ELEVATED TEMPERATURE TESTS - TUFF-N-NUFF Rock Shield

Testing of TUFF-N-NUFF rock shield has been completed under conditions as similar as possible to replicate actual service conditions of a pipeline. The testing essentially consisted of mounting TUFF-N-NUFF samples on a pipe maintained at 121C and buried in coarse sand. Physical attributes of the samples were taken before being subjected to the elevated temperature test. These same attributes were then measured on samples removed at 7, 14 and 21-day intervals.

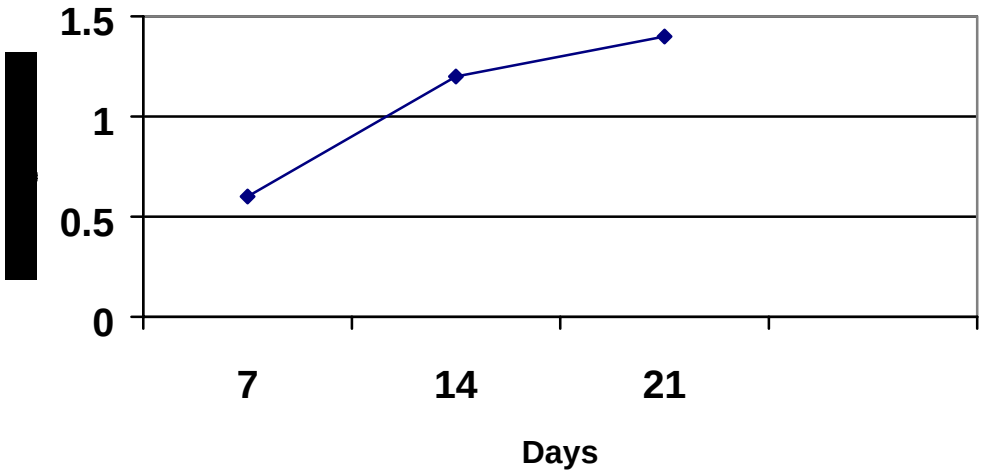
A temperature of 121 C was selected to accelerate the aging process and is one of the temperatures often used to evaluate flexible PVC materials. Retention of at least 75% of the original tensile strength and 50% of the original elongation after 7 days exposure, is accepted as being sufficient for long-term performance specification of PVC at 75 C. Testing was extended to 14 days and then 21 days to further evaluate the elevated temperature effects. The changes in properties were noted and are found in Table 1.

The test data confirms that TUFF-N-NUFF has performed extremely well. Weight loss, an indication of plasticizer loss, has been very minor and it's reflected in the retention of tensile properties. It can be seen that the rate of weight loss has decreased as was anticipated, indicating that a state of equilibrium is being reached. ***TUFF-N-NUFF maintains adequate tensile and elongation properties to easily meet the accepted minimum requirements of flexible PVC for 75C rated service.*** In fact, TUFF-N-NUFF maintained sufficient properties ***EVEN AFTER 21 DAYS, 3 times the duration of the typical test***.

TABLE 1 - Tensile Strength, Elongation, Weight Loss

Time / Temperature	Property	Initial Value	Value after Exposure	Percent Change
Specimen buried in coarse sand and secured to a pipe maintained at 121C for 7 days	Tensile Strength (lb/in of width)	26.88	26.53	-1.3%
	Elongation @ Maximum Load (%)	77.1	86.5	12.2%
	Weight (grams)	26.47	26.31	-0.6%
Specimen buried in coarse sand and secured to a pipe maintained at 121C for 14 days	Tensile Strength (lb/in of width)	26.88	23.68	-11.9%
	Elongation @ Maximum Load (%)	77.1	79.0	2.5%
	Weight (grams)	27.66	27.33	-1.2%
Specimen buried in coarse sand and secured to a pipe maintained at 121C for 21 days	Tensile Strength (lb/in of width)	26.88	30.32	12.8%
	Elongation @ Maximum Load (%)	77.1	80.7	4.7%
	Weight (grams)	28.86	28.45	-1.4%

Weight Loss Standard TNN Compound, 121C for 21 days



Additional tests have been completed to determine the change in compressive strength and impact resistance. These tests, performed by St. Louis Testing Laboratories, an independent third party agency, reveal further information as to how the TUFF-N-NUFF product is affected by elevated temperatures. ***Samples taken from the buried pipe at 121C after 21 days showed little to no effect on compressive strength or impact resistance from the elevated temperature***. Test data is listed in Table 2 and Table 3 (original of third party test report to follow).

TABLE 2 – Compressive Strength

Compression (%)	Non-Heat Treated Sample (Compressive Strength psi)	Heat Aged @ 121C for 21 days (Compressive Strength psi)	% Change
10	8	6	25%
20	23	16	30%
30	49	44	10%
40	107	100	6.5%
50	242	220	9%

TABLE 3 – Impact Resistance

Fusion Bonded Epoxy Plate Only	Fusion Bonded Epoxy Plate w/ Non Heat Treated TNN	Fusion Bonded Epoxy Plate w/ Heat Treated TNN (121C for 21 days)
32 in-lb	135 in-lb	132 in-lb (2% reduction)