Analysis of changes to heat load calculations resulting from changes to solar absorptance of external walls achieved by “Energy Star infra-red heat reflective coatings” on the external walls of a pre-cast panel test building.

House Energy Rating
Unit 7,938 South Road, Edwardstown-5038
ph: 1300 308 525
ABN 73 091 349 021
www.houseenergyrating.com

Summary:

This report demonstrates the effect on simulated heating and cooling loads in a test building from changes made to the solar absorptance of walls by the application of EnergyStar paints and the installation of bulk insulation. The intention is to show that the application of EnergyStar lowers the absorptivity of the external surface of a concrete panel wall and can reduce the combined heating and cooling load of a building by the same or greater amount than applying R1.5 bulk insulation to the internal wall surface. Based on Energy Star data the application of Energy Star coatings can be used instead of bulk insulation to show compliance with Building Code of Australia (BCA) 2007, Volume 1, Section J Energy Efficiency, Part 'JV3 Verification using a reference building', on a case by case basis when the simulation work is conducted by a qualified expert.

Background:

In radiant heat flow the heat flow rate depends on the difference between the emitting and receiving surfaces, as well as on the the surfaces' emittance and absorptance[1]. Standard solar absorptance values vary between 0.2 for a white surface and 0.9 for a dark surface.

'Energy Star infrared heat reflective coatings have been shown[2] to lower absorptance values for a given colour and can vary between 0.097 for a white surface and 0.67 for a dark surface such as charcoal.

BCA 2007, Energy Efficiency Section J aims to reduce greenhouse gas production by specifying minimum standards of acceptable building construction with regard to a building's energy efficiency. The BCA divides Australia into regions of similar climate or 'climate zones'. Minimum levels of bulk and reflective insulation are specified by the BCA for each construction type in each climate zone. The absorptivity of the surfaces is not specified.

The BCA 2007 Energy Efficiency Section J Part JV3 'Verification using a reference building' shows compliance for minimum acceptable construction for a building determined using a thermal calculation method where the annual energy consumption of the proposed building is less than the annual energy consumption of a reference building. The thermal calculation method must use suitable software and incorporate all BCA specifications with regard to building materials, occupancy patterns, comfortable temperature ranges, lighting, appliance use, heating and cooling plant and other particulars.

The benefit to pre-construction building simulation is the understanding gained by the developer of the probable size and breakdown of the energy use of the building. As the building is still in the design phase it is possible to make change to increase energy efficiency of the building and/or reduce the building cost.

BCA Alternative Solution:

The following sections of the Building Code of Australia 2007 are relevant to this report.

Volume 1, Section A Part A0.8
Volume 1, Section A Part A0.10
Volume 1, Section J Part JP1
Volume 1, Section J Part JV3 - Verification using a reference building

1 Thermal design of buildings – SV Szokolay, RAIA Education division, 1987.
2 See Appendix B for copies of tested values of EnergyStar products

House Energy Rating ph: 1300 308 525 ABN 73 091 349 021
Unit 7,938 South Road, Edwardstown-5038 www.houseenergyrating.com

Simulation Analysis:

The building simulation tool EnergyPlus[1] was used to model the test building. EnergyPlus was developed by the Department of Energy in the USA.

"EnergyPlus is an energy analysis and thermal load simulation program. Based on a user's description of a building from the perspective of the building's physical make-up, associated mechanical systems, etc., EnergyPlus will calculate the heating and cooling loads necessary to maintain thermal control set points, conditions throughout an secondary HVAC system and coil loads, and the energy consumption of primary plant equipment as well as many other simulation details that are necessary to verify that the simulation is performing as the actual building would. Many of the simulation characteristics have been inherited from the legacy programs of BLAST and DOE–2"[2]

EnergyPlus complies with the Australian Building Codes Board (ABCB) "Protocol for Building Energy Analysis Software Version 2006.1." This is used for specific class 3, 5, 6, 8 and 9 buildings. [3]

Test Building Analysis:

The building analysed was a theoretical simple building. Building dimensions, 30m long, 15m wide and 3.5m high. The building was located in Brisbane and the Brisbane Airport IWEC climate file was used.

The building is constructed of the following materials

Roof	Colorbond, R3.0 added insulation, absorptance 0.34, emittance 0.9
Floor	Concrete slab on ground
Walls	150mm concrete panel, conductivity 1.44 (W/m.K), density 2400 (kg/m3), specific heat 1000 (J/kg.K)
Windows	Window area 10% of wall area – Fixed glass – G James 3mm clear float glass in standard aluminium frames.

Method:

To quantify the effect of changing the absorptance and insulation values of the external wall all other variables which could affect the energy use in the building were kept constant. Astec Paints supplied figures for the emissivity and absorbptance of their products which had been tested by Underwriters Labs and Amdel.[4]

The default value of absorptance of 0.7 is used as it is specified in BCA 2007 Section J, Part JV3 (b) (B) "a solar absorptance of 0.7 to external walls and roofs". For the test building the roof absorptance is was at 0.34 and kept constant.

1 Information about EnergyPlus can be found at: - http://www.eere.energy.gov/buildings/energyplus/
2 Energyplus overview pg8 - http://www.eere.energy.gov/buildings/energyplus/about.html
3 Evidence for the complaince of EnergyPlus with the ABCB Protocol for Building Energy Analysis Software Version 2006.1. can be found in Appendix A.
4 See Appendix B for reports on the emissivity and absorptance figures of Astec paints products.

House Energy Rating ph: 1300 308 525 ABN 73 091 349 021
Unit 7,938 South Road, Edwardstown-5038 www.houseenergyrating.com

The test building using the parameters described above was entered into Energyplus and the following assessments were conducted:

1) The simulated energy use of the building, with no wall insulation, and a solar absorptance figure of 0.7.

2) The simulated energy use of the building, with R1.5 internal wall insulation, and a solar absorptance of 0.7.

3) The simulated energy use of the test building with no wall insulation, for EnergyStar paint colours Broken White 8091, Sandalwood 8086, Offwhite 8085.

4) The solar asbsorptance figure at which the simulated total energy use of the test building with uninsulated walls is lower than the simulated total energy use of the building with solar absorptance of 0.7 and internal insulation of R1.5.

5) The amount of bulk insulation required to be added to a wall of absorptance 0.7 so the building has the same simulated energy use as the building specified with uninsulated wall absorptance of 0.19 EnergyStar (Broken White 8091).

Results :

1) The simulated energy use of the building with no wall insulation and a solar absorptance figure of 0.7.

	Emissivity	Absorbtance	Total
No wall insulation	0.9000	0.7000	42880

2) The simulated energy use of the building, with R1.5 internal wall insulation, and a solar absorptance of 0.7.

	Emissivity	Absorbtance	Total
R1.5 Wall insulation	0.9000	0.7000	41897

3) The simulated energy use of the test building, with no wall insulation, for EnergyStar paint colours Broken White 8091, Sandalwood 8086, Off white 8085 were less than the simulated energy use of the building with solar absorptance 0.7 and R1.5 insulation

	Emissivity	Absorbtance	Total
Broken White 8091	0.8875	0.1870	41761
Sandal Wood 8086	0.8734	0.2330	41830
Off White 8085	0.9295	0.2530	41866

4) The solar asbsorptance figure at which the simulated total energy use of the test building with uninsulated walls is lower than the simulated total energy use of the building with solar absorptance of 0.7 and internal insulation of R1.5. The required value from (2) above is 41,897.

	Emissivity	Absorbtance	Total
limiting abs value	0.9000	0.2700	41891
limiting abs value	0.9000	0.2800	41908

The value required is between 0.27 & 0.28. For the purposes of the test building it is assumed this is sufficient accuracy.

House Energy Rating ph: 1300 308 525 ABN 73 091 349 021
Unit 7,938 South Road, Edwardstown-5038 www.houseenergyrating.com

5) The amount of bulk insulation required to be added to a wall of absorptance 0.7 so the building has the same simulated energy use as the building specified with uninsulated wall absorbtivity of 0.19 EnergyStar (Broken White 8091). Required value from (3) – Broken White 8091 above 41761.

	Emissivity	Absorbtance	Total
R2	0.9000	0.7000	41862
R2.5	0.9000	0.7000	41840
R3.0	0.9000	0.7000	41823
R3.5	0.9000	0.7000	41812
R4	0.9000	0.7000	41803

The test was stopped at R4.0 as that is the physical limit of installed insulation.

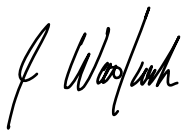
Discussion :

From the simulation runs it can be seen that for this test building with specifications as above in the Brisbane climate zone a wall surface with emissivity of 0.9 and absorptance of 0.27 will have a lower total energy use than the same building with an absorptivity of 0.7 and R1.5 bulk insulation internally installed in the building.

It was not possible to get the total energy use of the building to below the energy use of the building with absorptance of 0.19 by adding bulk insulation internally inside the building.

Building in this climate zone performing in a similar manner would be shown to comply with the BCA 2007 Vol 1. Section J Energy efficiency through verification method JV2.

This applies only to this building with its attendant location, orientation, class and specification. Changes in variables such as roof insulation, window size, location, building volume and building class will produce different results.



Jim Woolcock
House Energy Rating

House Energy Rating ph: 1300 308 525 ABN 73 091 349 021
Unit 7,938 South Road, Edwardstown-5038 www.houseenergyrating.com

Appendix A: – Evidence for EnergyPlus compliance with Australian Building Codes Board (ABCB) "Protocol for Building Energy Analysis Software Version 2006.1."

House Energy Rating ph: 1300 308 525 ABN 73 091 349 021
Unit 7,938 South Road, Edwardstown-5038 www.houseenergyrating.com

Department of Energy
Washington, DC 20585

18 April 2006

Kevin Morehouse, Manager
Australian Building Codes Board
GPO Box 9839
Canberra ACT 2601
Australia

REFERENCE: Compliance of the EnergyPlus building energy performance simulation software with the Australian Building Codes Board Protocol for Building Energy Analysis Software Version 2005.1 May 2005

Dear Mr. Morehouse:

We have reviewed the ABCB's Protocol for Building Energy Analysis Software version 2005.1 dated May 2005 and find that the U. S. Department of Energy's EnergyPlus building energy performance simulation software meets the requirements of the Protocol. Specifically, EnergyPlus:

- Has all the essential features described in Section 3 of the Protocol.
- Has all the specific capabilities listed in Section 4 of the Protocol.
- Allows all the inputs for calculating annual energy consumption required in Section 5 of the Protocol.
- Is based on heat balance methods well documented in the literature and is documented in our Engineering Reference (more than 700 pages in length with extensive citations) and all datasets provided with EnergyPlus are from established sources such as ASHRAE as described in Section 6 of the Protocol.
- Produces output reports which shows the annual energy consumption in MJ/m^2 by energy end-use and fuel source and extensive verification documentation of data inputs entered by the user. These output reports meet the energy analysis reporting required in Section 7 of the Protocol.
- Is continually tested using ASHRAE Standards 140-2001, 140-2004, and other available methods of test beyond the requirements of Section 8 of the Protocol. Reports of these tests for a new version are available on our web site within a few weeks of a new release.
- Has user training available per Section 9 of the Protocol. We have held more than 30 user workshops over the last few years including two recently in Australia. We are looking into organizing additional training on EnergyPlus in August or September in Australia.

The EnergyPlus building energy performance simulation program has been publicly available for more than 5 years with 10 major releases over that time. Development and support of EnergyPlus is provided by the U. S. Department of Energy. EnergyPlus capabilities are updated and extended continually with new versions released twice a year—in April and October. Support for EnergyPlus is provided by email, email lists, and the web site.

The EnergyPlus installation routines are available at no cost from our web site (www.energyplus.gov) and include the program, runtime utilities, all 2700 pages of documentation, input datasets (materials, constructions, schedules, greenhouse gases, energy tariffs) and a few example weather files. In addition, the documentation, testing and validation reports, weather data for more than 1100 locations worldwide, and other supporting material are also available on our web site. In addition there are already a number of

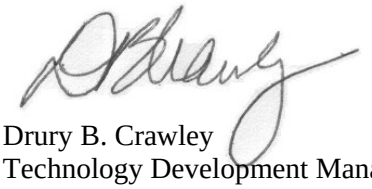
user interfaces for EnergyPlus available from private sector developers (also described on our web site). We recently jointly published a report with the University of Strathclyde, and University of Wisconsin which contrasts the features and capabilities of 20 building energy simulation programs from around the world. This report is also available from our web site: www.eere.energy.gov/buildings/tools_directory/pdfs/contrasting_the_capabilities_of_building_energy_performance_simulation_programs_v1.0.pdf

We have been working with Murray Mason at ACADS-BSG to ensure that the new Australian Climate Data set being developed will be available to users of EnergyPlus in a suitable format as soon as it is ready.

EnergyPlus has received several awards including the prestigious R&D 100 Award in October 2003. In the past 12 months, more than 9,000 copies of EnergyPlus have been downloaded by people in more than 100 countries including a number of users in Australia.

Please let me know if you have questions or need further clarification on any of this information. Please feel free to contact me at Drury.Crawley@ee.doe.gov.

Sincerely,



Drury B. Crawley
Technology Development Manager, Building Energy Tools
Office of Building Technologies
Energy Efficiency and Renewable Energy
U. S. Department of Energy

Copies: John Kennedy, Executive Director, ABCB
PC Thomas, Team Catalyst
Murray Mason, ACADS

Appendix B: Reports from Underwriters and Amdel on the emissivity and absorptance figures for Astec Paints products.

House Energy Rating
Unit 7,938 South Road, Edwardstown-5038
ph: 1300 308 525
ABN 73 091 349 021
www.houseenergyrating.com

28 November, 2005

Astec Paints Pty Ltd
24 Pinn St
ST MARYS SA 5042

Attention: Mr Mark Waters

REPORT 05MAAD12331 – Part 3

CLIENT REFERENCE:	Request
TITLE:	Astec BASIX test
SAMPLE IDENTIFICATION:	Astec Energy Star EC-100 TSM
WORK REQUESTED:	Determine colour classification according to Basix Thermal Comfort Protocol.
INVESTIGATING OFFICER(S):	Natalie Powell

Monty Luke
Laboratory Manager
Materials Services

Amdel Limited • 35-37 Stirling Street Thebarton SA 5031 • PO Box 338 Torrensville Plaza SA 5031
ABN 30 008 127 802 • Telephone: +61 8 8416 5200 • Facsimile: +61 8 8234 2760

1. INTRODUCTION

Mark Waters of Astec Paints Pty Ltd supplied reflectance and emittance data of Astec Energy Star EC-100 TSM samples of various colours to the Amdel Materials Services Laboratory. It was requested that Amdel should carry out calculations to determine the colour classification according to the BASIX Thermal Comfort Protocol. The samples supplied for evaluation were identified as follows.

- Astec Energy Star EC-100 TSM
- Astec Energy Star colours

2. PROCEDURE

The sample data supplied was inserted into the American Cool Roof Rating Council ASTM E 1980-01 calculator. Standard solar conditions of Solar Flux = 1000W/m^2 Ambient Air Temp = 310K (37ºC), Ambient Sky Temp = 300K (27ºC) and no conductive heat transfer were used for all calculations. Each sample used the Emittance value for Astec Energy Star EC-100 TSM white base of 0.88.

3. RESULTS

- Colour Classifications

The results of the calculations of the Astec Energy Star EC-100 TSM sample were as follows.

Colour	Solar Absorbance	BASIX
White Base	0.167	LIGHT
8068 C/B Heritage Red	0.625	MEDIUM
8069 Red Iron Oxide	0.61	MEDIUM
8070 Terracotta	0.576	MEDIUM
8071 Clay Tone	0.533	MEDIUM
8072 Warm Clay	0.405	LIGHT
8073 Tuscany	0.34	LIGHT
8074 C/B Ironbark	0.594	MEDIUM
8075 Pioneer	0.712	DARK
8076 Regal Brown	0.614	MEDIUM
8077Yallara Brown	0.63	MEDIUM
8078 C/B Weathered Copper	0.609	MEDIUM
8079 Charcoal	0.672	MEDIUM
8080 C/B Slate Grey	0.597	MEDIUM
8082 Nimbus	0.645	MEDIUM
8083 C/B Beige	0.457	LIGHT
8084 Merino	0.317	LIGHT
8085 Off White	0.253	LIGHT

Colour	Solar Absorbance	BASIX
8086 Sandalwood	0.233	LIGHT
8087 C/B Smooth Cream	0.215	LIGHT
8088 Mocca	0.424	LIGHT
8089 Stone	0.311	LIGHT
8098 Carraige Green	0.754	DARK
8099 Bruns Green	0.741	DARK
8100 Mist Green	0.56	MEDIUM
8101 C/B Rivergum	0.555	MEDIUM
8102 Olive Green	0.606	MEDIUM
8103 Blue Grass	0.64	MEDIUM
8104 Botanic	0.721	DARK
8105 French Green	0.461	LIGHT
8108 C/B Mountain Blue	0.745	DARK
8081 C/B Birch Grey	0.378	LIGHT
8094 Quarry	0.402	LIGHT
8095 Mid Biscuit	0.305	LIGHT
8097 Light Latte	0.291	LIGHT
8106 C/B Saltbush	0.442	LIGHT
8107 Cobalt	0.662	MEDIUM
8110 Pewter	0.393	LIGHT
8111 Autumn	0.391	LIGHT
8112 Chino	0.394	LIGHT
8091 Broken White	0.187	LIGHT
8092 Neutral White	0.215	LIGHT
8093 Pale Buscuit	0.246	LIGHT
8096 Light Cream	0.213	LIGHT
8109 Gull Grey	0.317	LIGHT

Underwriters Laboratories Inc.®

Northbrook Division
333 Pfingsten Road
Northbrook, IL 60062-2096 USA
www.ul.com
tel: 1 847 272 8800

File SV16101
Project 05CA51080

December 1, 2005

REPORT

on

COMMERCIAL INSPECTION AND TESTING INVESTIGATION OF
Roof Panel Coatings for Thermal Emittance and Solar Reflectance

Astec Paints Australia LTD
Australia

GENERAL

INVESTIGATION:

The products covered under this investigation are roof panel coatings identified by the manufacturer as described in Table 1 of Test Record No. 1. The test specimens were supplied by Astec Paints, Ltd., 24 Pinn St., St. Marys, Australia and were tested prior to aging or weathering.

The purpose of this investigation was to develop thermal emittance and solar reflectance test data, without conclusions, on the subject products in accordance with ASTM C 1371-04, "Determination of Emittance of Materials Near Room Temperature" and ASTM C 1549-02, "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer."

The test results apply only to the specific samples tested and are not intended to imply Listing, Classification or Recognition.

DESCRIPTION

PRODUCT TESTED:

The roof panel coatings used in the tests were submitted in a ready to use form and are identified in Table 1 of Test Record No. 1. Underwriters Laboratories did not witness the fabrication of the test specimens nor verified the product components.

TEST RECORD NO. 1

SAMPLE

Each sample consisted of a cured homogeneous liquid coating applied to a nominal 152 mm wide by 203 mm long light gauge metal substrate. The nominal thickness of each sample was 0.75 mm.

METHOD

Solar reflectance measurements were made with a portable reflectometer in accordance with ASTM C1549-02, "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer." Solar reflectance is identified as the fraction of solar flux reflected by a surface expressed within the range of 0.00 and 1.00.

Initial Thermal Emittance was determined in accordance with ASTM C1371-04 "Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using a Portable Emissometer." Thermal emittance is identified as the fraction of surface emittance expressed within the range of 0.00 to 1.00.

RESULTS

The tests were conducted on November 22, 2005 at UL's Northbrook, IL test facility. For all tests the ambient laboratory room temperature was 22 °C and 45% RH. The calibrated source and assigned emittance value for the thermal emittance readings were Standard #1267, 0.87 and Standard #1221, 0.05.

Table 1 - Results

Sample Description	Initial Emissivity	Initial Reflectance
Energy Star Cool Pave White	0.8664	0.896
Energy Star Sportscoat	0.9225	0.910
Energy Star Accent Astec C/B Iron Bark 8074	0.9225	0.402
Energy Star Accent Astec Mid Bruns Green 8099	0.8664	0.280
Energy Star Accent Astec Regal Brown 8076	0.9120	0.390
Energy Star Accent Charcoal 8079	0.8840	0.320
Energy Star Accent Astec C/B Mountain Blue 8180	0.9155	0.259
Energy Star Accent Astec 8180 R/B Rivergum	0.8279	0.428
Energy Star Accent Astec C/B Mist Green 8100	0.8699	0.419
Red Oxide 8069	0.8524	0.392
C/B Heritage Red 8068	0.8244	0.393
Mid Astec Warm Clay 8072	0.8314	0.594
White Astec C/B Smooth Cream 8087	0.8804	0.784

White Astec Sandalwood 8086	0.8734	0.775
White Astec Off White 8085	0.9295	0.752
Mid Astec C/B Beige 8083	0.8454	0.540

Table 1 (cont.)

Sample Description	Initial Emissivity	Initial Reflectance
Accent Astec C/B Slate Grey 8080	0.8524	0.405
White Astec Gull Grey 8109	0.8910	0.688
White Astec Light Cream 8096	0.8629	0.783
White Astec Neutral White	0.8279	0.779
White Astec Broken White 8091	0.8875	0.810
Accent Astec C/B Birch Grey 8081	0.8559	0.628
DG IR Elastic White	0.9120	0.898
Metal-Flex GLS/LS White	0.8910	0.892
Tile Guard SM White	0.8804	0.888
GLS/LS White	0.8840	0.884
Armatex White	0.9400	0.774
Astec E100 T SM White	0.9085	0.830
Ceram-4000 White	0.9015	0.838
DG IR Gloss White	0.8875	0.887
EC100 Dirtguard White	0.9085	0.896
Tileguard White	0.9085	0.888

The tests conformed with all requirements of ASTM C 1371-04 with the exception that one reading was taken for thermal emittances due to the smooth homogeneous nature of the tests specimens.

The tests conformed with all requirements of ASTM C 1549-02

Report by:

KARL AITTANIEMI
Senior Project Engineer
Fire Protection Division

Reviewed by:

KENNETH RHODES
Senior Staff Engineer
Fire Protection Division