Check Valve		0.000		0.000		0.000		0.000		0.000			
Valves - Lift Check Valve		0.000		0.000		0.000		0.000		0.000			
Valves - Gate/Ball/Plug Valve - Reduced Bore (0.8)		0.000		0.000		0.000		0.000		0.000			
Valves - Butterfly Valve		0.000		0.000		0.000		0.000		1		0.333	
Spare 1													
Total K Values for Fittings		0.70		0.67		0.33		3.45					
INLET Reducer or Expander?		None		None		None		None					
Number of Reducer/Expander													
Pipe ID, mm													
Reducer/Expander ID, mm													
Angle of Divergence, θ													
INLET REDUCER/EXPANDER, Total K													
OUTLET Reducer or Expander?		Tapered Reducer		None		None		Tapered Expander					
Number of Reducer/Expander		1						1					
Pipe ID, mm		154						78					
Reducer/Expander ID, mm		80						150					
Angle of Divergence, θ		31.7						31.7					
OUTLET REDUCER/EXPANDER, K		2.67						0.38					
Number of Orifice (Thin, Sharp)													
Orifice ID, mm													
Orifice K													
Is there an Entrance?		YES		NO		NO		NO					
Pipe Entrance, K		0.5		0		0		0					
Is there an Exit?		NO		NO		NO		YES					
Pipe Exit, K		0		0		0		1					
Sum of Other K Values													
Sum of Equiv Lengths of Other Equipment, m				19.48									
Age Factor		0%		0%		0%		0%					
Total K Value of System		3.95		5.64		1.20		6.18					
Equivalent Length of System, m		35.06		23.89		5.05		25.99					
PRESSURE LOSSES													
Line Frictional Pressure Drop, kPa		0.49		10.66		2.27		11.69					
Other Equipment P drop, kPa								100					
Control Valve Pressure Drop, kPa													
Or Known Cv Value													
Applied Control Valve Drop, kPa		0.00		0.00		0.00		0.00					
Total Losses (System Resistance), kPa		0.49		10.66		2.27		111.69					
Inlet Elevation, m													
Outlet Elevation, m													
Static Loss, kPa		0.00		0.00		0.00		0.00					
Outlet pressure, kPag		305.51		294.85		292.58		180.88					
TOTAL PRESSURE DROP, kPa		0.49		10.66		2.27		111.69					
Fluid Velocity, m/s		0.63		2.46		2.46		2.46					
Line Pressure Drop, kPa/100m		1.39		45.00		45.00		44.99					
<p align="center">Refer to "NOTES" Worksheet for all note details</p>													

This Calculation represents the work of Worley/Parsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by Worley/Parsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither Worley/Parsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.

CUSTOMER PROJECT SUBJECT PROJECT FILE LOCATION		Calculation Name Line Sizing & Hydraulic Calculation (Gasoline)			
		By / Date CMC / 23-Aug-19		Checked / Date ADW/OH / 23-Aug-19	
		Malaysia LNG Sdn Bhd		Project No. 412028-0005	
Provision of Engineering, Procurement, Construction and Commissioning for Gasoline and Natural Gas Liquid (NGL) Metering Skid		Line Sizing & Hydraulic Calculation - Gasoline Case 3B: RGLA Case, existing line size (NPS 80), maximum possible flow			
		Page 6		of 6	

DESCRIPTION	1		2		3		4		5		6	
	PIPING		PIPING		PIPING		PIPING					
	Notes	S1	Notes	S2	Notes	S3	Notes	S4				
From To	S2	S3	S3	S4	S4	S5						
Description	6"150# NGBE1	3"150# NGBE1	3"150# NGBE1	3"150# NGBE1								
CONDITIONS												
Inlet Pressure, kPag	306.00	305.51		294.85		292.57						
Temperature, °C	35.8	35.8		35.8		35.8						
Mass Flow Rate, kg/hr	26182	26182		26182		26182						
Design Margin	0%	0%		0%		0%						
Density @ PT, kg/m³	613.0	613.0		613.0		613.0						
Density @ 15 °C, kg/m³												
Viscosity, cP	0.20	0.20		0.20		0.20						
User Specified I.D. mm												
Nominal Pipe Size, mm	150	80		80		80						
Pipe Schedule	40	40		40		40						
VELOCITY												
Std. Volumetric Flow Rate, m³/hr												
Actual Volumetric Flow Rate, m³/hr	42.72	42.72		42.72		42.71						
Specific Gravity @ PT	0.613	0.613		0.613		0.613						
Pipe ID, mm	154.08	77.92		77.92		77.92						
Area, m²	0.0186	0.0048		0.0048		0.0048						
Fluid Velocity, m/s	0.64	2.49		2.49		2.49						
FRICTION FACTOR												
Reynolds Number, Re	300522	594257		594257		594203						
Flow Regime	Turbulent Flow	Turbulent Flow		Turbulent Flow		Turbulent Flow						
Froude number	0.5	2.8		2.8		2.8						
Minimum Liquid Height, m	0.07	0.07		0.07		0.07						
Darcy Friction Factor Constant, α	2.161E+21	1.235E+21		1.235E+21		1.235E+21						
Darcy Friction Factor Constant, β	3.500E-15	6.404E-20		6.404E-20		6.414E-20						
Darcy Friction Factor, f(Darcy)	0.0172	0.0185		0.0185		0.0185						
Line Pressure Drop, kPa/100m	1.39	45.00		45.00		44.99						
Roughness Factor (epsilon), m	0.00005	0.00005		0.00005		0.00005						
Turbulent Friction Factor, f(turbulent)	0.0152	0.0177		0.0177		0.0177						
EQUIVALENT LENGTH												
Straight length, m	0.706	1.414		3.653		5.654						
Complexity Factor Applied												
K-Value Method	Two-K	Two-K		Two-K		Two-K						
Elbow - 90°- Threaded, Standard -r/D = 1	0.000	1	0.532	0.000	1	0.532						
Elbow - 90°- Threaded, Long Radius -r/D = 1.5	0.000		0.000	0.000		0.000						
Elbow - 90°- Flanged, Welded, LR -r/D = 1.5	0.000		0.000	0.000		0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 1	0.000		0.000	0.000		0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 2	0.000		0.000	0.000		0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 4	0.000		0.000	0.000		0.000						
Elbow - 90°- Flanged, Welded, Bend -r/D = 6	0.000		0.000	0.000		0.000						
Elbow - 90°- Mitered, 1 Weld, 90°	0.000		0.000	0.000		0.000						
Elbow - 90°- Mitered, 2 Welds, 45°	0.000		0.000	0.000		0.000						
Elbow - 90°- Mitered, 3 Welds, 30°	0.000		0.000	0.000		0.000						
Elbow - 45°- Threaded, Standard -r/D = 1	0.000		0.000	0.000		0.000						
Elbow - 45°- Long Radius -r/D = 1	0.000		0.000	0.000		0.000						
Elbow - 45°- Long Radius -r/D = 1.5	0.000		0.000	0.000		0.000						
Elbow - 45°- Mitered, 1 Weld, 45°	0.000		0.000	0.000		0.000						
Elbow - 45°- Mitered, 2 Welds, 22.5°	0.000		0.000	0.000		0.000						
Elbows - 180°- Threaded, Closed Return -r/D = 1	0.000		0.000	0.000		0.000						
Elbows - 180°- Flanged -r/D = 1	0.000		0.000	0.000		0.000						
Elbows - 180°- All -r/D = 1.5	0.000		0.000	0.000		0.000						
Tees - Used as elbow	0.000		0.000	0.000		0.000						
Tees - Thru Branch Threaded -r/D = 1	1	0.701	0.000	0.000	3	2.389						
Tees - Thru Branch Threaded -r/D = 1.5		0.000	0.000	0.000		0.000						
Tees - Thru Branch Flanged -r/D = 1		0.000	0.000	0.000		0.000						
Tees - Thru Branch Stub-in Branch		0.000	0.000	0.000		0.000						
Tees - Run Thru Threaded -r/D = 1		0.000	0.000	0.133		0.000						
Tees - Run Thru Flanged -r/D = 1		0.000	0.000	0.000		0.000						
Tees - Run Thru Stub-in Branch		0.000	0.000	0.000		0.000						
Valves - Angle Valve - 45°- Full Line Size, d1=d2		0.000	0.000	0.000		0.000						
Valves - Angle Valve - 90°- Full Line Size, d1=d2		0.000	0.000	0.000		0.000						
Valves - Globe Valve - Standard, d1=d2		0.000	0.000	0.000		0.000						
Valves - Plug Valve - Branch Flow		0.000	0.000	0.000		0.000						
Valves - Plug Valve - Straight Through		0.000	0.000	0.000		0.000						
Valves - Plug Valve - Three-Way (flow through)		0.000	0.000	0.000		0.000						
Valves - Gate Valve - Standard, d1=d2		0.000	1	0.133		0.000						
Valves - Ball Valve - Standard, d1=d2		0.000	0.000	1		0.200	1					
Valves - Diaphragm Valve - Dam-Type		0.000	0.000	0.000		0.000						
Valves - Swing Check Valve		0.000	0.000	0.000		0.000						
Valves - Lift Check Valve		0.000	0.000	0.000		0.000						
Valves - Gate/Ball/Plug Valve - Reduced Bore (0.8)		0.000	0.000	0.000		0.000						
Valves - Butterfly Valve		0.000	0.000	0.000		0.000	1					
Spares												
Total K Values for Fittings		0.70	0.66	0.33		3.45						
INLET Reducer or Expander?		None	None	None		None						
Number of Reducer/Expander												
Pipe ID, mm												
Reducer/Expander ID, mm												
Angle of Divergence, θ												
INLET REDUCER/EXPANDER, Total K												
OUTLET Reducer or Expander?		Tapered Reducer	None	None		Tapered Expander						
Number of Reducer/Expander		1				1						
Pipe ID, mm		154				78						
Reducer/Expander ID, mm		80				150						
Angle of Divergence, θ		31.7				31.7						
OUTLET REDUCER/EXPANDER, K		2.67				0.38						
Number of Orifice (Thin, Sharp)												
Orifice ID, mm												
Orifice K												
Is there an Entrance?		YES	NO	NO		NO						
Pipe Entrance, K		0.5	0	0		0						
Is there an Exit?		NO	NO	NO		YES						
Pipe Exit, K		0	0	0		1						
Sum of Other K Values												
Sum of Equiv Lengths of Other Equipment, m			19.48									
Age Factor		0%	0%	0%		0%						
Total K Value of System		3.95	5.62	1.20		6.18						
Equiv Length of System, m		35.33	23.70	5.06		26.06						
PRESSURE LOSSES												
Line Frictional Pressure Drop, kPa		0.49	10.66	2.28		11.72						
Other Equipment P drop, kPa						100						
Control Valve Pressure Drop, kPa												
Or Known Cv Value												
Applied Control Valve Drop, kPa		0.00	0.00	0.00		0.00						
Total Losses (System Resistance), kPa		0.49	10.66	2.28		111.72						
Inlet Elevation, m												
Outlet Elevation, m												
Static Loss, kPa		0.00	0.00	0.00		0.00						
Outlet pressure, kPag		305.51	294.85	292.57		180.85						
TOTAL PRESSURE DROP, kPa		0.49	10.66	2.28		111.72						
Fluid Velocity, m/s		0.64	2.49	2.49		2.49						
Line Pressure Drop, kPa/100m		1.39	45.00	45.00		44.99						

Refer to "NOTES" Worksheet for all note details

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Customer	Malaysia LNG Sdn Bhd	Proj No	412028-00005
Project Title	Provision of Detailed Design Engineering Services for Gasoline and Natural Gas Liquid (NGL) Metering Skid	Calc No	412028-00005-00-PR-CAL-0001
Calculation Title	Hydraulic Calculation and Line Sizing Adequacy Check for Gasoline Metering Skid	Phase/CTR	Detailed Design
Elec File Location	\\Mymirwpfil01\data\Projects\412028-00005 MLNG METER-SKID\04_Process\1_Latest\2_Engineering\5_Calculations\CAL-0001 Hydraulic Cal Gasoline\Rev.A IFC\412028-00005-00-PR-CAL-0001 (Rev.A IFC).xlsx		

Appendix B

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked
A	23.08.2019	CMC	ADW/OH								

Appendix B
Piping Specification - NGBE1
Page 15

TABLE OF SCHEDULES

BRANCH CONNECTIONS 90 DEGREES

RUN SIZE	BRANCH SIZE												
	15	20	25	40	50	80	100	150	200	250	350	450	600
600	-	-	C	C	D	D	D	D	D	E	B	B	B
500	-	-	C	C	D	D	D	D	D	B	B	B	B
450	-	-	C	C	D	D	D	D	D	B	B	B	B
400	-	-	C	C	D	D	D	D	D	B	B	B	B
350	-	-	C	C	D	D	D	D	D	B	B	B	B
300	-	-	C	C	D	D	D	D	D	B	B	B	B
250	-	-	C	C	D	D	D	D	D	B	B	B	B
200	-	-	C	C	D	D	D	D	B	B	B	B	B
150	-	-	C	C	D	D	B	B	B	B	B	B	B
100	-	-	C	C	B	B	B	B	B	B	B	B	B
80	-	-	C	C	B	B	B	B	B	B	B	B	B
50	-	-	C	C	B	B	B	B	B	B	B	B	B
40	-	-	C	C	B	B	B	B	B	B	B	B	B
25	-	-	B	B	B	B	B	B	B	B	B	B	B
20	-	-	B	B	B	B	B	B	B	B	B	B	B
15	-	-	B	B	B	B	B	B	B	B	B	B	B

CODE EXPLANATION OF CHARACTERS

- A EQUAL TEE
- B REDUCING TEE
- C BRANCH NIPPLE PLAIN
- D OUTLET (WELDOLET)
- E REDUCING TEE + REDUCER

DESIGN LIMITS

TEMPERATURE IN DEGREES CELSIUS	-50		0		50		100		150		200	
	102.0	102.0	100.0	100.0	92.7	90.6	88.9	87.7	80.6	78.9	77.2	75.5
DN15 - 600	102.0	102.0	100.0	100.0	92.7	90.6	88.9	87.7	80.6	78.9	77.2	75.5

PRESSURE BAR GA

- FOR BALL V.
- DN15 - 25 68.0 68.0 68.0 47.0 29.0 18.2 -
- DN40 - 50 50.0 50.0 49.0 47.0 29.0 18.2 -
- NOTES
- DESIGN LIMITS ARE ACC. FLANGE RATING ANSI B16.5 MAT. GRP. 1.1
- AND BALL VALVE RATING ACC. BS5351.
- MAX. CONTINUOUS SERVICE TEMP. FOR BALL VALVE IS 180°C.
- LIFTED TYPE CHECK VALVE (DN15-40). FOR HORIZONTAL MOUNTING ONLY.
- FOR BENDING OF PIPE SEE DRP 31.38.01.31-GEN. (PAR. 3.3).

DOC. NO. : S-00-1360-001
REV. NO. : C
SHEET NO. : 148 OF 348

MATERIAL	: LT CARBON STEEL
CLASS	: NGCE6
RATING	: CL. 600
CA	: 1.5mm
NEW LETTERS	: C



Customer	Malaysia LNG Sdn Bhd	Proj No	412028-00005
Project Title	Provision of Detailed Design Engineering Services for Gasoline and Natural Gas Liquid (NGL) Metering Skid	Calc No	412028-00005-00-PR-CAL-0001
Calculation Title	Hydraulic Calculation and Line Sizing Adequacy Check for Gasoline Metering Skid	Phase/CTR	Detailed Design
Elec File Location	\\Mymirwpfil01v\data\Projects\412028-00005 MLNG METER-SKID\04_Process\1_Latest\2_Engineering\5_Calculations\CAL-0001 Hydraulic Cal Gasoline\Rev.A IFC\412028-00005-00-PR-CAL-0001 (Rev.A IFC).xlsx		

Appendix C

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked
A	23.08.2019	CMC	ADW/OH								

Appendix C
P&ID and Isometric Drawing
Page 17



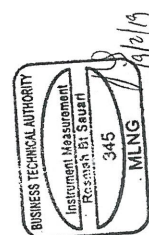
1. NEW FIELD INSTRUMENT.
2. EXISTING MOTOR OPERATED VALVE (MOPV) REPLACED WITH DOUBLE BLOCK & BLEED VALVE (DBBV).
3. EXISTING CONTROL VALVE REPLACED WITH PPE SPOOL.
4. EXISTING MANUAL GATE VALVE REPLACED WITH MANUAL DOUBLE BLOCK AND BLEED VALVE (DBBV).
5. INSTRUMENT TO BE PRESERVE AND REMAINSTE ONCE BOLTING AND GASKET REPLACED.
6. NEW MANUAL ISOLATION VALVE INSTALLED WITH RATED BUNG FLANGE.
7. NEW MANUAL DOUBLE BLOCK AND BLEED VALVE (DBBV).
8. EXISTING CHECK VALVE AND MANUAL BUTTERFLY REPLACE NEW.
9. N2 CONNECTION MANIFOLD FOR MAINTENANCE.
10. TO MAINTAIN EXISTING LOCATION OF INSTRUMENTS DUE TO UTILIZING EXISTING INSTRUMENT CABLE.

REFERENCE DRAWINGS 1.-	DRAWING NO.	DESCRIPTIONS
	1.T.1.5.19.6/22	PEFS LIGHT GASOLINE STORAGE AND HANDLING
		INCORPORATED WITH DIESEL FIRING FOR HP
		BOILER UNIT 3200
	1.T.11.500.4/05	REV. G. PEFS TYPICAL ARRANGEMENT FLANGE
		CONNECTION DETAILS.

[illegible]

AS-BUILT

OWNER :	MLNG DUA	CUSTOMER :	JCC-KELLOGG JOINT VENTURE
PLANT LOCATION :	BINTULLU, SARAWAK, MALAYSIA	PROJECT TITLE :	GASOLINE METERING SYSTEM
OWNER DOC. NO. :	1.2.724.712	DRAWING TITLE :	GASOLINE METERING SYSTEM (P&I DIAGRAM)
JV DOC. NO. :	V-2170-018-A-202	QUOTE NO. :	BRQ-93-WAL001/7N
JV JOB NO. :	0-7800	UNIT NO. :	TBA
		FILE NAME :	LNC2022
		DRAWING NO. :	LNC-1/202



LEGEND

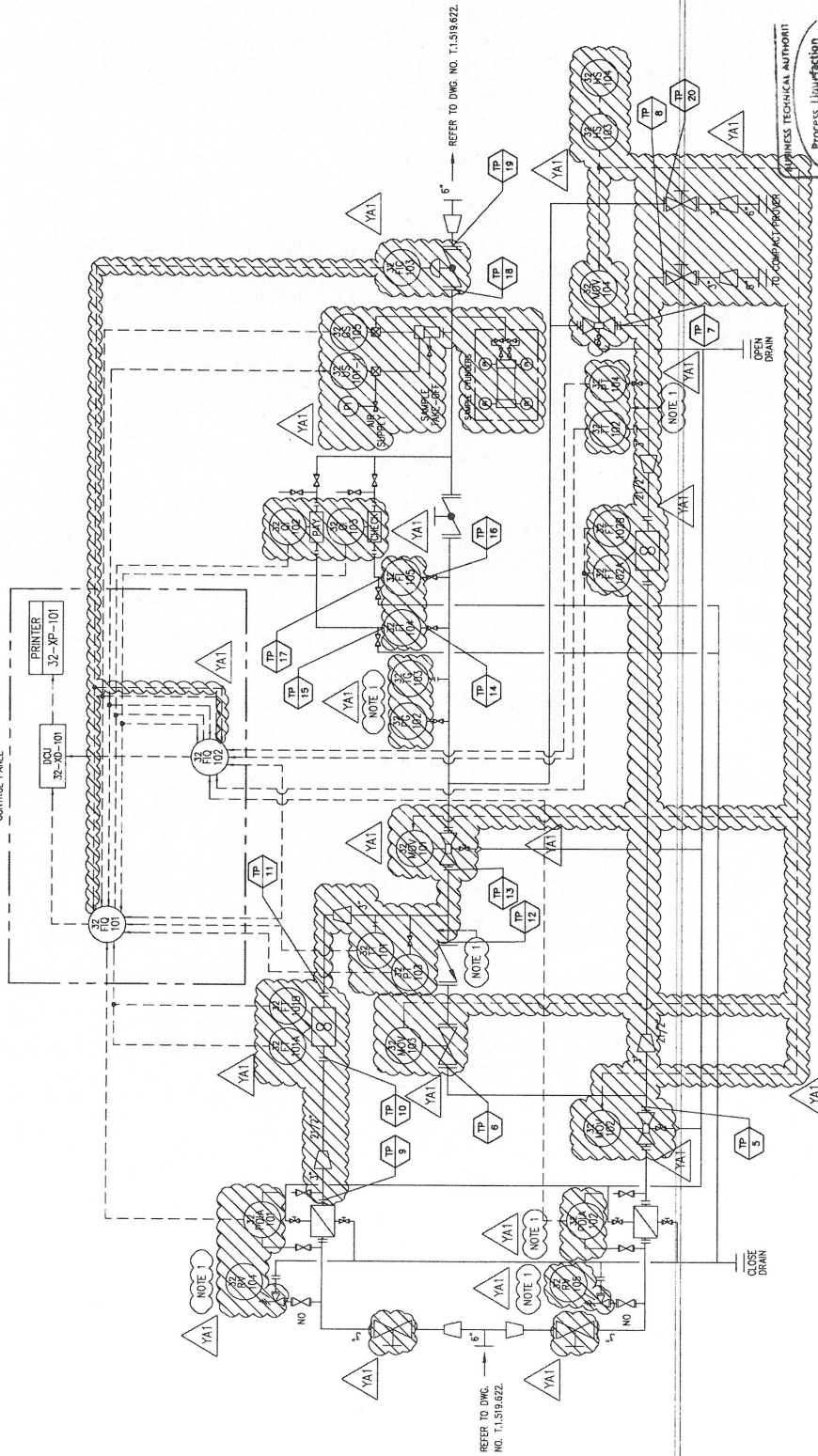
☁ DENOTES SCOPE OF WORK UNDER PC-20278

GENERAL NOTES

1. FIELD INSTRUMENT TO BE DISCONNECT AND REMOVE DUE TO BULBING AND GASKET REPLACEMENT.

Y/A1

CONTROL PANEL



REFER TO DWG. NO. T.1.519.822.

REFER TO DWG. NO. T.1.519.822.

REVISION	DESCRIPTION
1	ISSUED FOR APPROVAL (PC-20278)
2	INCORPORATED WITH DIESEL FIRING FOR UP
3	ROILER UNIT, 2000

10/2/21

NO.	DATE	BY	CHKD.	APPD.	REVISION
1	10/09/21	MLNG	MLNG	MLNG	1
2	10/09/21	MLNG	MLNG	MLNG	2
3	10/09/21	MLNG	MLNG	MLNG	3
4	10/09/21	MLNG	MLNG	MLNG	4
5	10/09/21	MLNG	MLNG	MLNG	5
6	10/09/21	MLNG	MLNG	MLNG	6
7	10/09/21	MLNG	MLNG	MLNG	7
8	10/09/21	MLNG	MLNG	MLNG	8
9	10/09/21	MLNG	MLNG	MLNG	9
10	10/09/21	MLNG	MLNG	MLNG	10
11	10/09/21	MLNG	MLNG	MLNG	11
12	10/09/21	MLNG	MLNG	MLNG	12
13	10/09/21	MLNG	MLNG	MLNG	13
14	10/09/21	MLNG	MLNG	MLNG	14
15	10/09/21	MLNG	MLNG	MLNG	15
16	10/09/21	MLNG	MLNG	MLNG	16
17	10/09/21	MLNG	MLNG	MLNG	17
18	10/09/21	MLNG	MLNG	MLNG	18
19	10/09/21	MLNG	MLNG	MLNG	19
20	10/09/21	MLNG	MLNG	MLNG	20

MLNG DUA SDN BHD
BINTULU SARAWAK
MALAYSIA

PROJECT TITLE :
GASOLINE METERING SYSTEM

DRAWING NO. :
P-B-2170-018-A

QUOTE NO. :
BRQ-93-MAL001/TN

FILE NAME :
LNG-2022

UNIT NO. :
TBA

AS-BUILT

ROSEMOUNT (SINGAPORE) PTE. LTD.

CUSTOMER :
JGC-KELLOGG JOINT VENTURE

PROJECT TITLE :
GASOLINE METERING SYSTEM

DRAWING TITLE :
GASOLINE METERING SYSTEM (P&I DIAGRAM)

QUOTE NO. :
P-B-2170-018-A

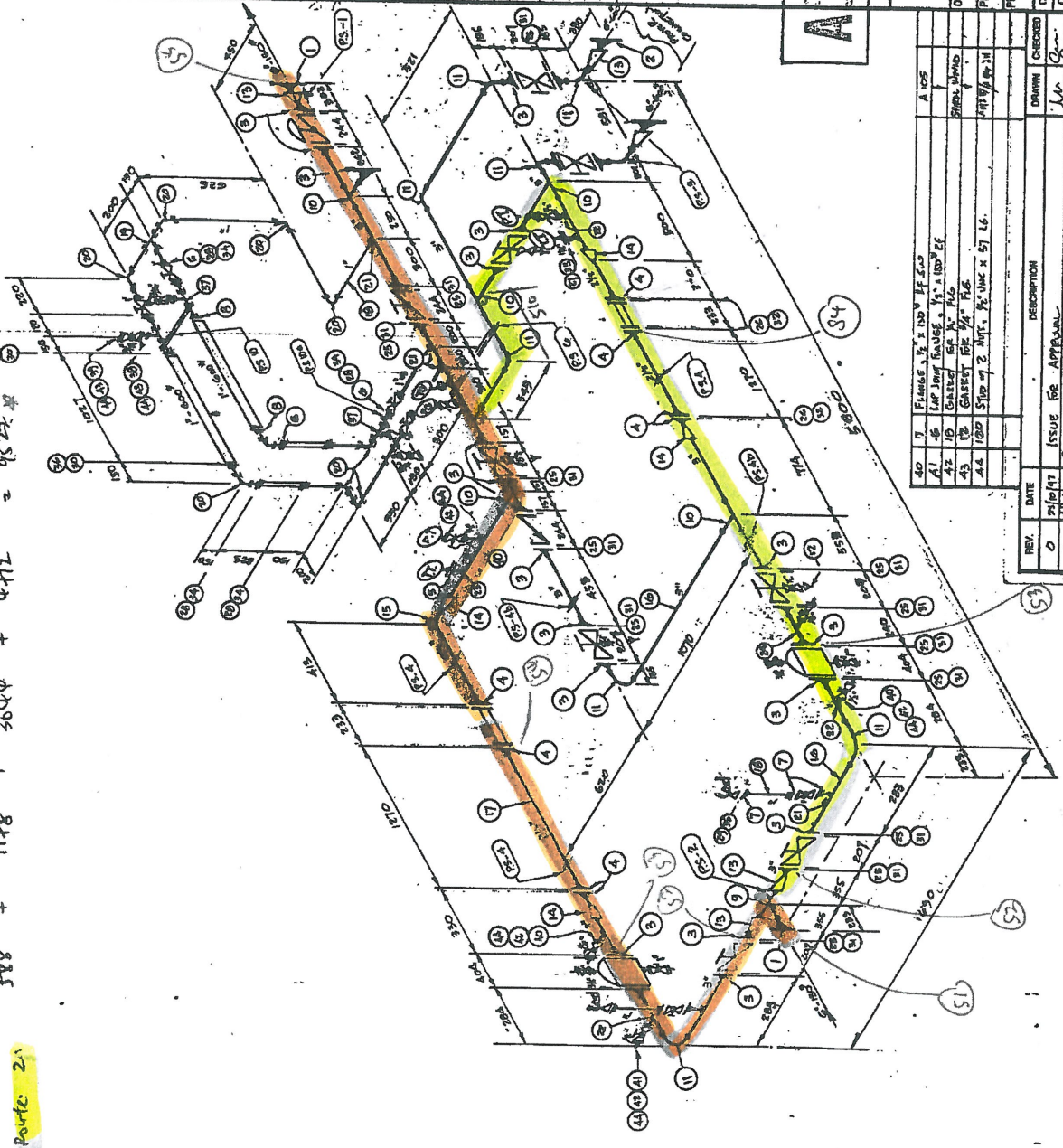
FILE NAME :
LNG-1/202

UNIT NO. :
TBA

LEGEND
DENOTES REMOVAL SCOPE OF WORK UNDER PC-20278
DENOTES SCOPE OF WORK UNDER PC-20278

588 + 1128 + 1600 + 3866 = 7232
 588 + 1128 + 3044 + 4712 = 9522

Part 2



MATERIAL LIST

ITEM	QTY	DESCRIPTION	MATERIAL	REMARK
1	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
2	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
3	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
4	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
5	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
6	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
7	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
8	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
9	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
10	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
11	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
12	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
13	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
14	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
15	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
16	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
17	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
18	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
19	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
20	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
21	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
22	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
23	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
24	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
25	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
26	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
27	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
28	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
29	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
30	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
31	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
32	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
33	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
34	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
35	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
36	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
37	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
38	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
39	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	
40	2	FLANGE, 6" - 150# RFWD, SCH 40	A 105	

ACE PRESSUREWELD INT'L. (PTE.) LTD.
 31, SENOKO LANE, SINGAPORE 278, TEL: 257181
 FAX NO: 786701 TELEX: APR1 RS 24194 CABLE: "ACEWELD SINGAPORE"

OWNER MLNG DUA
PROJECT MLNG DUA PLANT PROJECT
PLANT LOCATION Bintulu, Sarawak, Malaysia

DOCUMENT NO. JV 200 CODE NO. 0-7800
DRAWING NO. PB-2170-018 A
Scale:

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TITLE PIPING ISOMETRIC FOR METERING SYSTEM

REV.	DATE	DESCRIPTION	DRAWN	CHECKED
0	21/01/94	ISSUE FOR APPROVAL	[Signature]	[Signature]
1	21/01/94	REVISION AS PER COMMENT	[Signature]	[Signature]
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Customer	Malaysia LNG Sdn Bhd	Proj No	412028-00005
Project Title	Provision of Detailed Design Engineering Services for Gasoline and Natural Gas Liquid (NGL) Metering Skid	Calc No	412028-00005-00-PR-CAL-0001
Calculation Title	Hydraulic Calculation and Line Sizing Adequacy Check for Gasoline Metering Skid	Phase/CTR	Detailed Design
Elec File Location	\\Mymirwpl01v\data\Projects\412028-00005 MLNG METER-SKID\04_Process\1_Latest\2_Engineering\5_Calculations\CAL-0001 Hydraulic Cal Gasoline\Rev.A IFC\412028-00005-00-PR-CAL-0001 (Rev.A IFC).xlsx		

Appendix D

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked
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Appendix D
Pages from Technical Standards
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Pages from PTS 12.30.02, December 2017, Piping General

Service	Line Size, DN	Maximum Velocity, m/s	Pressure Drop	
			Normal (kPa/100m)	Maximum (kPa/100m)
Pump Discharge, P ≤ 50 barg	DN ≤ 200	2.5	35	45
	250 ≤ DN ≤ 300	3.0		
	350 ≤ DN ≤ 400	3.5		
Pump Discharge, P > 50 barg	450 ≤ DN ≤ 600	4 (Note 3)	70	90
Reciprocating Pump Suction		1		
Discharge		2		
Gravity flow		0.6	2.5	4.5
Thermosiphon reboiler (Note 5)			2	4
Side-stream draw-off (Note 2)	DN ≤ 50	0.6	6	9
	DN ≥ 80	0.9	6	9
Kerosene jet fuel		(Note 4)		
Rich amine Carbon steel		1.5		
Caustic soda		2.0		
Acid (H ₂ SO ₄) (Note 8)		0.75 (Note 8)		
Lean Amine		2.5		
Stripped sour water		3.0		
Sour water		2.0		
Cooling water Service water		3.0	15 (Note 6) 23 (Note 7)	35 (Note 7)
Demin water, desalinated water, service water, potable water		4	35	45

Notes:

1. Applicable to liquid containing dissolved gas
2. Provide a vertical pipe run of 3 meters minimum from nozzle, same as nozzle size, before reducing the size of the line

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Service	Pressure (barg)	Line Size, DN	Max Velocity (m/s)	Maximum (ρv^2 , kg/ms ²)	Pressure Drop	
					Normal (kPa/100m)	Maximum (kPa/100m)
	-	DN \geq 80	30	15000 (Note 2)	-	
Steam, superheated	-	DN \leq 15	15	15000 (Note 2)	-	Note 1
	-	80 \leq DN \leq 200	40	15000 (Note 2)	-	
	-	DN \geq 250	60	15000 (Note 2)	-	
Vacuum Pipe	-	-	90	-	-	-

Note:

- Maximum allowable pressure drop for steam lines (continuous operation):
 - Pressure below 10 barg: 0.24 bar/km (long headers) / 0.92 bar/km (short headers)
 - Pressure below or above 10 barg: 0.92 (long headers) / 2.30 bar/km (short headers)
 Limits may be relaxed when sufficient pressure drop is available (e.g. steam let down stations).
 For intermittent operation, the limits may be exceeded on a case to case basis.
- ρv^2 limit of 15 000 kg/ms² can be increased to 25 000 kg/ms² for steam let down stations.
- Indicative value. Do not exceed 10 000 kg/ms²
- Compressor vendor requirements, if any, shall prevail

FIV is more predominant in turbulent flow regime piping systems. This type of vibration leads to displacement of piping system and might lead to damage to pipe support. Table below shall be followed for the susceptibility to failure of piping systems due to FIV.

Fluid	Negligible	Medium	High
Liquid and multi-phase	$\rho v^2 < 10000 \text{ kg/ms}^2$	$10000 \text{ kg/ms}^2 < \rho v^2 \leq 20000 \text{ kg/ms}^2$	$\rho v^2 \geq 20000 \text{ kg/ms}^2$
Gas	$\rho v^2 < 10000 \text{ kg/ms}^2$ or $\rho v^2 < \frac{10000 \text{ kg}}{\sqrt{\frac{\mu_{gas}}{1.10^{-6}}}} \frac{kg}{ms^2}$	-	$\rho v^2 \geq 10000 \text{ kg/ms}^2$ or $\rho v^2 \geq \frac{10000 \text{ kg}}{\sqrt{\frac{\mu_{gas}}{1.10^{-6}}}} \frac{kg}{ms^2}$

- 1.1.5 For GRE / FRP pipe systems, the linear velocity for continuous service of liquids (normal flow of water / other liquids) should not exceed the limits 2 and 4 m/s respectively.

Type of valve/fitting			*L _e (m)
	Check valve	Swing type	40 D
		Ball or piston type, DN 40 and smaller	110 D
		Dual plate type	50D
	Plug valve	Regular pattern	60 D
	Butterfly valve	Concentric type	25 D
		Double offset type	50D
		Triple offsite type	60D
	Tee-equal	Flow straight through	20 D
Fittings	Elbow	Flow through side outlet	65 D
		90°, R = 1 1/2 D	20 D
	Bend	45°, R = 1 1/2 D	16 D
		90°, R = 4 D	14 D
		90°, R = 5 D	16 D
		180°, R = 4 D	25 D
	Enlargement	180°, R = 5 D	28 D
		Sudden, d/D = ¼	73D
		Sudden, d/D = ½	47D
		Sudden, d/D = ¾	16D
		Standard reducer, d/D = ½	35D
		Standard reducer, d/D = ¾	10D
	Contraction	Sudden, d/D = ¼	40D
		Sudden, d/D = ½	32D
		Sudden, d/D = ¾	20D
		Standard reducer, d/D = ½	16D
		Standard reducer, d/D = ¾	5D
Miscellaneous	Strainer	Pump suction Y-type and bucket type	250 D
	Nozzle	Product outlet nozzle vessel/tank	32 D
		Product inlet nozzle vessel/tank	64 D

* The Manufacturer's data shall be obtained in critical situations.

- iii. The Manufacturer's data shall be referred to determine the pressure drop of in-line instruments, such as vortex or Coriolis flow meters.
- iv. Data from equipment Manufacturer shall be referred to determine the pressure drop of equipment.

General equation for pressure drop calculation

- i. The pressure drop for a piping system is given by the equation:

$$\Delta p = \lambda \left(\frac{L p v^2}{2 d_i} \right) \quad (3)$$

in which: Δp = pressure drop (N/m²)

λ = friction factor (which depends on the Reynolds number and the roughness factor, ϵ ; λ and ϵ can be found in Appendix 4.

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				Appendix E			
Rev	Date	By	Checked	Rev	Date	By	Checked
A	23.08.2019	CMC	ADW/OH				

Appendix E
Gasoline Properties
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Pages from PC20278-PDD2-PRO-DES-002 Rev 0, PC20278: Process Instrument Datasheet.


	PC 20278 – MLNG DUA Gasoline Metering Upgrade	Title: PC20278: Process Instrument Datasheet
		Document No: PC 20278-PDD2-PRO-DES-002
		Revision : 0 Pages : 5 of 5

Table B: Gasoline Composition (derived using DUA Rating Model, using Feed Gas Compositions from MDD Process Design Basis Document BTU.2.90.1011)

	Component	AGAA	RGLA	High N ₂ Lean Gas
Gasoline Composition (mol%)	C3	0.0000022877	0.0000518276	0.0000000073
	IC4	0.0677281809	0.1384462838	0.0022783803
	NC4	0.2788227913	0.3278875781	0.0978265318
	iC5	0.2342365577	0.1864439962	0.2802974266
	nC5	0.1597772365	0.1067254860	0.2360400633
	nC6	0.1813026838	0.0799687419	0.2678965168
	nC7	0.0549250019	0.1337754473	0.0946539180
	Benzene	0.0136978931	0.0128586881	0.0131068032
	Toluene	0.0095073672	0.0138419510	0.0079003526
Properties	Viscosity (cP)	0.21	0.20	0.22
	Vapour Pressure (bara)	1.69	2.08	1.05
	Density (kg/m ³)	617	613	625
	Mol. Wt.	72	71	77

References:

1. BTU.2.90.0718 Unit-2500 Stabilization Unit Process Flow Scheme Average Gas Average Ambient (AGAA) Case
2. BTU.2.90.0719 Unit-2500 Stabilization Unit Process Flow Scheme Rich Gas Lean Ambient (RGLA) Case
3. BTU.2.90.1011 MDD Process Design Basis