MINEX®
Functional Filler

MINEX® – durability of nepheline syenite in cool colored roof coatings

Summary

MINEX is known and widely used to provide superior exterior durability in tinted architectural and industrial formulations. To consider if nepheline syenite can also provide the same durability with mixed metal oxide pigment technologies being utilized for non-white, cool colored roof coatings, MINEX grades were compared with ground calcium carbonate, feldspar, ground silica, wollastonite, and hollow glass spheres. Key tests considered were color retention (Delta E) and solar reflectance (SR) efficiency in a proven roof coating formula exposed for five years in Arizona.

MINEX 4 and hollow glass spheres gave the best durability or least color change overall for the 5 year duration. Initial SR efficiency for the coatings were slightly below Energy Star Rating requirement of 0.65, but all fillers tested complied with the Energy Star Rating of maintaining SR above 0.50 for the 5-year duration and it's only a requirement to maintain this level for the first three years. Glass spheres are more heavily promoted for cool roof coatings, but MINEX 4 as a more conventional and economic filler also provides increased performance with better value.

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Study

Mineral type and median particle size for test fillers used in this study are shown in Table 1. Cool colored roof coatings were made using a commercial light duty industrial roof coating formula shown in Table 2.

Table 1. Fillers tested in cool colored roof coatings

Filler	Mineral type	D_{50} (µm)
MINEX 4	Nepheline Syenite	6.8
MINEX 7	Nepheline Syenite	3.5
SNOWFLAKE™ PE	Calcium Carbonate	5.5
ATOMITE®	Calcium Carbonate	3.0
UNISPAR® PG-F5	Feldspar	4.8
IMSIL® A-15	Microcrystalline Silica	3.9
IMSIL 1240	Microcrystalline Silica	8.7
SCOTCHLITE™ K37	Hollow Glass Spheres	45
VANSIL® W-30	Wollastonite	4.5

Table 2. Durable acrylic emulsion roof coating formulation. Test fillers formulated at 10 gallons per 100 gallons of paint. Fillers weights were adjusted to equalize volume.

Ingredient	Lb	Gal
Water	144.65	17.33
Drew Plus™ Y281	1.37	0.18
Cellosize™	2.40	0.48
Ammonia	0.04	0.01
Tamol™ 1254	6.94	0.70
Shephard Yellow (10C272)	72.17	1.88
Mica C-3000™	26.67	1.13
Test Filler	217-242 (varies)	10.00
Disperse at high speed 15 minutes, then let down at low speed		
Water	16.60	2.0
Rhoplex AC-630™	545.10	61.33
Drewplus Y281	1.37	0.18
Troy® 678	5.80	0.60
Butyl Cellosolve™	13.33	1.78
Water	25.04	3.00
Totals	**861.52**	**100.59**

Test formulations were made with a BYK Dispermat® CV-3 and Cowles blade. The pigments and fillers were dispersed at 2800 rpm for 15 minutes, then let down and filtered through a 225 micron paint strainer. Test panels were prepared using Birchwood plywood panels (R1-W) from Leneta. The panels were primed with one coat of latex primer on the front, back and sides. Two coats of the test formulations were applied to the primed panels drying overnight between coats. The panels were then allowed to dry one week prior to testing.

Test panels were exposed at Q-Lab Arizona at a southern facing 34° incline. Roofing products are typically tested at this incline and southern facing. Every six months, a panel for each formulation were removed and returned to measure color change and solar reflectance with methods noted below.

Color measurement

Exposure panels were tested for color on a Gretag Macbeth Color i5 colorimeter in CIELAB (L*a*b*) color space with the specular component included. Measurements were done on three different locations on the panel and averaged by the instrument.

Solar reflectance measurement

Solar reflectance (SR) testing was performed by R&D Services in Cookeville, TN. The test was performed in accordance with ASTM C 1549-09 using a solar reflectometer built by Devices and Services Company. One panel for each formulation was submitted to R&D Services for testing every six months.

Results

The full five year test results can be found in Table 3. MINEX 4 and glass bubbles provided the most consistent color retention for the duration. Atomite, Snowflake PE, and Vansil W-30, feldspar and ground silica had more color change or increasing Delta E values.

Table 3. Color change (Delta E) of cool roof coatings placed in Arizona.

Exposure Months	6	12	18	24	30	36	48	60
MINEX 4	2.02	3.32	2.08	1.8	1.59	3.15	3.52	3.64
MINEX 7	3.78	3.64	2.75	2.23	2.44	3.11	6.12	6.23
SNOWFLAKE PE	3.79	3.32	2.53	3.29	3.48	4.61	5.14	4.66
ATOMITE	3.48	3.88	3.33	3.73	3.65	5.14	5.96	4.32
UNISPAR PG-F5	3.08	3.1	1.75	2.17	1.42	3.78	5.28	5.49
IMSIL 1240	3.73	2.72	2.32	2.26	2.35	5.09	7.72	6.38
SCOTCHLITE K37 Spheres	3.71	2.56	2.17	2.32	1.74	4.99	3.54	1.36
VANSIL W-30	3.55	2.84	3.34	4.26	4.36	6.34	7.96	7.41

The historical color change for 2, 3, 4 and 5 years is illustrated in Figure 1. Two years is considered the standard in outdoor exposure to show weathering differences and make determinations. While there weren't major differences at the 2 year readings, more separation became visible in year three where MINEX grades were the best. In years four and five, MINEX 4 and glass bubbles proved to be the best for color retention, showing these are viable formulas that could serve as starting point formulas. MINEX 4 and glass spheres had a Delta E of around 3.8 or less for the final readings and would represent very little color difference to a normal observer.

MINEX 4 is lower cost and more widely used than glass spheres in typical exterior formulas. Images of the returned MINEX 4 panels from year four and five are compared to the unexposed control in Figure 2.

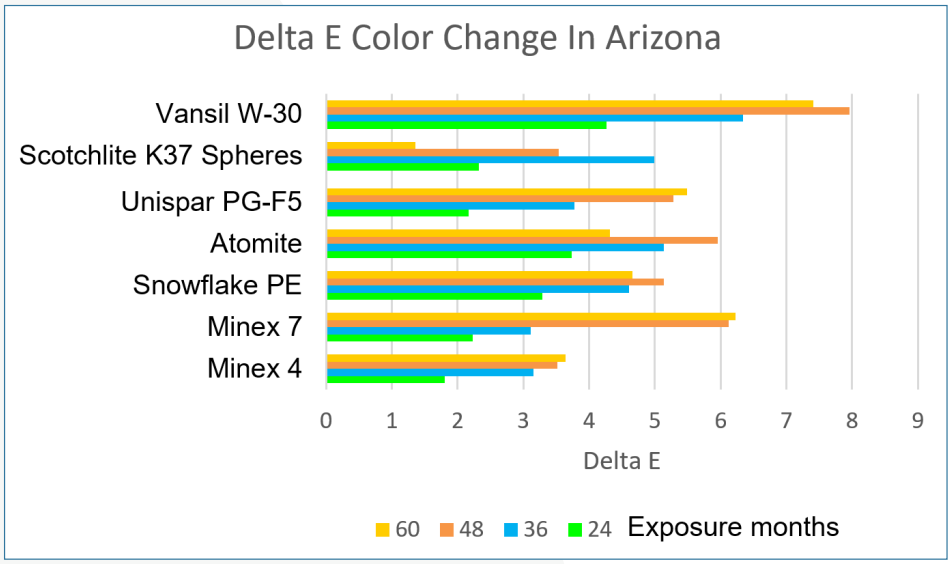

Figure 1. Color change panels exposed in Arizona from 24 to 60 months.

Figure 2. Visual comparison of unexposed MINEX 4 control with four and 5 year MINEX 4 test panels returned by Q-Labs.

Initial to 60 month SR testing is summarized in Table 4. The SR value of the pigment provided by Shepherd in a masstone formulation is 62%. The average SR for all the samples initially was 60.6% with a standard deviation of less than 1.0% and all the samples exhibit similar SR values. SR performance for each year of exposure time is illustrated in Figure 3. The change from initial testing to six months was most significant and suggests there is some initial change in SR, or panels may have darkened in color initially. Interestingly, the test coatings all returned to about their original SR between the 12 and 60 month time span. It is reasonable to assume that if the coatings had been formulated at the Energy Star Rating minimum of 65% for solar reflectance, that solar reflectance for three years and even out to five years would meet the minimum maintenance SR of 53%.

Table 4. Solar reflectance results of cool roof coatings.

Sample Number	Mineral Filler	Solar Reflectance (%)								
		Initial	6 months	12 months	18 months	24 months	30 months	36 months	48 months	60 months
53-143-1	MINEX 4	60.4	58.2	58.1	58.2	58.3	59.3	59.1	59.7	60.2
53-143-2	MINEX 7	60.2	58.1	58.2	58.1	58.5	59.2	59.0	59.8	60.4
53-143-5	SNOWFLAKE PE	60.7	58.7	58.8	59.0	59.0	60.0	59.6	60.3	60.6
53-143-6	ATOMITE	61.2	58.8	58.7	59.3	59.4	60.3	59.9	60.7	61.4
53-143-7	UNISPAR PG-F5	60.8	58.4	58.6	58.6	58.7	59.7	59.5	60.1	60.8
53-143-9	IMSIL 1240	61.1	58.9	58.8	59.3	59.4	60.1	60.1	61.0	61.3
53-143-10	SCOTCHLITE K37 SPHERES	62.0	59.0	59.2	59.6	59.6	60.4	59.9	60.7	61.3
53-143-11	VANSIL W-30	60.6	58.5	58.1	58.6	58.8	59.5	59.4	60.0	60.4

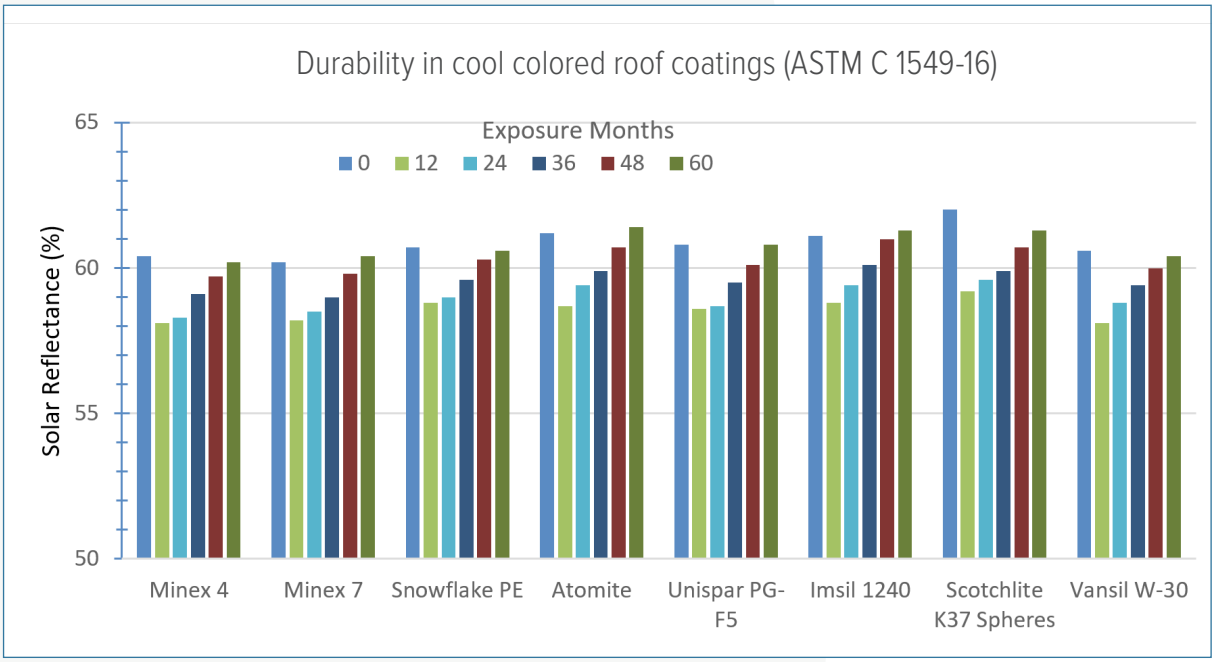

Figure 3. Comparison of solar reflective for test fillers versus exposure time in Arizona.

Conclusions

MINEX 4 nepheline syenite, already widely used in conventional durable exterior flat paints, along with hollow glass spheres showed the best and most consistent durability in a cool colored roof coating exposure study in Arizona compared to the other filler types. Initial Solar Reflectance could also be increased with more cool pigment or alternate color types. All formulations maintained high solar reflectance after a 3-year minimum and even out to 5 years if Energy Star ratings were desired.

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