COURSE OVERVIEW PE0127
Operations Abnormalities & Plant Upset

Course Title
Operations Abnormalities & Plant Upset

Course Date/Venue
September 14-18, 2025/TBA Meeting Room, The H Dubai Hotel, Sheikh Zayed Rd - Trade Centre, Dubai, UAE

Course Reference
PE0127

Course Duration/Credits
Five days/3.0 CEUs/30 PDHs

Course Description

This practical and highly-interactive course includes various practical sessions and exercises. Theory learnt will be applied using our state-of-the-art simulators.

This course is designed to provide participants with a detailed and up-to-date overview of Operations Abnormalities & Plant Upset. It covers the normal and abnormal operations, types and categories of abnormal situations; the root causes of plant upsets, early warning signs and alarm management; the risk assessment during abnormal conditions by identifying and evaluating risks, using risk matrices and consequence analysis and barriers and safeguards; the pressure vessel, tank upsets, pumps, compressors and mechanical equipment failures; the heat exchanger and furnace abnormalities, reactors and process chemistry deviations; the utility and support system failures, control loop and instrumentation issues; the systematic troubleshooting approach, process data and trends; and the communication and shift handover best practices.

During this interactive course, participants will learn the emergency operations, safe shutdown and managing human error in upset situations; the process hazard analysis (PHA), design considerations to minimize upsets, predictive maintenance and condition monitoring; the process hazard analysis (PHA), design considerations to minimize upsets, predictive maintenance and condition monitoring; the abnormal situation management (ASM) framework, incident investigation, root cause analysis (RCA) and cross-functional coordination during upsets; the reporting and documentation of abnormalities; and the management of change (MOC) during upsets.

Course Objectives

Upon the successful completion of this course, each participant will be able to:-

- Apply and gain in-depth knowledge on operations abnormalities and plant upset
- Discuss the normal and abnormal operations, types and categories of abnormal situations, root causes of plant upsets and early warning signs and alarm management
- Carryout risk assessment during abnormal conditions by identifying and evaluating risks, using risk matrices and consequence analysis and barriers and safeguards
- Identify pressure vessel and tank upsets, pumps, compressors and mechanical equipment failures and heat exchanger and furnace abnormalities
- Recognize reactors and process chemistry deviations, utility and support system failures and control loop and instrumentation issues
- Employ systematic troubleshooting approach, process data and trends and communication and shift handover best practices
- Apply emergency operations and safe shutdown and manage human error in upset situations
- Implement process hazard analysis (PHA), design considerations to minimize upsets, predictive maintenance and condition monitoring
- Apply alarm rationalization and management, operator training and simulation, incident investigation (RCA) follow-up, updating SOPs and work instructions and continuous improvement systems
- Describe abnormal situation management (ASM) framework, incident investigation and root cause analysis (RCA) and cross-functional coordination during upsets
- Report and document abnormalities and apply management of change (MOC) during upsets

Exclusive Smart Training Kit - H-STK®

*Participants of this course will receive the exclusive "Haward Smart Training Kit" (**H-STK®**). The **H-STK®** consists of a comprehensive set of technical content which includes **electronic version** of the course materials conveniently saved in a **Tablet PC**.*

Who Should Attend

This course provides an overview of all significant aspects and considerations of operations abnormalities and plant upset for superintendents, supervisors and foremen in various departments of process plants (production, operations, maintenance, utility, etc.). Further, the course is suitable for emergency teams, managers, supervisors and other technical staff.

Accommodation

Accommodation is not included in the course fees. However, any accommodation required can be arranged at the time of booking.

Course Certificate(s)

Internationally recognized certificates will be issued to all participants of the course who completed a minimum of 80% of the total tuition hours.

Certificate Accreditations

Haward's certificates are accredited by the following international accreditation organizations: -

- British Accreditation Council (BAC)

  Haward Technology is accredited by the **British Accreditation Council** for **Independent Further and Higher Education** as an **International Centre**. Haward's certificates are internationally recognized and accredited by the British Accreditation Council (BAC). BAC is the British accrediting body responsible for setting standards within independent further and higher education sector in the UK and overseas. As a BAC-accredited international centre, Haward Technology meets all of the international higher education criteria and standards set by BAC.

- The International Accreditors for Continuing Education and Training (IACET - USA)

  Haward Technology is an Authorized Training Provider by the International Accreditors for Continuing Education and Training (IACET), 2201 Cooperative Way, Suite 600, Herndon, VA 20171, USA. In obtaining this authority, Haward Technology has demonstrated that it complies with the **ANSI/IACET 2018-1 Standard** which is widely recognized as the standard of good practice internationally. As a result of our Authorized Provider membership status, Haward Technology is authorized to offer IACET CEUs for its programs that qualify under the **ANSI/IACET 2018-1 Standard**.

  Haward Technology's courses meet the professional certification and continuing education requirements for participants seeking **Continuing Education Units** (CEUs) in accordance with the rules & regulations of the International Accreditors for Continuing Education & Training (IACET). IACET is an international authority that evaluates programs according to strict, research-based criteria and guidelines. The CEU is an internationally accepted uniform unit of measurement in qualified courses of continuing education.

  Haward Technology Middle East will award **3.0 CEUs** (Continuing Education Units) or **30 PDHs** (Professional Development Hours) for participants who completed the total tuition hours of this program. One CEU is equivalent to ten Professional Development Hours (PDHs) or ten contact hours of the participation in and completion of Haward Technology programs. A permanent record of a participant's involvement and awarding of CEU will be maintained by Haward Technology. Haward Technology will provide a copy of the participant's CEU and PDH Transcript of Records upon request.

Course Instructor(s)

This course will be conducted by the following instructor(s). However, we have the right to change the course instructor(s) prior to the course date and inform participants accordingly:

Dr. Hesham Abdou, PhD, MSc, PgDip, BSc, is a **Senior Process & Petroleum Engineer** with over **30 years** of integrated experience within the **Oil & Gas** industries. His specialization widely covers in the areas of **Artificial Lift** System, **Artificial Lift** Methods, **Petroleum Economics**, **Petroleum Refinery Processing**, **Refinery** Material Balance Calculation, **Refinery** Gas Treating, **Asset Operational Integrity**, **Drilling** Operations, **Drilling Rig**, **Bits & BHA**, **Mud Pumps, Mud logging** Services, **Wireline & LWD Sensors**, **Casing & Cementing** Operation, **Completion & Workover** Operations, **Petroleum** Engineering, **Production Optimization**, **Well Completion**, **Rig & Rigless Workover**, Advanced **PVT & EOS Characterization**, **PVT/Fluid Characterization/EOS**, Advanced **Phase Behaviour & EOS Fluid Characterization**, **PVT Properties of Reservoir Fluids**, **Directional Drilling** Fundamentals, Application & Limitation, **Horizontal & Multilateral Wells** (Analysis & Design), **Directional**, **Horizontal & Multilateral Drilling**, Root Cause Analysis (**RCA**), Root Cause Failure Analysis (**RCFA**), **Root Cause Analysis** Study, **Root Cause Analysis** Techniques & Methodologies, Process Hazard Analysis (**PHA**), **Crude Oil Testing & Water Analysis**, **Crude Oil & Water** Sampling Procedures, **Equipment Handling** Procedures, **Crude & Vacuum Process** Technology, **Gas Conditioning & Processing**, **Cooling Towers** Operation & Troubleshooting, **Sucker Rod Pumping**, **ESP & Gas Lift**, **PCP & Jet Pump**, **Pigging** Operations, Electric Submersible Pumps (**ESP**), Progressive Cavity Pumps (**PCP**), **Natural & Artificial Flow Well Completion**, **Well Testing** Procedures & Evaluation, **Well** Performance, **Coiled Tubing** Technology, **Oil Recovery Methods** Enhancement**, Well Integrity** Management, **Well Casing & Cementing**, **Acid Gas** Removal, **Heavy Oil Production** & Treatment Techniques, **Water Flooding**, **Water Lift Pumps** Troubleshooting, **Water System Design** & Installation, **Water Networks Design** Procedures, **Water Pumping** Process, **Pipelines**, **Pumps**, **Turbines**, **Heat Exchangers**, **Separators**, **Heaters**, **Compressors**, **Storage Tanks**, **Valves** Selection, **Compressors**, **Tank & Tank Farms** Operations & Performance, **Oil & Gas Transportation**, **Oil & Gas Production** Strategies, **Artificial Lift** Methods, **Piping & Pumping** Operations, Oil & Water Source Wells Restoration, **Pump** Performance Monitoring, **Rotor Bearing** Modelling, **Hydraulic** Repairs & Cylinders, **Root Cause Analysis**, **Vibration & Condition** Monitoring, **Piping Stress** Analysis, **Amine Gas Sweetening & Sulfur Recovery**, Heat & Mass Transfer and Fluid Mechanics.

During his career life, Dr. Hesham held significant positions and dedication as the **General Manager**, **Petroleum Engineering Assistant General Manager**, **Workover Assistant General Manager**, **Workover Department Manager**, **Artificial Section Head**, **Oil & Gas Production Engineer** from Agiba Petroleum Company and **Engineering Consultant/Instructor** for various Oil & Gas companies as well as a **Senior Instructor/Lecturer** for **PhD, Master & BSc degree students** from **various universities** such as the Cairo University, Helwan University, British University in Egypt, Banha University.

Dr. Hesham has **PhD** and **Master** degrees as well as **Post Graduate Diploma** in **Mechanical Power Engineering** and a **Bachelor** degree in **Petroleum Engineering**. Further, he is a **Certified Instructor/Trainer** and a **Peer Reviewer**. Dr. Hesham is an active member of Egyptian Engineering Syndicate and the Society of Petroleum Engineering. Moreover, he has published technical papers and journals and has delivered numerous trainings, workshops, courses, seminars and conferences internationally.

Training Methodology

All our Courses are including **Hands-on Practical Sessions** using equipment, State-of-the-Art Simulators, Drawings, Case Studies, Videos and Exercises. The courses include the following training methodologies as a percentage of the total tuition hours:-

30% Lectures
20% Practical Workshops & Work Presentations
30% Hands-on Practical Exercises & Case Studies
20% Simulators (Hardware & Software) & Videos

In an unlikely event, the course instructor may modify the above training methodology before or during the course for technical reasons.

Course Fee

US$ 5,500 per Delegate + **VAT**. This rate includes H-STK® (Haward Smart Training Kit), buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Course Program

The following program is planned for this course. However, the course instructor(s) may modify this program before or during the course for technical reasons with no prior notice to participants. Nevertheless, the course objectives will always be met:

Day 1: Sunday, 14th of September 2025

0730 – 0800	*Registration & Coffee*
0800 – 0815	*Welcome & Introduction*
0815 – 0830	***PRE-TEST***
0830 – 0930	***Understanding Normal versus Abnormal Operations*** *Definitions and Distinctions • Indicators of Abnormal Conditions • Impact on Safety, Quality, and Production • Common Causes in Process Industries*
0930 – 0945	*Break*
0945 – 1030	***Types & Categories of Abnormal Situations*** *Equipment-Related Upsets • Process Chemistry Deviations • External Factor-Induced Abnormalities • Control System Failures*
1030 – 1130	***Root Causes of Plant Upsets*** *Mechanical Failures • Instrumentation/Control Failures • Human Error and Misoperation • Raw Material and Feedstock Variations*
1130 – 1215	***Early Warning Signs & Alarm Management*** *Recognizing Early Indicators • Role of Alarm Systems in Detection • Nuisance Alarms versus Critical Alarms • Prioritizing Operator Response*
1215 – 1230	*Break*
1230 – 1330	***Risk Assessment during Abnormal Conditions*** *Identifying and Evaluating Risks • Using Risk Matrices and Consequence Analysis • Barriers and Safeguards • Immediate versus Long-Term Actions*
1330 – 1420	***Case Studies of Major Industrial Upsets*** *Real-World Incidents and Causes • Lessons Learned • Mitigation Practices Used • How to Apply Lessons Locally*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day One*

Day 2: Monday, 15th of September 2025

0730 – 0830	***Pressure Vessel & Tank Upsets*** *Overpressure Scenarios • Vacuum Conditions and Collapse • Relief Valve Failures • Foam, Carryover and Contamination*
0830 – 0930	***Pumps, Compressors & Mechanical Equipment Failures*** *Cavitation and Vibration Issues • Seal and Bearing Failures • Reciprocating versus Centrifugal Upsets • Diagnostic Tools for Troubleshooting*
0930 – 0945	*Break*
0945 – 1100	***Heat Exchanger & Furnace Abnormalities*** *Fouling and Plugging • Tube Rupture and Leaks • Burner Instability • Effects on Downstream Operations*
1100 – 1230	***Reactors & Process Chemistry Deviations*** *Catalyst Deactivation • Exothermic Runaway Reactions • Feed Composition Change Impacts • Temperature/Pressure Control Loss*
1230 – 1245	*Break*
1245 – 1330	***Utility & Support System Failures*** *Cooling Water Failure • Steam System Upsets • Instrument Air Loss • Power Failure and Backup Systems*
1330 – 1345	***Control Loop & Instrumentation Issues*** *Sensor Drift and Failure • Controller Tuning Problems • Valve Malfunction • DCS and PLC Errors*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day Two*

Day 3: Tuesday, 16th of September 2025

0730 – 0830	***Systematic Troubleshooting Approach*** *Defining the Problem • Root Cause Hypothesis • Data Collection & Trend Analysis • Validating Solutions*
0830 – 0930	***Use of Process Data & Trends*** *Analyzing Real-Time Process Trends • Pattern Recognition • Identifying Leading versus Lagging Indicators • Historical Data Correlation*
0930 – 0945	*Break*
0945 – 1100	***Communication & Shift Handover Best Practices*** *Structured Communication Protocols • Ensuring Situational Awareness • Logbook and Verbal Handover Methods • Avoiding Miscommunication*
1100 – 1230	***Emergency Operations & Safe Shutdown*** *Emergency Response Plans • Partial versus Full Shutdown Procedures • Interlocks and Safety Instrumented Systems (SIS) • Operator Responsibilities Under Upset*
1230 – 1245	*Break*
1245 – 1330	***Managing Human Error in Upset Situations*** *Understanding Cognitive Load • Human-Machine Interface (HMI) Challenges • Reducing Reliance on Operator Memory • Tools for Decision Support*

1330 – 1345	***Case Studies on Diagnosing Complex Upsets*** *Multi-Factor Upset Scenarios • Escalation Due to Misdiagnosis • Coordination Across Departments • Recovery and Investigation*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day Three*

Day 4: Wednesday, 17th of September 2025

0730 – 0830	***Process Hazard Analysis (PHA)*** *HAZOP and What-If Reviews • Identifying Abnormal Scenarios • Safeguard Verification • Integration with MOC Process*
0830 – 0930	***Design Considerations to Minimize Upsets*** *Design Margins and Redundancy • Equipment and Control System Selection • Layout to Support Troubleshooting • Built-In Safety Systems*
0930 – 0945	*Break*
0945 – 1100	***Predictive Maintenance & Condition Monitoring*** *Vibration Analysis and Thermography • Oil Analysis and Corrosion Monitoring • Predictive Analytics in Abnormality Prevention • Link with Reliability-Centered Maintenance*
1100 – 1230	***Alarm Rationalization & Management*** *Alarm Prioritization • Elimination of Nuisance Alarms • Alarm Shelving and Suppression • Operator Overload Avoidance*
1230 – 1245	*Break*
1245 – 1330	***Operator Training & Simulation*** *Scenario-Based Simulator Training • Emergency Drills • Process Simulation Software • Learning from Mock Upsets*
1330 – 1345	***Implementing Lessons Learned*** *Incident Investigation (RCA) Follow-Up • Sharing Learnings Across Teams • Updating SOPs and Work Instructions • Continuous Improvement Systems*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day Four*

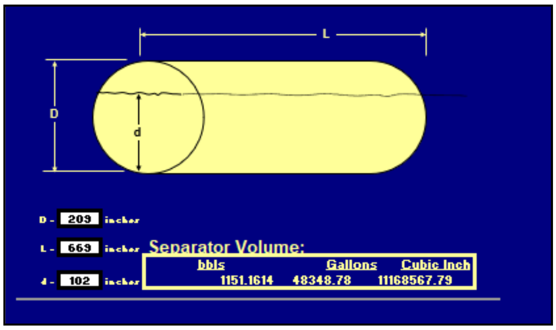
Day 5: Thursday, 18th of September 2025

0730 – 0830	***Abnormal Situation Management (ASM) Framework*** *What is ASM? • ASM Lifecycle and Strategies • Role of Automation and Control • Industry Standards for ASM*
0830 – 0930	***Incident Investigation & Root Cause Analysis (RCA)*** *Types of Investigations (5 Whys, Fishbone, Etc.) • Gathering Facts and Timeline • Recommendations and Follow-Up • Communication of Findings*
0930 – 0945	*Break*
0945 - 1100	***Cross-Functional Coordination during Upsets*** *Role of Operations, Maintenance, and Safety • Roles and Responsibilities • Decision-Making Authority • Crisis Management Coordination*
1100 – 1230	***Reporting & Documentation of Abnormalities*** *What to Document and Why • Tools (eLogs, EHS Systems) • Trend Analysis from Reports • Compliance and Audit Trail*

1230 – 1245	*Break*
1245 – 1345	***Management of Change (MOC) during Upsets*** *Temporary versus Permanent Changes • MOC Process during Emergency Fixes • Ensuring Proper Review and Sign-Off • Integrating with PSM*
1345 – 1400	***Course Conclusion*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Course Topics that were Covered During the Course*
1400 – 1415	***POST-TEST***
1415 – 1430	*Presentation of Course Certificates*
1430	*Lunch & End of Course*

Simulator (Hands-on Practical Sessions)

Practical sessions will be organized during the course for delegates to practice the theory learnt. Delegates will be provided with an opportunity to carryout various exercises using various online system calculator.

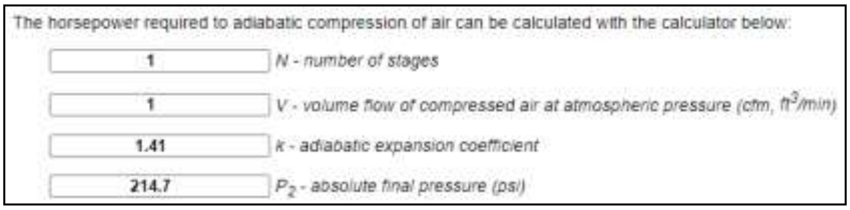


Tank Volume Calculator

Pressure Drop Online-Calculator

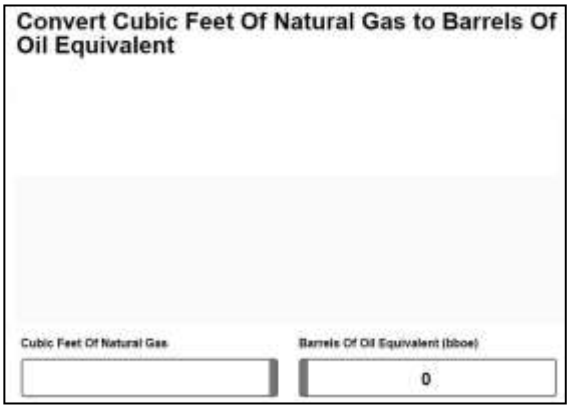
Nozzle Discharge

Nozzle Calculator

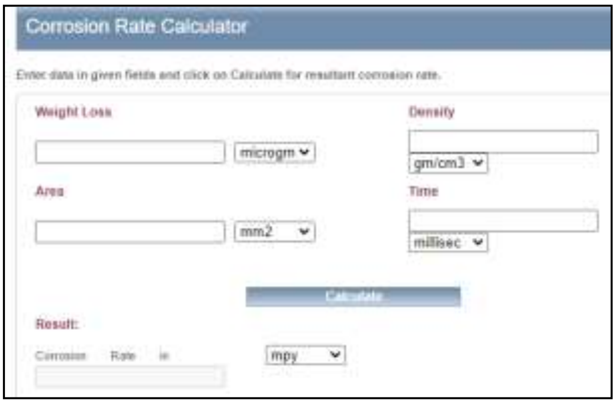


Horsepower Calculator

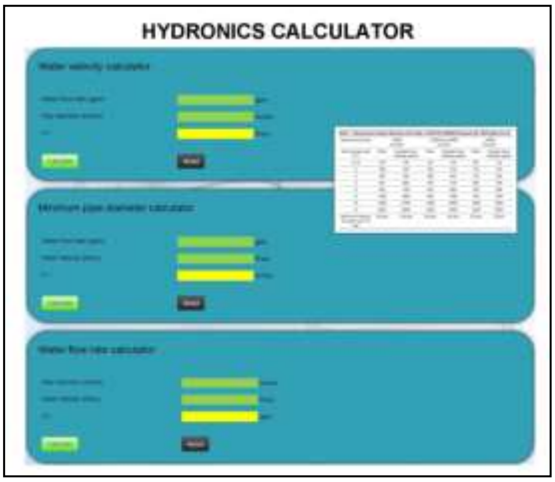
Water Flow Rate through an Orifice Calculator



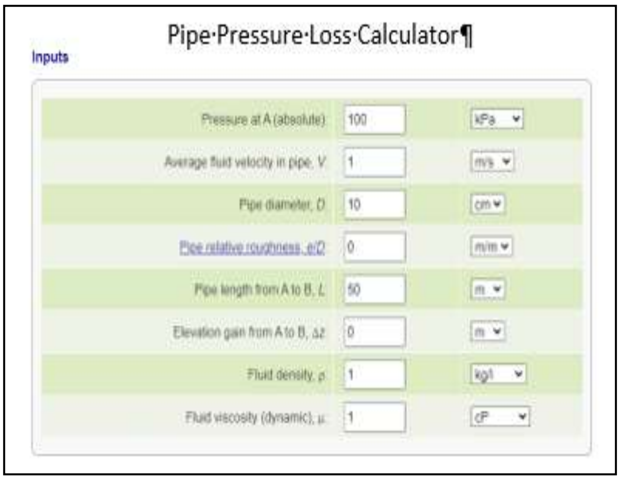
Cubic Feet Calculator



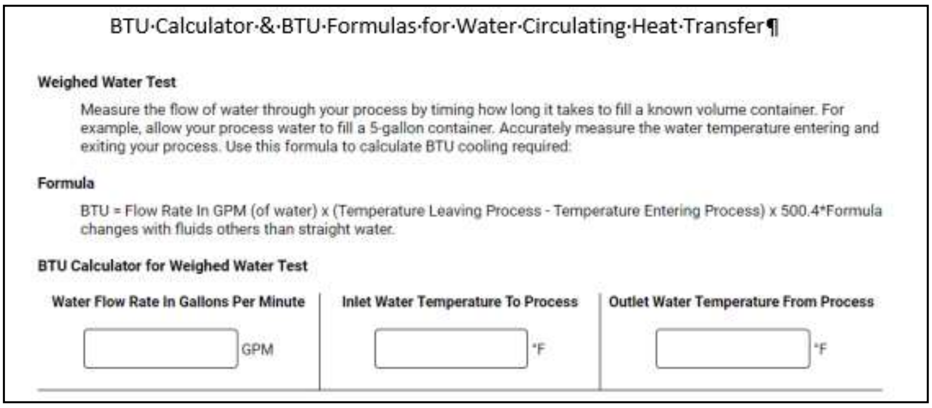
Corrosion Rate Calculator



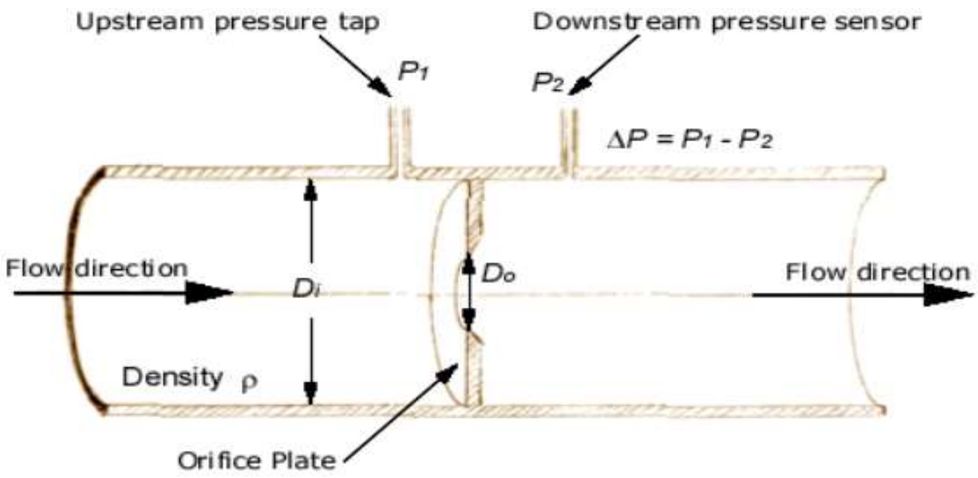
Hydronics Calculator



Pipe Pressure Loss Calculator



BTU Calculator



Inputs

Pipe (inlet) diameter upstream of orifice, D_i:	8	in
Orifice diameter (less than the inlet diameter), D_o:	3	in
Pressure difference across the orifice, Δp:	20	psi
Fluid density, ρ:	835	kg/m^3
Flow Coefficient, C_f:	0.82	

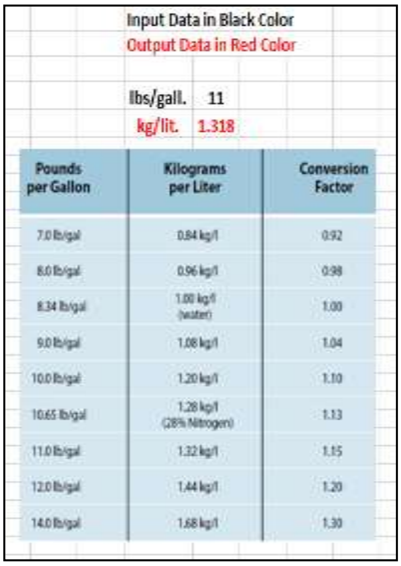
Answers

Velocity at the inlet, V_i:	2.10 m/s	m/s
Volumetric Flowrate, Q:	1080 gpm	gpm
Mass Flowrate:	56.7 kg/s	kg/s

Flow Rate through an Orifice or Valve Calculator

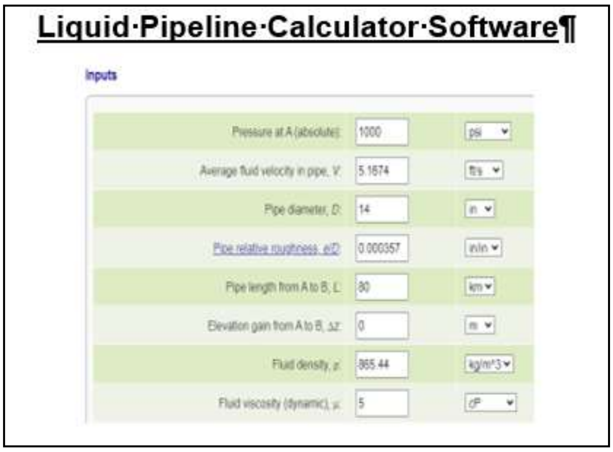
Net Positive Suction Head Calculator

Net Positive Suction Head Calculator

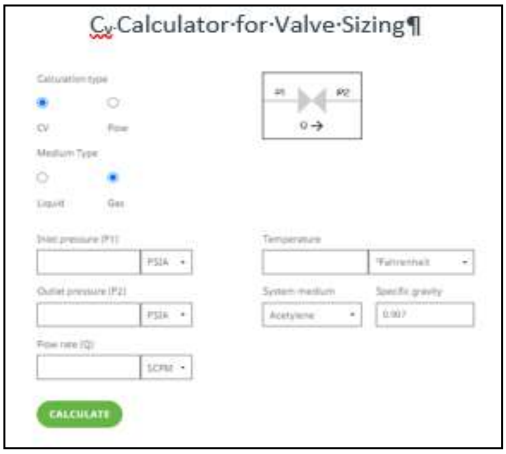


Pounds per Gallon	Kilograms per Liter	Conversion Factor
7.0 lb/gal	0.84 kg/l	0.92
8.0 lb/gal	0.96 kg/l	0.98
8.34 lb/gal	1.00 kg/l (water)	1.00
9.0 lb/gal	1.08 kg/l	1.04
10.0 lb/gal	1.20 kg/l	1.10
10.65 lb/gal	1.28 kg/l (28% Nitrogen)	1.13
11.0 lb/gal	1.32 kg/l	1.15
12.0 lb/gal	1.44 kg/l	1.20
14.0 lb/gal	1.68 kg/l	1.30

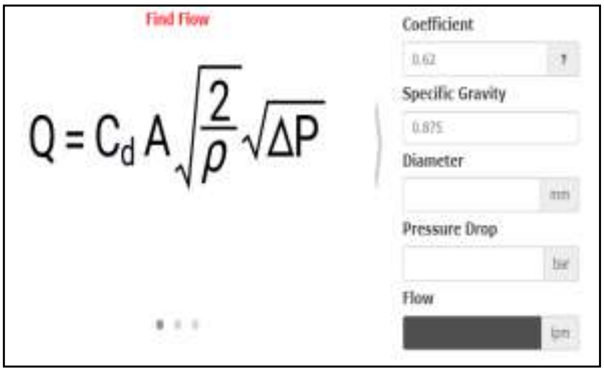
PPG to KG Calculator



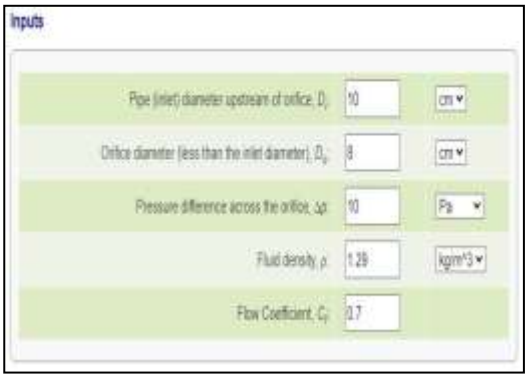
Liquid Pipeline Calculator



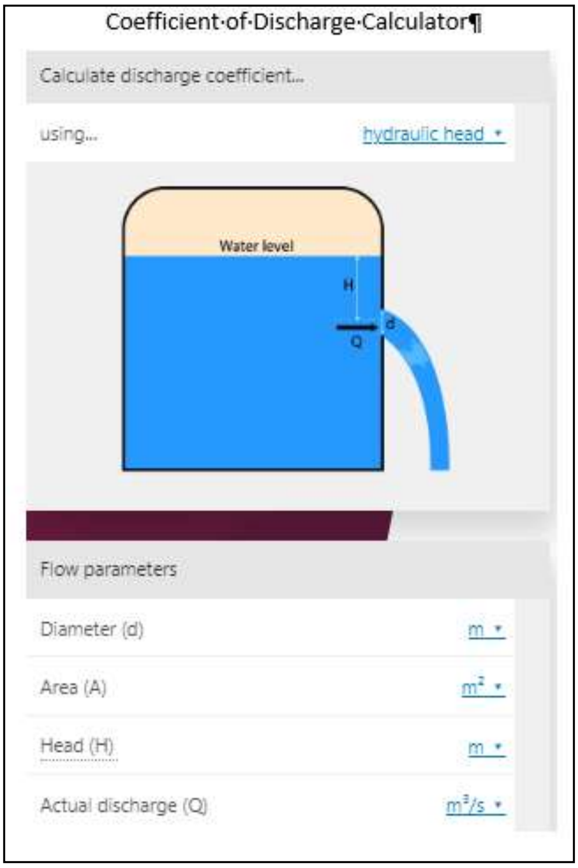
Cv Calculator



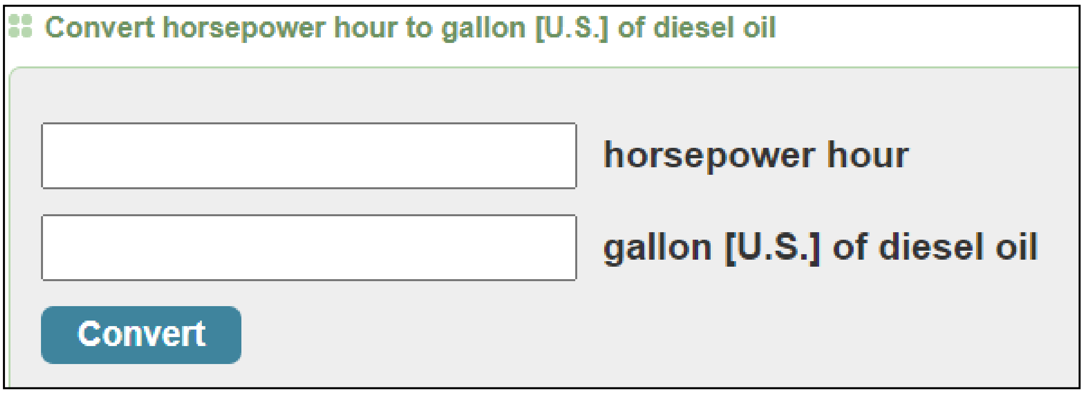
Find Flow Calculator



Flowrate Calculator



Coefficient Discharge Calculator

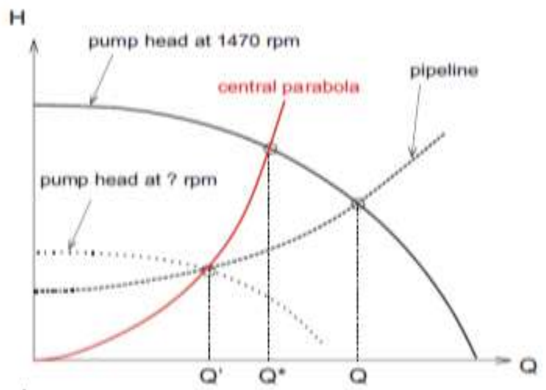


Horsepower Hour Calculator

Liquid Pumping Program	
Input Data	
API	28
c.P.	5
1000 bbl/d	3.3
Length, km	2.4384
I.D., in.	2.800
Rough. (E), in.	0.005
Difference in elev., m	50
Destination press., psi	60
Pump Suc. psi	80
Overall Pump Eff., %	65
Motor Eff., %	90
Motor Loading %	80

Output Results	
Flow Velocity, ft/s	5.0154
Erosion Velocity, ft/s	13.440
E/I.D.	0.001786
sp.gr.	0.8871
Re	19290.3
F	0.02987
Hf, psi	153.67
Hf, m water	108.17
Total Pump Dich. psi	276.68
TDP, psi	196.68
Hydr. Power, HP	16.99
Hydr. Power, Kw	12.67
Shaft Power, HP	18.88
Shaft Power, Kw	14.083
Nama Plate Motor HP	23.60
Nama Plate Motor Kw	17.60

A pump running at $1470[rpm]$ with $H_{pump} = 45 - 2781Q^2$ head delivers water into a pipeline with $H_{pipe} = 20 + 1125Q^2$. Calculate the required revolution number for the reduced flow rate $Q' = 0.05[m^3/s]$.



Solution:

- The actual working point is given by the solution of $H_{pump} = H_{pipe}$, which gives $Q = 0.08[m^3/s]$ and $H = 27.2[m]$.
- Affinity states that while varying the revolutionary speed, H/n^2 and Q/n remain constant. Thus, also H/Q^2 remains constant, let's denote this constant by a. So, while varying the revolutionary speed, the working point moves along the *central parabola* (see figure), given by $H_{ap} = a\,Q^2$.

However, as Q' is given and we also know that this point has to be located on the pipeline characteristic, we know that $H' = 20 + 1125 \times 0.05^2 = 22.81[m]$. Thus, the parameter of the affine parabola is $a = H'/Q'^2 = 9125$.

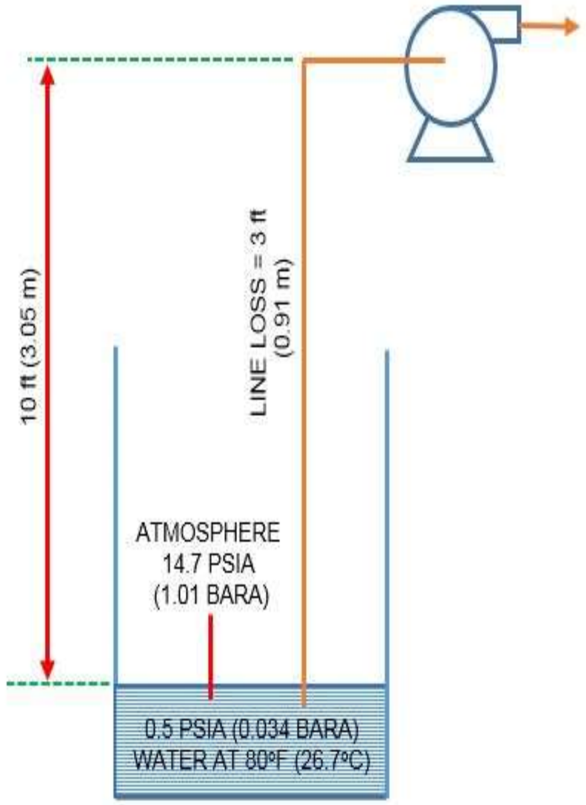
Q^* is given by the intersection of the affine parabola and the original pump characteristic: $H_{ap}(Q^*) = H_{pump}(Q^*)$, which gives $Q^* = 0.06148[m^3/s]$ with $H^* = 34.5[m]$.

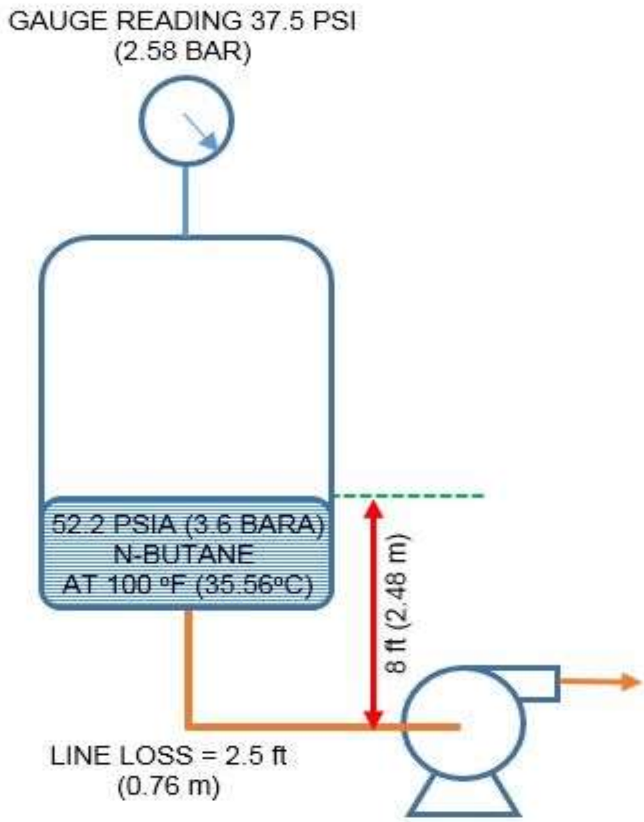
Now we can employ affinity between Q^* and Q':

$$n' = n^* \frac{Q'}{Q^*} = 1470 \times \frac{0.05}{0.06148} = 1195.5[rpm]$$

and just for checking the calculation

$$H' = H^* \left(\frac{n'}{n^*}\right)^2 = 34.5 \times \frac{1195.5^2}{1470^2} = 22.81[m].$$





NPSHA of pump – suction lift

NPSHA of pump – at boiling point
SG of n-butane at 100 deg F = 0.56

NPSHA = Hatmp.+/- Hs – Hf – Hvap.

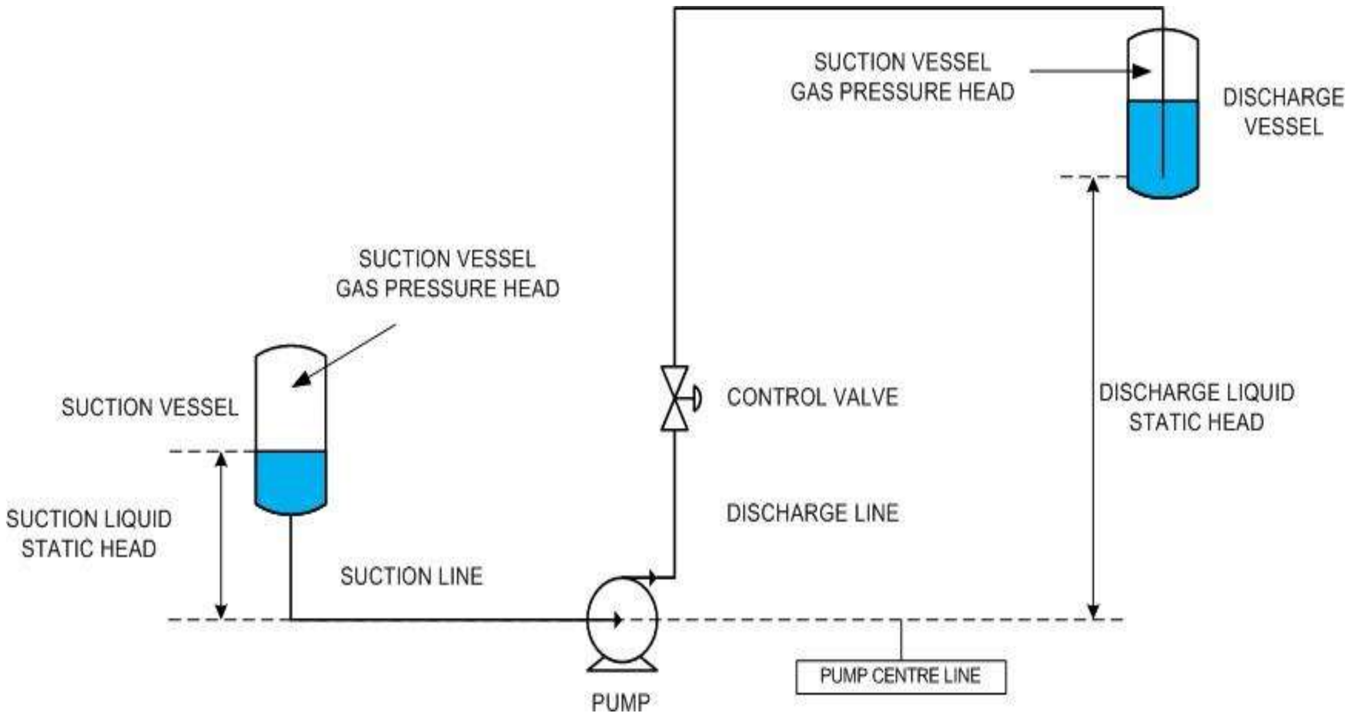
https://engineeringunits.com/net-positive-suction-head-calculator/?utm_content=cmp-true

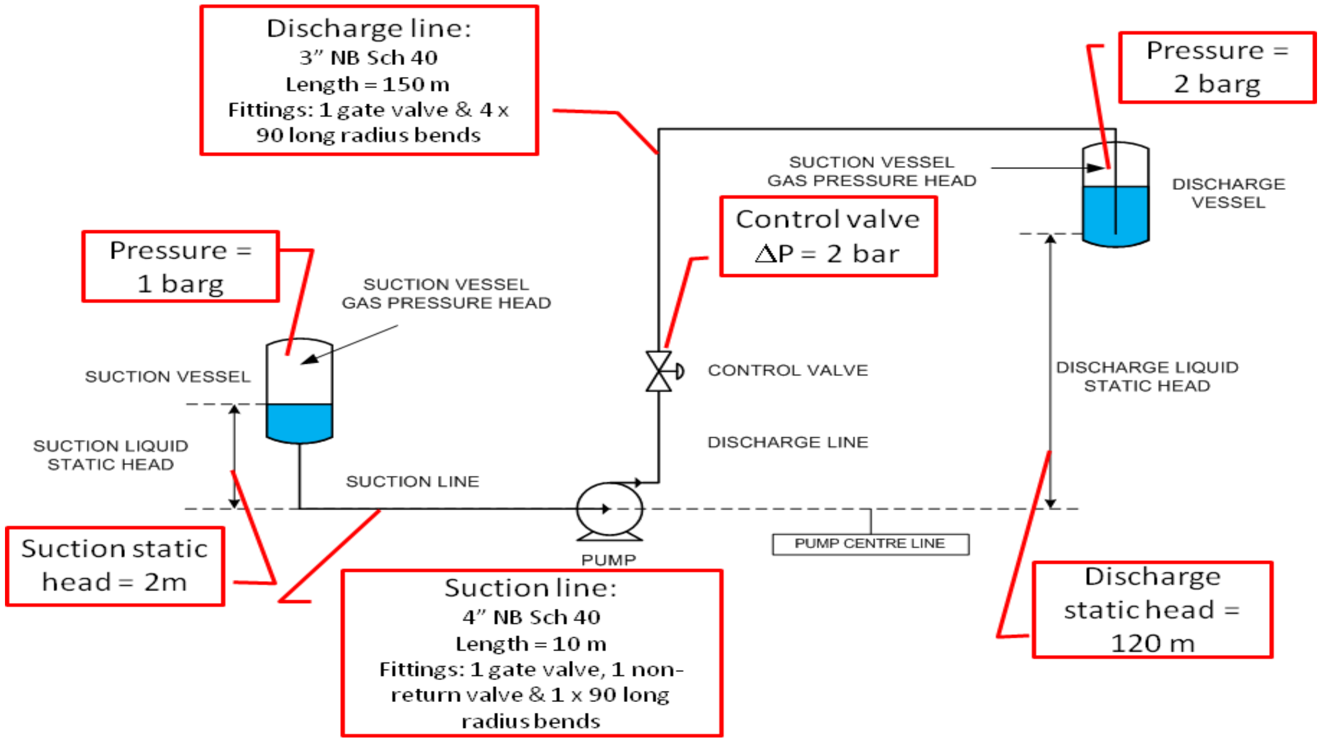
http://www.pressure-drop.com/Online-Calculator/index.html

NPSH Calculations

Input Data	
API	36
c.P.	3
Vapor pressure, psi	10
Atmp. Pressure, psi	14.7
Height above pump, ft	20
1000 bbl/d	2.0
Length, km	0.003
I.D., in.	2.992
Rough. (E), in.	0.005

Output Results	
Flow Velocity, ft/s	2.6620
E/I.D.	0.001671
sp.gr.	0.8448
Re	17363.9
F	0.0302
Hf, psi	0.048
Hf, ft water	0.111
NPSHA, ft oil	32.72
NPSHA, ft water	27.64


SUCTION VESSEL
GAS PRESSURE HEAD
DISCHARGE VESSEL
SUCTION VESSEL
GAS PRESSURE HEAD
SUCTION VESSEL
CONTROL VALVE
DISCHARGE LIQUID
STATIC HEAD
SUCTION LIQUID
STATIC HEAD
DISCHARGE LINE
SUCTION LINE
PUMP CENTRE LINE
PUMP


Discharge line:
3" NB Sch 40
Length = 150 m
Fittings: 1 gate valve & 4 x 90 long radius bends
Pressure = 2 barg
SUCTION VESSEL
GAS PRESSURE HEAD
DISCHARGE VESSEL
Control valve
ΔP = 2 bar
Pressure = 1 barg
SUCTION VESSEL
GAS PRESSURE HEAD
SUCTION VESSEL
CONTROL VALVE
DISCHARGE LIQUID
STATIC HEAD
SUCTION LIQUID
STATIC HEAD
DISCHARGE LINE
SUCTION LINE
PUMP
PUMP CENTRE LINE
Suction static head = 2m
Suction line:
4" NB Sch 40
Length = 10 m
Fittings: 1 gate valve, 1 non-return valve & 1 x 90 long radius bends
Discharge static head = 120 m

Calculator

PUMP DETAILS

Pump tag number		P-001	
Suction vessel tag number		V-001	
Discharge vessel tag number		V-002	
Barometric pressure	P_{atm}	1.013	bara
NPSH available margin	H_{margin}	0	m
Pump efficiency	η	70%	

FLUID PROPERTIES

Fluid		Water	
Phase		Liquid	
Flowrate	m	30000	kg/hr
Density	ρ	998	kg/m3
Viscosity	μ	1	cP
Vapour pressure	P_{vap}	0.023	bara

VESSEL GAS PRESSURES

Suction vessel gas pressure	$P_{suc.\_vessel}$	1	barg
Discharge vessel gas pressure	$P_{dis.\_vessel}$	2	barg

STATIC HEADS

Suction static head	$H_{suc.\_static\_head}$	2	m
Discharge static head	$H_{dis.\_static\_head}$	120	m

PIPELINES

		Suction Line	Discharge Line	
Pipe nominal diameter		4	3	inch
Pipe schedule		Sch 40	Sch 40	
Pipe internal diameter	d	102.26	77.92	mm
Pipe length	L	10	150	m
Absolute roughness	e	0.046	0.046	mm

OUTPUTS

Volumetric flow rate Q 30.060 m3/hr

		Suction Line	Discharge Line	
Relative roughness	e:d	0.00045	0.00059	
Flow area	A	0.00821	0.00477	m2
Velocity	u	1.02	1.75	m/s
Reynolds No.	Re	103758	136170	
Flow regime		turbulent	turbulent	
Friction factor	f	0.02011	0.02010	
Pipe velocity head loss	K_{pipe}	1.966	38.695	
Fittings total velocity head loss	$K_{fittings}$	1.724	2.152	
Frictional pressure loss	$\Delta P_{friction}$	0.02	0.62	bar
Frictional head loss	$H_{friction}$	0.19	6.38	m

Pump suction pressure	$P_{suction}$	2.19 bara
Pump suction head	$H_{suction}$	22.37 m
Pump discharge pressure	$P_{discharge}$	15.39 bara
Pump discharge head	$H_{discharge}$	157.16 m
Net positive suction pressure available	P_{NPSHA}	2.17 bara
Net positive suction head available	NPSHa	22.13 m
Pump total differential pressure	ΔP_{pump}	**13.20 bar**
Pump total differential head	H_{pump}	**134.79 m**
Pump absorbed power	E	**15.74 kW**

Results of above calculations may be confirmed through either of followinglinks:

https://www.swagelok.com/en/toolbox/cv-calculator

https://experttoolsonline.com/danfoss/orifice_calculator

https://www.efunda.com/formulae/fluids/calc_orifice_flowmeter.cfm

https://www.omnicalculator.com/physics/coefficient-of-discharge

Power Calculations:
https://inventory.powerzone.com/resources/centrifugal-pump-power-calculator/%3Aflu%3DGPM%3Apru%3DHEAD%20FT%3Apu%3DHP

http://irrigation.wsu.edu/Content/Calculators/General/Required-Water-Pump-HP.php

Required Compressor Horsepower
https://www.engineeringtoolbox.com/horsepower-compressed-air-d_1363.html

Input Data		Output Results	
T1, F	60	Compression Ratio	34.014
K	1.35	Cp, J/kg/K	1107
P1, psi	14.7	Gas, cfm	36791.50
P2, psi	500	Gas, kg/s	21.250
Gas sp.gr.	1	Theoretical Power, HP	9731.847
No. of Comp. stages	3	Total Required HP	12721.37
Gas million SCMD	1.5		
Eff. of Gas Comp., %	85		
Eff. of Driving Motor, %	90		

Heater Duty
https://www.advantageengineering.com/fyi/288/advantageFYI288.php

Input Data		Output Results	
Million BTU/hr.	0.75	Delta Temp., C	15.6
API	10.0	Mega Watt	0.220
Specific Heat, BTU/lb/F	1.00	Billion Joule/hr.	0.791
Delta Temp., F	60	gpm	25.0
Heater Eff., %	100	gallon/hr.	1498.4
		Lit./min.	94.5
		m3/hr.	5.7
		1000 bbl/d	0.856
		Required Diesel Lit./day	502.90
		Required Diesel bbl/d	3.16
		Required Gas, 1000 ft3/d	16.364
		Required crude oil, bbl/d	3.268

https://www.enggcyclopedia.com/2011/09/problem-solving-heat-exchanger-tubeside-pressure-drop-calculation/

Input Data		Output Results	
Mass Flow Rate, kg/hr.	2000.0	cm3/s	562.303
Fluid Density, Kg/m3	988.0	V, cm/s	110.9720
Visc., c.P.	0.53	Re	52544.59
Pipe Diameter (D), in.	1	f	0.0261
Roughness (E), mm	0.045	Total Hf, cm (per single tube)	22.5583
Tube Length, m	3.5	Total Hf, psi (per single tube)	0.3166
No. of tubes	1	Total Hf, bar (per single tube)	0.0218

Heat exchanger tube side pressure drop calculation

Calculate the tube side pressure drop for the following heat exchanger specification,

Process fluid = water

Inlet pressure = 4 barg

Inlet temperature = 50^0C

Outlet temperature = 30^0C

Tubeside flowrate = 50000 kg/hr

Number of tubes = 25

Tube ID (internal diameter) = 1 inch

Tube length = 3.5 m

Total volumetric flow = 50000 kg/hr ÷ 988.0 kg/m^3 = 50.61 m^3/hr Volumetric flow in each 1" tube = 50.61 ÷ 25 = 2.02 m^3/hr Pressure loss per unit length of the tube is then calculated using EnggCyclopedia's pressure drop calculators for pipes and tubes. This calculator is based on Darcy-Weisbach equation.

Pressure loss across a single tube (ΔP/L) = 6.17 bar/km

SINGLE PHASEFLOW INPUTS		
W – Mass flow capacity	2000	kg/h
ρ – Density of fluid	988	kg/m^3
μ – Viscosity of fluid (either liquid or gas)	0.53	cP
PIPE SPECIFICATIONS		
e – Effective roughness of the pipe	0.045	mm
d – Nominal diameter of the pipe	1	inches
sch – pipe schedule	STD	
Calculate pressure loss	Reset	
RESULTS		
Fluid Velocity	1.110	m/s
Volumetric flow	2.02	m^3/hr
Reynold's No.	52557.9	
Pressure loss	6.1715	bar/km

Tube length (L) = 3.5 m

Tubeside pressure drop (ΔP) = 6.17 × 3.5 / 1000 = 0.0216 bar

Another alternative is to directly use EnggCyclopedia's Heat Exchanger Tube side Pressure Drop Calculator. All the inputs given in the sample problem statements are given to the calculator and pressure drop across the tubeside is calculated as output. This calculator uses the same basic steps discussed above and hence the answer also matches with the figure above (0.0216 bar) . The following image is a snapshot of this direct calculation of tubeside pressure drop.

Exchanger tubeside pressure drop

Tubeside inputs		
Total tubeside mass flow	50000	kg/hr
Tubeside Density	988	kg/m^3
Tubeside Viscosity	0.53	cP
Number of tubes	25	
Total tube length (accounting for all tube passes)	3.5	m
Tube nominal diameter	1	inches
Tubeside roughness	0.045	mm
Calculate pressure drop	Reset	
Results		
Tubeside pressure drop	0.0216	bar

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