TECORP international

Design & Construction of Harp Type Slug Catchers

presented by

Lowell C. Thronson, P.E.

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Outline

- Slug Catcher and Slugging
- Most Common Types of Slug Catchers
- Design Codes
- Principles of Gas-Liquid Phase Separation
- Applying Gas-Liquid Phase Separation to HARP Slug Catchers
- Verifying Principles of Separation
- The “New Way?”
- Q & A

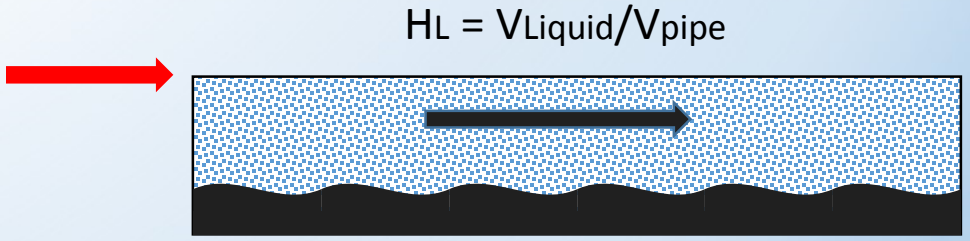
Design & Construction of Harp Type Slug Catchers

Slug Catcher

- Part of a two phase pipeline system for the separation of gas and liquid phases and for the temporary storage of liquids. In this presentation we are primarily discussing pipelines where the gas is the dominate phase but liquids will be present due to injection for transportation with the gas, normal condensation or retrograde condensation. Liquids can be received in slug catcher in both steady state operations carried along with the dominate phase and by slugging.

Slugging

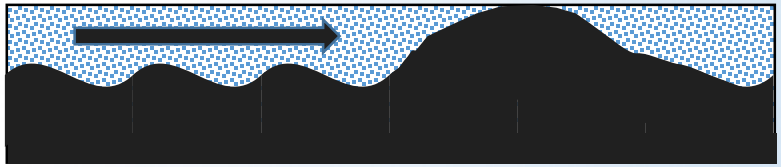
- Liquid Buildup (Holdup)
- Hydrodynamic Slugs
- Terrain Induced
- Pigging Operations



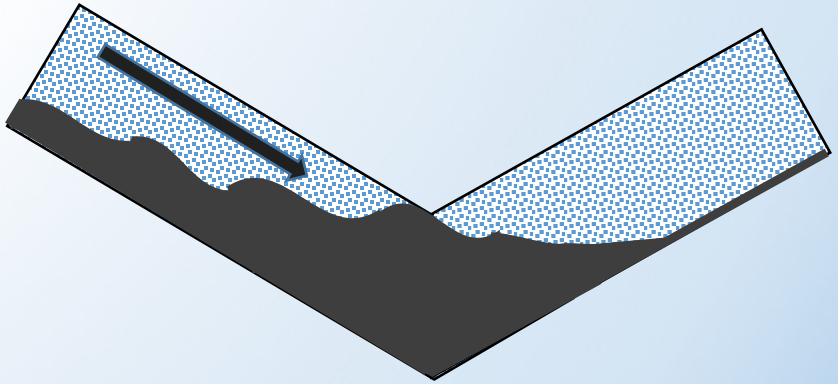
Design & Construction of Harp Type Slug Catchers

Common Slugging

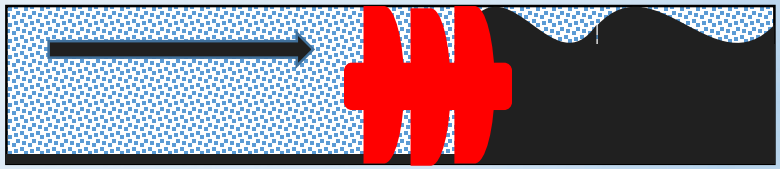
- Hydrodynamic Slugs



- Terrain Induced



- Pigging Operations



Design & Construction of Harp Type Slug Catchers

Most Common Types of Slug Catchers

- Vessel Type

  - Generally applicable to slug volumes of less than 100 M3 (~600 barrels)
  - Usually made of simple pressure vessels to BPVC
  - Predictable particle separation to less than 10 microns with internals
  - Small plot plan for installation
  - Very expensive when larger and multiple vessels are required

GAS STORAGE FACILITY INLET SLUG CATCHERS (70 BARRELS)

Design & Construction of Harp Type Slug Catchers

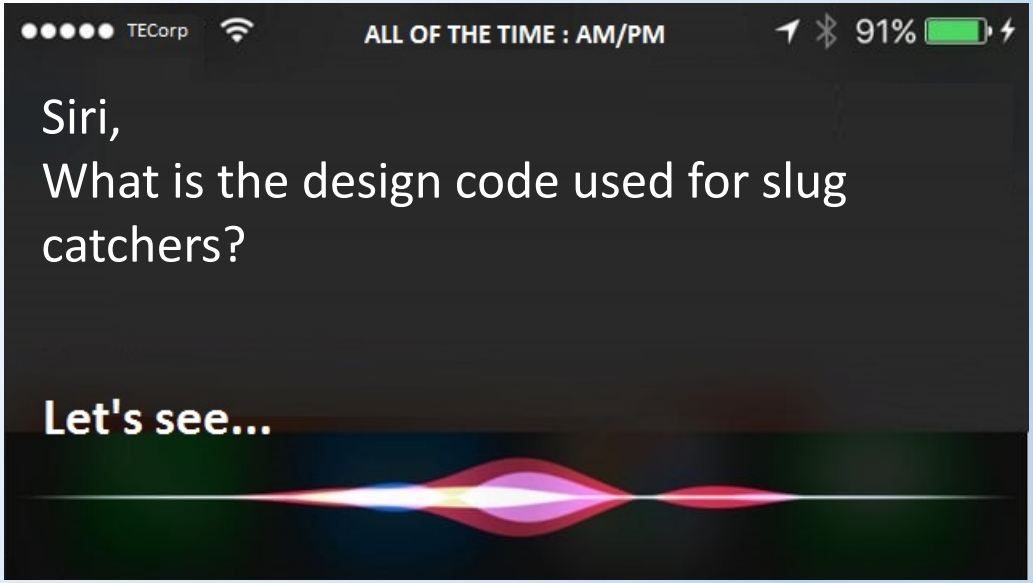
Most Common Types of Slug Catchers

- Multi-Pipe (HARP)
  - Generally designed for high volume applications (thousands of barrels)
  - Predictable particle separation to less than 100 microns and larger
  - Require larger plot plan for installation
  - Cost effective for large slug volumes & storage

ZHUHAI GAOLAN TERMINAL SLUG CATCHER (44,000 BARRELS)

What design code is used for multi-pipe (HARP) slug catchers?

Ask Siri!


TECorp
ALL OF THE TIME : AM/PM
91%
Siri,
What is the design code used for slug catchers?
Let's see...

What design code is used for Multi-Pipe (HARP) slug catchers?

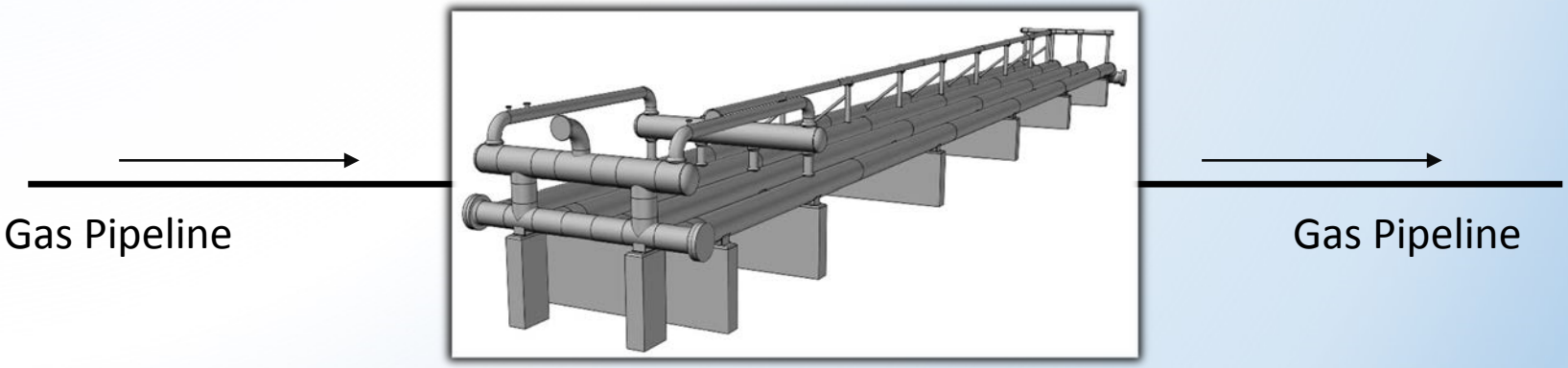
Answers:

- *ASME VIII, Div. 1 or Div. 2*
- *ASME B31.3*
- *Shell DEP 31.40.10.12-Gen.*
- *ISO 13623*
- *Any recognized Pressure Vessel Code*
- *ASME B31.8*

What design code is used for Multi-Pipe (HARP) slug catchers?

COMPARISON OF DESIGN FACTORS-LIQUID HANDLING EQUIPMENT/SLUG CATCHERS		
STANDARD/CODE	**DESIGN FACTOR**	**NOTE**
ASME B31.3	EXCLUDED FROM SCOPE	IMPLIED ~ 0.4-0.6 FROM ALLOWABLE STRESS VALUE
SHELL DEP 31.40.10.12-GEN	0.40-0.6	LOCATION CLASS DEPENDENT
ISO 13623	0.45-0.67	LOCATION CLASS DEPENDENT
ASME B31.8	0.40-0.6	LOCATION CLASS DEPENDENT
49 CFR 192.111	0.4-0.6	LOCATION CLASS DEPENDENT

What design code is used for Multi-Pipe (HARP) slug catchers?



Slug Catcher

Fabricated Assembly
Class Location 1 & 2 F= 0.6
Class Location 3, F = 0.5
Class Location 4, F = 0.4

B31.8

What design code is used for Multi-Pipe (HARP) slug catchers?

UNPUBLISHED
ASME B31.8 INTERPRETATIONS
To be published within the next Edition

Subject: ASME B31.8-2012 Edition, Para. 843.3.1 – Gas Treating Facilities
Date Issued: September 28, 2015
Item: 15-446

Question
Does ASME B31.8-2012, para. 843.3.1(b) apply to slug catchers, specifically finger type slug catchers?

Reply
Yes.

Last updated: 9/28/15

B31.8

What design code is used for Multi-Pipe (HARP) slug catchers?

843 COMPRESSOR STATIONS

843.1 Compressor Station Design

843.2 Electrical Facilities

843.3 Compressor Station Equipment

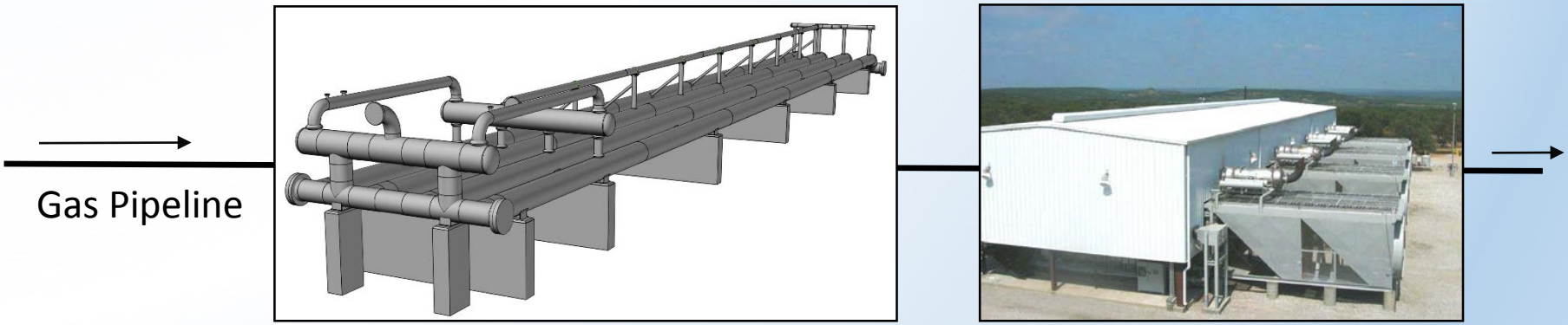
843.3.1 Gas Treating Facilities

(a) Liquid Removal

(b) Liquid Removal Equipment. Liquid separators shall be manufactured in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code, except liquid separators constructed of pipe and fittings with no internal welding may be constructed in accordance with ASME B31.8 utilizing a design factor of 0.4.

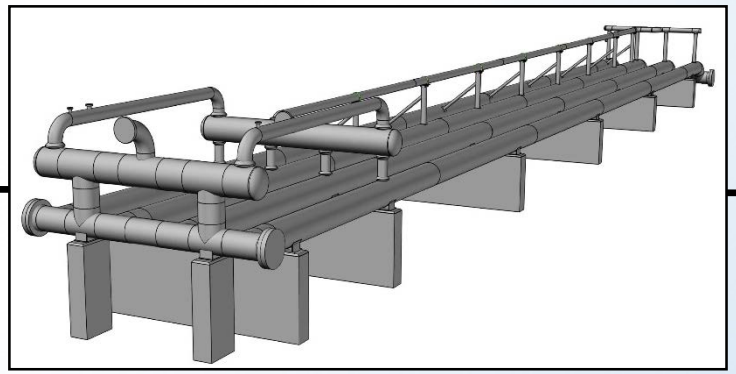
B31.8

What design code is used for Multi-Pipe (HARP) slug catchers?



What design code is used for Multi-Pipe (HARP) slug catchers?

Gas Pipeline



Slug Catcher
Fabricated Assembly
Class Location 1 & 2 F= 0.6
Class Location 3, F = 0.5
Class Location 4, F = 0.4

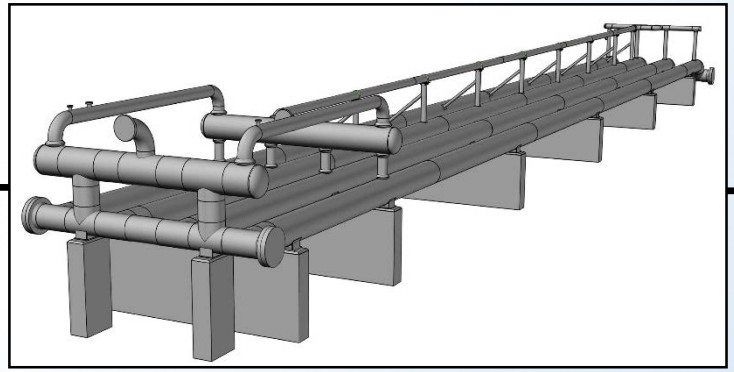
Compressor Station

F = 0.5
Compressor Station Piping

B31.8

What design code is used for Multi-Pipe (HARP) slug catchers?

Gas Pipeline



Slug Catcher
Liquid Removal Equipment
F = 0.4
Para 843.3.1(b)*

Compressors
F = 0.5
Compressor Station Piping

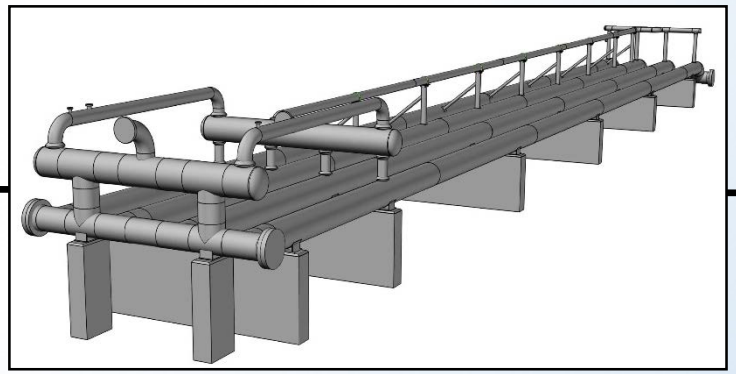
Compressor Station

B31.8

* Liquid separators when constructed of pipe and fittings without internal welding shall be in accordance with Location Class 4 requirements. See Interpretation 15-446, 2015

What design code is used for Multi-Pipe (HARP) slug catchers?

Gas Pipeline



Slug Catcher
Fabricated Assembly
Class Location 1 & 2, F = 0.6
Class Location 3, F = 0.5
Class Location 4, F = 0.4

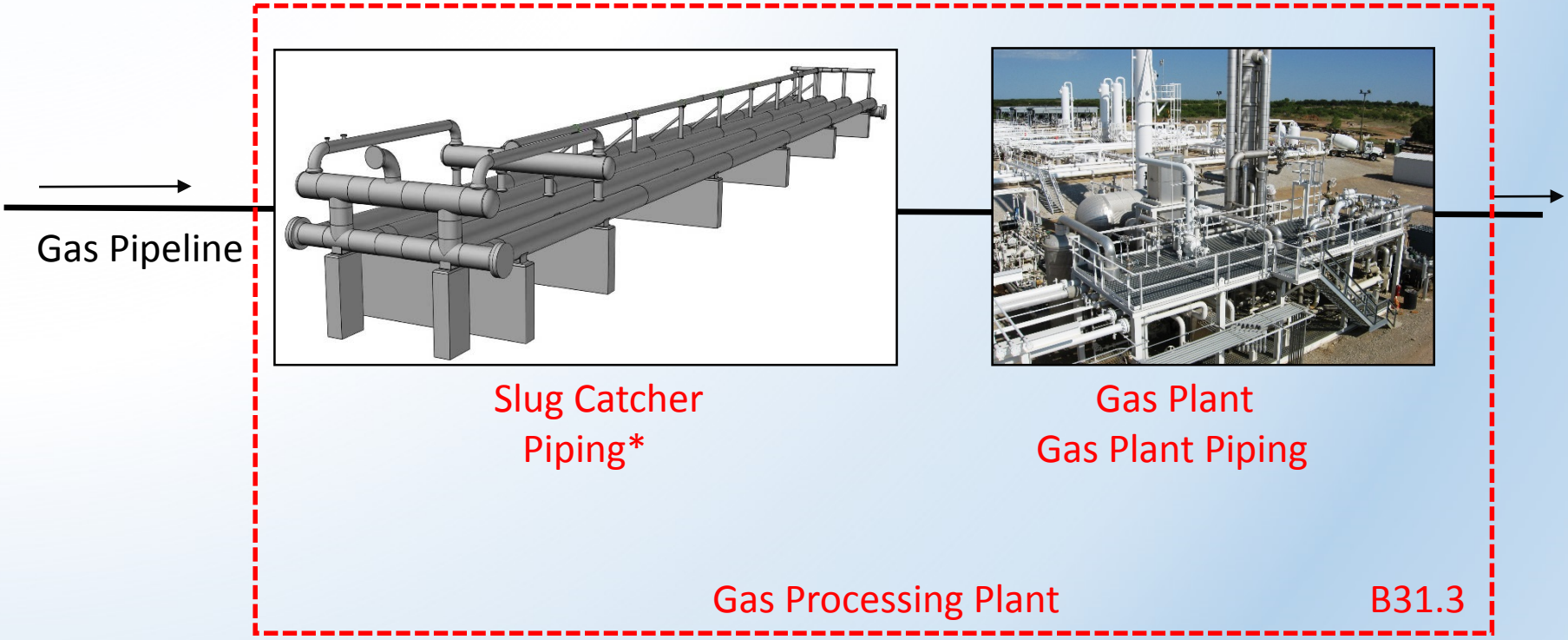
B31.8

Gas Plant

B31.3
Gas Plant Piping

B31.3

What design code is used for Multi-Pipe (HARP) slug catchers?



* Piping: assemblies of piping components used to convey, distribute, mix, separate, discharge, meter, control or snub fluid flows.

What design code is used for Multi-Pipe (HARP) slug catchers?

2018 Revision

836 LIQUID REMOVAL EQUIPMENT AT LOCATIONS OTHER THAN COMPRESSOR STATIONS

New

Liquid separators shall be manufactured in accordance with Section VIII of the BPV Code, except that those constructed of pipe and fittings without any components welded to the inside of the pipe may be constructed in accordance with ASME B31.8 utilizing a design factor from Table 841.1.6-2. The designer of the liquid removal equipment shall apply an appropriate corrosion allowance and shall address all liquid and water hammer loads so that Code-allowable stresses are not exceeded.

New

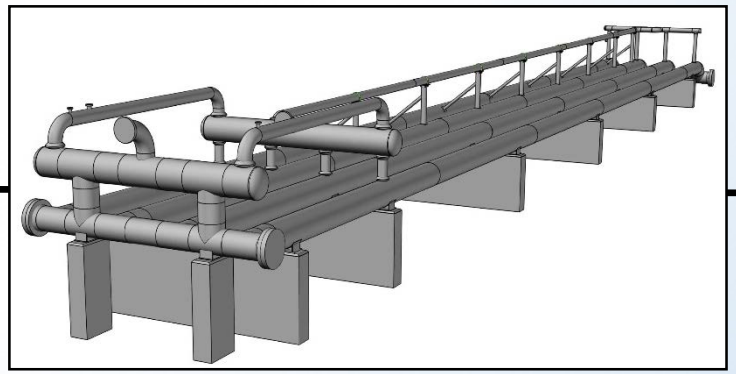
Table 841.1.6-2 Design Factors for Steel Pipe Construction

	Location Class				
	1				
Facility	**Div. 1**	**Div. 2**	**2**	**3**	**4**
Liquid separators constructed of pipe and fittings without internal welding [see para. 836]	0.50	0.50	0.50	0.50	0.40

What design code is used for Multi-Pipe (HARP) slug catchers?

2018 Revision

Gas Pipeline



Slug Catcher
Class Location 1, 2 & 3, F = 0.5
Class Location 4, F = 0.4

Compressors
F = 0.5
Compressor Station Piping

B31.8

What design code is used for Multi-Pipe (HARP) slug catchers?

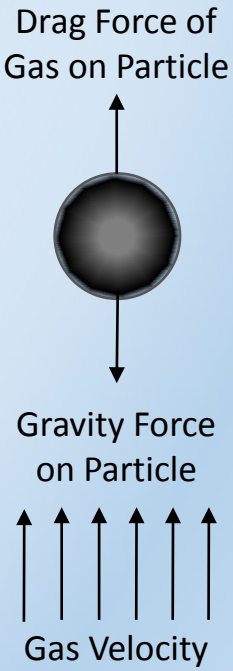
The owner, or owners' designated engineer, should specify the appropriate code for the slug catcher.

Principles of Gas-Liquid Phase Separation

- Coalescing
- Gravity Settling
- Momentum

Momentum, coalescing and gravity settling are all well established principles used in the design of separators. The predominate mechanism used in a Harp Type Slug Catcher is gravity settling to determine terminal velocity of liquid particles to drop out of, or settle out, of the gas.

The drag coefficient (C') is a dimensionless quantity used to quantify the drag or resistance of an object. C' has been function of shape of the particle and the Reynolds number, (Re.)



Principles of Gas-Liquid Phase Separation

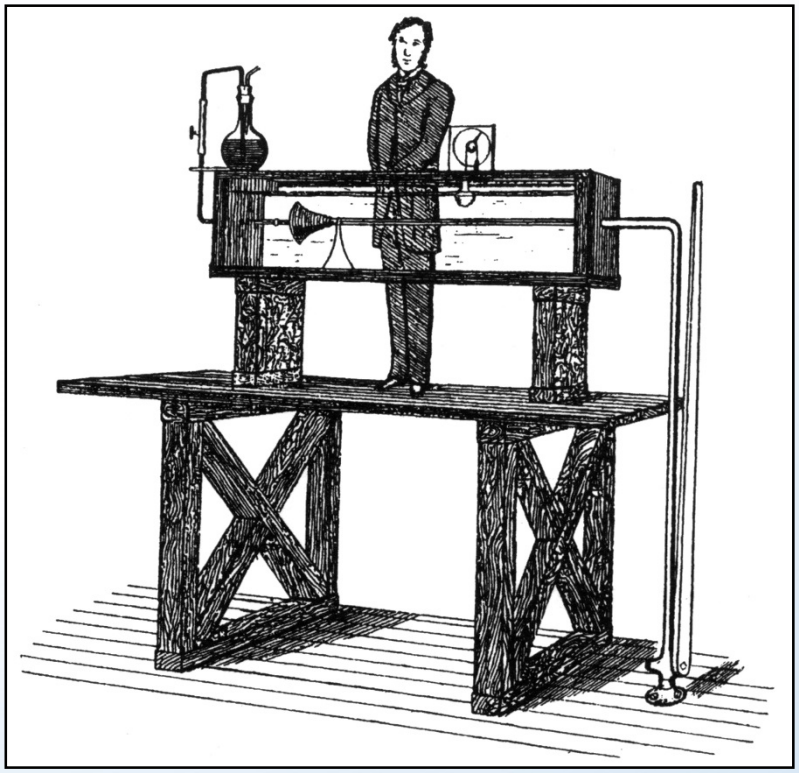
All objects have a drag coefficient.

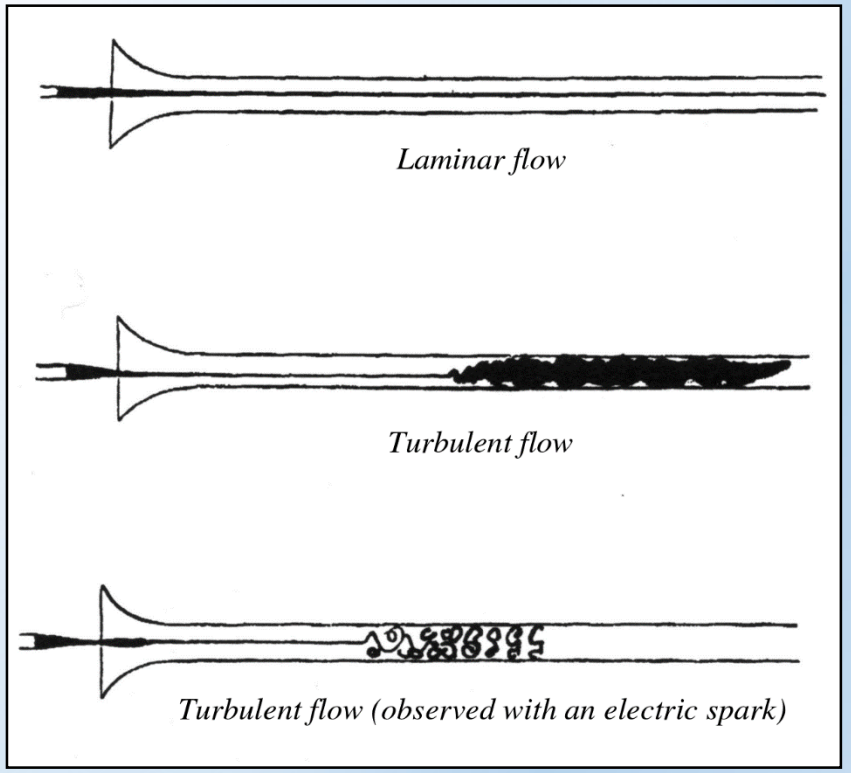
C’ = 0.23

C’ = 0.41

Verifying Principles of Fluid Dynamics

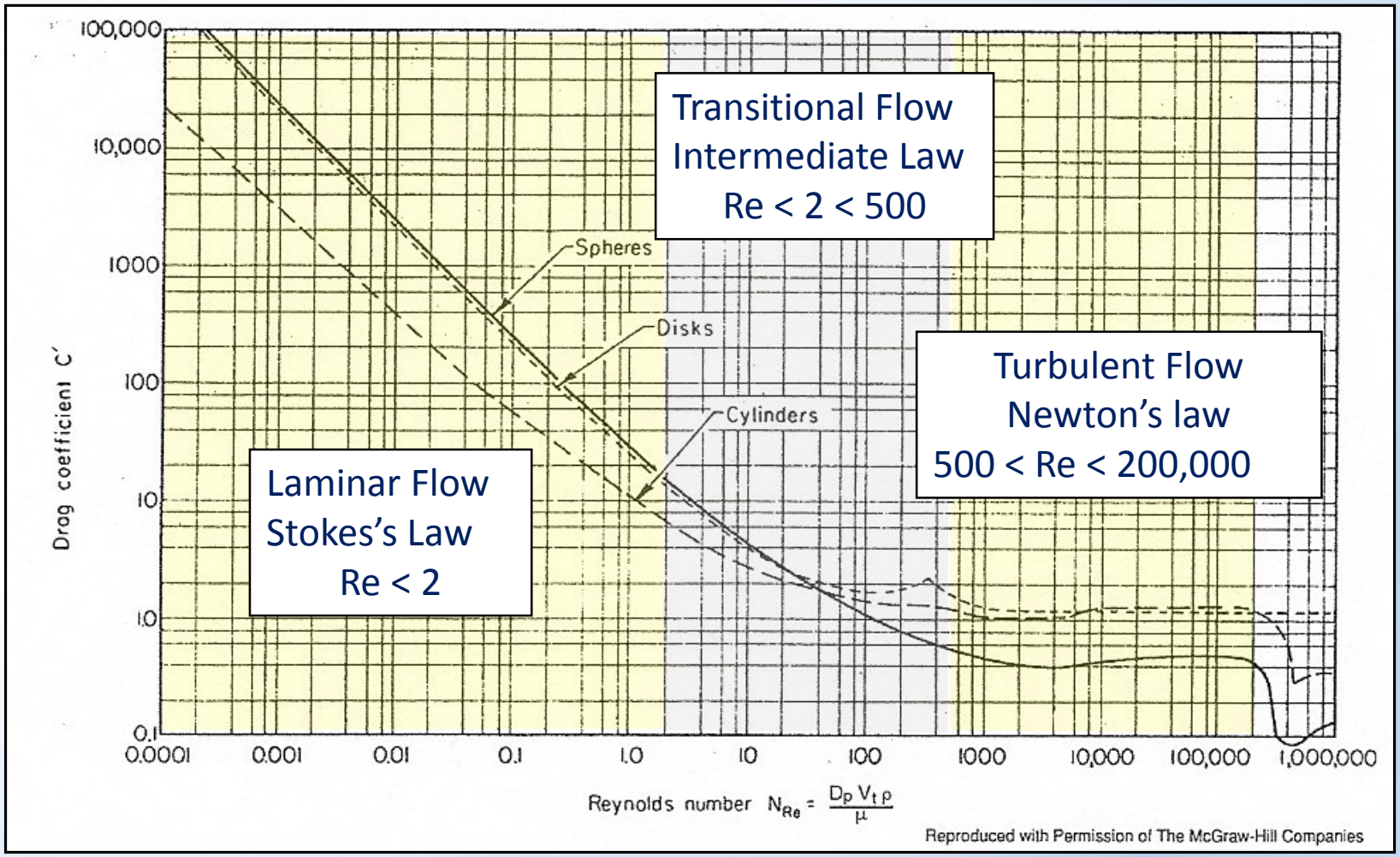
The "Old Way"





Osborne Reynolds apparatus to demonstrate flow regimes (1883)

Principles of Gas-Liquid Phase Separation

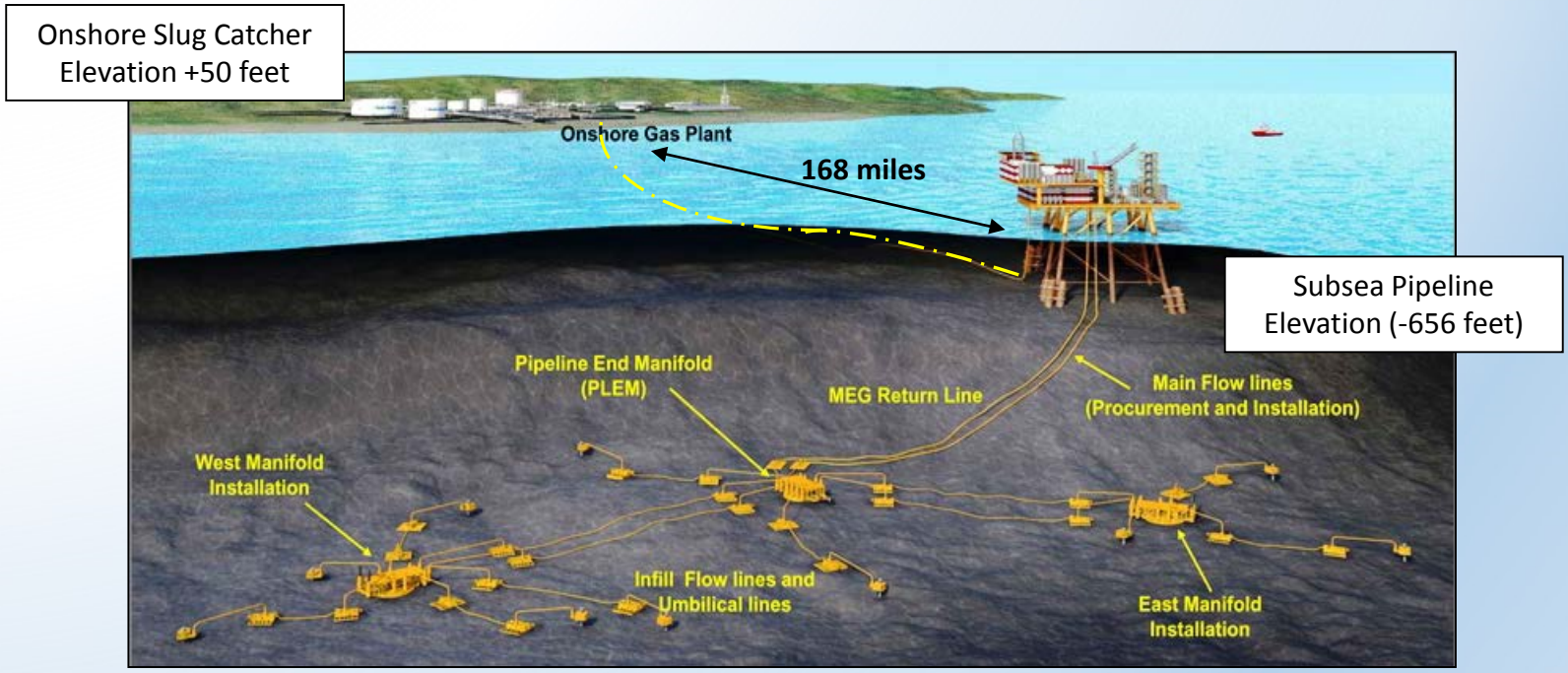


Drag Coefficients vs Re (From *Lapple & Shepard, 1940)*

Applying Principles of Gas-Liquid Phase Separation to HARP Slug Catchers

Momentum = Mass X Velocity or p = mv

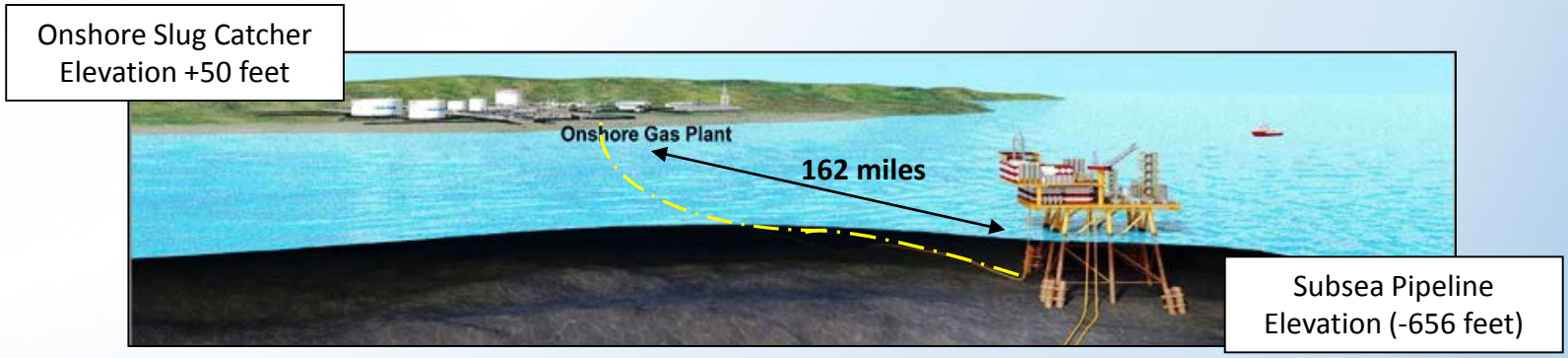
Example Project -Case History



Applying Principles of Gas-Liquid Phase Separation to HARP Slug Catchers

Momentum = Mass X Velocity or p = mv

Example Project -Case History



From subsea design report:

- Slug volume during pigging operations = 12,283 M^3
- Pig speed = 1.5 M/S
- P = mv = 12,283 M^3 x 1.5 M/S x SG (0.69) x 35.32 CF/M^3 x 62.4 LB/CF x 2.204 Kg/LB P

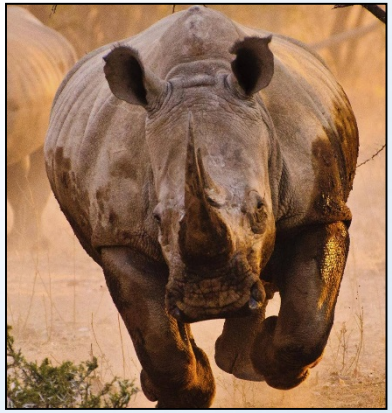
→

= 12,707,545 Kg-M/S

Applying Principles of Gas-Liquid Phase Separation to HARP Slug Catchers

Momentum = Mass X Velocity or p = mv

Example Project -Case History



3629 Kg x 30 MPH = 48,600 Kg-M/S

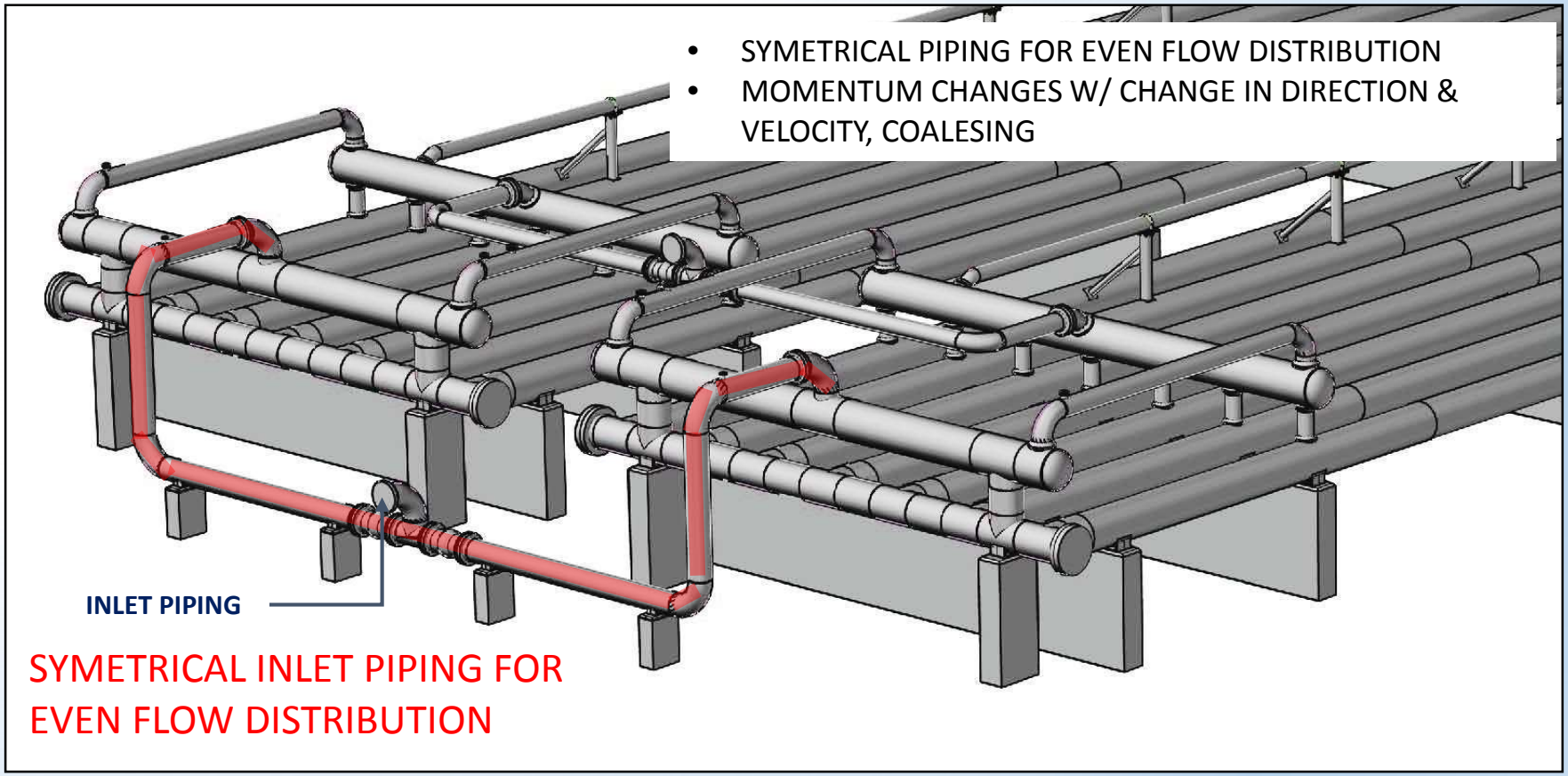
12,707,545 Kg-M/S = 261 Charging Rhinoceros @ 30 MPH

Applying Principles of Gas-Liquid Phase Separation to HARP Slug Catchers

Momentum = Mass X Velocity or p = mv

Don’t underestimate the power of momentum!

Applying Principles of Gas-Liquid Phase Separation to HARP Slug Catchers



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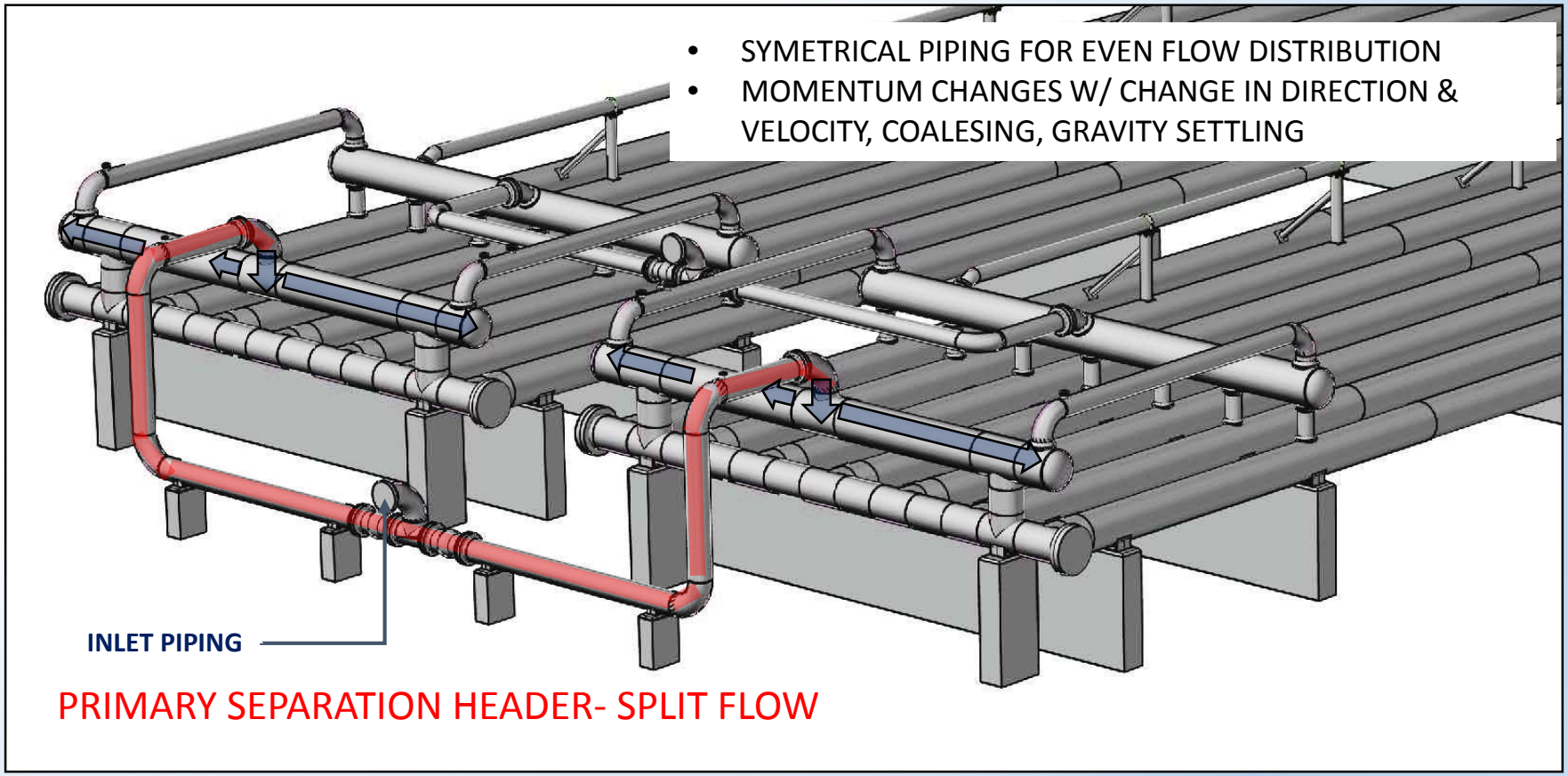

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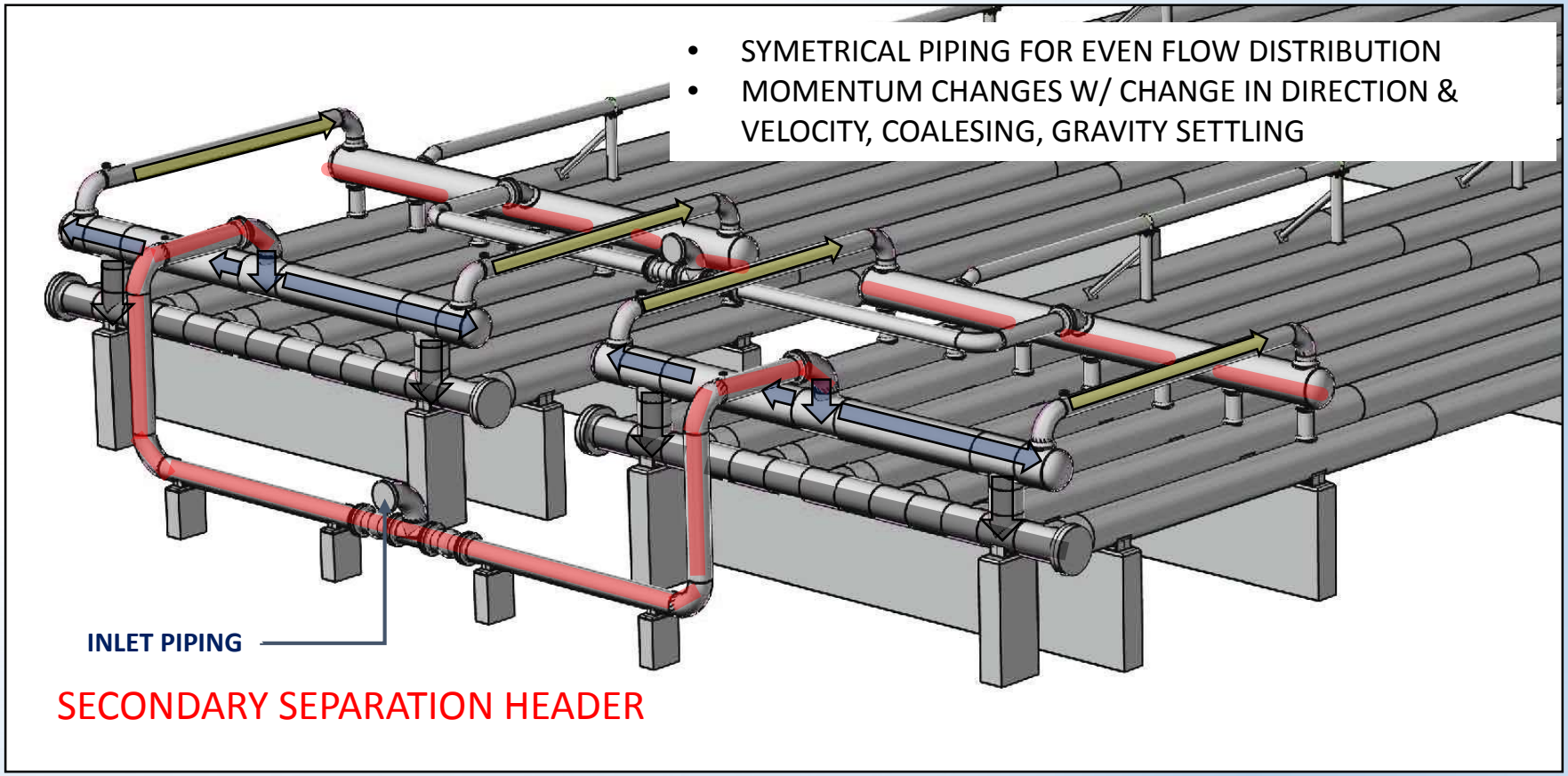

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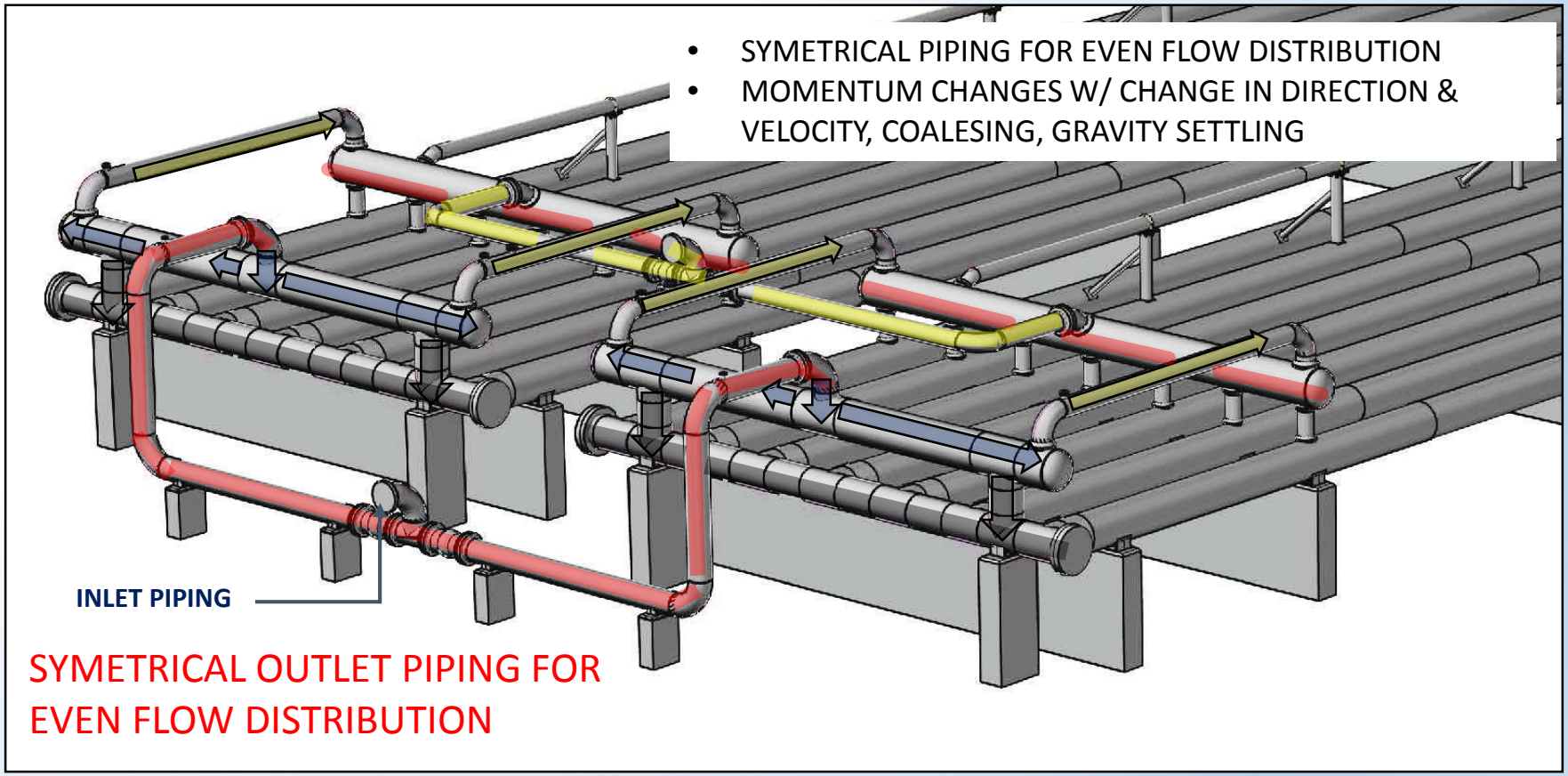

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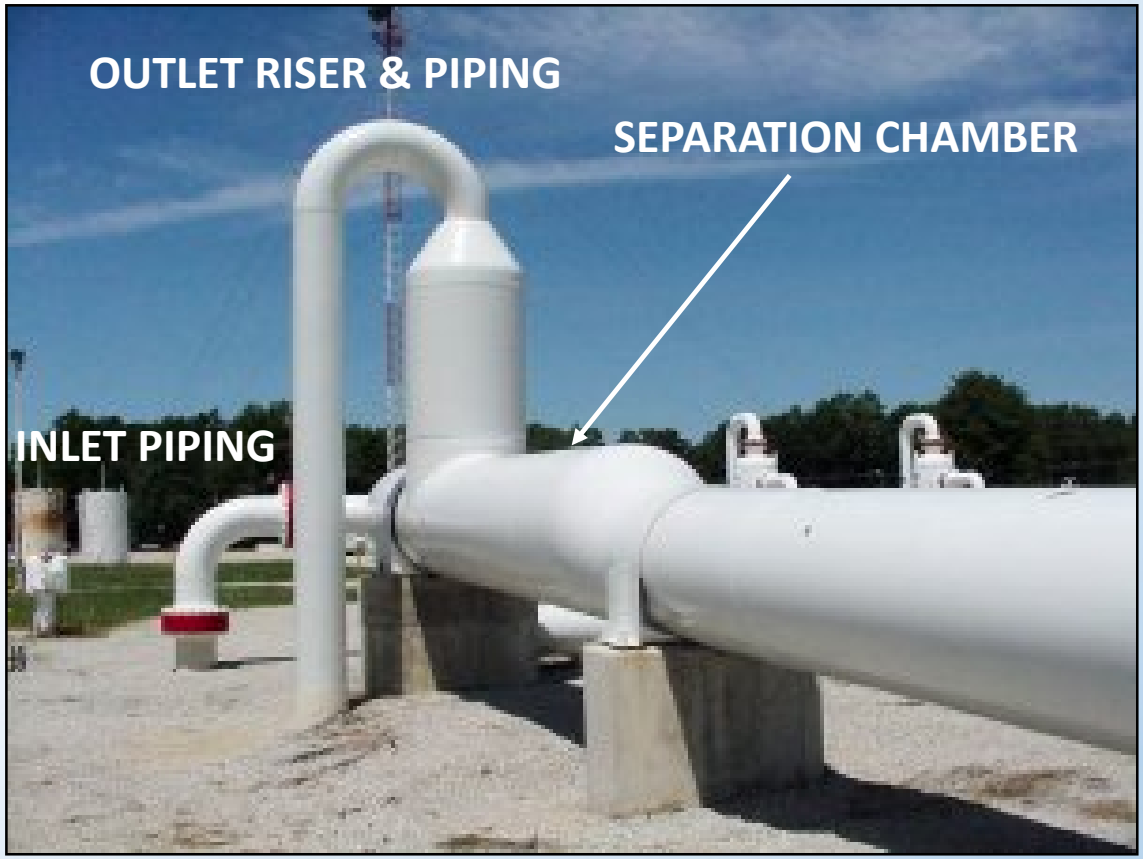

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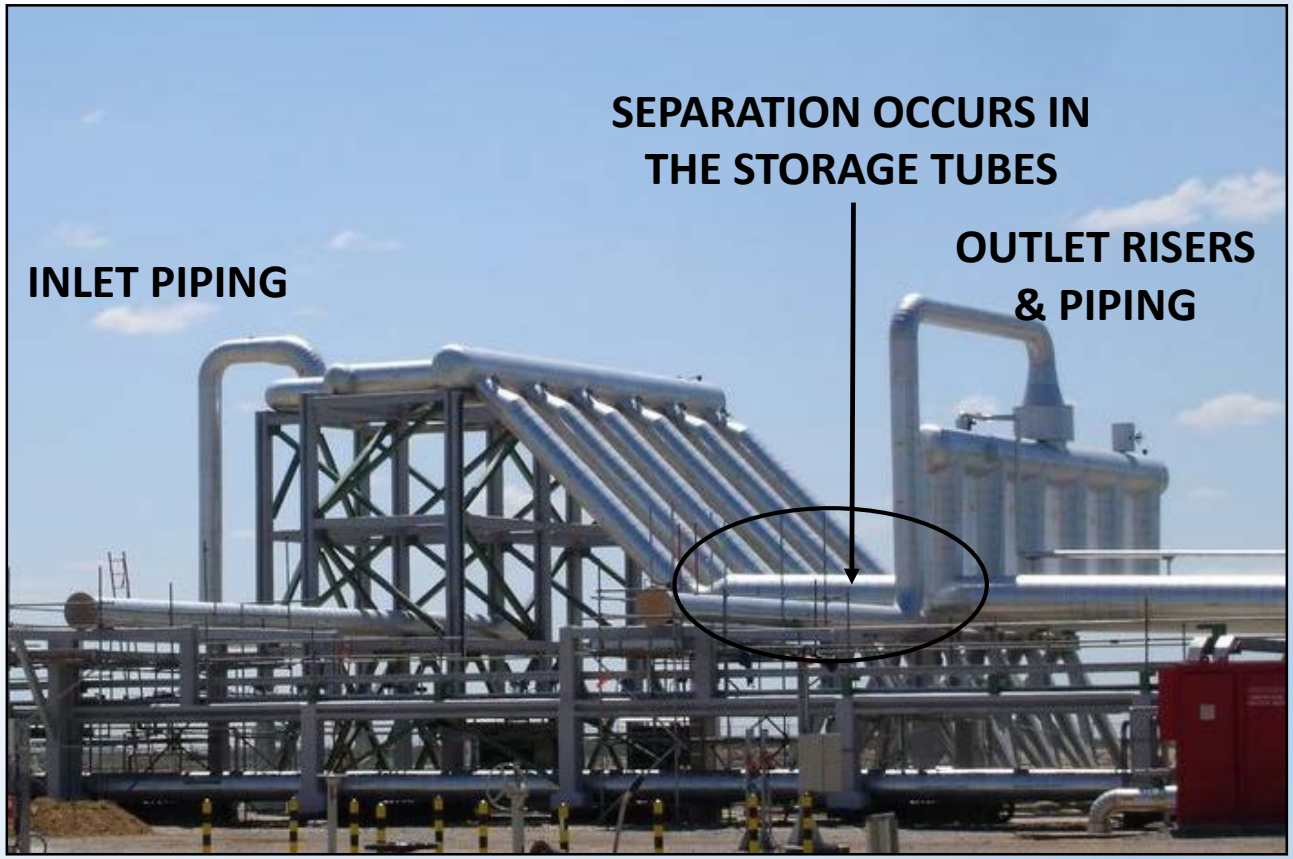

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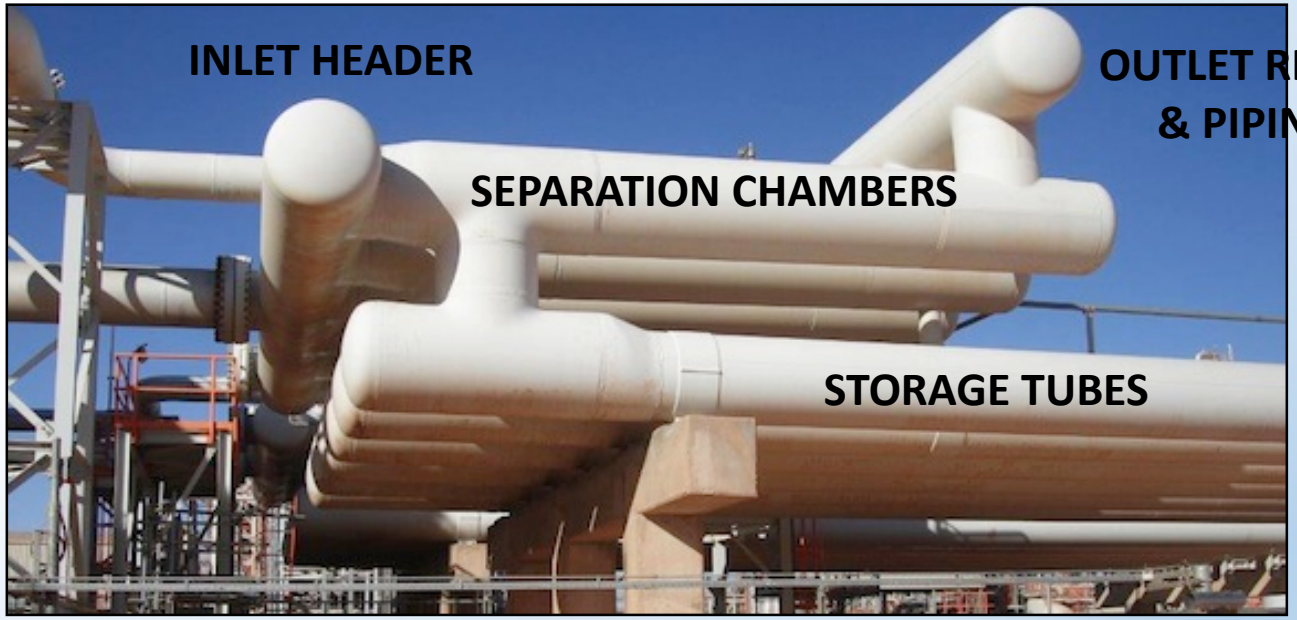

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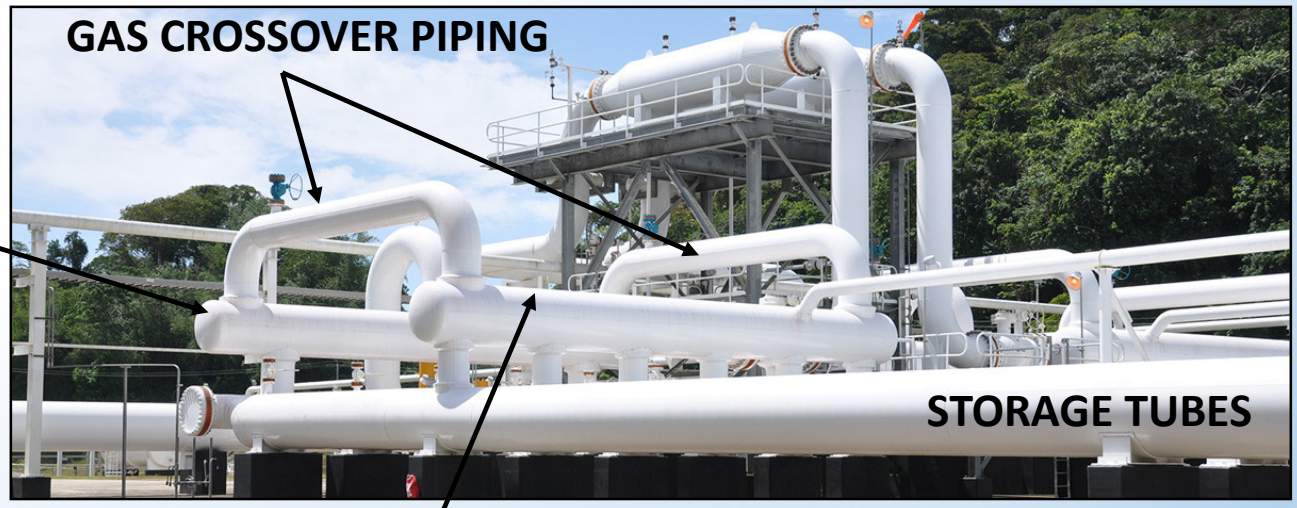


Verifying Principles of Fluid Dynamics
The "New Way"

Flow Assurance

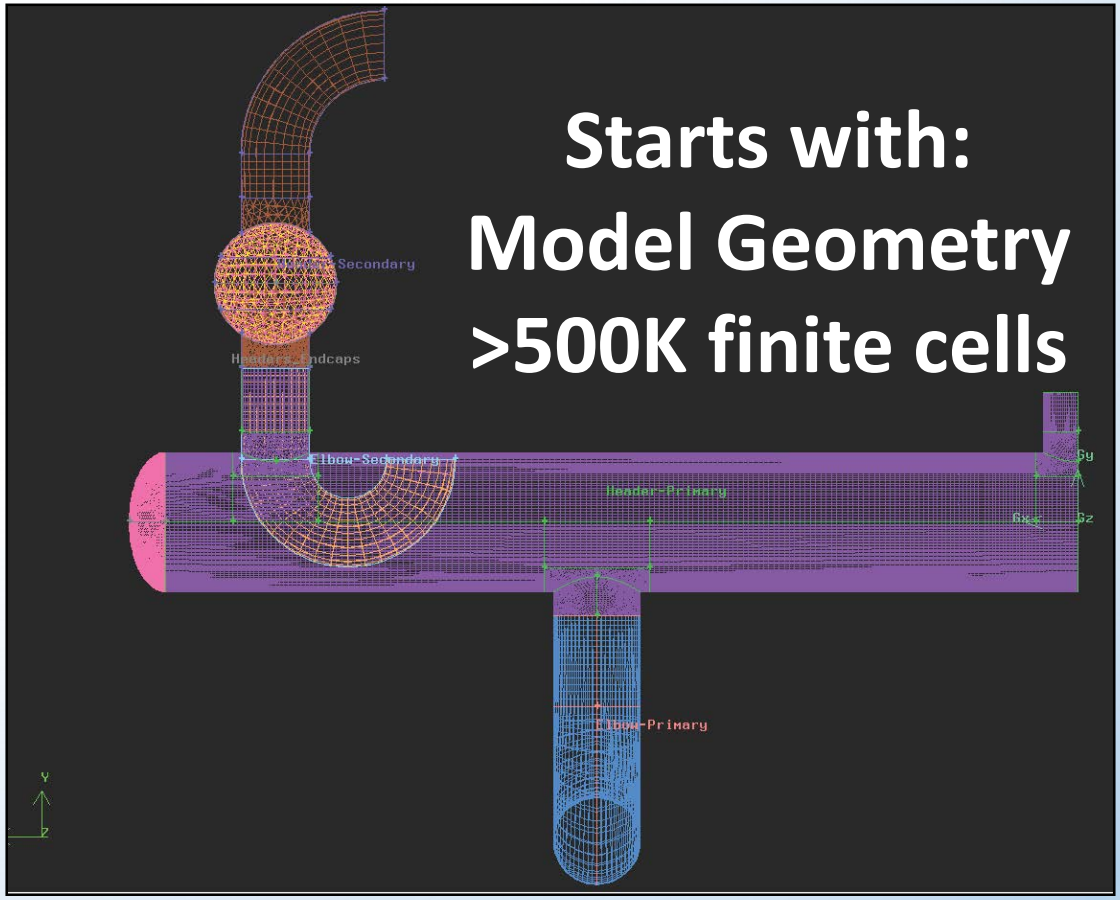
- Relatively new term in oil and gas industry
- Generally refers to ensuring successful and economical flow of hydrocarbon streams from reservoirs to the point of sale
- The term was coined by Petrobras in the early 1990s in Portuguese as "Garantia do Escoamento," meaning "Guarantee of Flow"
- Emerged as a technical specialty
- Offshore Technology Conference has entire technical sessions on flow assurance

Computational Fluid Dynamics (CFD)

- Branch of fluid mechanics that uses numerical analysis and algorithms to solve and analyze fluid flow problems

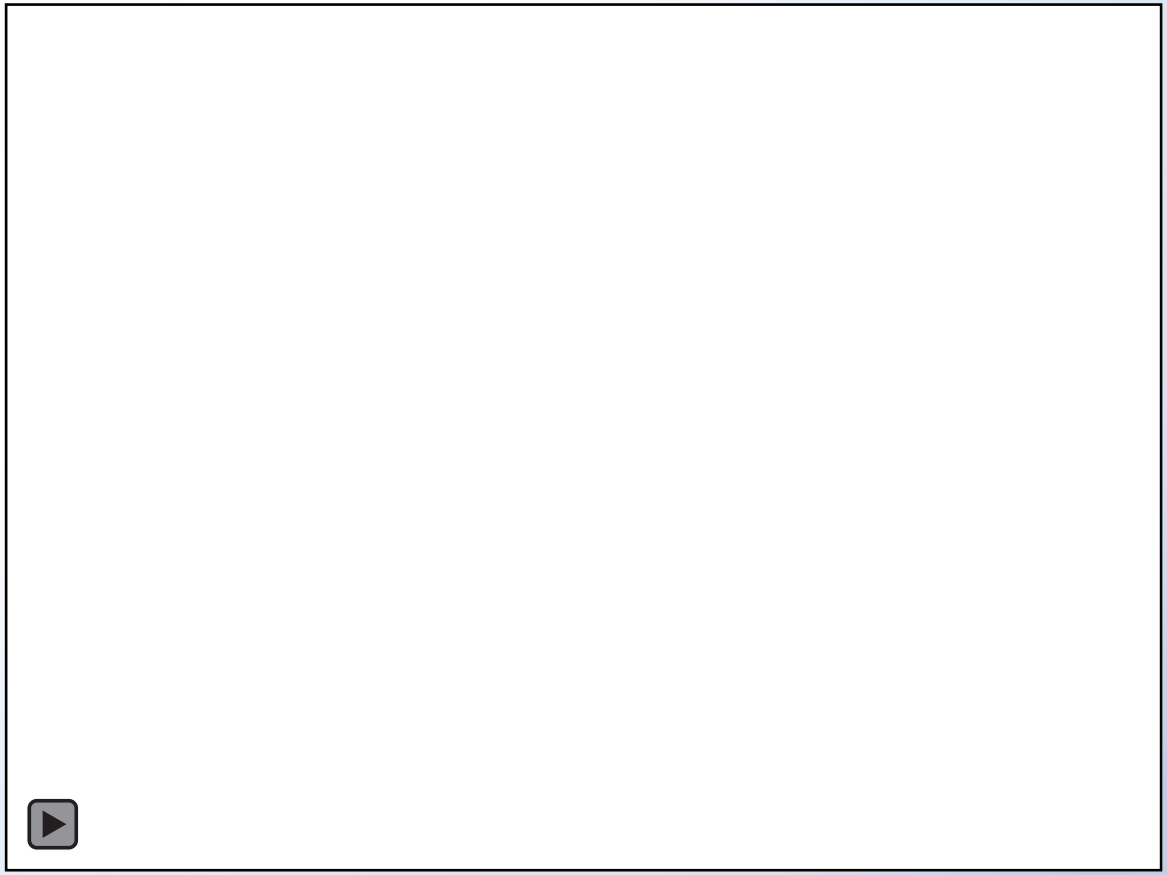
Verification Principles of Fluid Dynamics

The "New Way"



Verifying Principles of Fluid Dynamics

The "New Way"

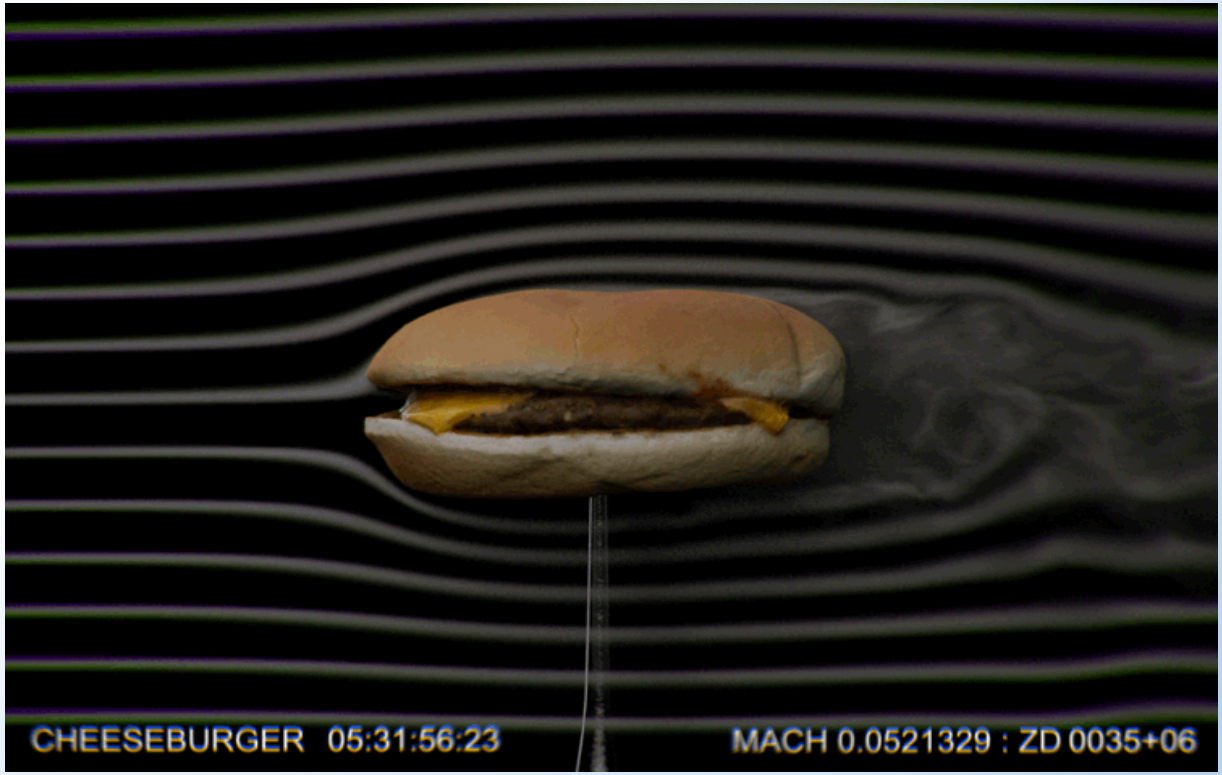


(If the video does not start automatically click in the box.)

The "New Way" Really?

Maybe some of those Old Ways still work just fine!

The "New Way" Really?



CFD of a cheeseburger traveling at 40 mph!

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