

FLOW OF FLUIDS

Excel Workbook



- PETROLEUM
- REFINING
- PETROCHEMICAL
- CHEMICAL ENGINEERING







PREFACE

The most diverse substances are transported and distributed in piping systems every single day. They include aggressive fluids in the chemical industry, hydrocarbons in petrochemistry or steam for energy transmission.

Chemical engineers who are designing these piping systems and specifying associated equipment like valves, pumps and flow meters probably face more fluid flow problems than any other.

Pressure drop calculations help the engineer size pipes and ducts, determine performance requirements for pumps and fans, and specify control valves and flow meters. And although the underlying theory is rather simple, its practical application can be confusing due to the empirical nature of important correlations, multiple methods for expressing parameters, many variable inputs, and alternative units of measurement.

To help you assess flow of fluids, calculate pressure drops, size pipes, control valves and flow meter devices, we have developed an Excel VBA based engineering tool : *Flow of Fluids Excel Workbook*.

Flow of Fluids Excel Workbook simulates the operation of small piping systems transporting liquids and industrial gases under a variety of operating conditions.

Flow of Fluids Excel Workbook is based on industry recognized principles and standards from ASME, HI, IEC, AWWA, ISA, and ANSI...

Flow of Fluids Excel Workbook is easy-to-use and has a highly intuitive user interface.



A. PHYSICAL PROPERTIES OF FLUIDS

1. PROPERTIES OF WATER AND STEAM

a. SATURATION PROPERTIES WITH TEMPERATURE

b. SATURATION PROPERTIES WITH PRESSURE

c. PROPERTIES GIVEN PRESSURE AND TEMPERATURE

d. PROPERTIES GIVEN PRESSURE AND ENTHALPY

2. DYNAMIC VISCOSITY OF GASES

3. KINEMATIC VISCOSITY

4. WEIGHT DENSITY OF LIQUIDS

a. FORMULA1

b. FORMULA 2

c. FORMULA3

5. SPECIFIC GRAVITY OF LIQUIDS

a. FORMULA1

b. FORMULA 2

6. SPECIFIC GRAVITY - DEG API

7. SPECIFIC GRAVITY - DEG BEAUME

8. SPECIFIC VOLUME

9. WEIGHT DENSITY OF IDEAL GASES

10. WEIGHT DENSITY OF REAL GASES



A. PHYSICAL PROPERTIES OF FLUIDS

- 11. GAS COMPRESSIBILITY FACTOR
- 12. SPECIFIC GRAVITY OF GASES
- 13. BOILING POINT PURE COMPONENT
- 14. VAPOR PRESSURE : PURE COMPONENT
- 15. VAPOR PRESSURE : MIXTURE





B. NATURE OF FLOW IN PIPE

1. RATE OF FLOW AT FLOWING CONDITION a. FORMULA 1 b. FORMULA 2

- 2. RATE OF FLOW
 - a. FORMULA 1 b. FORMULA 2
 - c. FORMULA2

3. MEAN VELOCITY OF FLOW IN PIPE

- a. FORMULA 1
- b. FORMULA 2
- c. FORMULA3

4. REYNOLDS NUMBER

- a. FORMULA1
- b. FORMULA 2
- c. FORMULA3
- d. FORMULA4
- e. FORMULA 5
- f. FORMULA6
- g. FORMULA7



C. BERNOULLI'S THEOREM

1. TOTAL HEAD OR FLUID ENERGY

2. LOSS OF STATIC PRESSURE HEAD (hL) DUE TO FLUID FLOW

D. HEAD LOSS, PRESSURE DROP AND FRICTION FACTOR THROUGH PIPE

1. LOSS OF STATIC PRESSURE HEAD

- a. FORMULA 1
- b. FORMULA 2
- c. FORMULA3
- d. FORMULA 4
- e. FORMULA 5
- f. FORMULA6

2. PIPE PRESSURE DROP

- a. FORMULA 1
- b. FORMULA 2
- c. FORMULA3
- d. FORMULA 4
- e. FORMULA 5
- f. FORMULA6
- g. FORMULA 7



D. HEAD LOSS, PRESSURE DROP AND FRICTION FACTOR THROUGH PIPE

3. PRESSURE DROP FOR LAMINAR FLOW ACCORDING TO POISEUILLE'S LAW

4. PRESSURE DROP FOR TURBULENT FLOW ACCORDING TO HAZEN-WILLIAMS FORMULA

- 5. FRICTION FACTOR FOR LAMINAR FLOW
- 6. FRICTION FACTOR FOR TURBULENT FLOW
 - a. COLEBROOK EQUATION
 - **b. SERGHIDE EQUATION**
 - c. SWAMEE-JAIN EQUATION



E. GAS CALCULATIONS

1. PERFECT GAS LAW

- a. DETERMINING THE NUMBER OF MOLES OF A PERFECT GAS
- b. DETERMINING THE PRESSURE OF A PERFECT GAS
- c. DETERMINING THE TEMPERATURE OF A PERFECT GAS
- d. DETERMINING THE VOLUME OF A PERFECT GAS

2. NON-IDEAL GAS LAW

- a. DETERMINING THE NUMBER OF MOLES OF A NON-IDEAL GAS
- b. DETERMINING THE PRESSURE OF A NON-IDEAL GAS
- c. DETERMINING THE TEMPERATURE OF A NON-IDEAL GAS
- d. DETERMINING THE VOLUME OF A NON-IDEAL GAS
- 3. STANDARD ◀► ACTUAL GAS FLOW

F. COMPRESSIBLE FLOW IN STRAIGHT HORIZONTAL PIPELINE

1. COMPLETE ISOTHERMAL EQUATION

G. GAS PIPELINES : MASS FLOW RATE EQUATION



H. HORIZONTAL GAS PIPELINES : STANDARD VOLUMETRIC FLOW RATE EQUATIONS

1. GENERAL STANDARD VOLUMETRIC FLOW RATE

2. WEYMOUTH STANDARD VOLUMETRIC FLOW RATE EQUATION FOR SIZING HORIZONTAL GAS PIPELINES IN FULLY TURBULENT FLOW

 PANHANDLE "A" STANDARD VOLUMETRIC FLOW RATE EQUATION FOR SIZING HORIZONTAL GAS PIPELINES IN PARTIALLY TURBULENT FLOW
PANHANDLE "B" STANDARD VOLUMETRIC FLOW RATE EQUATION FOR SIZING HORIZONTAL GAS PIPELINES IN FULLY TURBULENT FLOW

I. ELEVATED GAS PIPELINES : STANDARD VOLUMETRIC FLOW RATE EQUATION

J. LIQUID FLOW THROUGH ORIFICES

K. LIQUID FLOW THROUGH ISA 1932 NOZZLES

L. LIQUID FLOW THROUGH LONG RADIUS NOZZLES

M. LIQUID FLOW THROUGH VENTURI NOZZLES



- N. LIQUID FLOW THROUGH VENTURI METERS
- **O. GAS FLOW THROUGH ORIFICES**
- P. GAS FLOW THROUGH ISA 1932 NOZZLES
- Q. GAS FLOW THROUGH LONG RADIUS NOZZLES
- **R. GAS FLOW THROUGH VENTURI NOZZLES**
- S. GAS FLOW THROUGH VENTURI METERS
- T. RESISTANCE COEFFICIENT FOR PIPES, VALVES AND FITTINGS
- 1. CONTRACTION
- 2. ENLARGEMENT
- 3. GATE VALVES
- 4. GLOBE AND ANGLE VALVES
- 5. SWING CHECK VALVES
- 6. LIFT CHECK VALVES
- 7. TILTING DISC CHECK VALVES
- 8. STOP CHECK VALVES



T. RESISTANCE COEFFICIENT FOR PIPES, VALVES AND FITTINGS

- 9. FOOT VALVES WITH STRAINER
- 10. BALL VALVES
- **11. BUTTERFLY VALVES**
- **12. DIAPHRAGM VALVES**
- 13. PLUG VALVES
- 14. MITRE BENDS
- 15. 90° PIPE BEND AND FLANGED OR BW 90° ELBOWS
- 16. MULTIPLE 90° PIPE BENDS
- 17. CLOSE PATTERN RETURN BENDS
- 18. STANDARD ELBOWS
- 19. PIPE ENTRANCE
- 20. PIPE EXIT
- 21. TEES AND WYES CONVERGING FLOW
- 22. TEES AND WYES DIVERGING FLOW
- 23. ORIFICES, NOZZLES AND VENTURIS



U. HEAD LOSS AND PRESSURE DROP THROUGH VALVES AND FITTINGS

- 1. LOSS OF STATIC PRESSURE HEAD
 - a. FORMULA 1
 - b. FORMULA 2
 - c. FORMULA3
- 2 PIPE PRESSURE DROP
 - a. FORMULA 1
 - b. FORMULA 2
 - c. FORMULA3

V. FLOW OF FLUIDS THROUGH VALVES, FITTINGS AND PIPE

1. LIQUID FLOW THROUGH A VALVE, FITTINGS AND PIPE

- a. FORMULA 1
- b. FORMULA 2
- c. FORMULA3
- d. FORMULA4
- e. FORMULA 5
- f. FORMULA6
- g. FORMULA 7



V. FLOW OF FLUIDS THROUGH VALVES, FITTINGS AND PIPE

2. GAS FLOW THROUGH A VALVE; FITTINGS AND PIPE

- a. FORMULA 1
- b. FORMULA 2
- c. FORMULA3
- 3. VALVE FLOW COEFFICIENT "Cv"
 - a. FORMULA 1
 - b. FORMULA 2
- 4. VALVE RESISTANCE COEFFICIENT "K"

W. CALCULATIONS FOR CENTRIFUGAL PUMP

- 1. PUMP HEAD
 - a. HEAD FORMULA
 - b. PUMP IN SUCTION HEAD
 - c. PUMP IN SUCTION LIFT
- 2. PUMP DISCHARGE PRESSURE
- 3. NET POSITIVE SUCTION HEAD REQUIRED
- 4. NET POSITIVE SUCTION HEAD AVAILABLE
- 5. TOTAL DYNAMIC HEAD
- 6. SUCTION SPECIFIC SPEED (Nss)
- 7. SPECIFIC SPEED (Ns)



X. PUMP AFFINITY LAWS

- 1. IMPACT OF SPEED ON FLOW
- 2. IMPACT OF SPEED ON HEAD
- 3. IMPACT OF SPEED ON BHP
- 4. IMPACT OF IMPELLER DIAMETER ON FLOW
- 5. IMPACT OF IMPELLER DIAMETER ON HEAD
- 6. IMPACT OF IMPELLER DIAMETER ON BHP
- 7. PUMP BRAKE HORSPOWER
- 8. PUMP EFFICIENCY

Y. FLOW OF WATER THROUGH SCHEDULE 40 STEEL PIPE

1. CALCULATIONS FOR PIPE OTHER THAN SCHEDULE 40

Z. FLOW OF AIR THROUGH SCHEDULE 40 STEEL PIPE

- 1. CALCULATIONS FOR PIPE OTHER THAN SCHEDULE 40
- 2. CALCULATIONS FOR OTHER SET OF TEMPERATURE AND PRESSURE
- 3. FROM STANDARD TO ACTUAL VOLUME FLOW



ZZ. CONVERSION TABLES

- 1. LENGTH
- 2. AREA
- 3. VOLUME
- 4. VELOCITY
- 5. MASS
- 6. MASS FLOW RATE
- 7. VOLUMETRIC FLOW RATE
- 8. FORCE
- 9. PRESSURE AND LIQUID HEAD
- 10. ENERGY, WORK AND HEAT
- 11. POWER
- 12. WEIGHT DENSITY
- 13. TEMPERATURE
- 14. DYNAMIC VISCOSITY
- 15. KINEMATIC VISCOSITY







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