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OPERATING INSTRUCTIONS

FOR

HYDRAULIC SLIDE RULE - Model H--1

Made and Distributed by
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HYDRAULIC SLIDE RULE --- Model H--1

This special slide rule contains two hydraulic formulae which are commonly used in the solution of problems dealing with the flow of fluids in pipes. On one face is printed the Hazen-Williams formula for friction losses in full-flowing pipes, while on the other is printed the Continuity Equation, $Q = Av$. Included with both formulae are many conversion scales which will greatly simplify changing from one set of units to another.

A brief study of all the scales on this rule is recommended in the interest of easier and faster operation of the rule.

Consider first the side of the rule which contains the Continuity Equation:

The top-most scale, Q_1, expresses volume in cubic feet per second. Immediately adjacent, the Q_2 scale gives the corresponding volume in U.S. gallons per minute.

On the slide, the top scale gives velocity in feet per second. Immediately adjacent, the corresponding velocity head is given. ($v^2/2g$)

Along the top edge of the bottom section three arrows will be found. Note that each arrow there are listed various values for "f" to be used in the relationships: $GPM = fQ_2$ and $CFS = fQ_1$. The use of these multipliers will permit the easy solution of problems which would otherwise fall outside of the range of the given scales.

The bottom scales, Diameter and Area, give actual diameters (for hose, tubing, and pipes other than standard) and nominal diameters of standard weight steel pipe, and their corresponding areas in square inches. Note that since the dimensional units of both scales are the same, they may be used to find areas for diameters given in feet, millimeters, meters, etc., or vice versa.

Consider next the side of the rule which contains the Hazen-Williams Formula:

The top pair of scales express friction loss per 100 feet of pipe length in terms of pounds per square inch (psi), and feet of head. These scales may be used independantly to convert feet of head to psi, or vice versa.

On the slide, the top scale expresses flow in U.S. gallons per minute, while the bottom scale gives actual diameters (for hose, tubing, and pipe other than standard) and the nominal diameters of standard-weight steel pipe.

The bottom-most scales, three in number, give friction factors for various ranges of pipe size, extending from 0.1" to 100". Note that the use of the two outside scales requires the application of a multiplier.

For convenience, a table of values for "c", the friction coefficient, is given for various materials of construction.

HYDRAULIC SLIDE RULE --- MODEL H—L

OPERATING INSTRUCTIONS

To Find	Knowing	Use Scales	Example
v, velocity (ft/sec)	Q, flow-rate (GPM or CFS) A, Area, or d, Diameter	Q = Av	Find velocity of 25 GPM thru 1" Std pipe. Set middle arrow of slide over 1" pipe dia. Read answer of 9.2 fps on velocity scale directly beneath GPM of 25. (Note multiplier used = 1)
			Find velocity of 25 GPM thru 1" I.D. Hose or metal tube. Set middle arrow of slide over 1.0 on dia. scale. Read answer of 10.2 fps on velocity scale directly beneath GPM of 25. (Note multiplier used = 1)
			Find velocity of 25 GPM thru an area of 1 sq. inch. Set middle arrow over 1.0 on area scale. Read answer of 8 fps on velocity scale under GPM of 25. (Note multiplier = 1) (See Hints for using rule)
d, Diameter	Q, flow-rate (GPM or CFS) V, Velocity (FPS)	Q = Av	Find diameter of pipe required to carry 1,000,000 GPM at velocity of 10 FPS. To get on Q_2 scale, use multiplier, f. If arrow on your right is used, f = 100,000. 1,000,000/100,000 = 10. Set velocity of 10 FPS under 10 on Q_2 scale. Read answer of 200" Dia. under arrow on your right. (Note that size had to be between 40" & (400" due to "f" selected.)
Q, flow-rate	A, Area V, Velocity (FPS)	Q = AV	Find flow-rate (CFS) carried by duct, 300" x 400", at 5 FPS. Area = 120,000 sq in. Area/10,000 = 12.0 Set middle arrow over 12.0 on Area scale. Above velocity of 5 FPS read answer of 0.42 on Q_1 scale. Multiply 0.42 x 10,000 to get final answer of 4,200 CFS.
CFS	GPM	Q_1 & Q_2	Convert 990 GPM to CFS. To get on scale, divide 990 by 10. Find 99 on Q_2 scale. Read across to value of 0.22 on Q_1 scale. Answer equals 2.2. (0.22 x 10)
d, Diameter of circular duct	A, Area	Diameter & Area	Convert area of 300 sq in. to Diameter (in.) Divide 300 by 100 to get 3, which is on "Area" scale. Read value of 1.95" on Dia. scale. Since Dia varies as square root of Area, multiply by $\sqrt{100}$ or 10 for Answer of 19.5 inches.
V, Velocity (FPS)	Velocity ($v^2/2g$)	Velocity & Velocity Head	Convert 10' of head to velocity. From 10 on Vel Hd scale read across to velocity of 25.2 ft/sec.
			Convert 200' Vel Hd to velocity. (200/100=2) From 2 on Vel Hd read 11.2 vel. Answer equals 112 FPS. (11.2 x $\sqrt{100}$)

OPERATING INSTRUCTIONS

To Find	Knowing	Use Scales	Example
Q, flow-rate	Head on orifice	Velocity Hd, and $Q = AV$	Find flow-rate from 2" orifice under head of 10 feet. Set middle arrow over 2.0 on Dia. scale. From 10 on velocity head scale, read across to velocity of 25.2 FPS. Beneath this on Q_2 scale read answer of 248 GPM, or 0.55 CFS on Q_1 scale. For final answer, apply discharge coefficient of orifice.
To multiply or divide	Any pair of numbers	Volume & Velocity	Disregard decimals & ciphers-- Use in same manner as A & B scales of Std slide rule. Multiply 18 x 75; Set 1 of velocity scale under 18 on Q_2 scale. Read answer of 1350 on Q_2 scale above 75 on velocity scale.
			Divide 84 x 6.5; Set 6.5 of velocity scale under 84 on Q_2 scale. Read answer of 12.9 on Q_2 scale over 1 of velocity scale.
Tank Volume	Diameter & Height	$Q = AV$ For CF, read direct. For Gallons, read GPM x 1/60.	Find volume of 30' dia tank of 40' depth. Consider tank as pipe of 360" dia, find flow-rate for velocity of 40 FPS. To get on Dia scale, divide 360 by 100 =3.6 Over 3.6 on Dia scale, set arrow on right. Note that for 360" Dia, f = 100,000. Above velocity of 40' read Q_1 of 0.282. Multiply by "f" to get answer of 28,200 CF For answer in gallons, read Q_2 of 127.- 127/60 = 2.11. 2.11 x "f" = 211,000 Gallons
Tank Volume	Diameter & Height Constant of 24.	$Q = AV$	Use of this method requires remembering a constant of 24. Tank Dia = 30', Depth = 40'. Divide Dia. by 10 = 3.0; Set arrow on your right over 3.0 on Dia scale. Read area of tank section in square feet. Multiply this by 10^2 to get 5,300 sq. ft. area. Multiply by depth to get volume of 212,000 CF.

OPERATING INSTRUCTIONS

To Find	Knowing	Use Scales	Example
Friction Loss	Pipe Dia, GPM flow, Pipe Condition & Length	Friction formula	Find friction loss of 300 GPM thru 3" Std pipe, 50' long. Assume average loss coefficient of 100. Set 3" pipe over middle scale (since 3 falls in 1 to 9 range), then read loss of 34'/100' above 300 GPM. 34 x 50/100 = 17' loss or 7.4 psi loss.
Pipe Dia.	GPM flow, Pipe Condition & Length, Permissable Friction Loss	Friction formula	Find pipe Dia. which will pass 60 GPM thru 300' of average pipe with a loss not to exceed 20 psi. Divide 20 by 3 to find loss per 100' = 6.67 psi. Read across top scale to 15.3'. Set 60 GPM under this value. Read pipe dia over 100 of middle coeff. scale. Answer is 2".
GPM flow	Pipe Dia., Pipe Condition, & Length, Head at pipe inlet.	Friction formula	How much water will be discharged thru 200' of 2" Std pipe if head at pipe inlet is 70' ? Divide 70 by 2 to get 35'/100' loss. Set 2" pipe over 100 of middle coeff. scale. Read answer of 118 GPM under 35' loss.
Ft of Head	Head in PSI	Friction loss scale	Convert 32' head to PSI. Find 32' on ft/100' scale, read across to 13.8 psi.
Head, PSI	Head in Feet	Friction loss scale	Convert 60 PSI to Feet of Head. Find 60 on PSI/100' scale. Read across to 138 ft of head on ft/100' scale.

Note: The methods described above can be applied to the solution of problems involving the use of hose, tubing, conduits, and pipe other than Standard Weight Steel.