

CSPE Performance & History in Long Term Potable Water Storage Applications

Brian Fraser MBA,¹ Steven Roades², Mike Neal³, Alex Gersch⁴

¹Layfield USA Corp., 2500 Sweetwater Springs Blvd. Spring Valley CA, USA;

e-mail: Brian.Fraser@layfieldgroup.com

²Burke Industries, 2250 S 10th St, San Jose, CA, USA;

e-mail: SteveRoades@burkeindustries.com

³Layfield USA, Eugene, Oregon;

email: Mike.Neal@layfieldgroup.com

⁴Layfield Australia, Glenelg, South Australia 3434;

email: Alex.Gersh@layfieldgroup.com

THIS PAPER WAS ORIGINALLY PRESENTED AT THE 2019 GEOSYNTHETICS CONFERENCE | HOUSTON, TX, USA

ABSTRACT

Chlorosulfonated polyethylene (CSPE) is a synthetic rubber material noted for its outstanding resistance to chemicals, temperature extremes, and ultraviolet light. CSPE as a geomembrane was first developed over 40 years ago in the United States as a pond liner material and a roofing membrane. It has also been used extensively in various regions of the world as a geosynthetic floating cover material for municipal potable water storage and industrial process water containment applications. CSPE floating covers are designed and used to eliminate evaporation and to prevent contamination and debris from entering the stored water source.

This paper highlights the long history of CSPE floating covers in potable water storage and the materials outstanding UV performance and chemical resistance to chlorine and other chemicals disinfectants used in water treatment. The paper further profiles three larger floating cover projects located in hot, dry regions for potable water containment where the covers were used in exposed applications for an average of 30 years. Two of these floating cover projects are in California and the third in the State of South Australia. In potable water applications, disinfectants including chlorines and chloramines are commonly used for water treatment. These disinfectants can often act as accelerators in the breakdown of the certain geomembrane anti-oxidant packages resulting in premature material aging and failure. With CSPE, the material goes through a unique polymer cross linking process where several of the product's mechanical and endurance properties improve as the material ages.

With over forty years of documented applications, CSPE has proven to be one of the best performing materials for floating covers and geomembranes in long term potable water storage applications.

For up-to-date technical information, be sure to visit us online at www.LayfieldGeo.com

HISTORY OF CSPE AS A GEOMEMBRANE

CSPE is a synthetic rubber-based material manufactured by a calendaring process into multiple layers and combines a polyester reinforcement fabric for additional strength. In polymer science, Hypalon is a DuPont trademark for Chlorosulfonated polyethylene (CSPE) synthetic rubber (CSM) noted for its resistance to chemicals, temperature extremes, and ultraviolet light (Wikipedia). Hypalon is a product that was developed by DuPont Performance Elastomers. It was originally developed by planned polymer chemistry efforts to manufacture a new generation material to address some of the limitations at the time of materials produced from polyvinyl chloride, polyisoprene and butyl rubber. In the early 1950's, DuPont commercialized the development of CSPE and began to market the material under the trademark name of Hypalon. This material referred to a group of sulphur and peroxide cured elastomers created through a cross linking process with chlorinated polyethylene (CPE) and CSPE. In the late 1960's Burke Industries in San Jose, California began working with DuPont on the development of a flexible liner grade material from this CSPE/Hypalon resin.

Beginning in the mid 1970's CSPE/Hypalon was introduced as a new generation engineered liner primarily positioned for water and

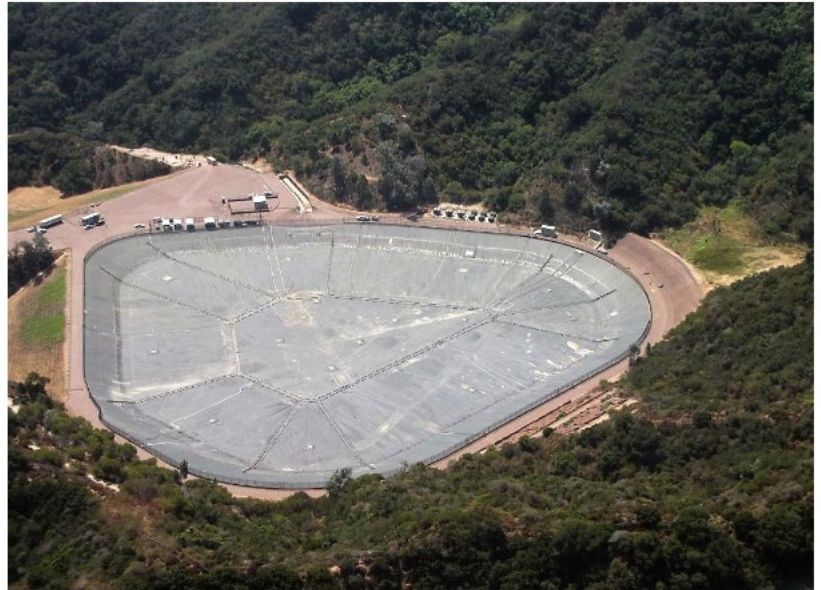


Figure 1. LADWP, Santa Ynes Reservoir, CA. Floating Cover 2010

wastewater containment applications. The initial markets and applications included potable storage and wastewater treatment for government municipalities and tailings ponds for the mining sector. The first floating covers on record using CSPE were installed in the late 1970 in Southern California reservoirs for municipal potable water storage. The covers were designed and used for evaporation control as well as to prevent dirt and debris from contaminating the water storage supply.

In June of 2009 DuPont made the decision to exit the production of certain resin products including CSPE. Fortunately, there was a qualified backup source of CSPE resin out of Japan. This source remains the primary resin being used in CSPE products today. Since its inception as a liner grade product, the manufacturer has confirmed over 46,452,000 m² (500,000,000 ft²) of CSPE has been supplied into the market as either a geomembrane, floating covers or single-ply roofing. A good portion of this material reported by the main CSPE producer is reportedly still in service.

PROPERTIES OF CSPE

CSPE has many advantages over other commonly used polymers such as polyvinyl chloride (PVC), polyolefins and ethylene ketone ethylene ester (KEE) resin technology. One of the primary differences is that CSPE is manufactured as a thermoplastic material that will vulcanize over time, becoming a thermoset material capable of surviving thermally stressful and high-temperature environments and UV exposure. When formulated and calendared into a lining grade material, it provides outstanding UV

resistance and weathering properties allowing it to be used for long term exposed containment applications. In standard exposed applications it demonstrates slow reduction of its mechanical and endurance properties.

The material's unique cross-linking properties provide it very good overall chemical resistance to several chemicals used as disinfectants in municipal water treatment. These include chlorine, sodium hypochlorite and chloramines. In water treatment these chemicals can often act as accelerators attacking and breaking down the antioxidant

packages of a number of geomembrane types. This can result in environmental stress cracking and premature material failure (Mills 2011). No plasticizers are used in the formulation of CSPE geomembranes resulting in no issues relating to plasticizers that can leach out and cause embrittlement or cracking of plasticized liners. Its inherent low coefficient of thermal expansion and contraction provides excellent dimensional stability and lay-flat characteristics. CSPE also has a very low thermal expansion coefficient compared to that of rigid membranes such as HDPE, and so expansion and contraction problems caused by temperature changes are virtually nonexistent. Elasticity is important in liners because of the settling that occurs after reservoirs or impoundments are filled (Scheirs 2009).

CSPE's synthetic rubber properties also provide it with a unique combination of flexibility and durability. In geomembrane and floating cover applications, CSPE is typically factory fabricated. Fabricated geomembranes are lining materials that are flexible enough for panels to be joined in a factory environment to create large prefabricated panels of material that can be folded, rolled, and transported efficiently to a containment project site. From there these larger prefabricated panels are unrolled into position and field welded on site. Factory fabrication can significantly reduce the amount of field welding which reduces installation time and construction costs. It also provides consistent seam integrity and liner quality (Fabricated Geomembrane Institute).

Standard reinforced CSPE geomembrane grade products are available in 0.91, 1.14, and 1.52 mm (36, 45, 60 mil) thicknesses and meet the Geosynthetic Institute standard GM28 (Geosynthetic Institute). This specification provides the specific test methods, properties and testing frequency for reinforced CSPE material. CSPE also has good overall thermal properties allowing it to be installed and handled in temperatures ranging from -30 C (-22 F) to 46 C (115 F).

Figure 3 below shows some mechanical index testing by the manufacturer on a 20-year exposed jobsite material sample. Test results showed the materials tensile breaking strength, tensile elongation and hydrostatic resistance after 20 years meeting or exceeding its published specifications.



Figure 2. MWDS Skinner Reservoir, CSPE Cover installed 2010

Roll No. SAMPLE #1		Hypalon Quality Surveillance Report						Obtained Results	Pass/Fail
		Reinforced Sheet							
Date:	3/12/2007	20 year old CSPE/Hypalon							
Product No.									
Lot No.	N/A								
Test Property	Method	Minimum Required	Actual Results						
			Sample Number						
20yr. SAMPLE #2									
Thickness, mils	ASTM D-751	45	43	43	42	43	43		
Breaking Strength, lbs.									
Machine Direction	ASTM D-751	220	321	317	348		329	Pass	
Gross Machine Direction	Grab Method		334	334	343		327	Pass	
Elongation @ Break, %									
Machine Direction	ASTM D-751	30	27	22	26		25	Fail	
Gross Machine Direction	Grab Method		35	26	32		31	Pass	
Hydrostatic Resistance, lbs	ASTM D-751 Method A	250	430	435			433	Pass	

Figure 3. 20 Year Exposed CSPE Sample Test Results from Burke Ind.

PROJECT PROFILES

CSPE is one of a few industry materials where we have 40 years of confirmed history showing the performance as a liner and floating cover in potable water containment applications. There are several important factors that contribute to achieving long term performance of floating covers in any containment project. These include the initial cover design; selection of material; quality of the workmanship including factory fabrication and field installation. On the operations side, an important factor is the need for regular inspections and preventative maintenance of the cover systems recommended on an annual basis.

In the following section we highlight 3 projects where CSPE liner and floating covers have been used in longer term applications in hot, dry climates for municipal potable water storage. The profiles help to demonstrate the unique weathering ability of CSPE to withstand the elements of time, temperature, UV exposure and chemicals used for water disinfectant.

Project Profile 1: Hinkle Reservoir

- San Juan Water District
- Granite Bay, California
- Hinkle Reservoir
- 238 Million Liters (62 million Gallon) Capacity
- Potable Water Storage
- CSPE Liner & Cover installed in 1980

San Juan Water District’s Hinkle Reservoir had a 1.14 mm (45 mil) CSPE liner and floating cover installed in 1980. The cover has a defined sump design however



Figure 4. Hinkle Reservoir, 37-Year-Old CSPE Floating Cover Picture 2017

with the floatation system installed on the bottom side of the cover. The water district initially chose an open top reservoir with a floating cover based on the substantial cost savings versus other storage options. When the reservoir was initially reconstructed, alternative such as steel and concrete tanks were considered. Being a municipal facility both cost and performance were equally considered in the determination of the storage facility. It was determined at the time that the cost of a CSPE liner and floating cover system was approximately 60% to 80% less than alternative storage systems considered. This also factored in lifecycle cost for maintenance and servicing. As a result, CSPE was specified and the material was designed, fabricated and installed as one of the first-generation larger scale floating covers at the time. Fully extended, the floating cover spans 5.7 hectares (14 acres). The Hinkle reservoir is located north east of Sacramento, CA. The region is known for its hot, arid summers and high UV exposure. The winters are typically a bit cooler, wet, and partly cloudy. Over the course of the year, average temperature can vary from 4°C to 40°C (35°F to 104°F).

In 2016 when the CSPE material reached the 36-year mark, the material was tested by the manufacturer with the results shown below in Figure 5. The material tensile strengths and tensile elongation properties were shown to be above the original published material specifications. Further independent third-party testing was conducted by the water district. The reservoir is currently scheduled to have a new liner and cover installed over the next couple of years. At that time the original installed liner and cover materials will have been in service for 40 years. A key to the outstanding success of this floating cover was the regular maintenance and servicing performed by the San Juan Water District. It is believed that the Hinkle Reservoir is one of the longest reported CSPE floating cover systems still operating. It should be noted that the resin producer with the support of San Water District published a press release in 2003 on the Hinkle Reservoir as the cover system reached its 23-year mark (Hinkle: A Pioneer in Floating Cover Reservoirs).

Project Profile 2: Happy Valley Reservoir

- South Australia Water Corp, South Australia
- Happy Valley Reservoir
- 100 Million Liters (26,418,000-gallon) Capacity
- Potable Water Storage
- CSPE Liner & Cover originally installed in 1988

In the mid 1980's, SA Water Corp. was evaluating the feasibility of installing geomembrane liners and covers on two new 100 million liter (24.4 million-gallon) earth bank potable water storage reservoirs adjacent to the Happy



Figure 5. Aerial of Twin Happy Valley Reservoirs, Adelaide, AU

Valley water treatment plant. This plant provides potable water for most of the southern Adelaide region. Ambient temperatures for the area can often reach as high as 44°C (114°F) and extreme high solar exposure in the summer months. Due to the proximity to the treatment plant, higher levels of chlorine were expected at the inlet stream. Extensive research and testing were carried out during the preliminary design stage on all liner materials available at the time. Significant focus was placed on the puncture resistance, flexibility, UV resistance and long-term durability of materials. This was due to the fact South Australia has some of the

highest solar conditions in the developed world. Specific puncture resistance tests were conducted using material obtained from the site and HDPE, CSPE (Hypalon), EDPM and Butanol were all evaluated.

Resulting from the evaluation process, 1.14mm (45 mil) CSPE was selected as the most suitable material. Black material was selected for the liner while the cover material was black on the underside in contact with the potable water and a tan top surface to reduce surface temperatures and provide a more aesthetic appearance.

The liner and cover for storage 1 were factory fabricated off-site. The twin storages were constructed using compacted cut and fill material with an underfloor drainage system. After final surface preparation, a heavy weight non-woven geotextile cushion layer was installed by the contractor before installation of the pre-fabricated CSPE liner panels. All field seams carried out on the liner were performed using CSPE adhesive. The covers were installed in the same manner. Storage 1 was completed in 1988 and storage 2 was completed a year later. Annual inflations of the CSPE floating covers were carried out to facilitate inspection and cleaning of the liners. Three years after installation during one of these regular inflations the cover on Storage 1 was torn open by a gust of wind resulting in large tear over halfway across the cover and displacing approximately 25% of the cover area. Over the following days the cover was manually pulled back into place and successfully repaired using the CSPE gluing process. The repairs carried out in 1991 on the cover on storage 1 remained for the full remaining life of the material.

The decision to replace the CSPE liners and covers was made taking several factors into account. This included the planned 25-year asset life had been achieved. Changes to flow were also necessary as water quality standards had progressed over the previous 25 years and short circuiting was an issue as the inlets & outlets were relatively close to each other.

After 26 years of service, the liner and cover on storage 1 was replaced in 2014. While the tan top surface of the cover was stained the CSPE material was still completely pliable and black underside surface appeared near new. The liner material when cleaned appeared to be in close to new condition. The 26-year-old CSPE liner and cover material was appeared to still have some life in it and were cut and re-used as drop in liners, evaporation pit liners, tarpaulins & haystack covers.

In 2016, after 27 years of service, the liner and cover on storage 2 was replaced. The CSPE material was in the same near new condition as in storage 1 and was again recovered and re-used in other applications. The new replacement 45mil CSPE covers were constructed with integral CSPE baffle curtains to improve chlorine contact/residence time and eliminate short circuiting.

Project Profile 3: Upper Reservoir

- Otay Water District, Spring Valley, California
- Upper Reservoir
- 139 Million Liters (36,700,000 gallon) Capacity
- Potable Water Storage
- CSPE Liner & Cover originally installed in 1988

Otay Water is a water, recycled water, and sewer service provider. The California State Legislator originally



Figure 6. Aerial of Upper Reservoir CSPE Cover

authorized the establishment of the Otay Water District in 1956 as a special district. The district today provides water services to customers within 200 km² (125 m²) of the densely populated region of southeastern San Diego County. The district's facilities service the water and sewer needs of customers residing in several southern communities of San Diego Country up to the border of Mexico. This region has a very not hot arid climate with summer average temperatures ranging for 20C to 38C (70F to 100F). Winter average temperature can range for 7C to 16C (45F to 60F). The San Diego County is known for a very high to extreme UV index through most months of the year.

The original cover and liner material for the Upper Reservoir were installed in 1988 using a 1.14 mm (45 mil) CSPE. A special aqua skin color was chosen for the skin layer of the CSPE for its aesthetic. The Upper Reservoir is used for portable water reservoir servicing a rapidly growing population base in San Diego County. A weighted tension cable system was initially chosen for the cover design based on its lower maintenance cost primarily the result of not having any surface floats or sumps required to tension the cover. It also allows the operator to use the existing hardware when replacing the cover at the end of its life representing a measurable cost savings during replacement.



Figure 7. Mechanical Tensioning Tower System on Upper Valley

In 2018 the existing cover and liner needed to be replaced to allow for mechanical pipe and pump upgrading requirements. At the time of relining the Upper Reservoir floating cover had been in operation for 30 years with no reported major problems encountered during its long operational life. Both the CSPE manufacturer and liner installer were of the opinion after physical inspection of the material that it was still in overall good condition and would have functioned for a few more years. An important part of the cover longevity can be contributed to Otay Water's regular inspection and maintenance programs and the quality design and workmanship of the original installation. The new CSPE cover system incorporated most of the existing hardware a benefit to using the mechanical tension cable system. In terms of industry records, Otay Water's Upper Reservoir was one of the longest performing CSPE floating cover projects for potable water storage in Southern California.

CONCLUSION

In the relatively short history of polymeric geomembranes, CSPE has proven to be an excellent choice of material for long term exposed applications. The geomembrane industry has seen several products introduced and promoted into potable water storage however to date, no other material has consistently demonstrated the successful long-term performance when compared with CSPE. CSPE is backed by an industry leading 30 year weathering warranty. It is one of the few materials that has truly passed the test of time.

ACKNOWLEDGEMENTS

Tony Barela, San Juan Water District, Granite Bay, CA, USA
Paul Vince, WSP Engineering, Adelaide, SA, Australia
David Jaensch, SA Water Corp, Adelaide, SA, Australia
Bob Kennedy, Otay Water District, Spring Valley, CA, USA
Andrew Mills, Layfield Environmental, Edmonton, AB, Canada
Doug Hilts, Hilts Consulting Group, Orange Country, CA, USA
Bob Pitman, Burke Industries, San Jose, CA, USA

REFERENCES

Wikipedia contributors. (August 20, 2018) Hypalon, In *Wikipedia, The Free Encyclopedia*, Retrieved August 12, 2018 from <https://en.wikipedia.org/wiki/Hypalon>

General Information of Fabricated Geomembranes. The Fabricated Geomembrane Institute, University of Illinois at Urbana-Champaign, Dept. of Civil and Environmental Engineering, Avenue, Urbana, IL, <https://www.fabricatedgeomembrane.com/resources/faqs>

GM 28, Geosynthetic Institute, 475 Kendron Ave. Folsom, PA, 19033, <http://geosynthetic-institute.org/grispecs/gm28.pdf>

WaterWorld. (2004, December 1). *Hinkle Reservoirs Pioneers Floating Cover with 45 year lifetime* (Press Release) Retrieved from <https://www.waterworld.com/articles/2004/12/hinkle-reservoir-pioneers-floating-cover-with-45-year-lifetime.html>. In Text: (Water World 2004)

Mills, A. (2011) 'The effects of chlorine on very low-density thermoplastic olefins', Geofrontiers 2011, Dallas TX, IFAI.

Scheirs, J. (2009). A Guide to Polymeric Geomembranes: A Practical Approach, 1st ed., Wiley The Atrium, Southern Gate, Chichester, West Sussex, UK

To Learn More About CSPE - [Click Here](#)