Developed for Ultra-pure Water

Spears® Low Extractable piping is produced from a non-contaminating PVC material specially developed for ultra-pure water (UPW) systems in semiconductor, electronics, university research laboratories, hospital dialysis, industrial laboratories, Federal and state police forensic laboratories and biotechnology applications. Spears® Low Extractable PVC material has been subjected to independent laboratory leach studies during both static and dynamic exposure to 18.2 meg-ohm deionized water. Tests have shown relatively low TOC, Anion/Cation and trace metal contamination levels in comparison to conventional high purity piping system materials including PVDF and Natural Polypropylenes

Spears® Low Extractable Piping Systems offer unique advantages for many ultra-pure water applications:

• Complete line of pipe, fittings and valves IPS Sizes 1/2" – 6" diameters

• Strong Schedule 80 dimensions for pressure service

• Advanced Spears® Low Extractable material significantly reduces leachable contamination compared to conventional PVC and other piping materials.

• Exceptionally smooth interior walls minimize particle generation and reduce potential for bacterial growth.

• Fast, reliable installation with simple, inexpensive joining methods

• Proprietary one-step fast-setting joining method reduces

TOC contamination and rinses up quickly

• Unique blue translucency enables visual inspection of joint integrity

• Good chemical/corrosion resistance, high-impact strength, low thermal conductivity

• Bagged, sealed and boxed on-line for use in high-purity environments

• High Quality

• Low Maintenance

• Cost Effective

Material

Spears® Low Extractable piping is produced from an innovative PVC compound that has been specifically formulated to reduce leachable contamination when exposed to ultra-pure water environments. Minor ingredients necessary for processing have been scrupulously selected to address their potential for contamination, and are then carefully blended in precise ratios. This results in a much cleaner material than conventional PVC compounds, and compares favorably to alternate materials typically used for UPW piping applications. This has been validated with extensive static and dynamic leach studies during exposure to 18.2 megohm ultra-pure water conducted by a reputable third party.

Spears® Low Extractable material meets the toxicological requirements of NSF International Standard 61 as being safe for use in potable water applications, and also complies with the provisions of Title 21 of the United States FDA Code of Federal Regulations as being safe for use in food contact applications.

Physical Properties

Although the extractable contaminants of Spears® Low Extractable are much lower than common PVC piping, Spears® Low Extractable has physical properties very similar to those of conventional PVC piping. As a result, Spears® Low Extractable products exhibit the well-known physical characteristics and other benefits of conventional PVC piping, such as good chemical and corrosion resistance, low thermal conductivity, high strength-to-weight ratio, good impact resistance, and ease of installation.

Physical Properties	Value	Test Method
Cell Classification	12343	ASTM D 1784
Specific Gravity	1.327	ASTM D 792
	(g/cu.Cm @ 73°F)	
Tensile Strength, @ yield	6720 psi	ASTM D 638
Tensile Modulus of Elasticity	384,200 psi	ASTM D 638
Flexural Strength, @ yield	11,440 psi	ASTM D 790
Flexural Modulus of Elasticity	378,000 psi	ASTM D 790
Izod Impact (avg 2 complete breaks) (avg 3 partial & 2 complete breaks)	 1.3 ft-lbs /inch 10.9 ft-lbs /inch	ASTM D 256
Coefficient of Linear Expansion	3.89 x 10^{-5} in/in°F	ASTM D 696
Compressive Strength	8732 psi	ASTM D 695
Heat Distortion Temperature	152°F	ASTM D 648
Hardness, Shore D	82.2 ± 3	ASTM D 2240
Maximum Temperature Use	140°F	

Design and Dimensions

Spears® Low Extractable piping is produced to Schedule 80 dimensions in strict accordance with ASTM D 1785, and exhibits a Type II pressure rating. Spears® Low Extractable fittings are produced to Schedule 80 dimensions per ASTM D 2467. Joining of product produced to the dimensional requirements of these standards ensures that strong connections with good pressure-bearing capability can be made up quickly and consistently using common, inexpensive tools. See Spears® Low Extractable fitting weight & dimension and price list publication for fitting information and selection.

SCHEDULE 80

Nom. Pipe Size (in.)	O.D	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
1/2	0.840	0.526	0.147	0.213	420
3/4	1.050	0.722	0.154	0.289	340
1	1.315	0.936	0.179	0.424	320
1-1/4	1.660	1.255	0.191	0.586	260
1-1/2	1.900	1.476	0.200	0.711	240
2	2.375	1.913	0.218	0.984	200
3	3.500	2.864	0.300	2.010	190
4	4.500	3.786	0.337	2.938	160
6	6.625	5.709	0.432	5.610	140

The pressure ratings given are for water, non-shock, @ 73°F. The following temperature de-rating factors are to be applied to the working pressure ratings (WP) listed when operating at elevated temperatures.

Multiply the working pressure rating of the selected pipe at 73°F, by the appropriate de-rating factor to determine the maximum working pressure rating of the pipe at the elevated temperature chosen.

De-Rating Factors

Operating Temp (°F)	De-Rating Factor
73	1.00
80	0.88
90	0.75
100	0.62
110	0.51
120	0.40
130	0.31
140	0.22

Processing & Packaging

Correct processing techniques ensure proper dispersion and fusion of the compound, resulting in uniform properties of this special materials. Optimizing processing conditions and providing smooth internal surfaces greatly reduce the potential for extractable and particle contaminants.

Spears® Low Extractable pipe and fittings are specially handled to minimize contamination, sealed in anti-static polybags and boxed on-line at time of manufacture.

Solvent Cement Joining

The Spears® Low Extractable system is primarily joined with standard solvent cementing using a special one-step solvent-cement specifically formulated for use with this product in UPW application. When properly used, this system results in very short cure times prior to pressure testing, and produces a solvent-cemented assembly with an exceptionally low percentage of chemical additives, reducing the potential for system contamination. The use of solvent cements and/or primers other than Low Extractable One-Step is not acceptable. Installers must become familiar with solvent cementing procedures prior to assembly. See Installation section for basic guidelines to solvent cement welding. All solvent cemented connections must be allowed to set and cure properly prior to pressure testing or rinsing.

Low Extractable UPW Solvent Cement Set and Cure Times

Set and cure times are a function of pipe size, temperature, pressure, humidity and tightness of fit. The initial set time is the recommended waiting period prior to handling a newly assembled joint. After the initial set time, the joints will withstand the stresses of normal installation. The cure time is the recommended waiting period prior to pressurizing newly assembled joints. Minimum cure time prior to pressure testing is dependent on pipe size, temperature, humidity, tightness of fit and test pressure required. Longer cure times must be allowed when working at higher humidity and colder temperatures. Refer to the following tables for minimum set and cure times.

Initial Set Time

Temp	Pipe Size 1/2" – 1-1/4"	Pipe Size 1-1/2" – 2"	Pipe Size 3" – 6"
60° - 100°F	2 min	3 min	30 min
40° - 60°F	5 min	8 min	2 hrs
0° - 40°F	10 min	15 min	12 hrs

Joint Cure Schedule

Relative Humidity 60% or less*	Pipe Size 1/2" – 1-1/4"		Pipe Size 1-1/2" – 2"		Pipe Size 3" – 6"
Temp Range during assembly and cure periods	up to 160 psi	160 to 370 psi	up to 160 psi	160 to 315 psi	up to 160 psi
60° - 100°F	15 min	6 hrs	25 min	12 hrs	1-1/2 hrs
40° - 60°F	20 min	12 hrs	30 min	24 hrs	4 hrs
0° - 40°F	30 min	48 hrs	45 min	96 hrs	72 hrs

If damp or humid weather allow 50 percent longer cure times.

Additional Joining Methods

Additional joining devices include flanges, unions, and threaded adapters produced from this special material. See Installation section for basic guidelines to flange and threaded joint make up. UPW applications typically require use of PTFE envelope gaskets for flanges and TFE tap sealant on threaded joints.

Hangers and Supports

As with standard PVC piping, support location and spacing is dependent on the pipe diameter, operating temperature of the system, and the location of any concentrated stress loads (i.e., valves, flanges, test equipment and any other heavy system components). Hangers used must have an adequate load-bearing surface free of any rough or sharp edges that could damage the pipe during use, must not restrict linear movement due to thermal expansion and contraction. See Installation section specified spacing and guideline applicable to Schedule 80 PVC pipe.

Thermal Expansion and Contraction

As with all thermoplastic piping materials, consideration must be given during the design of the system to the effects of thermal expansion and contraction. The coefficient of linear expansion for Spears® Low Extractable pipe is 3.89 x 10^{-5} in./in./°F. The rate of expansion or contraction can be calculated as follows:

$\Delta L = 12\ yL\ (T)$

Where:

ΔL = amount of expansion or contraction in inches y = 3.89 x 10^{-5}

L = length of piping run in feet

ΔT = temperature change °F

(T max. - T @ time of installation or lowest system temperature or maximum system temperature, whichever is greater.)

Additional Considerations

Proper system engineering, design, construction practices and operation are the responsibility of the design authority. Consideration must be given to ensure the Spears® Low Extractable system is not exposed to any conditions that will exceed the product limitations regarding temperature, pressure, chemical compatibility, and mechanical strength.

Spears® does not recommend the use of this product for the distribution of compressed air or gases.

Excessive surge pressure must be avoided. The system must be designed to ensure that surge potentials generated by pump operation, entrapped air, flow velocity, and valve closure are kept to a minimum. Spears® does not recommend flow velocities in excess of five feet per second.

Spears® Low Extractable piping systems are not formulated for outdoor use. Prolonged exposure to ultraviolet radiation (UVR) will affect physical properties.

Spears® recommends that newly installed systems be allowed to cure for a minimum period of 24 hours prior to rinsing procedures to reduce the potential for TOC contamination. Rinsing procedures, chemical rinse and other cleanup/disinfection procedures to be used are at the discretion of the system design authority.

Spears® Low Extractable piping is compatible with hydrogen peroxide at concentrations up to 30% at 73°F. Contact Spears® for additional chemical compatibility information concerning the use of Spears® Low Extractable products.

Application Qualification Testing

Static Leach Analysis

Detailed extractable analysis is conducted on piping samples after seven-day static leach utilizing 18.2 megohm ultra-pure water at ambient temperature. Static leach of large pipe samples (120-square-inch wet surface area) is representative of a piping system "off-line" for an extended period of time. Under these conditions the effects of UPW can be extremely aggressive, severely affecting the amount of leachable contaminants present within the piping material.

Pipe Material

Element	DL *(Detection Limit)* ppb	Spears® Low Extractable	High Purity PVDF	High Purity PP	Brand X Clean PVC	Conv. PVC	CPVC
TO C	5	59	90	94	1176	*	50
Fluoride	2	*	77	*	*	*	*
Chloride	0.25	2.33	1.0	0.66	2.45	0.84	49.54
Aluminum	0.05	0.30	2.3	0.68	0.54	3.10	1.16
Barium	0.01	0.04	0.24	0.09	0.01	0.22	0.05
Calcium	3	7	*	12	206	2787	15
Magnesium	0.02	0.81	0.66	1.0	2.15	11.15	2.17
Sodium	0.06	0.83	0.51	0.18	0.49	1.23	23.22
Tin	0.02	0.93	*	*	0.15	0.51	1.19
Zinc	0.06	0.49	0.47	0.96	*	0.51	1.19

*** = Below Detection Limit**

- All samples pre-rinsed identically with UPW prior to test.
- Independent Laboratory Extractable Analysis (Balazs Analytical Laboratory)
- Seven-Day Static Leach @ ambient temperature
- 450mL 18.2 megohm ultra-pure water
- 120-square-inch wet surface contact area
- Based on 1" diameter pipe without solvent-cemented joint
- Concentration units expressed as ug/L of Leachate (ppb)

Dynamic Leach Analysis

Spears® Low Extractable piping has been subjected to on-line dynamic flow analysis with 18.2 megohm UPW to evaluate particles, TOC, resistivity, anions, cations, and trace metals. This testing utilized solvent-cemented flange assemblies (spool piece) to see the effect that the cement had on TOC, resistivity and particle generation in a freshly assembled pipe section. Grab samples were also pulled periodically (at start-up, five minutes, 50 minutes and five hours) to analyze anions, cations and trace metals under flowing conditions. Spears® Low Extractable Flanges were assembled utilizing Low Extractable One-Step Cement and allowed to cure 24 hours prior to testing. Dynamic testing revealed that Spears® Low Extractable piping assemblies did not contribute significantly to particle generation or leachable contamination under flowing conditions throughout the test duration. Additional detailed information is available from Spears®.

Dynamic Test Description

Ambient temperature dynamic leach utilizing 18.2 megohm UPW flowing at 9.35 GPM (turbulent flow). 1" diameter pipe 30" long, solvent-cemented flanges each end (approximately 82-square-inch wet surface contact area). Approximately 1-1/2 grams of Low Extractable solvent cement used in assembly of components. Solvent-cemented assembly was allowed to cure 24 hours prior to start-up. Dynamic test was conducted for a period of five hours.

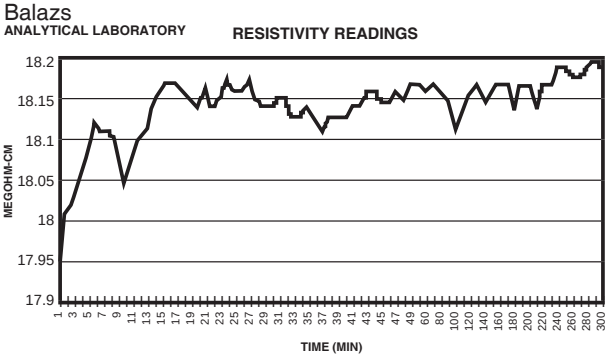
Leachable Contamination

Anions/Cations – IC grab sample analysis revealed low levels of sulfate (0.15 ppb) five minutes into the test, and low levels of ammonium at 50 minutes (0.05 ppb) and five hours (0.07 ppb) into the test. All other IC contaminants were below the limit of detection.

Trace Metals – Of the 68 trace metal contaminants evaluated, all were below the limit of detection with the exception of aluminum, detected at 0.012 ppb at the five-minute interval. This element remained below the limit of detection throughout the remainder of the leach.

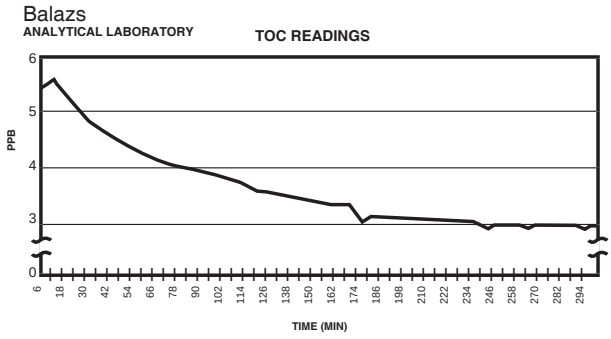
Resistivity

Resistivity measured 17.95 megohms at the start of the leach and rose quickly to 18.12 megohms during the first 6 minutes. Resistivity readings continued to rise until reaching the background level of 18.2 megohms after five hours of leaching.



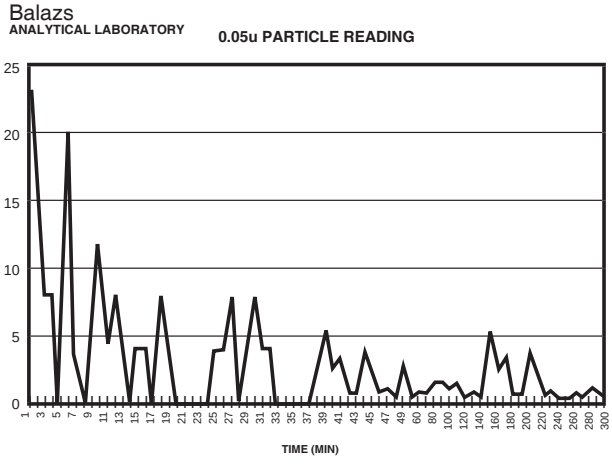
Total Oxidizable Carbon (TOC)

Dynamic testing revealed that after four hours of leaching, TOC readings reached and maintained the background levels throughout the test duration. This data confirmed the fast cure time of Low Extractable One-Step Cement. Conventional solvent cements and primers used for joining typically effect TOC contamination as a result of the leach.



Particles

Dynamic testing revealed that average particle counts decreased rapidly during the first six minutes of the leach. After 12 minutes of leaching the average smallest particles measured (0.05 micron size range) were representative of the background levels.



Surface Analysis

Spears® Low Extractable piping has a non-porous, exceptionally smooth interior surface that greatly reduces the potential for extractable and particle contamination while impeding bacterial growth. Spears® Low Extractable components (pipe and fittings) exhibit an average Roughness Analysis value of: ≤ .25 µm (≤ 10 µ inch) and has been evaluated side-by-side with other common piping materials at various magnifications for surface roughness comparison.