This article is intended to help the hydraulic design of pressure pipelines flowing under pressure wherein the hydraulic gradient over its entire length lies above the crown soffit of the pipes. The Hazen-Williams formula has been commonly in use for such designs.C = Hazen-Williams C-factor k = 6.79 for V in m/s, D in m The C-factor ranges between 0 to 150 depending on the material and age of the pipe.The commonly used Hazen-Williams Formula has following inherent limitations.The numerical constant in Hazen-Williams formula (1.318 in FPS units or 0.85 in MKS units) has been calculated for an assumed hydraulic radius of 1 foot and friction slope of 1/1000. However, the formula is used for all ranges of diameter and fiction slopes. This practice may result in an error up to +/- 30% in the evaluation of velocity and +/- 55% in the estimation of frictional resistance head loss.The Darcy-Weisbach formula is dimensionally consistent. The Hazen-Williams coefficient C is usually considered independent of pipe diameter, velocity of flow and viscosity. However, to be dimensionally consistent and to be representative of friction conditions, it must depend on relative roughness of pipe and Reynolds's number. A comparison between estimates of Darcy-Weisbach friction factor 'f', and its equivalent value computed from Hazen-Williams C for different pipes materials brings out the error in estimation of 'f' up to +/- 45% in using Hazen-Williams formula. It has been observed that for higher "C' values (new and smooth pipes) and larger diameter, the error is less, whereas it is appreciable for lower 'C' values (old and rough pipes) and lower diameters at higher velocities.The Hazen-Williams formula is dimensionally inconsistent, since the Hazen-Williams 'C' has dimension of L^(-0.37) T^(-1) and therefore is dependent on units employed.In 1986, Dr. D. M. Mohan submitted thesis in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the Center for Environmental Science and Engineering of Indian Institute of Technology, Bombay. In this research study, Dr. Mohan, proposed the Modified Hazen-Williams Formula, stated below:V = velocity of flow in m/s,Cr = pipe roughness coefficient, (1 for smooth pipes; < 1 for rough pipes),r = hydraulic radius in m,h = friction head loss in m.The Modified Hazen-Williams Formula has been derived from Darcy-Weisbach and Colebrook-White equations and obviates the limitations of Hazen-Williams formula.Analysis carried out to evaluate effect of temperature (viscosity) on value of Cr reveals that the maximum variation of Cr for a temperature range of 10 Degree Celsius to 30 Degree Celsius is 4.5% for a diameter of 2000 mm at a velocity of 3 m/s. In the light of this revelation, Cr values are presented for average temperatures of 20 Degree Celsius which are okay for practical purposes.The use of Hazen-Williams C results in under utilization of new pipe material. The extent of under-utilization varies from 13 to 40 percent for CI (metallic) pipes; 23 percent for RCC and AC pipes; and 8.4 percent for HDPE and PVC pipes.The resulted values of head loss using Modified Hazen-Williams formula are nearer to head loss resulted using Darcy-Weisbach formula when compared to Modified Hazen-Williams formula.Manual on Water Supply and Treatment by Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, Government of IndiaGuidelines for Planning and Design of Piped Irrigation Network, Central Water Commission, Government of IndiaState Government Water Boards and Public Health Engineering Departments (PHEDs) in IndiaUrban Local Bodies, Rural Water Boards and Urban local bodies/ Municipal Corporations in India.©Copyright DTK Hydronet Solutions, 2019 (This article is purely based on the study by Dr. D. M. Mohan and we duly acknowledge the inventor's contribution, DTK does not claim any Intellectual Authority over Modified Hazen-Williams Formula discussed in the above article.) Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution — You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. The Modified Hazen-Williams equation can be used in the analysis of an aging pressure pipe system where a more accurate estimation of frictional resistance and reduced carrying capacity is warranted. It is an alternative to arbitrarily reducing Hazen-Williams C, and also involves less computational overhead than the Darcy-Weisbach and Colebrook-White equations. The formula is as follows: Library © 2013-2025 University of MoratuwaPrivacy policyEnd User AgreementSend Feedback The Darcy-Weisbach equation with the Moody diagram is considered to be the most accurate model for estimating frictional head loss for a steady pipe flow. Since the Darcy-Weisbach equation requires iterative calculation an alternative empirical head loss calculation like the Hazen-Williams equation may be preferred: h100ft = 0.2083 (100 / c)1.852 q1.852 / d4.8655 (1) where h100ft = friction head loss in feet of water per 100 feet of pipe (fth20 /100 ft pipe) c = Hazen-Williams roughness constant q = volume flow (gal/min) d = inside diameter of pipe (inches) Note that the Hazen-Williams formula is empirical and lacks a theoretical basis. Be aware that the roughness constants are based on "normal" conditions with approximately 1 m/s (3 ft/sec) . Example - Friction Head Loss in Water Pipe 200 gal/min of water flows in a 3 inch PEH pipe DR 15 with inside diameter 3.048 inches. The roughness coefficient for PEH pipe is 140 and the length of the pipe is 30 ft. The head loss for 100 ft pipe can be calculated as h100ft = 0.2083 (100 / 140)1.852 (200 gal/min)1.852 / (3.048 in)4.8655 = 9 ftH2O/100 ft pipe The head loss for 30 ft pipe can be calculated h30ft = h100ft (30 ft) / (100 ft) = 9 (30 ft) / (100 ft) = 2.7 ft H2O Related Mobile App from The Engineering ToolBox Water Pipes Head Loss Calculator App - free apps for offline use on mobile devices. Online Hazens-Williams Calculator Imperial Units The calculators below can used to calculate the specific head loss (head loss per 1 00 ft (m) pipe) and the actual head loss for the actual length of pipe. Default values are from the example above. Make Shortcut to this Calculator on Your Home Screen? Hazen-Williams equation in an Excel template The Hazen-Williams equation is not the only empirical formula available. Manning's formula is commonly used to calculate gravity driven flows in open channels. The flow velocity can be calculated as v = 0.408709 q / d2 (2) where v = flow velocity (ft/s) Limitations The Hazen-Williams equation is assumed to be relatively accurate for water flow in piping systems when For hotter water with lower kinematic viscosity (example 0.55 cSt at 130 oF (54.4 oC)) the error will be significant. Since the Hazen-Williams method is only valid for water flow - the Darcy Weisbach method should be used for other liquids or gases. 1 ft (foot) = 0.3048 m 1 in (inch) = 25.4 mm 1 gal (US)/min =6.30888×10-5 m3/s = 0.227 m3/h = 0.0631 dm3 (liter)/s = 2.228×10-3 ft3/s = 0.1337 ft3/min = 0.8327 Imperial gal (UK)/min Water flow and pressure loss (psi/ft) due to friction in copper tubes ASTM B88 Types K, L and M. The Darcy-Weisbach equation can be used to calculate the major pressure and head loss due to friction in ducts, pipes or tubes. Calculate minor pressure loss in piping systems with the Equivalent Pipe Length Method. Friction head loss (ft/100 ft) vs. water flow in steel, copper and PVC plastic pipes. Hazen-Williams friction loss coefficients for commonly used piping materials. The Hazen-Williams equation can be used to calculate the pressure drop (psi) or friction loss in pipes or tubes. Equivalent length of fittings like bends, returns, tees and valves in hot water heating systems - equivalent length in feet and meter. Pressure drop diagrams for PTFE, PP, PFA and PVDF lined pipes. Calculate cross-sectional average velocity flow in open channels. Calculate cross-sectional areas, weight of empty pipes, weight of pipes filled with water, inside and outside surface areas. Friction head loss (ft/100 ft) vs. water flow in plastic pipes like PVC, PP, PE or PEH. Calculate pressure loss in pipes connected in series or parallel. Minor loss in PVC and CPVC fittings expressed as equivalent length of straight pipe. Water flow in thermoplastic PVC and CPVC pipes Schedule 40 - friction loss (ft/100 ft, psi/100 ft) and flow velocities at dimensions ranging 1/2 to 16 inches. Friction loss (psi/100 ft) and velocity for water flow in plastic PVC pipe schedule 40. Maximum water flow capacities in steel pipes - pipe dimensions ranging 2 - 24 inches. Friction loss and velocity diagrams - in imperial (psi/100 ft, ft/s) and SI (Pa/100m, m/s) units. Water flow and pressure loss in schedule 40 steel pipes - Imperial and SI units - gallons per minute, liters per second and cubic meters per hour. Water flow in steel pipes schedule 80 - pressure drop and velocity diagrams in SI and Imperial units. Materials used in water distribution pipes. Reynolds number for clean cold water flow. Free online tool for designing water supply systems in buildings.