AQUAMINE®, LLC

A Victaulic Company

ENGINEERING DATA

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Primary Specifications and Performance Characteristics

Aquamine pipe and couplings are made from a special formulation of poly(vinyl chloride) or PVC. The PVC material used is designated as Class 12454-B in accordance with **ASTM D 1784**. It has a hydrostatic design stress of 2000 psi (14 MPa). The Aquamine PVC formulation includes impact modifiers, heat stabilizers and ultraviolet inhibitors to give it a higher impact strength over a longer period of time. It is formulated for tough, extreme duty applications where normal PVC pipe would not survive very long.

Aquamine products meet or exceed the following minimum requirements for Class 12454-B as listed on Table 1 of **ASTM D 1784**:

Property	Value	ASTM Test Spec. No.
Tensile Strength, min	7,000 PSI (48.3 MPa)	D638
Modulus of Elasticity, min.	400,000 PSI (2758 MPa)	D638
Impact Strength (Izod) min.	0.65 ft-lbs./in. (34.7 J/m) of notch	D256
Deflection Temp., min.	158°F (70°C)	D648
Flammability	Self-extinguishing	D635
Chemical Resistance	B	D543

Please note that the values listed on the above table are minimum values. Aquamine pipe includes special additives which improve performance properties above these minimums. For example, Izod impact test values for Aquamine pipe have been regularly demonstrated to exceed 1.15 ft-lbs per inch of notch.

Aquamine pipe is extruded to meet or exceed all requirements of **ASTM D 2241** – *Standard Specification for Poly(Vinly Chloride) (PVC) Pressure-Rated Pipe (SDR Series).* Also, Aquamine pipe meets **ASTM F 1057** – *Standard Practice for Estimating the Quality of Extruded Poly (Vinyl Chloride) (PVC) Pipe by the Heat Reversion Technique.*

All Aquamine joints and couplings conform to **ASTM D 3139** – *Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.*

All O-rings used in Aquamine products meet **ASTM F 477** – *Specification for Elastomeric Seals (Gaskets) for Joining PVC Pipe.* The standard o-ring material used in all Aquamine products is polyisoprene (IR). Other o-ring materials can be provided by special order.

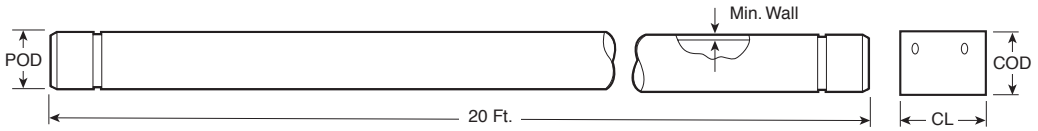
NSF Listing

Aquamine pipe and couplings are listed under NSF Standard 14 and certified NSF-PW for use in all potable water piping systems. This means that Aquamine products meet all applicable performance standards for a pressure rated application as required in ANSI/NSF Standard 14, and comply with ANSI/NSF Standard 61 for health effects. This listing assures the purchaser that the Aquamine Piping System continues to pass NSF's rigorous testing program which includes: compliance to ASTM specifications, performance testing and testing for toxic substances.

Canadian Fire Resistance and Anti-Static Compliance

Aquamine pipe has been tested by Energy, Mines and Resources Canada, and has been certified to comply with Canadian Standards Association CAN/CSA-M427-M91 "Fire Performance and Antistatic Requirements for Ventilation Materials" for water service applications in gaseous underground mines. (Ref: Certificate No. 992)

Dimensions



SIZE Nom. In./ mm	SDR	Press. Rating PSI/Kpa	Pipe O.D. In./mm	Minimum Wall In./mm	Wgt. Per Ft. Lbs./kg	Coupling O.D. (COD) In./mm	Coupling Length (CL) In./mm	Coupling Wgt. Ea. Lbs./kg
2 50	17	250 1724	2.375 60,3	0.140 3,56	0.69 0,3	3.20 81,28	5.25 133,35	0.92 0,4
	21	200 1379	2.375 60,3	0.113 2,88	0.57 0,3	3.20 81,28	5.25 133,35	0.92 0,4
3 80	9	500 3447	3.500 88,9	0.389 9,88	2.34 1,1	4.77 121,16	7.25 184,15	3.03 1,4
	17	250 1724	3.500 88,9	0.206 5,21	1.45 0,7	4.38 111,25	7.25 184,15	1.90 0,9
	21	200 1379	3.500 88,9	0.167 4,24	1.19 0,5	4.38 111,25	7.25 184,15	1.90 0,9
4 100	9	500 3447	4.500 114,3	0.500 12,7	3.87 1,8	6.00 152,40	8.25 209,55	5.04 2,3
	12.4	350 2413	4.500 114,3	0.363 9,22	2.96 1,3	6.00 152,40	8.25 209,55	5.04 2,3
	17	250 1724	4.500 114,3	0.265 6,73	2.40 1,1	5.47 138,94	8.25 209,55	3.07 1,4
	21	200 1379	4.500 114,3	0.214 5,44	1.96 0,9	5.47 138,94	8.25 209,55	3.07 1,4
	26	160 1103	4.500 114,3	0.173 4,39	1.60 0,7	5.47 138,94	8.25 209,55	3.07 1,4
6 150	9	500 3447	6.625 168,3	0.736 18,69	8.39 3,8	8.72 221,49	8.25 209,55	10.46 4,7
	12.4	350 2413	6.625 168,3	0.534 13,56	6.42 2,9	8.72 221,49	8.25 209,55	10.46 4,7
	17	250 1724	6.625 168,3	0.390 9,91	5.20 2,4	7.84 199,14	8.25 209,55	5.62 2,5
	21	200 1379	6.625 168,3	0.316 8,03	4.26 1,9	7.84 199,14	8.25 209,55	5.62 2,5
	26	160 1103	6.625 168,3	0.255 6,48	3.46 1,6	7.84 199,14	8.25 209,55	5.62 2,5
8 200	12.4	350 2413	8.625 219,1	0.696 17,68	11.03 5,0	10.75 273,05	9.50 241,3	15.20 6,9
	17	250 1724	8.625 219,1	0.508 12,9	8.81 4,0	10.19 258,83	9.50 241,3	11.07 5,0
	21	200 1379	8.625 219,1	0.410 10,41	7.21 3,3	10.19 258,83	9.50 241,3	11.07 5,0
	26	160 1103	8.625 219,1	0.332 8,43	5.91 2,7	10.19 258,83	9.50 241,3	11.07 5,0
10 250	21	160* 1103	10.750 273,1	0.511 12,98	11.25 5,1	12.44 315,98	12.00 304,80	18.05 8,2
	26	160 1103	10.750 273,1	0.413 10,49	9.20 4,2	12.44 315,98	12.00 304,80	18.05 8,2
12 300	21	160* 1103	12.750 323,9	0.606 15,39	15.88 7,2	14.65 372,11	12.00 304,80	24.17 11,0
	26	160 1103	12.750 323,9	0.490 12,45	12.98 5,9	14.65 372,11	12.00 304,80	24.17 11,0

* Pressure rating of these items are limited by the pressure rating of the coupling.

Impact Resistance\

One of the key performance characteristics that sets Aquamine pipe apart from regular PVC pipe is its high impact strength. Aquamine pipe is regularly tested for impact resistance according to the test procedures cited in **ASTM D2444**. This test uses a falling weight, or "tup", and impact values are recorded in foot-pounds of energy.

The following table lists the tested impact values for Aquamine pipe:

Nominal Size In./mm	Impact Values – ft.-lbs./N·m			
	SDR 26	SDR 21	SDR 17	SDR 12.4
2 50	– –	135 183	170 231	– –
3 80	– –	200 271	245 332	– –
4 100	210 285	255 346	320 434	435 590
6 150	305 414	380 515	470 637	635 861
8 200	400 542	495 671	610 827	835 1132
10 250	500 678	530 719	– –	– –
12 300	500 678	530 719	– –	– –

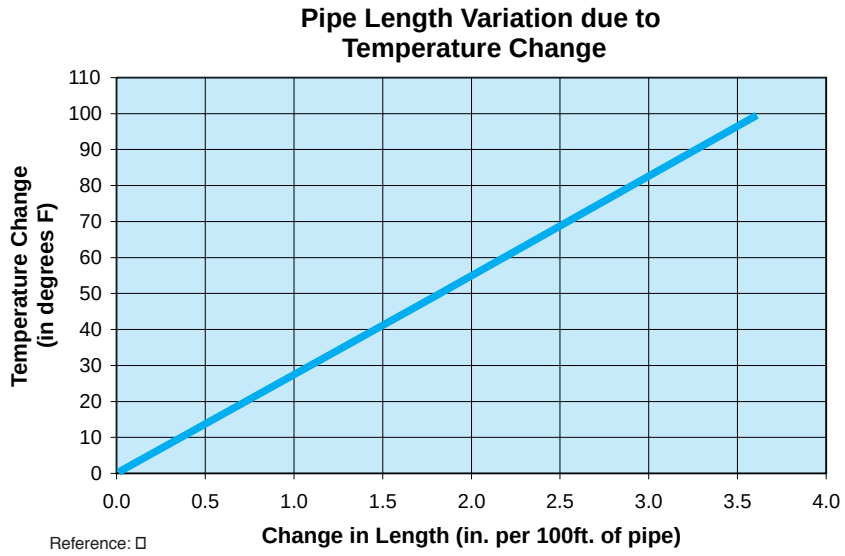
Flexibility/ Bending

Aquamine pipe is surprisingly flexible. It bends to follow rough overland terrain or the smooth curvature of an underground directional bore. In many cases, this feature will reduce the number of fittings that will be required. Bending the pipeline, however, can change the shape of the pipe at the o-ring seal in the coupling. To prevent possible leakage, please limit the amount of bending to the values in the table below:

Nominal Size In./mm	Min. Radius of Curvature ft./m	Offset per 20 ft. (6.1 m) Length In./mm
2 50	59 18	40 1016,0
3 80	88 27	27 685,8
4 100	100 30	24 609,6
6 150	150 46	16 406,4
8 200	200 61	12 304,8
10 250	250 76	10 254,0
12 300	300 91	8 203,2

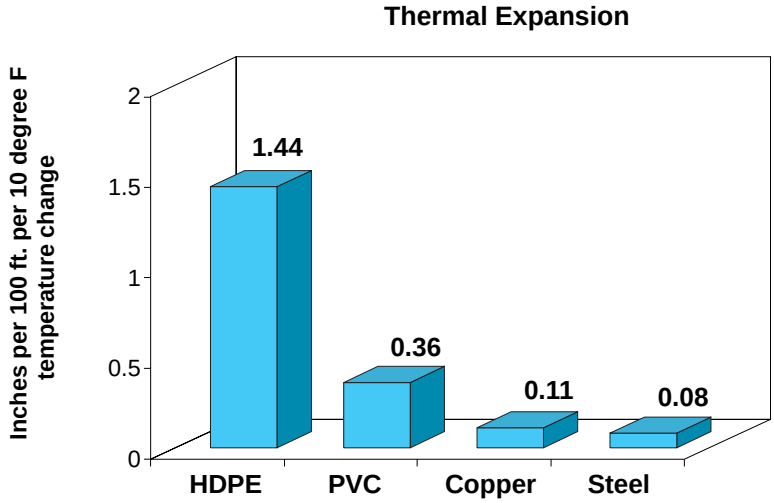
Thermal Expansion and Contraction

All materials, including pipe, machinery, structures and buildings, experience dimensional changes as a result of changes in temperatures. Any pipe subjected to temperature changes should incorporate a means to accommodate thermal expansion/contraction to avoid excessive stresses. The following chart shows the expected thermal expansion or contraction for Aquamine PVC pipe with changes in temperature. It is based on a Thermal Expansion Coefficient of 3.0 x 10^5 in./in./°F. This information may be used for estimating purposes when determining expected pipe growth or shrinkage. As a general rule, for every 10°F change in temperature, Aquamine PVC pipe will expand or contract 3/8 inches per 100 feet of pipe length.



Reference: □
Uni-Bell Handbook of PVC Pipe

PVC experiences greater thermal expansion than most metals and yet less than other thermoplastics, such as high density polyethylene (HDPE). The following chart shows, graphically, how the expansion of PVC compares to other materials.



Maximum Tensile Loads/ Pulling Forces

Whether Aquamine pipe is being pulled through a horizontal directional bore or suspended vertically down a shaft, it is important not to exceed the maximum allowable, short-term tensile load or pulling force listed on the table below.

In cases where the pipe is also under pressure (such as a filled, working pipeline suspended in a vertical shaft) the end load developed from internal pressure should not be superimposed with the tensile pull load.

Maximum Pulling Force		
Nominal Pipe Size In./mm	**SDR**	**Maximum Recommended Pulling Force (Straight Pull) lbs./kg**
2 50	17 or 21	2,500 1134
3 80	17 or 21	5,000 2268
4 100	17 or 21	8,000 3629
6 150	17 or 21	11,500 5216
8 200	17 or 21	27,000 12247
10 250	21 or 26	32,000 14515
12 300	21 or 26	37,000 16783

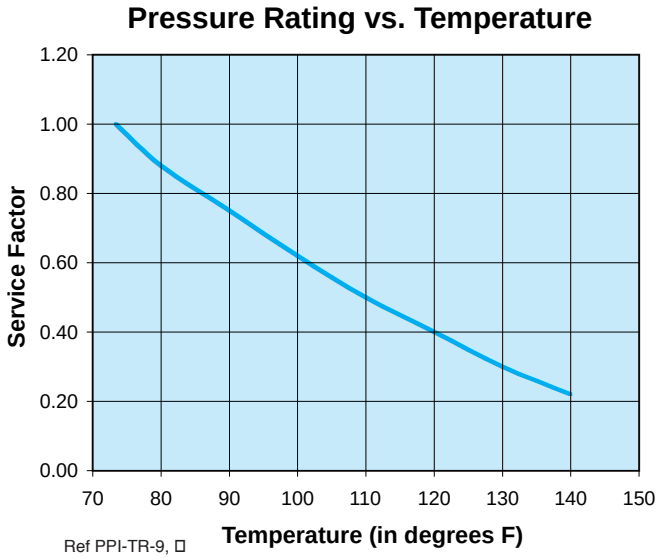
Pressure Rating at Elevated Temperatures

The published maximum working pressures of Aquamine PVC pipe/coupling assemblies are based on an ambient temperature of 73.4°F. The physical properties of PVC are very temperature-sensitive. As a result, the pressure ratings will decrease as the temperature increases. The following chart may be used to determine the pressure handling capability of Aquamine PVC products at temperatures above 73.4°F. Multiply the published working pressure by the PVC service factor for the intended operating temperature to find the reduced pressure rating at that temperature.

Example: Find the pressure rating of 4" SDR17 Aquamine pipe (250 psi at 73.4°F) at 100°F.

Service Factor from chart is 0.62.

The rating of this pipe at 100°F would be 0.62 × 250 or 155 PSI.

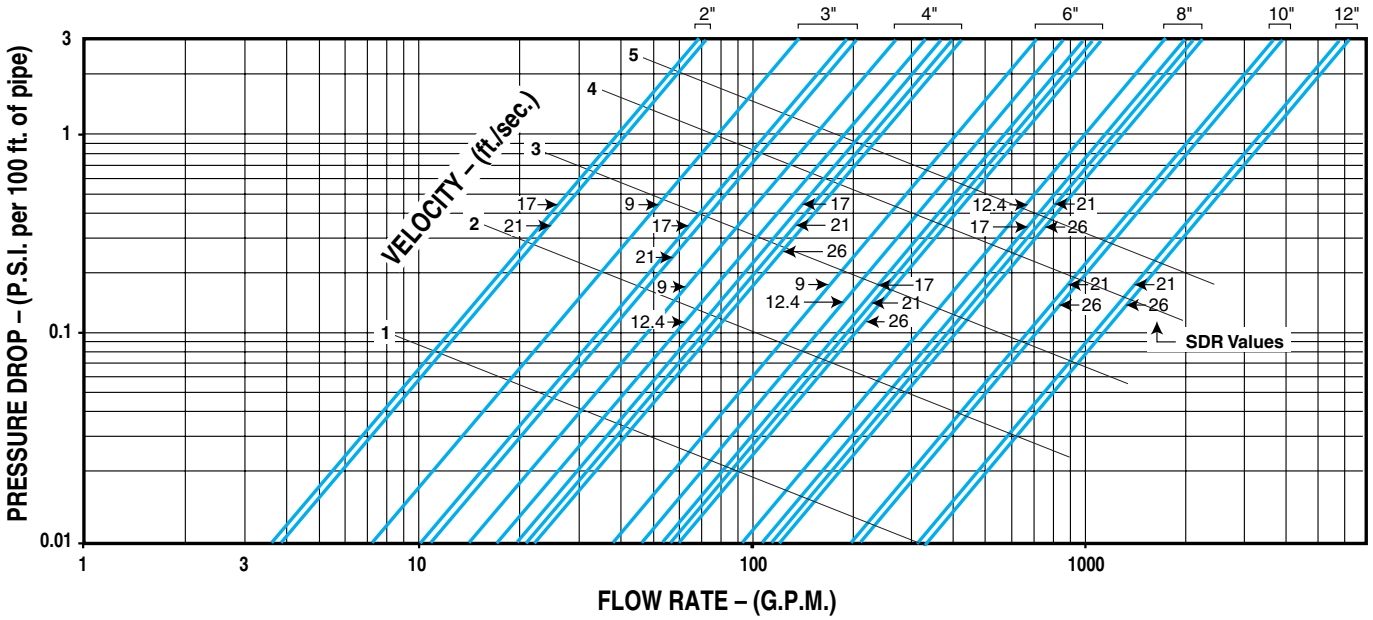


Ref PPI-TR-9, □
Recommended Design Factors for Pressure Application of Thermoplastic Piping Materials

Friction Loss

The smooth inner wall of Aquamine PVC pipe provides for exceptionally low pressure loss due to friction compared with other common piping materials. The following charts provide typical flow friction loss values for Aquamine pipe versus flow rates. Flow friction losses through Aquamine couplings will be negligible, so the same values provided for the pipe may be used in system flow calculations. All values are based on the Hazen-Williams formula for friction loss using a flow coefficient of C = 150.

Good piping practice suggests that flow velocities for PVC pipe should be kept below 5 ft./sec. (1.5 m/sec.). Special considerations must be given to surge pressures and other conditions when velocities exceed 5 ft./sec. (1.5 m/sec.). These higher velocities also result in higher head losses.



Pressure Surges and Air Entrapment

Pressure surges may occur when the flow rate is abruptly changed, such as during sudden pump start-up/shut-down or quick valve opening/slamming. Entrapped air pockets in piping systems may also generate pressure surges, as air is easily compressed and will tend to act like a spring which can store and release significant amounts of energy. **COMPRESSED AIR CAN CREATE A VERY DANGEROUS CONDITION IN A PVC PIPING SYSTEM AND MUST BE AVOIDED AT ALL TIMES.**

Pressure surges can be minimized through good piping practices. These include:

- the proper use of ventilation devices to purge the system of any air which may become trapped in the line,
- the use of vacuum/pressure air relief valves at changes in grade and at high points in the piping system,
- the gradual start-up and shut-down of pumps to minimize sudden changes in flow rate.

The total system pressure, including the operating pressure, surge pressure and appropriate surge factor (as determined by the system designer) of up to 50 psi for every 1 ft./sec. change in flow velocity, must not exceed the maximum rated pressure of the pipe for the given operating temperature. In addition, flow velocity should ideally be kept below 3 or 4 ft./sec. and should never exceed 5 ft./sec. during operation. At startup, during the filling operation, the flow velocity should be kept low, below 1 ft./sec., until all the air is purged from the system.

Pipe/Coupling Support Spacing Design

Hanger spacing for the various sizes and SDR wall thicknesses of Aquamine PVC pipe are provided in the table below. Pipe and water weight per foot are also provided. Please note that these values are for evenly distributed loads. Concentrated loads such as at valves and other flow devices will require additional support.

SIZE Nom. Inches Actual mm	SDR	Actual O.D. Inches mm	Mininum Wall Thickness Inches mm	Hanger Spacing at 73.4° F (23° C) Feet/meters	Hanger Spacing at 120° F (49° C) Feet/meters
2 50	17	2.375 60,3	0.140 3,6	5.0 1,5	4.6 1,4
	21	2.375 60,3	0.113 2,9	4.8 1,5	4.4 1,3
3 80	09	3.500 88,9	0.389 9,9	7.5 2,3	6.9 2,1
	17	3.500 88,9	0.206 5,2	6.5 2,0	6.0 1,8
	21	3.500 88,9	0.167 4,2	6.2 1,9	5.7 1,7
4 100	09	4.500 114,3	0.500 12,7	8.8 2,7	8.1 2,5
	12.4	4.500 114,3	0.363 9,2	8.3 2,5	7.6 2,3
	17	4.500 114,3	0.265 6,7	7.7 2,4	7.1 2,2
	21	4.500 114,3	0.214 5,4	7.3 2,2	6.7 2,0
	26	4.500 114,3	0.173 4,4	6.9 2,1	6.3 1,9
6 150	09	6.625 168,3	0.736 18,7	11.4 3,5	10.5 3,2
	12.4	6.625 168,3	0.534 13,6	10.7 3,3	9.9 3,0
	17	6.625 168,3	0.390 9,9	10.0 3,1	9.1 2,8
	21	6.625 168,3	0.315 8,0	9.4 2,9	8.7 2,7
	26	6.625 168,3	0.255 6,5	8.9 2,7	8.2 2,5
8 200	12.4	8.625 219,1	0.696 17,7	12.8 3,9	11.7 3,6
	17	8.625 219,1	0.502 12,8	11.9 3,6	10.9 3,3
	21	8.625 219,1	0.411 10,4	11.2 3,4	10.3 3,1
	26	8.625 219,1	0.332 8,4	10.6 3,2	9.8 3,0
10 250	21	10.750 273,1	0.511 13,0	13.0 4,0	12.0 3,7
	26	10.750 273,1	0.413 10,5	12.3 3,8	11.3 3,4
12 300	21	12.750 323,9	0.606 15,4	14.6 4,4	13.4 4,1
	26	12.750 323,9	0.490 12,5	13.8 4,2	12.7 3,9

PRESSURE DESIGN INFORMATION

SDR

Aquamine pipe is designed to meet **ASTM D 2241**, which is the standard specification for PVC pressure-rated, SDR sized pipe. SDR stands for standard dimensional ratio. It simply means the ratio of the average outside diameter of the pipe to the minimum wall thickness.

Pressure – Stress Equation

The pressure rating of PVC pipe is calculated in accordance with standard practice defined by the International Standards Organization (ISO) Equation R161-1960 which can be transposed as follows to define pressure rating:

$$P = \frac{2S}{(SDR - 1)}$$

Where: P = pressure rating, PSI
S = design stress, PSI
SDR = standard dimensional ratio

Calculated Pressure Rating

Aquamine pipe is made from a special formulation of Type 1, Grade 1 PVC, Class 12454-B, in accordance with **ASTM D 1784**. According to **ASTM D 2241**, pipe manufactured with this material, designated as PVC1120, has a hydrostatic design stress of 2000 psi. (14Mpa). By using this design stress in the equation above, the pressure rating of the pipe can be calculated for any given SDR value. For example, the pressure rating for any SDR 21 pipe (200 psi.) is derived as follows:

$$P = \frac{2S}{(SDR - 1)} \qquad P = \frac{2(2000)}{(21 - 1)} \qquad P = 200PSI$$

This pressure rating represents the maximum allowable system operating pressure including pressure surges.

Sustained Pressure

Unlike many non-plastic pipes, which show insignificant changes over time, the hydrostatic pressure capacity of PVC pipe is time dependent. By using long term testing methods as defined in **ASTM D 1598** and **D 2837**, results can be plotted to generate a stress vs. time line also known as a stress regression curve. The response of PVC pipe to the applied hoop stress after a period of 100,000 hours (11.4 years) determines the Hydrostatic Design Basis (HDB). For Aquamine pipe this HDB is equal to 4000 psi. (27.58Mpa). The following table shows the minimum sustained pressures that pipe with material designation PVC 1120 must meet according to **ASTM D 2241**. Aquamine pipe exceeds these values.

Minimum Sustained Pressure for water at 73° F/23° C

SDR	PSI/kPa
12.4	735 5067
17	530 3654
21	420 2895
26	340 2344

Quick Burst Pressure

The following table lists the minimum quick burst pressures that Aquamine pipe meets. In the quick burst pressure test, pressure is applied for only 60 to 70 seconds. It is meant to be a quality control test only. Aquamine piping system design should be based on the pressure rating of the pipe and not the short term quick burst test results.

Minimum Quick Burst Pressure for water at 73° F/23° C

SDR	PSI/kPa
12.4	1120 7721
17	800 5515
21	630 4343
26	500 3447

TYPICAL SPECIFICATION FOR AQUAMINE PIPING SYSTEM

1.0 SCOPE

This specification covers the requirements for a reusable, spline-connected, high impact polyvinyl chloride (PVC) piping system as manufactured by Aquamine, LLC (a Victaulic Company).

The pipe and couplings used in this system shall be listed in NSF Certified Product Listing under Standard 014, for potable water service, and designated as NSF-PW.

NOTE: The Aquamine PVC piping system is not to be used in compressed air and gas service.

2.0 PIPE

Pipe shall be Aquamine high impact type manufactured from a special formulation of PVC 1120 defined as type 1, grade 1 (class 12454-B) according to ASTM D-1784 and shall contain impact modifiers and ultraviolet inhibitors to enhance long-term performance.

Pipe shall be designed to meet all PVC pipe requirements as specified in ASTM D-2241. Each pipe end shall be grooved to be connected using a specially designed coupling and spline.

Pipe shall be listed under NSF Standard 014 for potable water service and designated as NSF-PW.

3.0 COUPLINGS

Couplings shall be Aquamine AquaLink brand made from a special high impact formulation of PVC 1120 (type 1, grade 1 or class 12454-B according to ASTM D-1784). Couplings shall be designed to meet ASTM D-3139 standards for joints for plastic pressure pipes using flexible elastomeric seals.

Couplings shall provide a restrained joint by means of a nylon spline inserted into the space created when the groove on the pipe and the interior groove in the coupling are aligned.

Couplings shall contain a pre-lubricated permanent type O-ring seal on each end for a watertight hydraulic seal. The O-rings shall meet ASTM F-477 (Standard Specification for Elastomeric Seal for Joining PVC Pipe).

Couplings shall be listed under NSF Standard 014, for potable water service, and designated as NSF-PW.

4.0 FITTINGS

Fittings shall be manufactured by Aquamine, LLC with spline-grooved ends for use with Aquamine pipe and couplings.

5.0 VALVES

Valves shall be Aquamine AQV Series butterfly valves, rated 250 psi at 73 degrees F (1725kPa at 23 degrees C). NOTE: Operating pressure is reduced at temperatures greater than 70 degrees F. Ductile iron (ASTM A-536, grade 65-45-12) housing, PVC 1120 body. Ductile iron disc, rubber encapsulated with Grade "T" Nitrile compound conforming to ASTM D-2000 designation 5BG615A14B24.

6.0 ASSEMBLY

Assembly of Aquamine couplings and pipe shall be in accordance with the latest revision of the Aquamine Assembly and Installation Instructions AM-I-100.

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