Predictive Assessment on Fluid-Hammer Effect in Piping Networks of LNG Regasification System

International Research Experience For Students (IRES)

Programme 2021

Big Data in Energy & Related Infrastructure

Presentation Outline

Background of research

Problem Statement

Research Methodology

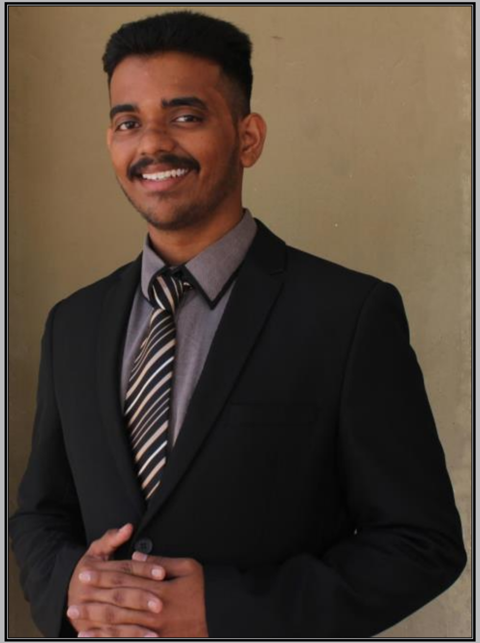
Results & Discussion

Limitations

Conclusion & Future Research

Group Members

UNIVERSITI TEKNOLOGI PETRONAS



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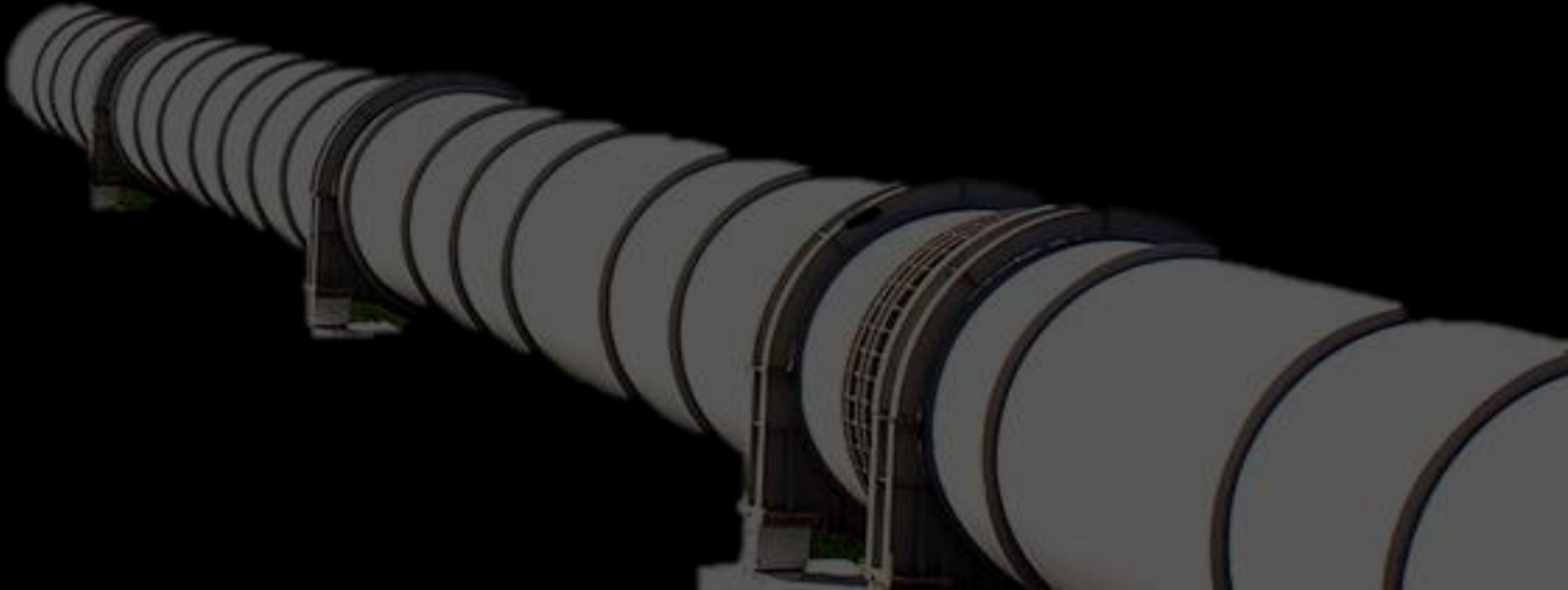
BACKGROUND OF RESEARCH



Offshore Drilling Overview

Offshore Drilling in Malaysia

Peninsular Malaysia:
The Malay Basin
Sarawak Basin, Sabah Basin (MPRC, 2020)

Gas Fields

One of the key gas producers in the Asia-Pacific region

Source: GIPHY

Offshore Drilling in U.S

Central & Western Gulf of Mexico (Worldometer, 2020)

Gas Fields

One of the highest gas producing country in the world

Overview of LNG Operation

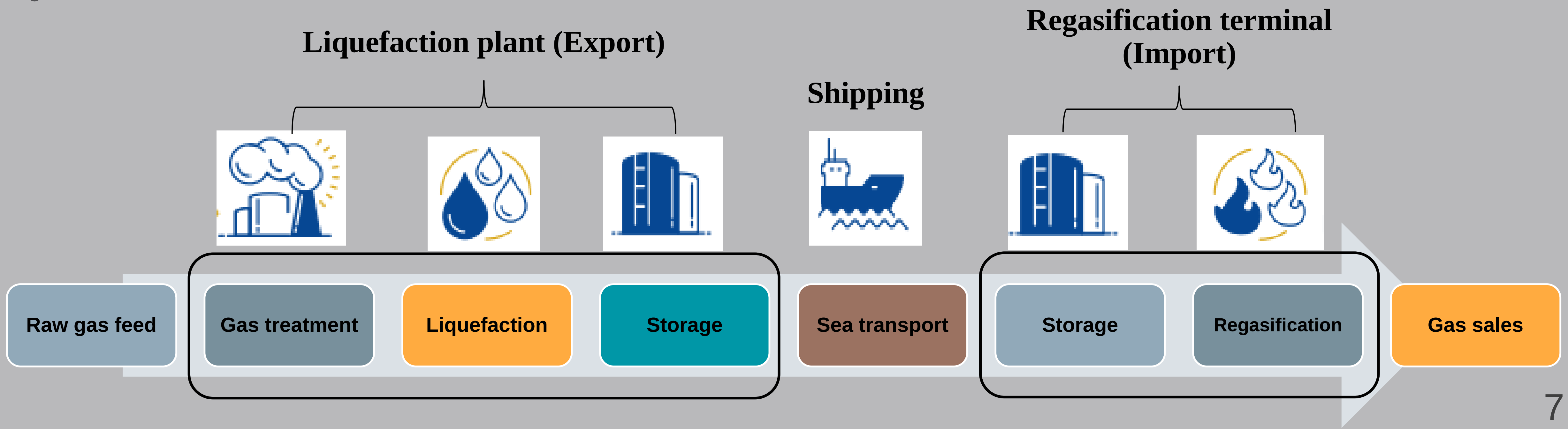
What is LNG?

Why is the LNG operation done?

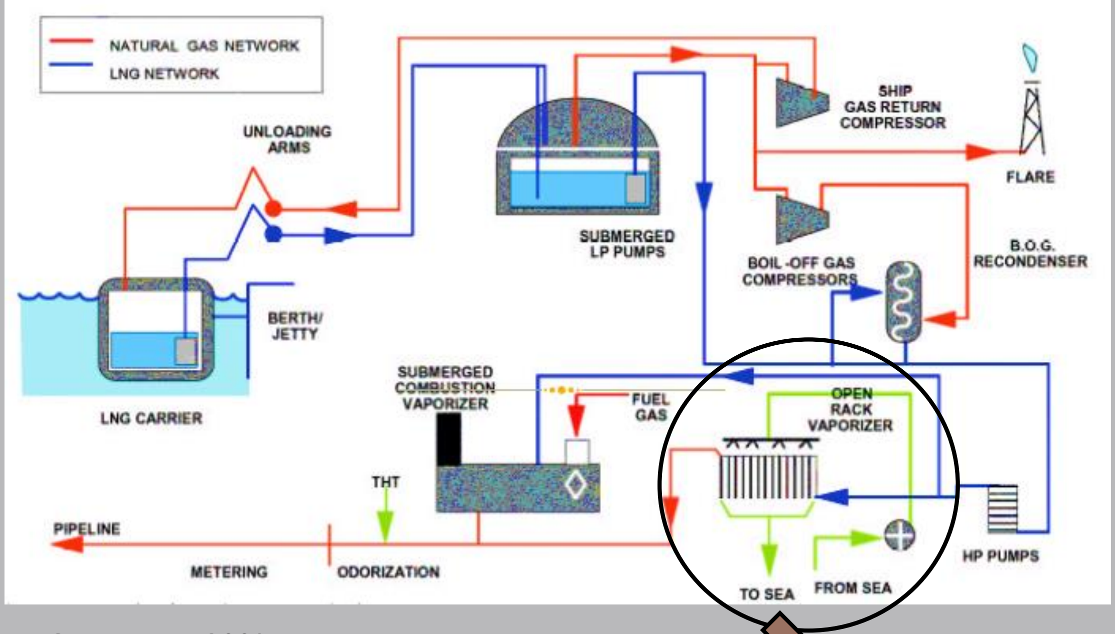
How is the LNG processed?

What is the final stage of this process?

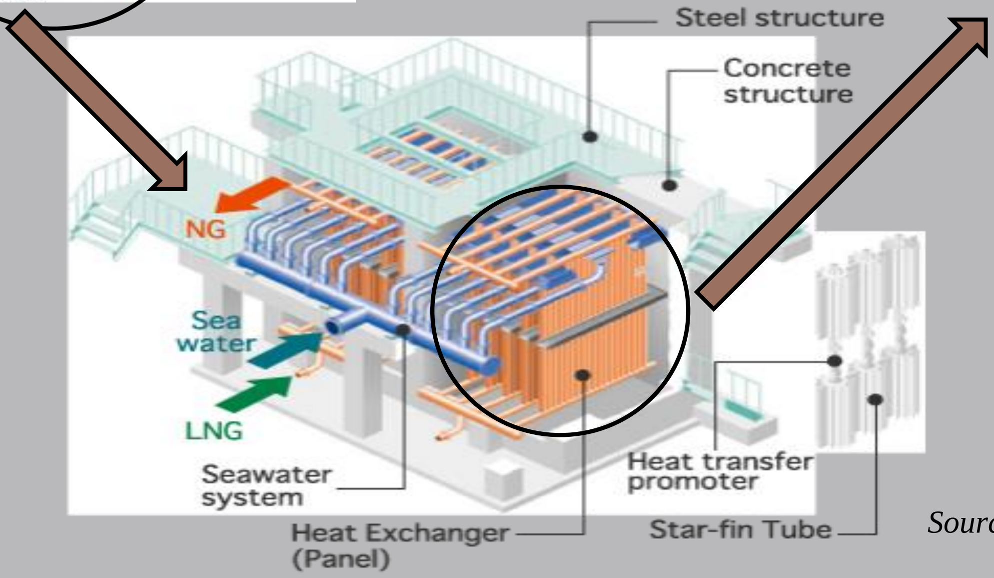
LNG Process Chain



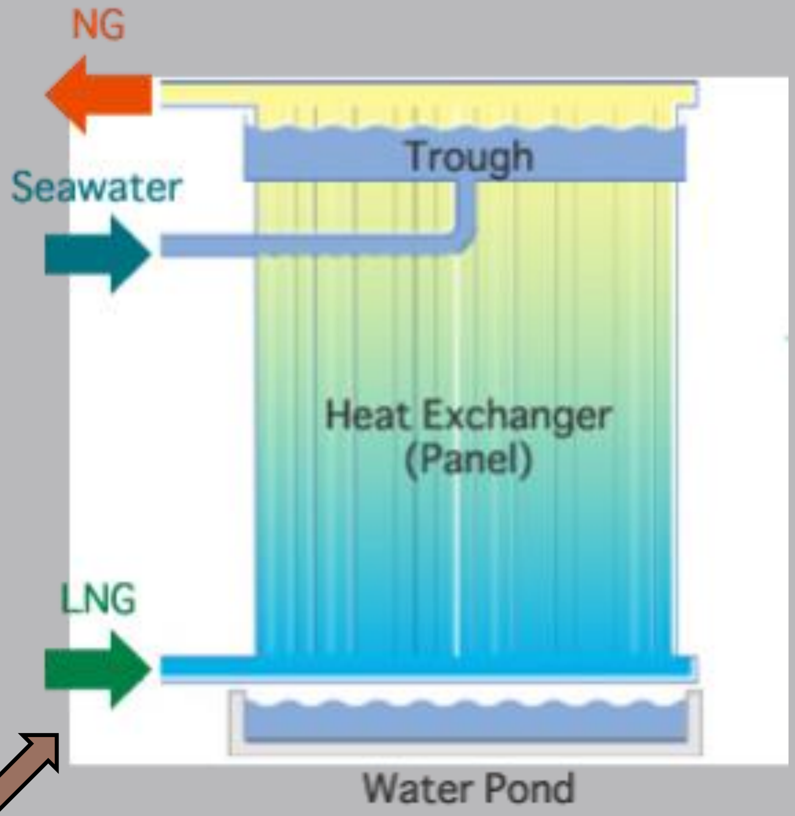
LNG Import Terminal Process



Source: BV 2009



Source: TOKYO Gas

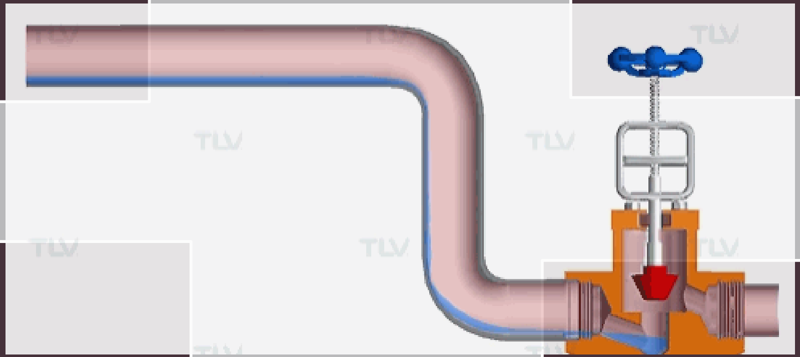


Source: TOKYO Gas

Water Hammering Effect

What is water hammering effect?

How does it occur?

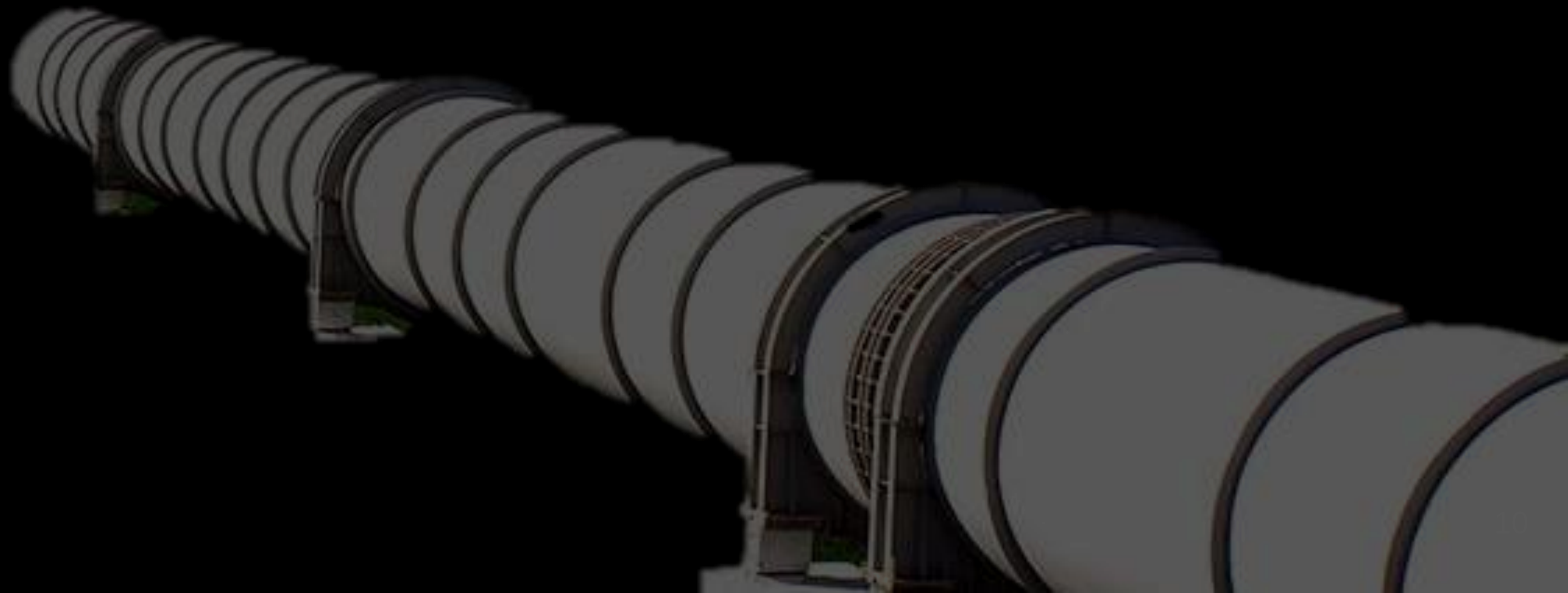


Source: TLV

Why it occurs?

Where does it occurs?

PROBLEM STATEMENT



Problem Statement

Literature review

- LNG Regasification Process
- Water Hammering

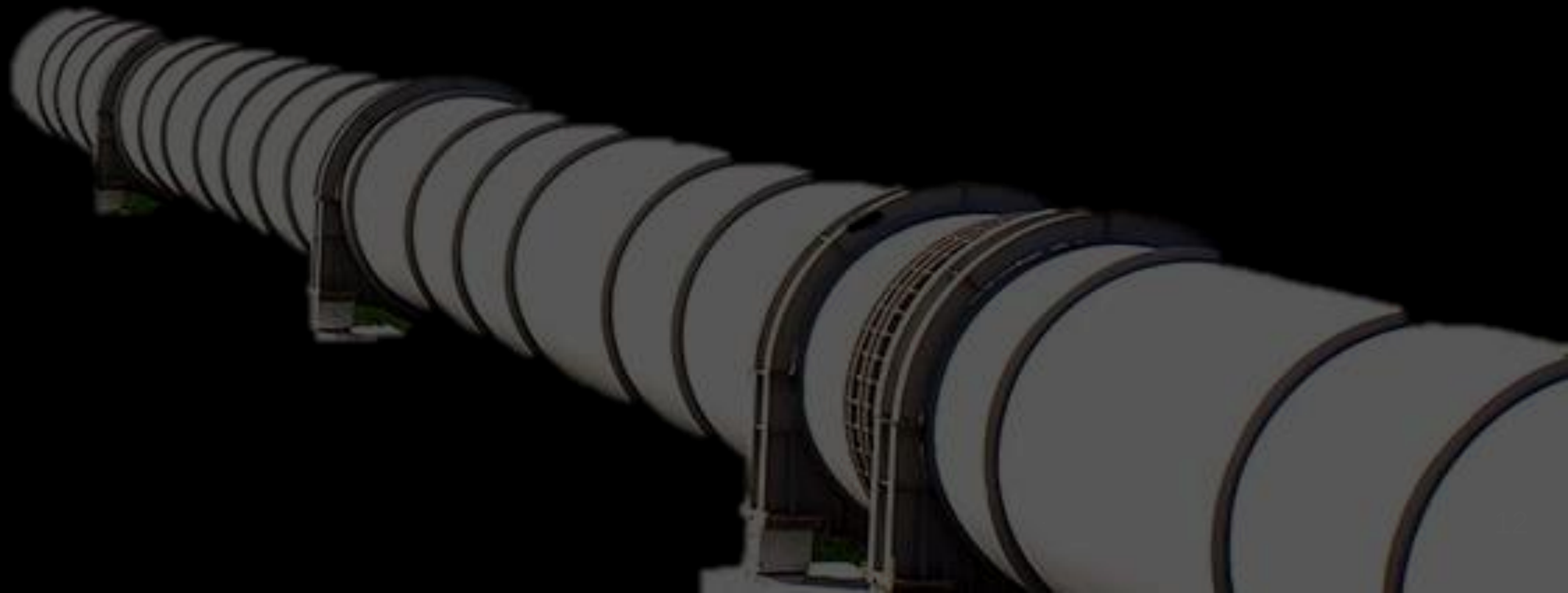
Objective

- To conduct predictive assessment of Fluid Hammering Effect in pipe networks of LNG regasification system through analysis of modelling simulations and visualization softwares.

Scope of research

- The case study that we will be analyzing is on **‘Simulation’ Based Modelling’**

RESEARCH METHODOLOGY



General Research Methodology

Literature Review

- Perform literature review

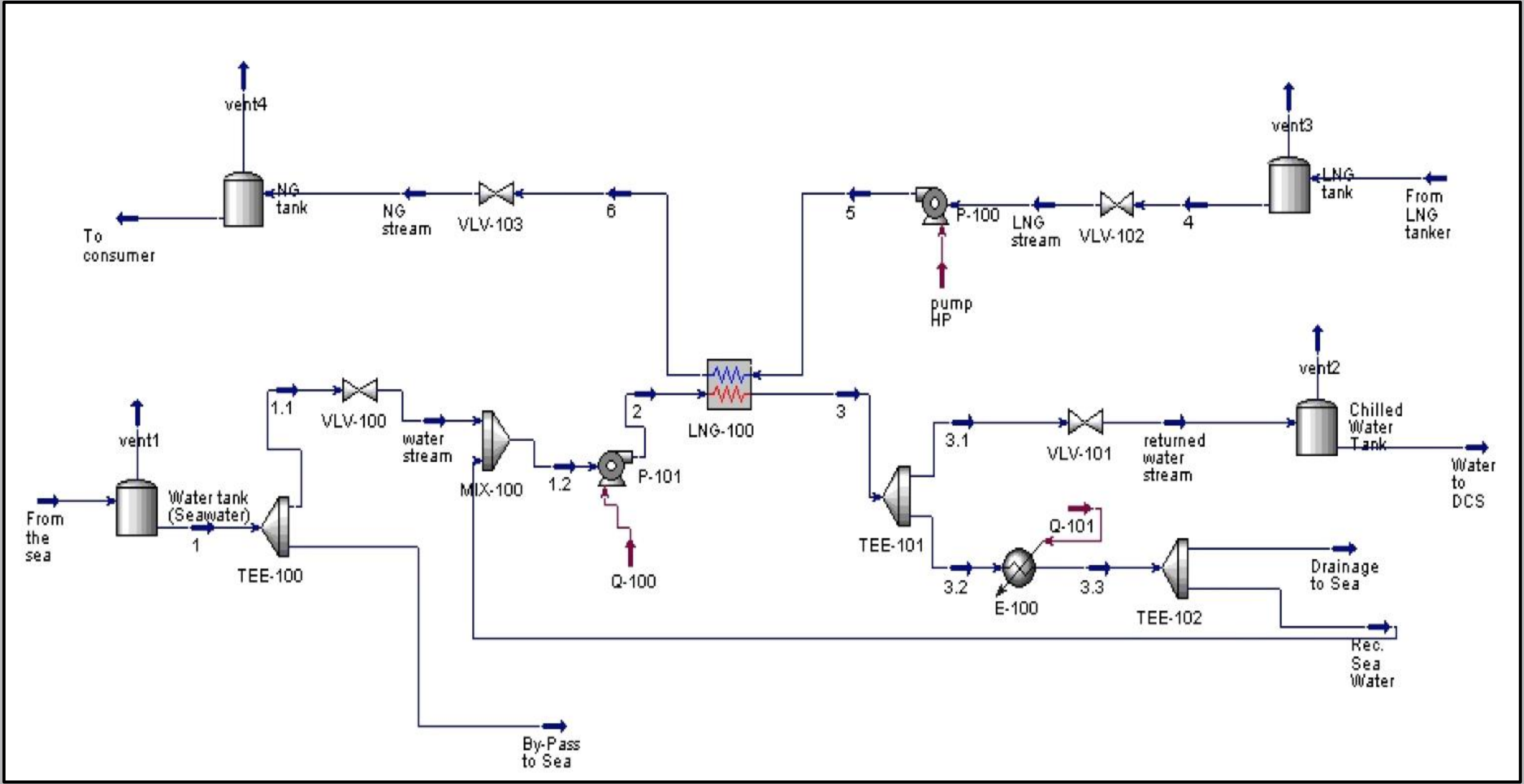
Perform Simulation

- Simulation using the Aspen HYSYS software

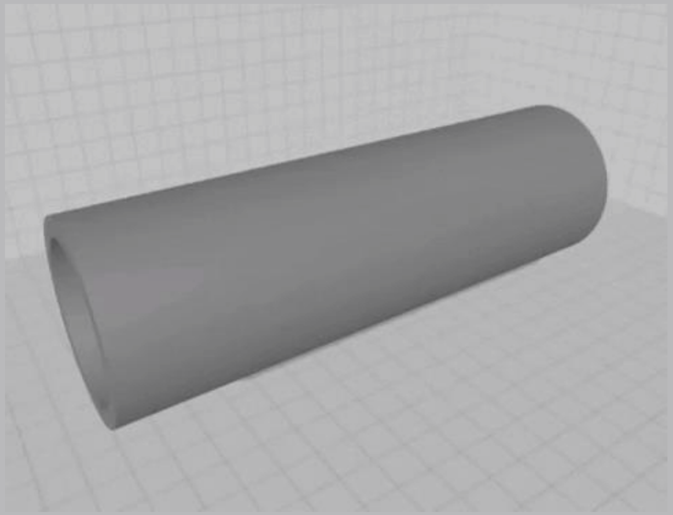
Data Analysis & Visualization

- Analyze & Visualize the data from the simulation using TABLEAU software

Simulation Model (ASPEN HYSYS)



Simulation Run Design



Source: Gyfcat

Diameters of pipe: 0.25, 0.4, 0.5, 0.8 meters

Low Flowrates (<2500 m³/h):

- 1000 m³/h
- 1050 m³/h
- 1550 m³/h
- 2000 m³/h
- 2010 m³/h

Medium Flowrates (~5000 m³/h):

- 3720 m³/h
- 4090 m³/h
- 4570 m³/h
- 4640 m³/h
- 5370 m³/h

High Flowrates (>7000 m³/h):

- 7790 m³/h
- 7960 m³/h
- 8180 m³/h
- 8390 m³/h
- 9140 m³/h

Preparing the Data Set

1 **Determine change in fluid velocity for different pipe attributes.**

$$\frac{\partial v}{\partial t} =$$

- ➔ *100% V0*
- ➔ *90% V0*
- ➔ *80% V0*

2 **Calculate wave speed for each pipe diameter.**

$$c = \sqrt{\frac{1}{\rho\left[\frac{1}{K} + \frac{D}{E.t}\right]}}$$

Source: Yang (2011)

ρ = 1000 kg/m^3
K = 2.19 x 10^9 Pa
E = 2.02 x 10^11 Pa

D = Pipe diameter
t = Pipe wall thickness

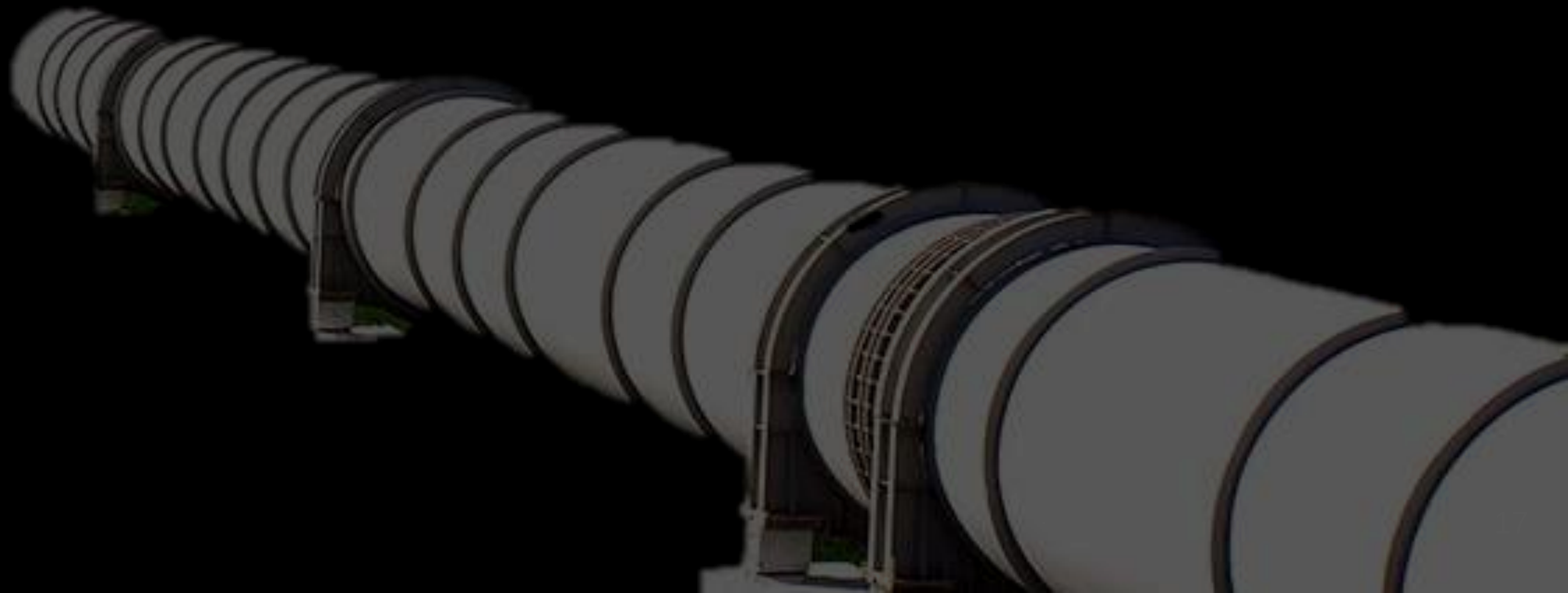
3 **Find pressure surge for each case.**

Joukowsky Equation:

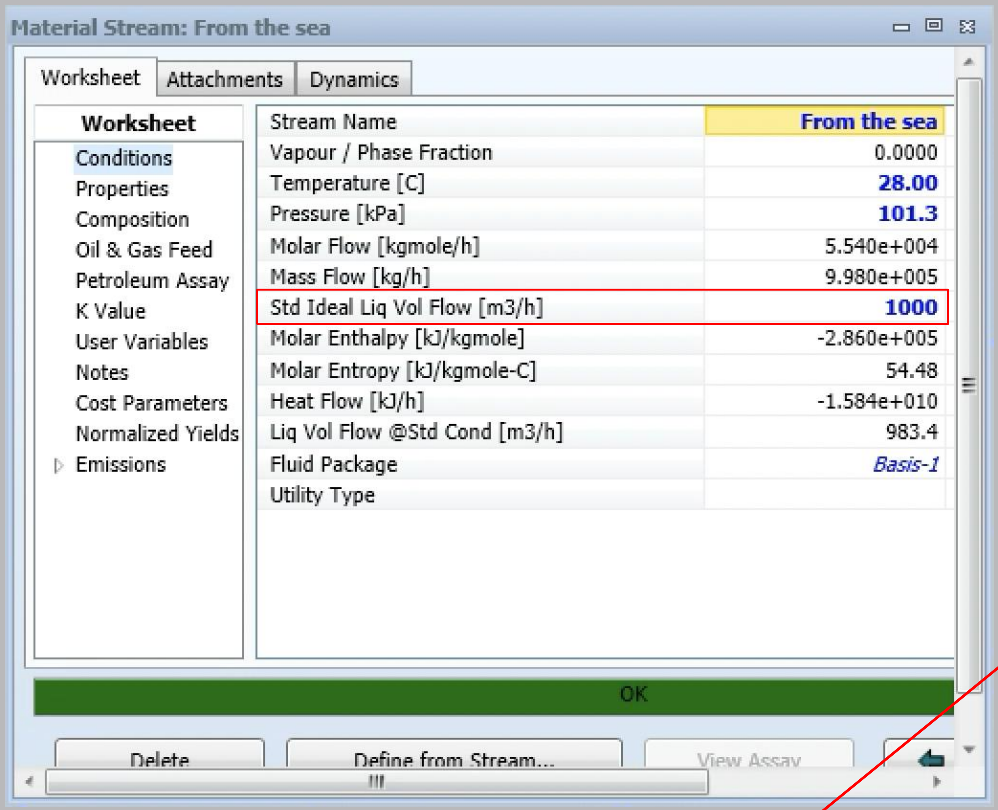
$$\frac{\partial P}{\partial t}\,(pressure\ surge) = \rho(fluid\ density) x\ c\ (speed\ of\ wave\ during\ fluid\ hammer) \times \frac{\partial v}{\partial t}$$

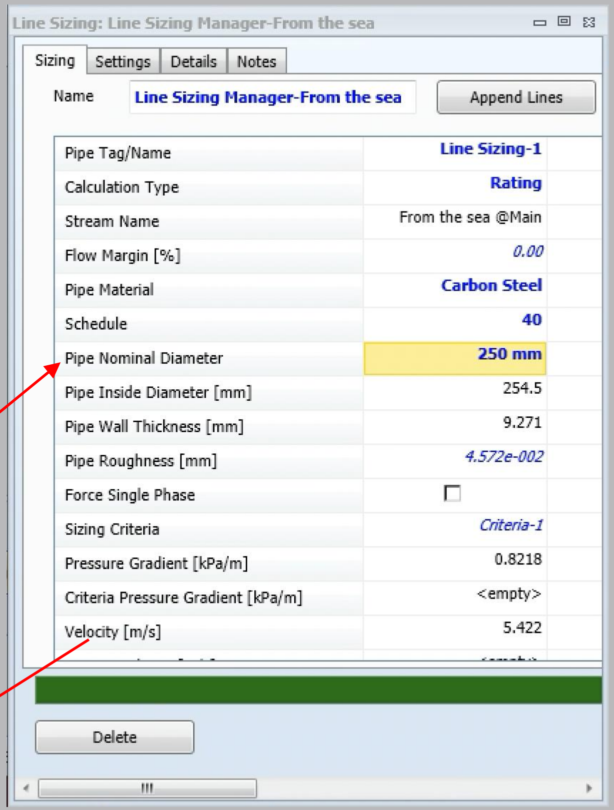
Source: Tijsseling (2006)

RESULTS & DISCUSSIONS



Simulation Results from ASPEN HYSYS

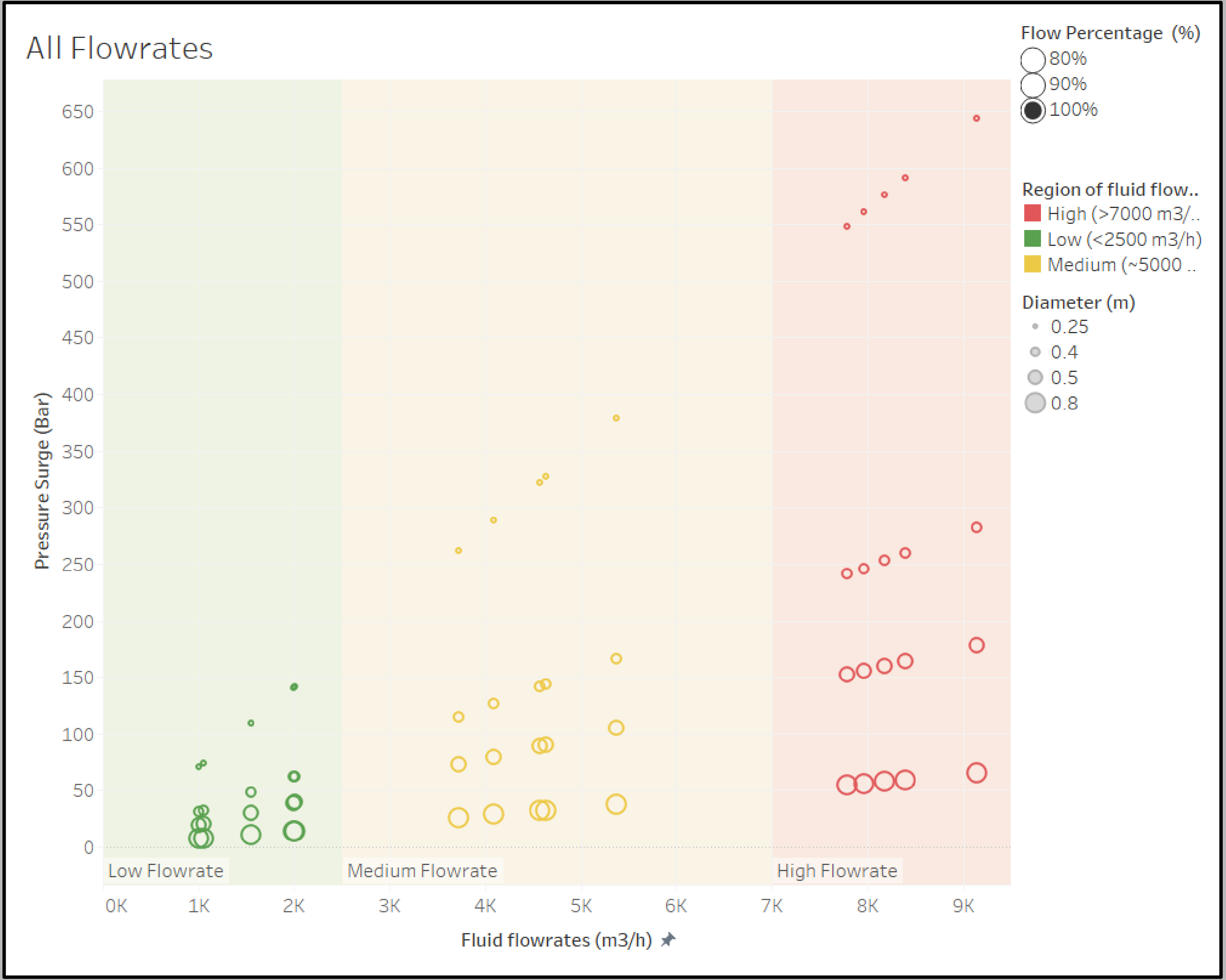




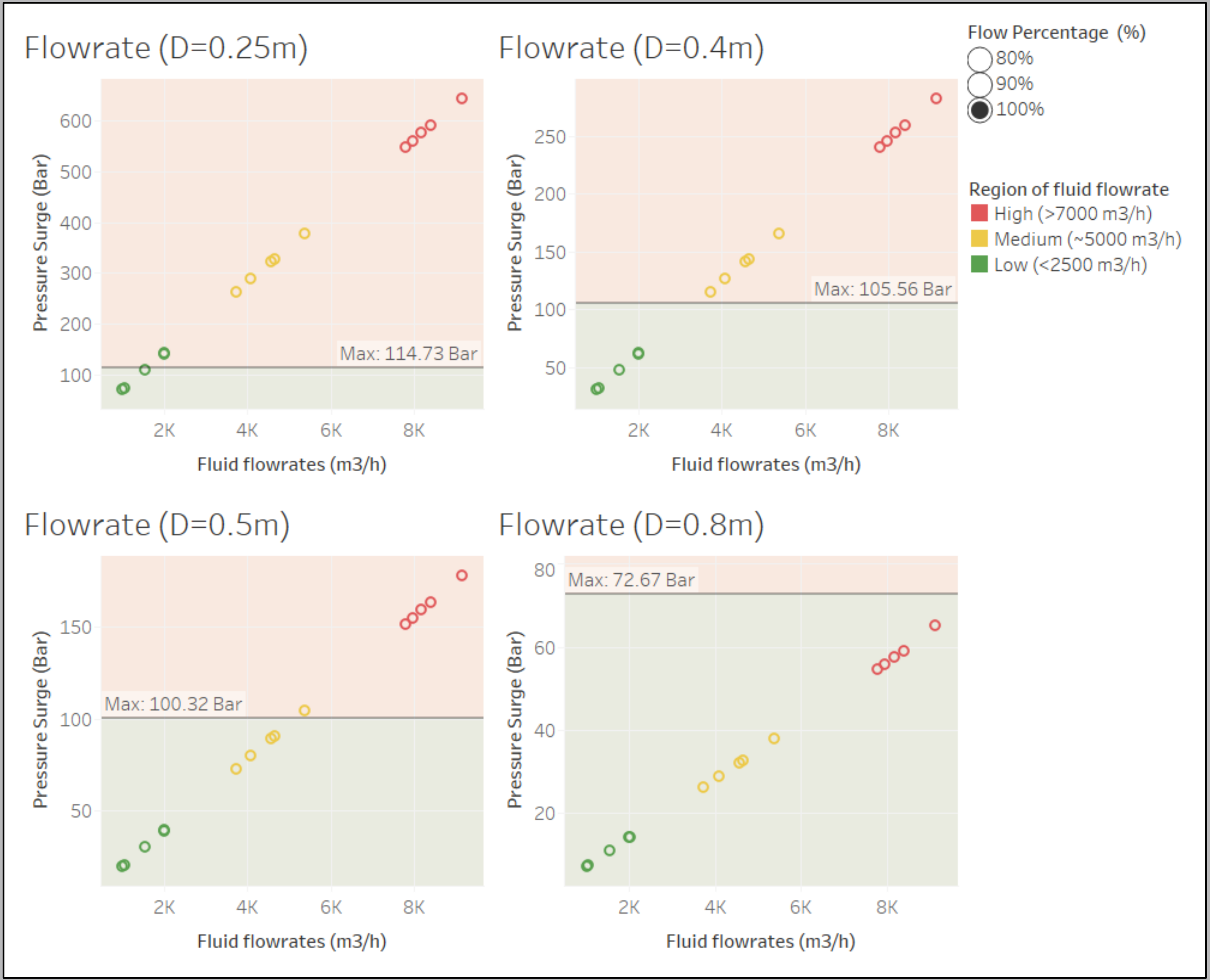
Datasheet generated using Google Sheets

Diameter (m)	Fluid Velocity (V0, m/s)	Wall thickness (m)	Flow Percentage (x, out of 1)	Adjusted Fluid Velocity (V0 * x)	c (m/s)	Pressure Surge (Pa)	Pressure Surge (Bar)	Reynolds number
			1	5.422		7.06E+06	70.6	
			0.9	4.8798		6.35E+06	63.5	
0.250	5.422	0.009271	0.8	4.3376	1301.76	5.65E+06	56.5	1.66E+06

Data Visualization & Analysis



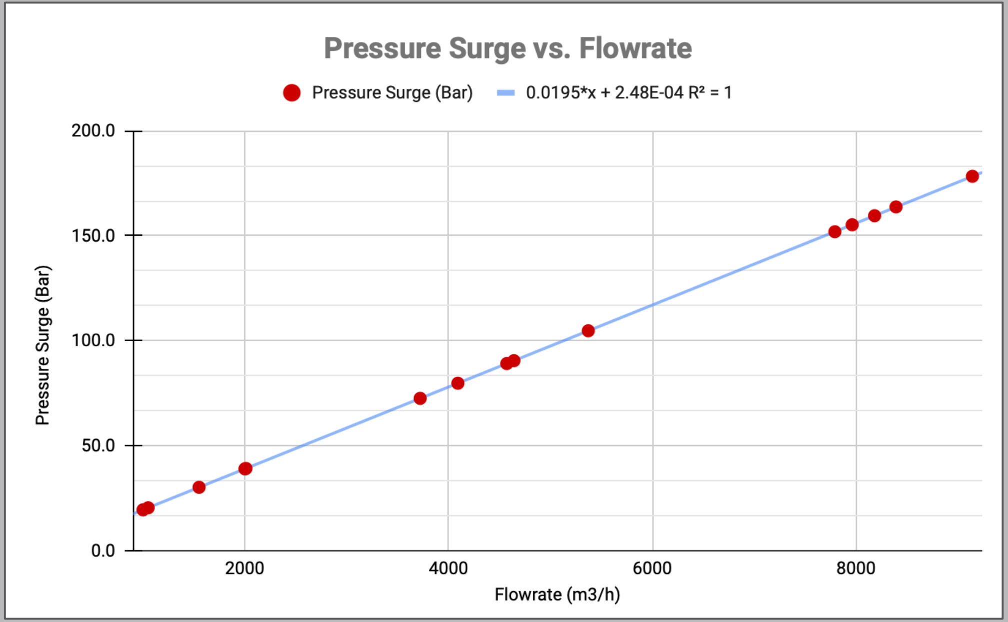
Data Visualization & Analysis

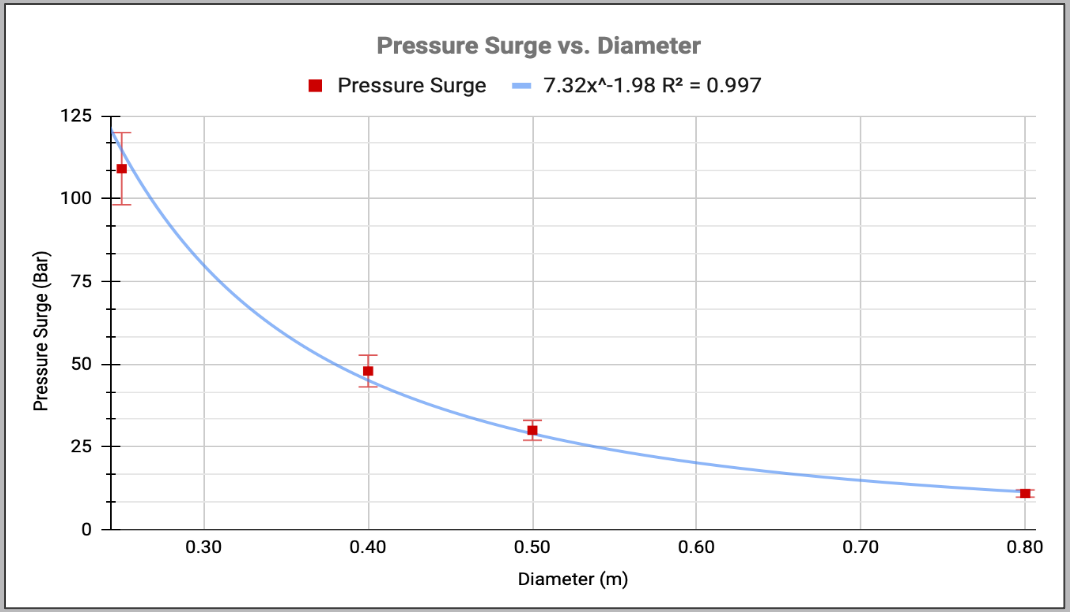


Sensitivity Analysis

- ➢ The relationship between pressure surge and flowrate is linear.

- ➢ Halving the diameter results in around a 360% increase in pressure surge.

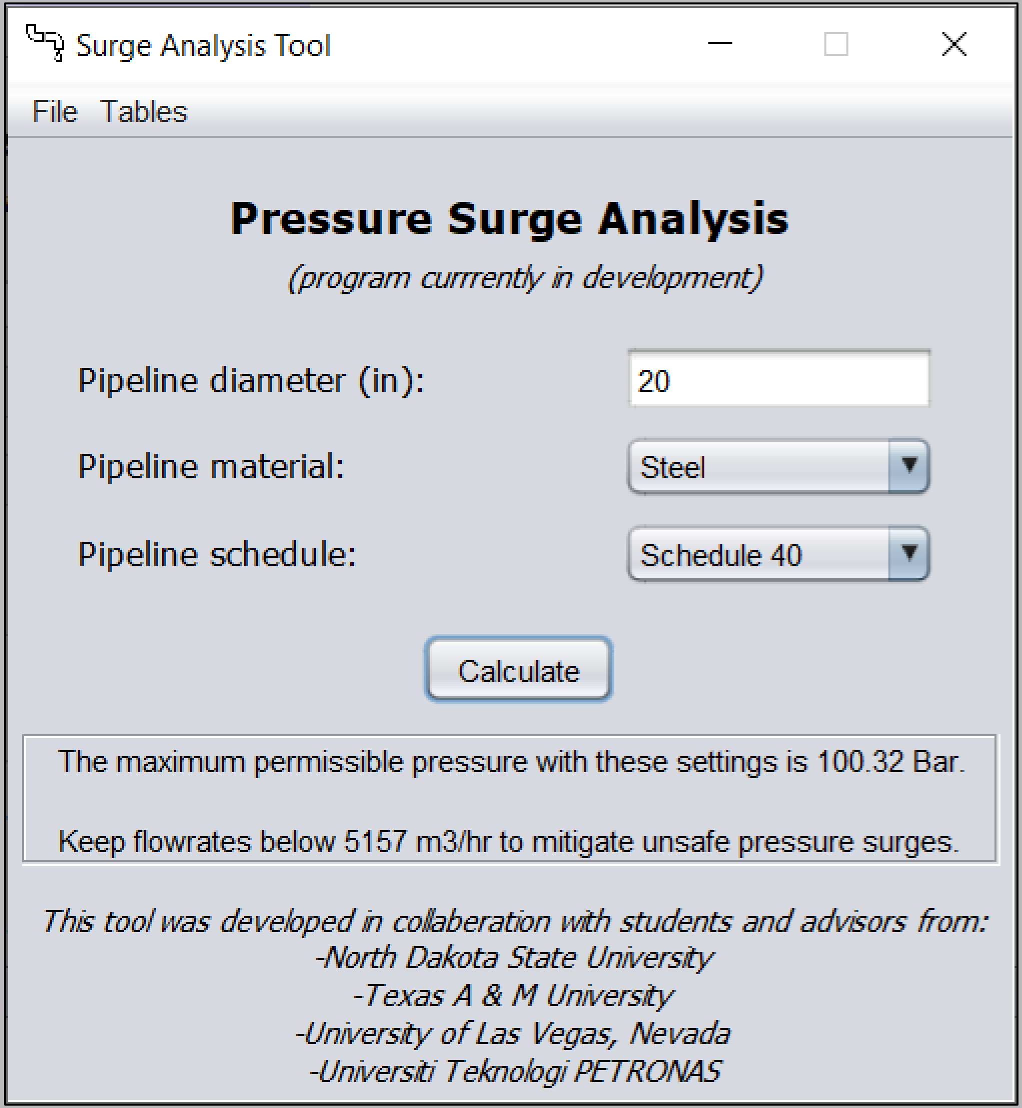


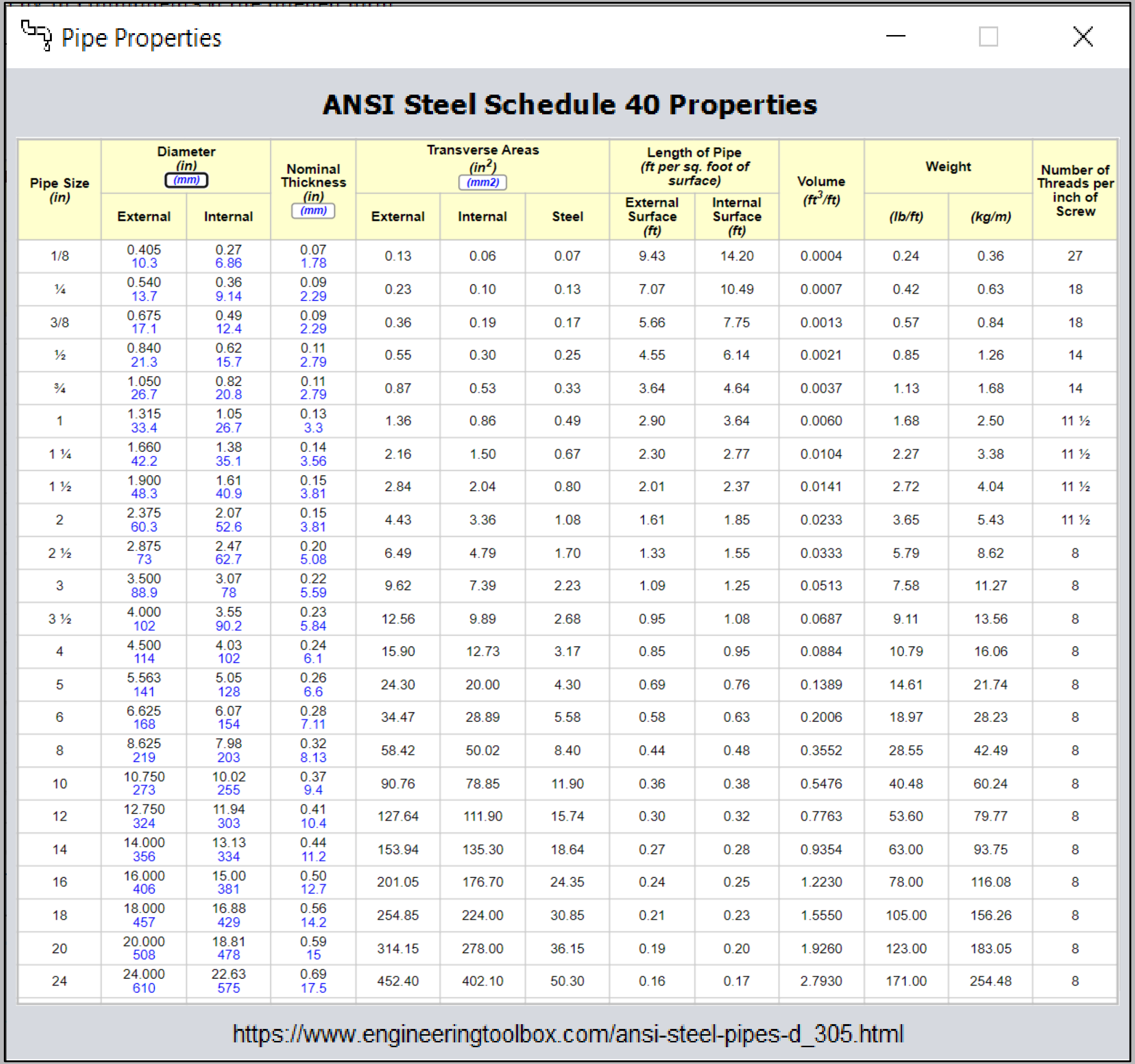


0.500 m Diameter pipe at 100% Fluid Velocity

1550 m^3/h Flowrate at 100% Fluid Velocity

Surge Analysis Tool



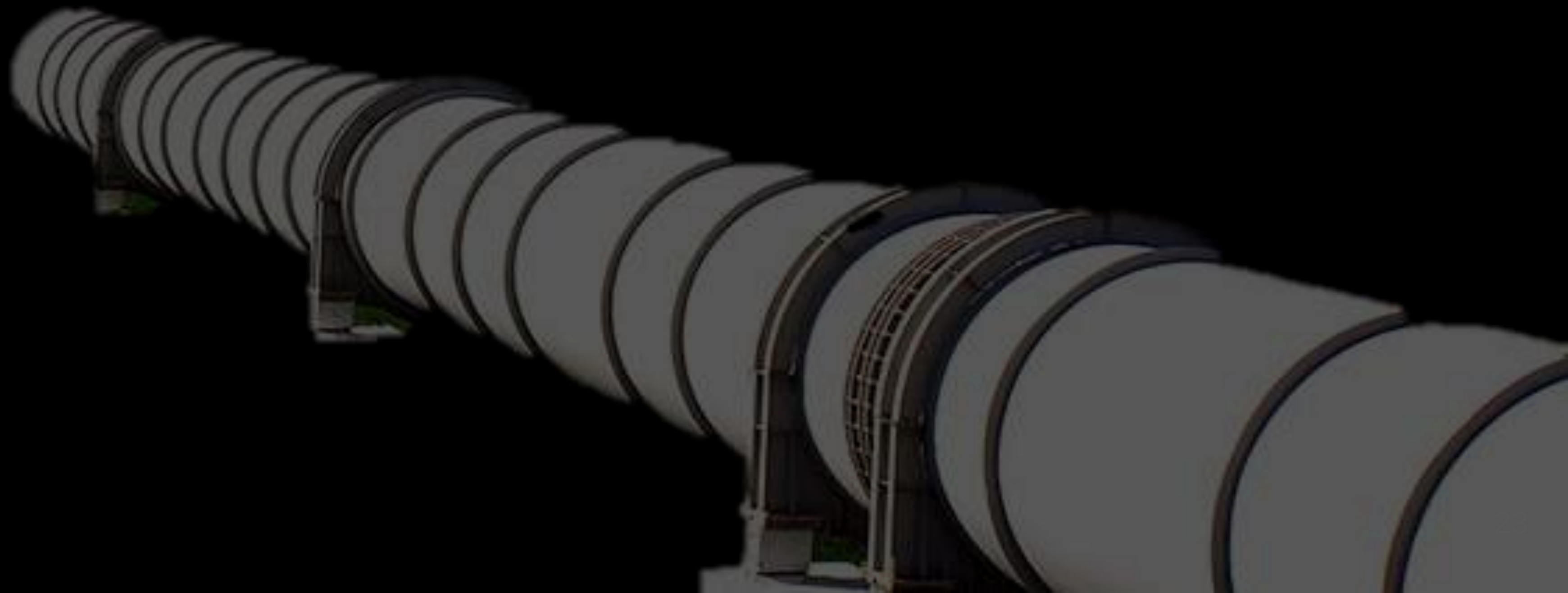


ANSI Steel Schedule 40 Properties

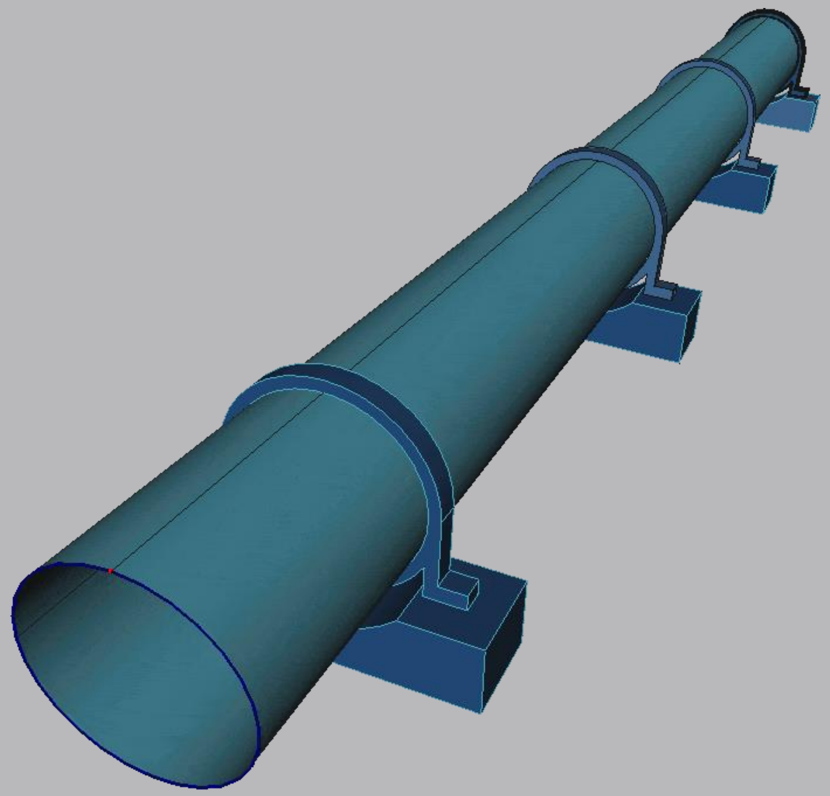
Pipe Size (in)	Diameter (in) (mm)		Nominal Thickness (in) (mm)	Transverse Areas (in^2) (mm2)			Length of Pipe (ft per sq. foot of surface)		Volume (ft^3/ft)	Weight		Number of Threads per inch of Screw
	External	Internal		External	Internal	Steel	External Surface (ft)	Internal Surface (ft)		(lb/ft)	(kg/m)	
1/8	0.405 10.3	0.27 6.86	0.07 1.78	0.13	0.06	0.07	9.43	14.20	0.0004	0.24	0.36	27
¼	0.540 13.7	0.36 9.14	0.09 2.29	0.23	0.10	0.13	7.07	10.49	0.0007	0.42	0.63	18
3/8	0.675 17.1	0.49 12.4	0.09 2.29	0.36	0.19	0.17	5.66	7.75	0.0013	0.57	0.84	18
½	0.840 21.3	0.62 15.7	0.11 2.79	0.55	0.30	0.25	4.55	6.14	0.0021	0.85	1.26	14
¾	1.050 26.7	0.82 20.8	0.11 2.79	0.87	0.53	0.33	3.64	4.64	0.0037	1.13	1.68	14
1	1.315 33.4	1.05 26.7	0.13 3.3	1.36	0.86	0.49	2.90	3.64	0.0060	1.68	2.50	11 ½
1 ¼	1.660 42.2	1.38 35.1	0.14 3.56	2.16	1.50	0.67	2.30	2.77	0.0104	2.27	3.38	11 ½
1 ½	1.900 48.3	1.61 40.9	0.15 3.81	2.84	2.04	0.80	2.01	2.37	0.0141	2.72	4.04	11 ½
2	2.375 60.3	2.07 52.6	0.15 3.81	4.43	3.36	1.08	1.61	1.85	0.0233	3.65	5.43	11 ½
2 ½	2.875 73	2.47 62.7	0.20 5.08	6.49	4.79	1.70	1.33	1.55	0.0333	5.79	8.62	8
3	3.500 88.9	3.07 78	0.22 5.59	9.62	7.39	2.23	1.09	1.25	0.0513	7.58	11.27	8
3 ½	4.000 102	3.55 90.2	0.23 5.84	12.56	9.89	2.68	0.95	1.08	0.0687	9.11	13.56	8
4	4.500 114	4.03 102	0.24 6.1	15.90	12.73	3.17	0.85	0.95	0.0884	10.79	16.06	8
5	5.563 141	5.05 128	0.26 6.6	24.30	20.00	4.30	0.69	0.76	0.1389	14.61	21.74	8
6	6.625 168	6.07 154	0.28 7.11	34.47	28.89	5.58	0.58	0.63	0.2006	18.97	28.23	8
8	8.625 219	7.98 203	0.32 8.13	58.42	50.02	8.40	0.44	0.48	0.3552	28.55	42.49	8
10	10.750 273	10.02 255	0.37 9.4	90.76	78.85	11.90	0.36	0.38	0.5476	40.48	60.24	8
12	12.750 324	11.94 303	0.41 10.4	127.64	111.90	15.74	0.30	0.32	0.7763	53.60	79.77	8
14	14.000 356	13.13 334	0.44 11.2	153.94	135.30	18.64	0.27	0.28	0.9354	63.00	93.75	8
16	16.000 406	15.00 381	0.50 12.7	201.05	176.70	24.35	0.24	0.25	1.2230	78.00	116.08	8
18	18.000 457	16.88 429	0.56 14.2	254.85	224.00	30.85	0.21	0.23	1.5550	105.00	156.26	8
20	20.000 508	18.81 478	0.59 15	314.15	278.00	36.15	0.19	0.20	1.9260	123.00	183.05	8
24	24.000 610	22.63 575	0.69 17.5	452.40	402.10	50.30	0.16	0.17	2.7930	171.00	254.48	8

https://www.engineeringtoolbox.com/ansi-steel-pipes-d_305.html

CONCLUSIONS & FUTURE RESEARCH



Implications for Engineers and Managers



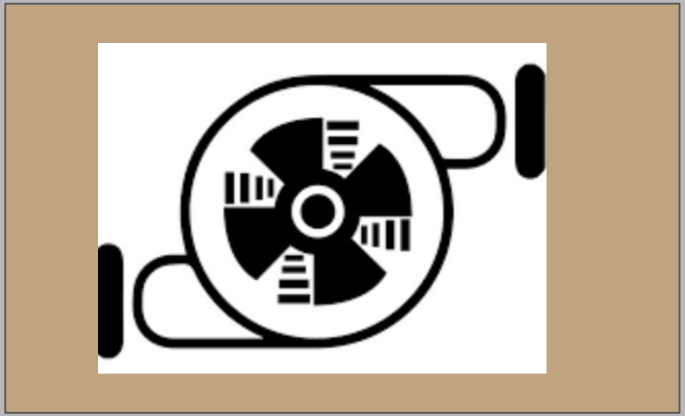
Source: Motrhys

In order to use higher flowrates, larger diameter pipes must be considered.

Limitations

Computer Simulation

Cost of Infrastructure



Water Pump

Conclusion

Research Problem Statement

The Fluid hammer effect on pipe Systems

Research Contribution

Effect of diameter on pressure

Findings and Implications

Larger Diameters > Smaller Diameters

Limitations

Cost: Infrastructure & Energy

Further Research

ACKNOWLEDGEMENTS

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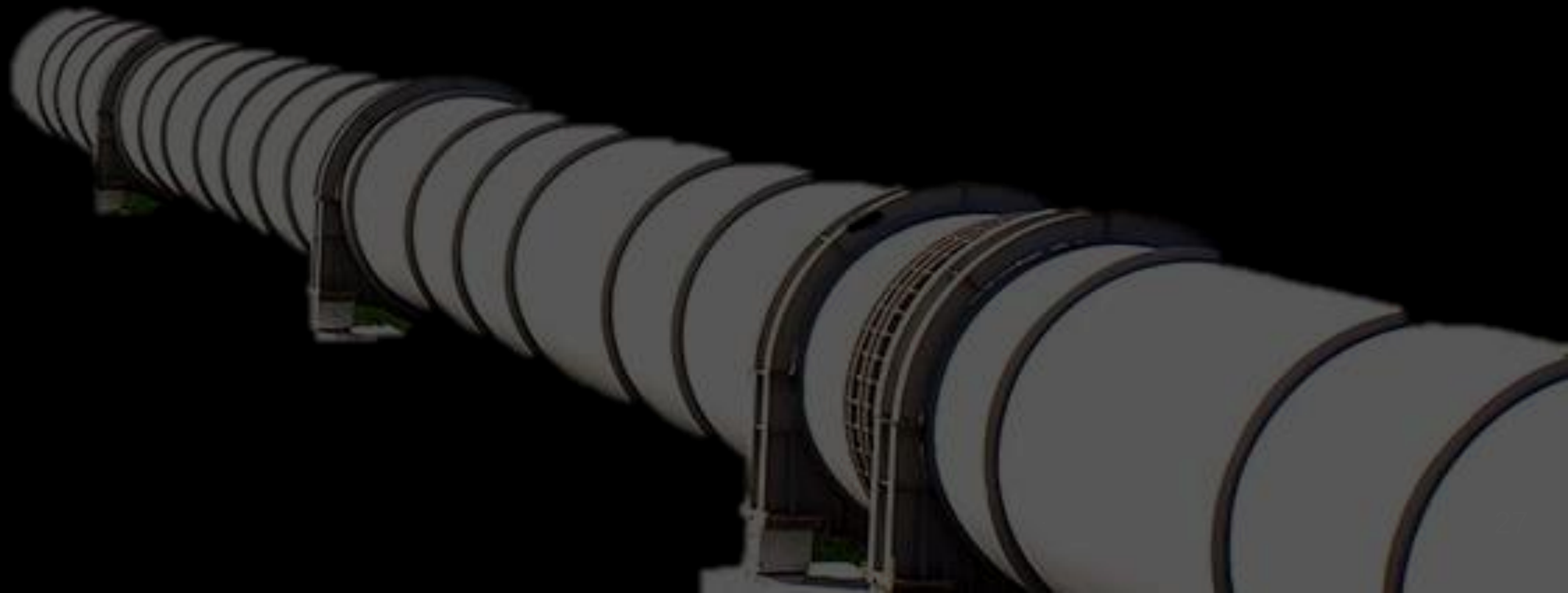
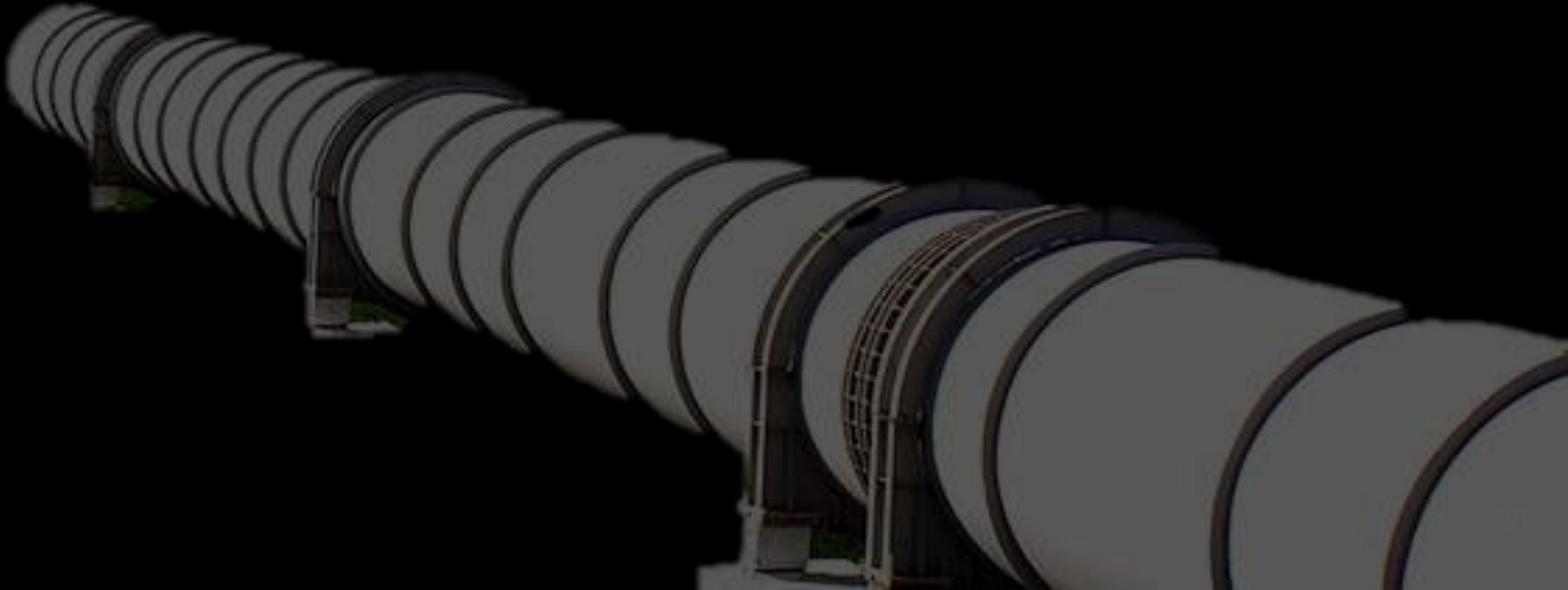
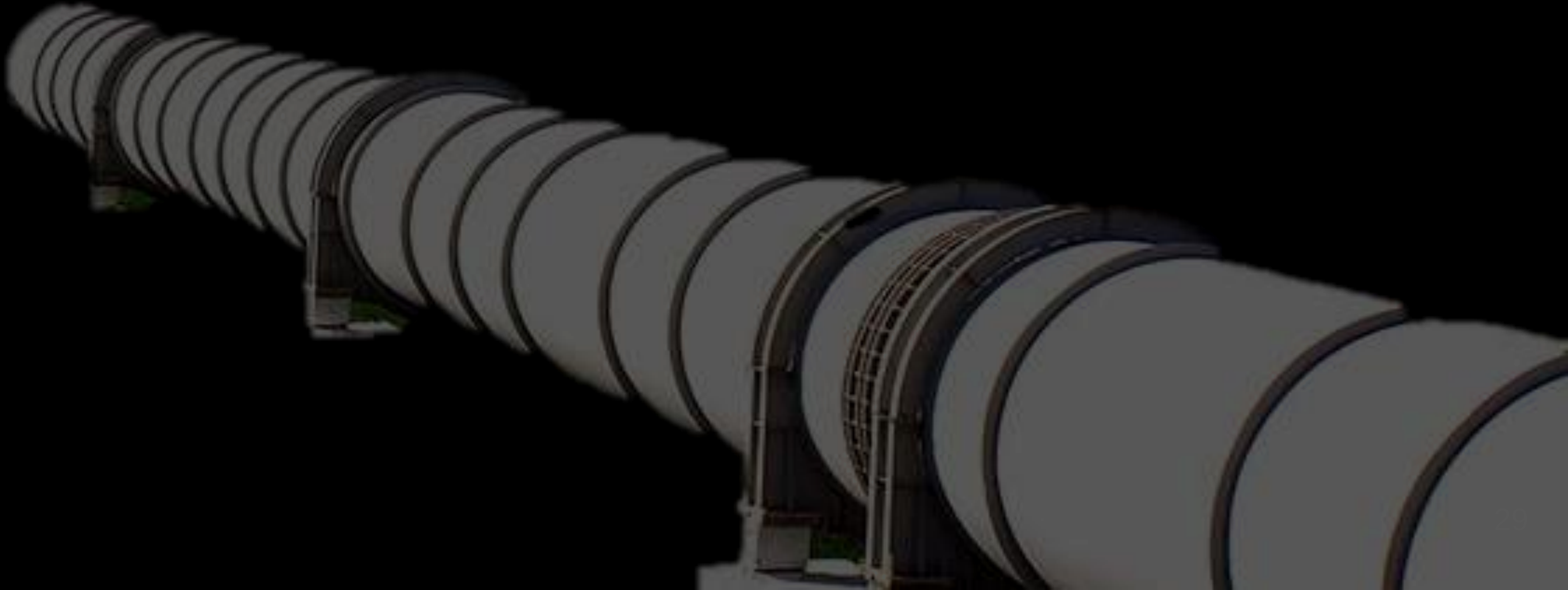


Q&A SESSION



THANK YOU



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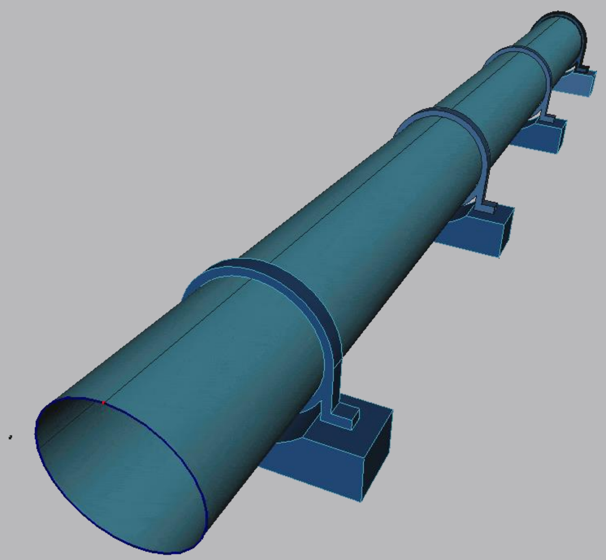
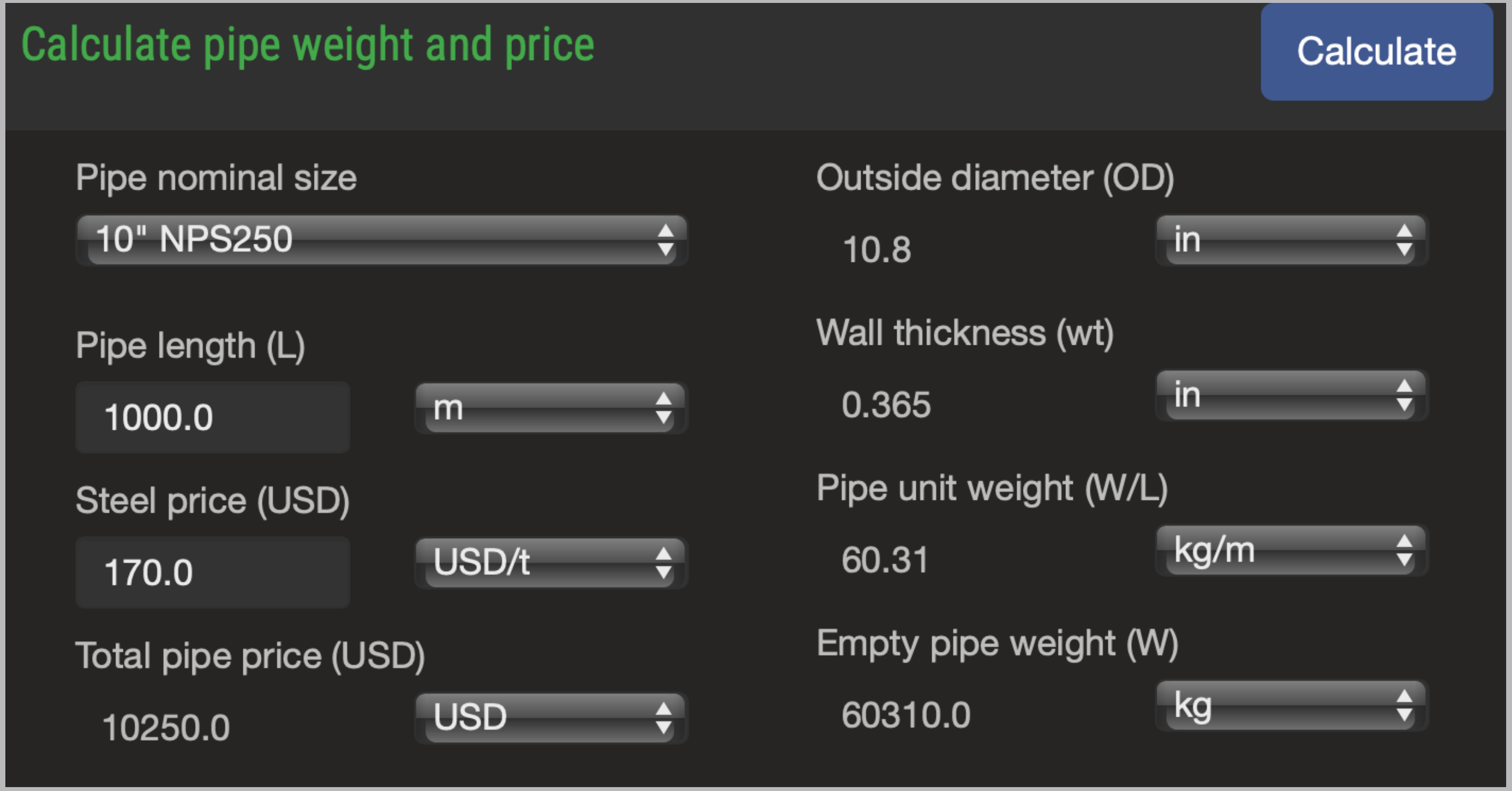
Cost Data



Source: Motrhys



Calculation Software from "[Pipe Flow Calculations]" website (pipeflowcalculations.com).