CITY OF
CHULA VISTA

Development Services Department

Building Division

January 12, 2012

California Energy Commission
1516 Ninth Street
Sacramento, Ca. 95814-5512

Re: Application for Locally Adopted Energy Standards by the City of Chula Vista In Accordance With Section 10-106 of the California Code of Regulations, Title 24, Part 1

Dear Commissioners,

At its meeting of January 10, 2012, City Council placed an ordinance mandating cool roof standards on first reading and directed staff to bring it to Council for second reading and adoption after CEC review and approval. See attached RECORD OF ACTION TAKEN AT THE REGULAR MEETING OF THE CITY COUNCIL OF THE CITY OF CHULA VISTA ON JANUARY 10, 2012.

At its meeting, City Council made the determination that mandating Tier 2 cool roof standards for new low-rise residential buildings in Climate Zone 10 will not require buildings to consume more energy than permitted by the current California Energy Code and are determined to be cost effective based on a cost-effectiveness study by Gabel Associates, LLC.

Enclosed with this application are the following:

1. The proposed Ordinance which includes statements that the proposed standards are cost-effective and will not require buildings to consume more energy than permitted by the current California Energy Code, and evidence that the Ordinance was approved and placed on first reading at a noticed public meeting.

2. A study with supporting analysis showing how the City determined the energy savings and that the proposed standards are cost effective.

Per the request of Commission Staff, we would like to express to you our firm commitment to have the City enforce the current Title 24 Building Energy Efficiency Standards as part of the implementation of our local energy ordinance. As the Building Official, I will work with staff involved in energy plan review and field inspection to improve their working knowledge of the

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energy standards, including special training as needed which focuses on enforcement of the energy standards and the special requirements of local energy standards.

Respectfully,

Lou El-Khazen, PE, CBO, CASp
Building Official
(619) 409-1960
lelkhazen@chulavistaca.gov

CITY OF CHULA VISTA

Office of the City Clerk

RECORD OF ACTION TAKEN AT THE REGULAR MEETING OF THE CITY COUNCIL OF THE CITY OF CHULA VISTA ON JANUARY 10, 2012

The following is the action taken by the Chula Vista City Council at its meeting of January 10, 2012 regarding an Ordinance of the City of Chula Vista related to green building standards.

ACTION: Mayor Cox moved to place the Ordinance of the City of Chula Vista Amending Chapter 15.12, Green Building Standards, of the Chula Vista Municipal Code and adding Section 15.12.030, Cool Roof, attached hereto as Attachment 1, on first reading. Deputy Mayor Bensoussan seconded the motion, and it carried with the following vote: AYES: Aguilar, Bensoussan, Castaneda, Ramirez, and Cox; NAYS: None; ABSTENTIONS: None.

for Donna R. Norris, CMC
City Clerk
City of Chula Vista

ORDINANCE NO. _____

ORDINANCE OF THE CITY OF CHULA VISTA AMENDING CHAPTER 15.12, GREEN BUILDING STANDARDS, OF THE CHULA VISTA MUNICIPAL CODE, ADDING SECTION 15.12.030, COOL ROOF

WHEREAS, on May 3, 2011 City Council approved Resolution 2011-076 in which City Council adopted the Climate Adaptation Plans and approved their implementation; and

WHEREAS, the adopted Climate Adaptation Strategies will help reduce the City's future risks and costs from expected local climate change impacts; and

WHEREAS, the Implementation Plan for Strategy #3, Cool Roofs, proposed amending the City's Green Building Standards, Chula Vista Municipal Code (CVMC) Chapter 15.12, to require what are currently voluntary cool roof measures in the 2010 California Green Building Standards Code on new low-rise residential developments; and

WHEREAS, the California Energy Commission determined that because cool roofing is currently one of the compliance options available in the California Energy Code and because it affects the energy efficiency of buildings, mandating cool roofs requires the California Energy Commission's review and approval prior to a cool roof ordinance taking effect; and

WHEREAS, the California Energy Commission's review and approval process requires City Council's determination that the proposed local standards will not require buildings to consume more energy than permitted by the current California Energy Code and are cost-effective; and

WHEREAS, a study prepared by Gabel Associates, LLC analyzed the energy savings and cost-effectiveness of requiring Tier 1 and Tier 2 residential cool roof standards, which are currently voluntary standards in the 2010 California Green Building Standards Code, in the two Climate Zones that are within the boundary of Chula Vista; and

WHEREAS, the results of the study showed that requiring Tier 1 or Tier 2 cool roof standards in Climate Zone 7 is not cost-effective, however the requirements are cost-effective in Climate Zone 10; and

WHEREAS, based on the results of the study, Gable Associates, LLC recommends requiring Tier 1 or Tier 2 standards only in Climate Zone10; and

WHEREAS, based on the results of the study, Tier 2 cool roof standards in Climate Zone 10 are more cost-effective than Tier 1 standards; and

WHEREAS, based on staff research, the majority of new residential developments in Chula Vista will have steep-sloped roofs with concrete or clay tile roofing that will meet or exceed Tier 1 cool roof standards; and

WHEREAS, the Director of Development Services has reviewed the proposed activity for compliance with the California Environmental Quality Act (CEQA) and has determined that the activity falls within the Class 8 Categorical Exemption pursuant to California Code of Regulations Title 14, Chapter 3, Article 19 (the "State CEQA Guidelines") section 15308 and therefore is exempt from environmental review; and notwithstanding the Class 8 Categorical Exemption, the Director of Development Services has further determined that there is also no possibility that the activity may have a significant effect on the environment; therefore, pursuant to section 15061(b)(3) of the State CEQA Guidelines the activity is exempt from the provisions of CEQA.

SECTION I: NOW THEREFORE BE IT ORDAINED, that the City Council of the City of Chula Vista does hereby find and determine that:

Mandating Tier 2 cool roof standards in Climate Zone 10 will not require buildings to consume more energy than permitted by the current California Energy Code; and

Tier 2 cool roof standards in Climate Zone 10 are cost-effective; and

Mandating Tier 2 cool roof standards in Climate Zone 10 is necessary due to local climatic and environmental conditions.

SECTION II: BE IT FURTHER ORDAINED, that the City Council of the City of Chula Vista does hereby find and determine that Chapter 15.12 of the Chula Vista Municipal Code is hereby amended by adding Section 15.12.030, Cool Roof, as follws:

Section 15.12.030 Cool Roof
The voluntary Tier 2 cool roof measures found in Subsection A4.106.5 of the California Green Building Standards Code are mandatory in Climate Zone 10 for new low-rise residential developments.

SECTION III: EFFECTIVE DATE

This Ordinance shall take effect after the City Council acknowledges receipt of actions taken by the California Energy Commission pursuant to Title 24, Part 1 of the California Code of Regulations (the "California Administrative Code") section 10-106 but no sooner than the thirtieth day from and after this Ordinance's final adoption.

Presented by

Gary Halbert P.E., AICP
Assistant City Manager/Development Services Director

Approved as to form by

For Glen R. Googins
City Attorney

Cost-Effectiveness of Cool Roof for a Proposed Chula Vista Energy Ordinance

June 30, 2011

Report prepared for:
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1.0 Executive Summary

Gabel Associates has researched and reviewed the energy cost-effectiveness of a proposed City of Chula Vista ordinance which would require that low-rise residential buildings include "cool roof" coatings that meet the 2010 CALGreen Tier 1 or Tier 2 prescriptive criteria. If such an ordinance is adopted, this study may be included in the City's application to the California Energy Commission which must meet the criteria specified in Section 10-106 of the California Code of Regulations, Title 24, Part 1, LOCALLY ADOPTED ENERGY STANDARDS. A proposed Chula Vista ordinance would be enforceable after the Commission reviews and approves the local energy standards as meeting all requirements of Section 10-106; and the Ordinance is filed with the Building Standards Commission.

Case studies of two low-rise residential building designs were used in Climate Zones 7 and 10 to consider the cost-effectiveness of going from roofs which do not meet any cool roof requirements to the Tier 1 and Tier 2 levels specified in CALGreen for Climate Zone 10. These case studies, as directed by City Staff, have been used to consider the following questions for common building types in each climate zone:

- What is the incremental (added) construction cost per square foot of cool roofs performing at or above the Tier 1 levels?
- What is the annual energy saving in each case study? What is the annual energy cost saving for each scenario?
- What is the Simple Payback for the added energy measures?
- Which cool roofs in which climate zones appear cost-effective?

2.0 Potential Impacts of a Cool Roof Ordinance

Energy performance impacts of a proposed cool roof ordinance have been evaluated using two case studies which reflect the range of low-rise residential buildings typical in Chula Vista:

- 2,500 sq.ft., 2-story single family house
- 8,442 sq.ft., 8 unit 2-story multi-family building

Case Study Method

The methodology used in these case studies is based on the way that real buildings are designed and evaluated in just meeting or exceeding the energy standards.

(a) A base case for each building design just meets the CALGreen Tier 1 performance requirements so that it exceed the 2008 Standards by 15%, but with no cool roof specification (i.e., solar reflectance = 0.08, thermal emittance = 0.85). The air conditioning system is assumed to just meet the prescriptive requirements: 13.0 SEER, 10.0 EER, R-6 ducts in a standard ventilated attic.

Note: the current Chula Vista energy ordinance requires 15% better than Title for Climate Zone 7, and 20% better in Climate Zone 10. The difference in Climate Zone 10 (20% vs. 15%) is not significant in determining the change (i.e., delta) in energy use from the various cool roof scenarios from the baseline.

(b) For each building prototype, a series of computer simulations are performed, first with no radiant barrier:

- Low-slope, Tier 1: Solar Reflectance = 0.55, Emittance = 0.75
- Steep-slope, Lightweight, Tier 1: Solar Reflectance = 0.20, Emittance = 0.75
- Steep-slope, Heavyweight, Tier 1: Solar Reflectance = 0.15, Emittance = 0.75
- Low-slope, Tier 2: Solar Reflectance = 0.65, Emittance = 0.85
- Steep-slope, Lightweight, Tier 2: Solar Reflectance = 0.23, Emittance = 0.85
- Steep slope, Heavyweight, Tier 2: Solar Reflectance = 0.23, Emittance = 0.85

(c) A minimum and maximum range of incremental costs of added energy measures is established from the research presented at the California Energy Commission on June 10, 2011 in the 2013 Standards public workshops (see Appendix 1). Site energy KWh and Therms is calculated for each run to establish the annual energy savings, and energy cost savings as compared with the base case.

(d) Steps "a", "b" and "c" above are repeated after first including a radiant barrier in the base case and the cool roof variations. The point is to see what extent first including a radiant barrier affects the incremental energy impacts of cool roofs.

Incremental Costs

A California Energy Commission study (6/10/11) presented in support of the 2013 standards development work is included as Appendix A. This presentation includes recent data on the incremental costs of various types of cool roof. The incremental cost cool roof assumptions of this report are as follows:

- Steep Slope Lightweight, No Cool Roof to Tier 1 or 2: $0.00 - $0.10/sf, Avg = $0.05/sf
- Steep Slope Heavyweight (Ceramic Tile), No Cool Roof to Tier 1 or 2: $0.05/sf
- Flat/Low Slope (Built-Up Roof or Shingles), No Cool Roof to Tier 1 or 2: $0.00 - $1.00, Avg = $0.50

3.0 Results and Cost Effectiveness

The tables in this section are based upon the following:

- The assumption of air conditioning where there is some cooling energy savings from cool roof coatings;
- Incremental site electricity (kWh) and natural gas (therms) saved per year as calculated using the most current 2008 Standards state-approved software, Micropas v8.1;
- Average utility rates for residential buildings: $0.19/kWh for electricity and $1.14/therm for natural gas (in constant dollars);
- The assumption that there is no change (i.e., no inflation or deflation) in utility rates in constant dollars over time
- The assumption that there is no increase in summer temperatures even though most scientific studies predict that global climate change will increase temperatures in the Western U.S. which will increase air conditioning energy use
- Simple Payback includes neither the cost of financing nor any external cost associated with global climate change

Based on California Energy Commission studies, the useful life of lightweight cool roof coatings is assumed to be 15 years. A built-up-roof or asphalt shingle cool roof with a payback of around 15 years or less would be considered cost-effective. Steep slope heavyweight cool roofs such as ceramic tile may be expected to last up to 30 years.

The data summarized here is intended to be illustrative, not comprehensive or definitive, in demonstrating the scale of typical results and the variability of results depending on the selection of a particular cool roof CRRC rating and the actual longevity of the roof coating used.

Table 1: 2,500 Sq. Ft. Single Family House, Climate Zone 7, No Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Yr Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Steep-slope, Lightweight: Tier 1	14	0	$75	$3	28.2
Steep-slope, Heavyweight: Tier 1	5	1	$75	$2	35.9
Steep-slope, Lightweight: Tier 2	24	-3	$75	$1	65.8
Steep-slope, Heavyweight: Tier 2	25	-3	$75	$1	56.4

Table 2: 2,500 Sq. Ft. Single Family House, Climate Zone 7, With Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Yr Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Steep-slope, Lightweight: Tier 1	7	0	$75	$1	56.4
Steep-slope, Heavyweight: Tier 1	0	1	$75	$1	65.8
Steep-slope, Lightweight: Tier 2	7	-2	$75	-$1	-78.9
Steep-slope, Heavyweight: Tier 2	10	-2	$75	$0	-197.4

Table 3: 2,500 Sq. Ft. Single Family House, Climate Zone 10, No Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Year Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Steep-slope, Lightweight: Tier 1	61	0	$75	$12	6.5
Steep-slope, Heavyweight: Tier 1	10	2	$75	$4	17.9
Steep-slope, Lightweight: Tier 2	142	-4	$75	$22	3.3
Steep-slope, Heavyweight: Tier 2	142	-4	$75	$22	3.3

Table 4: 2,500 Sq. Ft. Single Family House, Climate Zone 10, With Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Yr Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Steep-slope, Lightweight: Tier 1	29	0	$75	$6	13.6
Steep-slope, Heavyweight: Tier 1	7	1	$75	$2	30.4
Steep-slope, Lightweight: Tier 2	66	-2	$75	$10	7.3
Steep-slope, Heavyweight: Tier 2	68	-2	$75	$11	7.0

Table 5: 8,442 Sq. Ft. Multi-family Building, Climate Zone 7, No Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Yr Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Low-Slope: Tier 1	305	-15	$2,111	$41	51.7
Low-Slope: Tier 2	362	-26	$2,111	$39	53.9

Table 6: 8,442 Sq. Ft. Multi-family Building, Climate Zone 7, With Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Yr Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Low-Slope: Tier 1	116	-8	$2,111	$13	163.4
Low-Slope: Tier 2	149	-15	$2,111	$11	188.3

Table 7: 8,442 Sq. Ft. Multi-family Building, Climate Zone 10, No Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Yr Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Low-Slope: Tier 1	1410	-24	$2,111	$241	8.8
Low-Slope: Tier 2	1864	-41	$2,111	$307	6.9

Table 8: 8,442 Sq. Ft. Multi-family Building, Climate Zone 10, With Radiant Barrier

Building Description	Total KWh/Year Saving	Total Therms/Yr Saving	Incremental First Cost ($)	Cost Savings ($/Yr)	Simple Payback (Years)
Low-Slope: Tier 1	734	-12	$2,111	$126	16.8
Low-Slope: Tier 2	982	-23	$2,111	$160	13.2

4.0 Conclusions and Recommendation

Climate Zone 7

Based on the site energy results obtained by modeling the single family home case study with the 2008 state-approve version of Micropas v8.1, steep-sloped roofs in Climate Zone 7 do not appear to be cost-effective for either Lightweight or Heavyweight roof types (with or without the presence of radiant barriers). This is consistent with the fact that Climate Zone 7 is a mild climate with very low air conditioning use. The incremental cooling energy savings from cool roof alone are projected to be very low, even though the typical incremental costs for steep slope cool roofs are also small. For low-sloped or flat roofs as modeled in the two-story multi-family building, neither Tier 1 or Tier 2 cool roof requirements are cost-effective for the same reason.

Climate Zone 10

For steep-sloped roofs in Climate Zone 10, lightweight cool roofs appear extremely cost-effective for both Tier 1 and Tier 2 values with or without a radiant barrier. Assuming a 30 year life of ceramic tile, heavyweight cool roofs are marginally cost effective for Tier 1 with a radiant barrier, but apparently easily cost-effective without radiant barrier achieving Tier 1; and more cost-effective in meeting Tier 2 values with or without a radiant barrier. This makes sense in that Climate Zone 10 has much greater cooling loads than Climate Zone 7, while the incremental cost of cool roof remains the same.

Low-sloped or flat roofs in the two-story multi-family building are cost-effective in Climate Zone 10 with or without a radiant barrier.

Recommendation

If the City wishes to proceed with a local reach code which makes selected cool roof requirements mandatory, our recommendation based on this limited study is to implement either Tier 1 or Tier 2 values in Climate Zone 10 only; and not have any cool roof requirements for buildings in Climate Zone 7. This is based on the distinctly different cost-effectiveness profiles of the same buildings when comparing them in CZ7 vs. CZ10.

Appendix A:

Cool Roof Cost Data Study
6/10/11 CEC Presentation

2013 Building Energy Efficiency Standards Staff Workshop

Dan Suyeyasu
Director of Energy Programs
Architectural Energy Corporation

for the
California Energy Commission

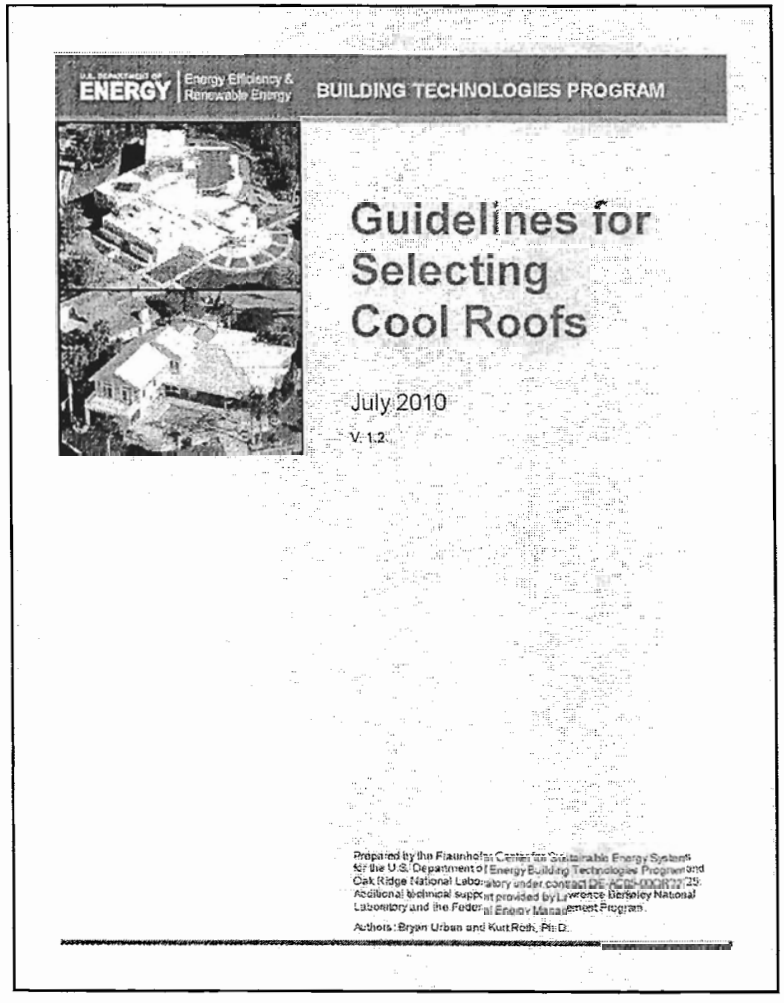
June 10, 2011

Costs – Moving from No Standard

Table 4. Cost premiums for cool varieties of common low-sloped roofing products.

Roofing Product	Cool Variety	Cost Premium ($/ft²)
ballasted BUR	use white gravel	up to 0.05
BUR with smooth asphalt coating	use cementitious or other white coatings	0.10 to 0.20
BUR with aluminum coating	use cementitious or other white coatings	0.10 to 0.20
single-ply membrane (EPDM, TPO, CSPE, PVC)	choose a white color	0.00 to 0.05
modified bitumen (SBS, APP)	use a white coating over the mineral surface	up to 0.05
metal roofing (both painted and unpainted)	use a white or cool color paint	0.00 to 0.05
roof coatings (dark color, asphalt base)	use a white or cool color coating	0.00 to 0.10
concrete tile	use a white or cool color	0.00 to 0.05
cement tile (unpainted)	use a white or cool color	0.05
red clay tile	use cool red tiles	0.10

Costs – Moving from No Standard


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy BUILDING TECHNOLOGIES PROGRAM

Guidelines for Selecting Cool Roofs

July 2010

V. 1.2

Prepared by the Fraunhofer Center for Sustainable Energy Systems for the U.S. Department of Energy Building Technologies Program and Oak Ridge National Laboratory under contract DE-AC05-00OR22725. Additional technical support provided by Lawrence Berkeley National Laboratory and the Federal Energy Management Program.

Authors: Bryan Urban and Kurt Roth, Ph.D.

- 2010 DOE Study on Cool Roof options

Costs – Moving from No Standard

Table 5: Roof Surfaces, Cool Alternatives, and Approximate Price Premiums*

Roof	Typical Non-Cool Surface	Cool Alternative	Price Premium ($/ft^2)
Built-Up Roof	Mineral aggregate embedded in flood coat	Light-colored aggregate, like marble chips, gray slag	0.00
	Asphaltic emulsion	Field applied coating on top of emulsion	0.80-1.50
	Mineral surfaced cap sheet	White mineral granules	0.50
Metal[§]	Unpainted metal	May already be cool	0.00
		Factory applied white paint	0.20
	Painted metal	Cool-colored paint	0.00-1.00+
Modified Bitumen	Mineral surfaced cap sheet	Factory applied coating, white mineral granules	0.50
	Gravel surface in bitumen	Light colored gravel	0.00
	Metallic foil	May already be cool	0.00
		Field applied coating	0.80-1.50
	Asphalt coating	Field applied coating on top of asphaltic coating	0.80-1.50
Shingles[§]	Mineral granules	White granules	0.00
		Cool-colored granules	0.35-0.75
Sprayed Polyurethane Foam	Liquid applied coating	Most coatings are already cool to protect the foam	0.00
	Aggregate	Light colored aggregate	0.00
Thermoplastic Membranes	White, colored, or dark surface	Choose a white or light colored surface	0.00
Thermoset Membranes	Dark membrane, not ballasted (adhered or mechanically attached)	Cool EPDM formulation	0.10-0.15
		Factory cool ply or coating on dark EPDM	0.50
Tiles[§]	Non-reflective colors	Clay, slate: naturally cool	0.00
		Cool colored coatings	0.00

*Premiums are the extra cost, per square foot of roof area, of installing the cool roof option as compared with the corresponding non-cool option. Premiums are based on achieving the minimum cool roof characteristics described in Table 1. Values are approximate, and are based on discussions with roofing contractors, manufacturers, wholesalers, and RSMeans cost data.
[§]These roofs may be used in steep slope applications where cool roof requirements are less stringent. Uncoated metal roofs normally meet requirements for steep slope, but not for low slope. Premiums for shingles & tiles are based on steep slope requirements. All other premiums are based on low slope requirements.

Costs – Moving from No Standard

07 54 Thermoplastic Membrane Roofing

07 54 19 – Polyvinyl-Chloride Roofing

07 54 19.10 Polyvinyl-Chloride Roofing (P.V.C.)

0010	POLYVINYL-CHLORIDE ROOFING (P.V.C.)									
8200	Heat welded seams									
8700	Reinforced, 48 mils, 0.33 P.S.F.									
8750	Loose-laid & ballasted with stone/gravel (12 P.S.F.)	G-5	51	.784	Sq.	97	25	3.69	125.69	153
8800	Mechanically attached		35	1.143		90	36.50	5.40	131.90	168
8850	Fully adhered with adhesive		26	1.538		118	49.50	7.25	174.75	220
8860	Reinforced, 60 mils, .40 P.S.F.									
8870	Loose-laid & ballasted with stone/gravel (12 P.S.F.)	G-5	51	.784	Sq.	96.50	25	3.69	125.19	152
8880	Mechanically attached		35	1.143		89.50	36.50	5.40	131.40	165
8890	Fully adhered with adhesive		26	1.538		118	49.50	7.25	174.75	219

07 54 23 – Thermoplastic Polyolefin Roofing

07 54 23.10 Thermoplastic Polyolefin Roofing (T.P.O)

0010	THERMOPLASTIC POLYOLEFIN ROOFING (T.P.O.)									
0100	45 mils, loose laid & ballasted with stone (1/2 ton/sq.)	G-5	51	.784	Sq.	90.50	25	3.69	119.19	146
0120	Fully adhered		25	1.600		80.50	51.50	7.55	139.55	182
0140	Mechanically attached		34	1.176		80	38	5.55	123.55	157
0160	Self adhered		35	1.143		88	36.50	5.40	129.90	164
0180	60 mil membrane, heat welded seams, ballasted		50	.800		107	25.50	3.77	136.27	165
0200	Fully adhered		25	1.600		96	51.50	7.55	155.05	200
0220	Mechanically attached		34	1.176		99	38	5.55	142.55	178
0240	Self adhered		35	1.143		109	36.50	5.40	150.90	187

Source: RS Means, *Building Construction Cost Data*, 2010

Costs – Moving from No Standard

07 51 13 – Built-Up Asphalt Roofing

07 51 13.20 Built-Up Roofing Systems	Crew	Daily Output	Labor-Hours	Unit	2010 Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
1100 4 plies glass fiber felt (type IV), mopped	G-1	20	2.800	Sq.	135	92.50	24	251.50	330
1150 On nailable decks		19	2.947		121	97.50	25	243.50	325
1200 Coated & saturated base sheet, 3 plies #15 asph. felt, mopped		20	2.800		104	92.50	24	220.50	294
1250 On nailable decks		19	2.947		96.50	97.50	25	219	294
1300 4 plies #15 asphalt felt, mopped		22	2.545		121	84	21.50	226.50	297
2000 Asphalt flood coat, smooth surface									
2100 Asphalt base sheet & 3 plies #15 asphalt felt, mopped	G-1	24	2.333	Sq.	100	77	19.85	196.85	260
2150 On nailable decks		23	2.435		92.50	80.50	20.50	193.50	259
2200 4 plies #15 asphalt felt, mopped		24	2.333		117	77	19.85	213.85	279
2250 On nailable decks		23	2.435		110	80.50	20.50	211	278
2900 Coated glass fiber base sheet, mopped, and 2 plies of									
2910 glass fiber felt (type IV)	G-1	25	2.240	Sq.	86.50	74	19.05	179.55	239
3100 On nailable decks		24	2.333		81	77	19.85	177.85	240
3200 3 plies, mopped		23	2.435		104	80.50	20.50	205	272
3300 On nailable decks		22	2.545		97.50	84	21.50	203	271
3800 4 plies glass fiber felt (type IV), mopped		23	2.435		123	80.50	20.50	224	292
3900 On nailable decks		22	2.545		116	84	21.50	221.50	291
4000 Coated & saturated base sheet, 3 plies #15 asph. felt, mopped		24	2.333		98.50	77	19.85	195.35	258
4200 On nailable decks		23	2.435		91.50	80.50	20.50	192.50	257
4300 4 plies #15 organic felt, mopped		22	2.545		116	84	21.50	221.50	291
4500 Coal tar pitch with gravel/slag surfacing									
4600 4 plies #15 felted felt, mopped	G-1	21	2.667	Sq.	183	88	22.50	293.50	375
4900 3 plies glass fiber felt (type IV), mopped		19	2.947		150	97.50	25	272.50	355
5000 Coated glass fiber base sheet, and 2 plies of									
5010 glass fiber felt, (type IV), mopped	G-1	19	2.947	Sq.	148	97.50	25	270.50	355
5300 On nailable decks		18	3.111		130	103	26.50	259.50	345
5600 4 plies glass fiber felt (type IV), mopped		21	2.667		206	88	22.50	316.50	402
5800 On nailable decks		20	2.800		188	92.50	24	304.50	385

Source: RS Means, *Building Construction Cost Data*, 2010

Costs – Moving from No Standard

- RS Means:
  - Built-up roofing ≈ $2.60/ft^2
  - Single-ply membrane ≈ $1.75/ft^2
  - Suggests cost savings in moving to a cool roof even without energy benefits
- Cost Premium from No Standard to $R_{aged} = 0.70$

Conservative estimate of $0.50/ft$_2$