APPROVAL REPORT

DERBIGUM SP FACTORY MUTUAL, DERBICOLOR FACTORY MUTUAL AND DERBICOAT HP ROOF COVERS FOR USE IN CLASS 1 INSULATED STEEL DECK ROOF CONSTRUCTION

Prepared For:

PERFORMANCE ROOF SYSTEMS, SA
IMPERBEL GROUP
PARC INDUSTRIAL
B-1360 PERWEZ
BELGIUM

3005257
Class 4470
Date: June 12, 2000

FACTORY MUTUAL | Factory Mutual System

Factory Mutual Research
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I INTRODUCTION

1.1 Performance Roof Systems, SA submitted their Derbigum SP Factory Mutual, Derbicolor Factory Mutual and Derbicoat HP modified bitumen roof covers to determine if they meet the requirements of Factory Mutual Research Approval Standard 4470 - Class 1 Roof Covers (1986) when used as a component in Class 1 insulated steel deck roof construction.

1.2 The examination included fire testing above and below the roof deck, simulated wind uplift testing, susceptibility to leakage testing and simulated hail damage testing. Resistance to foot traffic testing was waived due to previous successful testing of the similar Derbigum GP and Derbicolor roof covers manufactured by Performance Roof Systems, Inc. That data was released to this project by the project sponsor.

1.3 Tests show that Performance Roof Systems, SA Derbigum SP Factory Mutual, Derbicolor Factory Mutual and Derbicoat HP modified bitumen roof covers meet the requirements of Factory Mutual Research Approval Standard 4470 - Class 1 Roof Covers (1986) when installed as described in the CONCLUSIONS of this report.

II MATERIAL DESCRIPTIONS

2.1 Derbigum SP Factory Mutual is a 0.16 in. (4 mm) thick fire retardant polymer modified bitumen roof cover. It is reinforced with a fiberglass mat and a nonwoven polyester scrim. It is supplied in rolls 43.3 in. (1.1 m) wide by 32.8 ft (10.0 m) or 23.8 ft (7.27 m) long weighing approximately 103.4 lb (47 kg) or 94.6 lb (43 kg) .

2.2 Derbicolor Factory Mutual is a 0.16 in. (4 mm) thick fire retardant polymer modified bitumen roof cover with a mineral granule surfacing. It is reinforced with a fiberglass/polyester composite mat. It is supplied in rolls 43.3 in. (1.1 m) wide by 23.8 ft (7.27 m) long weighing approximately 90 lb (41 kg).

2.3 Derbicoat HP is a 0.10 in. (2.5 mm) thick polymer modified bitumen base sheet. It is reinforced with a fiberglass/polyester composite mat. It is supplied in rolls 43.3 in. (1.1 m) wide by 41.7 ft (12.73 m) long weighing approximately 90 lb (41 kg).

2.4 Imperbel Stik On 7A+ is a modified asphalt based cold applied adhesive. It is available in 11 lb (5 kg) and 55 lb (25 kg) containers.

2.5 Other roofing products manufactured by other manufacturers were also included in this program.

2.6 The proprietary formulations and specifications of the materials described above are on file at Factory Mutual Research.

III TESTS AND PROCEDURES

3.1 Tests were conducted as required by Factory Mutual Research Approval Standard 4470 - Class 1 Roof Covers (1986).

3.2 Factory Mutual Research Calorimeter Fire Test

The fire test from below the roof deck was conducted using the Factory Mutual Research Construction Materials Calorimeter which measures the maximum rate of fuel contribution by the sample roof, also expressed as maximum heat release rate (HRR); e.g, for a Class 1 rating, the assembly must exhibit a HRR no greater than 410 Btu/ft^2/min (77.6 kW/m^2) in any 3 minute time frame during the 30 minute fire exposure.

3.3 Factory Mutual Research Windstorm Classification Tests

3.3.1 The tests were conducted using the Factory Mutual Research simulated wind uplift test apparatus to evaluate the ability of the above deck components to resist various simulated wind forces without failure of the assembly.

3.3.2 The uplift pressure test utilizes a 9 ft (2.7 m) long by 5 ft (2.5 m) wide x 2 in. (51 mm) deep steel pressure vessel arranged to apply air pressure at pre-established standard rates to the underside of the test panel which forms the top of the pressure vessel. The vessel is pressurized with compressed air.

3.3.3 A net force of 30 psf (1.4 kPa) was applied to each test sample and maintained for one minute. The force was increased to 45 psf (2.2 kPa), then to 60 psf (2.9 kPa) and held for one minute at each increment. The pressure was increased in increments of 15 psf (0.7 kPa) every minute until failure occurred.

3.4 ASTM E108-96 Spread of Flame Tests

3.4.1 The fire tests from above the roof cover were conducted in accordance with ASTM E108-96 Spread of Flame Tests.

3.4.2 Sample size was 3-1/3 by 8ft. (1.0 by 2.4 m). The wind velocity over the top of the standard panel was adjusted to 12±0.5 mph (5.3±0.2 m/s).

3.4.3 Flame exposure: The flame was adjusted to 1400±50°F (760±28°C) for Class A tests. The flame temperature was measured by a thermocouple located 1 in. (25.4 mm) above the surface of the standard panel and ½ in. (13 mm) toward the flame source from the lower edge of the standard panel. The flame was applied to each test panel for 10 minutes.

3.4.4 During and after the application of the flame, each panel was observed for the distance of maximum flame spread, glowing brands and other damage.

3.5 Factory Mutual Research Simulated Hail Damage Tests

3.5.1 Tests were conducted using the Factory Mutual Research Simulated Hail Damage Test Apparatus to evaluate the ability of the roof covers to withstand a hailstorm without damage to the membrane. After each drop the sample is inspected and there must be no evidence of splitting, delamination or rupture of the roof cover.

3.5.2 A 1-3/4 in. (49 mm) diameter steel ball weighing 0.78 lbs. (0.3 kg) was dropped on the test sample from a 17 ft 9-1/2 in. (5.4 m) height through a 33-3/4 in. (0.86 m) length of PVC pipe with a 2 in. (51 mm) inside diameter. This procedure was repeated several times on various sections of each sample. After each drop the sample was inspected for damage to the weatherproof membrane. Following initial testing, each sample was conditioned (weathered) for 1000 hours in the Factory Mutual Research Ultraviolet Weatherometer. The initial procedure was then repeated on the conditioned sample.

3.6 Factory Mutual Research Susceptibility to Leakage Test

3.6.1 A test was conducted in accordance with the Factory Mutual Research Susceptibility to Leakage Test Procedure to evaluate the ability of the roof cover to resist leakage of water under the conditions of the test. There must be no signs of water leakage during the 7 day period or during or after the pressure cycles following the exposure.

3.6.2 The test apparatus consists of top and bottom sections which are bolted together with the specimen being evaluated placed as a diaphragm between the sections. The top and bottom sections consist of 9-1/4 in. (235 mm) diameter cap cemented to 7-3/4 in. (197 mm) clear acrylic pipe. An 11-5/8 in. (295 mm) diameter pipe flange is cemented to the other end of each pipe section. Both top and bottom sections are bolted together at the flanges with the cover being evaluated placed between them. The apparatus is fabricated to allow both a standing head of water above and additional air pressure below the test sample. Each section is fabricated with two ½ in. (13 mm) diameter pipe outlets to allow connection of an air pressure source and a pressure gauge.

3.6.3 After conditioning (weathering) for 1000 hours in the Factory Mutual Research Ultraviolet Weatherometer a 10 in. (254 mm) diameter specimen was cut from the sample and bolted in place between the flanges of the test apparatus. Water was placed over the sample to a depth of 6 in. (152 mm) and maintained for a period of 7 days. At the end of the 7 day period, air was introduced below the sample at a pressure of 1 psi (6.3 kPa) and cycled 25 times from 1 psi (6.3 kPa) to ambient.

4.0 TEST SAMPLES

4.1 Factory Mutual Research Calorimeter Test Panel

One 4-1/2 by 5 ft. (1.4 by 1.5 m) panel was constructed. The components and sequence of installation were as follows:

Sample No. 1:
- Factory Mutual Research Approved 18 gauge steel deck
- Mechanically fastened 1.6 in. (40 mm) thick Thermaroof TR27 FM roof insulation
- Derbicoat HP mechanically fastened
- Derbigum SP Factory Mutual adhered with Stik On 7A+ applied at 1.5 gal/sq (0.6 L/m^2)

4.2 Factory Mutual Research Windstorm Classification Test Panels

Four 5 ft x 9 ft (1.5 m x 2.7 m) simulated wind uplift pressure test panels were constructed as follows:

Sample No. 1: - Factory Mutual Research Approved 22 ga (0.75 mm) steel roof deck
- 1.6 in. (40 mm) thick Thermaroof TR27 FM roof insulation, preliminary securement
- Derbigum SP Factory Mutual mechanically fastened with Dekfast Hex metal plates and #12 screws spaced 12 in. (305 mm) oc along the membrane 6 in. (152 mm) wide side laps. The laps were torch sealed.

Sample No. 2: - Factory Mutual Research Approved 22 ga (0.75 mm) steel roof deck
- 1.6 in. (40 mm) thick Thermaroof TR27 FM roof insulation, preliminary securement
- Derbicoat HP mechanically fastened with Dekfast Hex metal plates and #12 screws spaced 12 in. (305 mm) oc through the base sheet 3 in. (76 mm) wide side laps and in one row 24 in (610 mm) oc along the centerline of the sheet.
- Derbigum SP Factory Mutual torch applied

Sample No. 3: - Factory Mutual Research Approved 22 ga (0.75 mm) steel roof deck
- 1.6 in. (40 mm) thick Thermaroof TR27 FM roof insulation, preliminary securement
- Derbicoat HP mechanically fastened with Dekfast Hex metal plates and #12 screws spaced 12 in. (305 mm) oc along the base sheet 3 in. (76 mm) wide side laps and in one row 24 in (610 mm) oc along the centerline of the sheet.
- Derbigum SP Factory Mutual adhered with Stik On 7A+ applied at 1.5 gal/sq (0.6 L/m^2)
- The 4 in. (102 mm) side lap was torch sealed

Sample No. 4: - Factory Mutual Research Approved 22 ga (0.75 mm) steel roof deck
- 1.6 in. (40 mm) thick Thermaroof TR27 FM roof insulation fastened with Dekfast Hex metal plates and #12 screws at 5 per 1.96 x 3.93 ft (0.6 x 1.2 m) board
- Derbigum SP Factory Mutual adhered with Stik On 7A+ applied at 1.5 gal/sq (0.6 L/m^2)
- The 4 in. (102 mm) side lap was torch sealed

4.3 ASTM E108-96 Spread of Flame Test Panels

Four 3-1/3 by 8 ft. (1.0 by 2.4 m) panels were constructed. The components and sequence of installation were as follows:

Sample Nos. 1-2: - ½ in. (13 mm) plywood
- 1.6 in. (40 mm) thick Thermaroof TR27 FM roof insulation, mech. fastened
- Derbigum SP Factory Mutual mechanically fastened

Sample Nos. 3-4: - ½ in. (13 mm) plywood
- 1.6 in. (40 mm) thick Thermaroof TR27 FM roof insulation, mech. fastened
- Derbicoat HP mechanically fastened
- Derbigum SP Factory Mutual adhered with Stik On 7A+ applied at 1.5 gal/sq (0.6 L/m^2)

4.4 Factory Mutual Research Simulated Hail Damage Test Panel

One 2 by 4 ft. (0.6 by 1.2 m) panel was constructed with Derbigum SP Factory Mutual applied loose over Thermaroof TR27 FM.

4.5 Factory Mutual Research Susceptibility to Leakage Test Panel

One 18 in. (460 mm) diameter panel of Derbigum SP Factory Mutual roof cover with a center seam was prepared.

V RESULTS

5.1 Factory Mutual Research Calorimeter Fire Test

The calorimeter test showed the test panel to have fuel contribution rates below the maximum permissible rates for Class 1 construction. These rates and the Class 1 limits are noted below:

Maximum Average Rate of Fuel Contribution
for Various Time Intervals
Btu/ft^2/min (kW/m^2)

Time Interval	3 min	5 min	10 min	Average
Class 1 Standard	410 (77.6)	390 (73.8)	360 (68.1)	285 (53.9)
Sample No. 1	389 (73.6)	366 (69.2)	345 (65.3)	281 (53.2)

5.2 Factory Mutual Research Windstorm Classification Tests

All the test panels described in 4.2 above exceeded the 60 psf (2.9 kPa) minimum Factory Mutual Research requirements for Class 1-60 windstorm classification. Sample Nos. 1, 2 and 4 also exceeded the 90 psf (4.3 kPa) minimum Factory Mutual Research requirement for Class 1-90 windstorm classification.

5.3 ASTM E108-96 Spread of Flame Tests

5.3.1 The results of the ASTM E108 Spread of Flame tests were as follows:

Sample No.	Slope	Max. Flame Spread	Rating
1	0.5/12 (4.2%)	4.00 ft (1.22 m)	Class A
2	0.5/12 (4.2%)	4.08 ft (1.24 m)	Class A
3	0.5/12 (4.2%)	3.00 ft (0.92 m)	Class A
4	0.5/12 (4.2%)	3.00 ft (0.92 m)	Class A

5.3.2 Deck exposure, flying brands and significant lateral flame spread were not observed during the tests.

5.4 Factory Mutual Research Simulated Hail Damage Tests

No damage to the roof cover on the test panel was observed after each drop of the simulated hail impactor before or after conditioning (weathering).

5.5 Factory Mutual Research Susceptibility to Leakage Test

No signs of water leakage through the test panel were observed during the 7 day exposure to a head of water or during or after the pressure cycles following the exposure.

VI CONCLUSIONS

6.1 The test results from this and previous Approval programs released to this program indicate that Performance Roof Systems, SA Derbigum SP Factory Mutual, Derbicolor Factory Mutual and Derbicoat HP modified bitumen roof covers meet Factory Mutual Research Approval Standard 4470 - Class 1 Roof Covers (1986) requirements when installed as described below.

6.1.1 Steel (new) Minimum 2 in. (51 mm) thick Thermaroof TR28 FM or minimum 1.6 in. (40 mm) thick Recticel Powerdeck 20 polyisocyanurate insulation or Roofslab 345, 341 or 360 or Rockacier 381, 340, SA360 or Hardrock 391 insulation is secured to the deck per Factory Mutual

Research preliminary fastening requirements. One ply of Derbigum SP Factory Mutual is fastened with Dekfast fasteners and hex metal plates spaced 12 in. (305 mm) oc along the 6 in. (152 mm) wide side laps. The laps are then torch sealed. Meets Class 1-90 Windstorm Classification.

6.1.2 Steel (new) Insulation is installed per 6.1.1. One ply of Derbicoat HP is fastened with Dekfast fasteners and hex metal plates spaced 12 in. (305 mm) oc through the 3 in. (76 mm) wide side laps and in one row along the base sheet centerline spaced 24 in. (610 mm) oc. One ply of Derbigum SP Factory Mutual or Derbicolor Factory Mutual is then torch applied. Meets Class 1-90 Windstorm Classification.

6.1.3 Steel (new) Insulation and Derbicoat HP are installed per 6.1.1. One ply of Derbigum SP Factory Mutual or Derbicolor Factory Mutual is then adhered with Stik On 7A+ applied at 1.5 gal/sq (0.6 L/m^2). The 4 in. (102 mm) side laps are torch sealed. Meets Class 1-60 Windstorm Classification.

6.1.4 Steel (new) Minimum 2 in. (51 mm) thick Thermaroof TR28 FM insulation is secured to the deck with Dekfast fasteners and hex metal plates at 20 per 3.9 x 7.9 ft (1.2 x 2.4 m) board (maximum tributary area of 1.54 ft^2, 0.14 m^2 per fastener). One ply of Derbigum SP Factory Mutual or Derbicolor Factory Mutual is then adhered with Stik On 7A+ applied at 1.5 gal/sq (0.6 L/m^2). The 4 in. (102 mm) side laps are torch sealed. Meets Class 1-90 Windstorm Classification.

6.2 The above constructions meet the Factory Mutual Research Severe hail rating and ASTM E108 Class A noncombustible deck rating at a maximum slope of 0.5 per 12.

6.3 Test results show that the above roof constructions in and of themselves would not create a need for automatic sprinkler protection.

6.4 Roof system securement must be enhanced at the roof corners and perimeter as outlined in FM Global Loss Prevention Data Sheets 1-28 and 1-29.

6.5 The roof covers must be installed using an Factory Mutual Research Approved roof perimeter flashing system.

6.7 The tested constructions meet the Factory Mutual Research Approval criteria and when Approval is effective will be listed in the Factory Mutual Research Approval Guide. Approval is effective when the Approval Agreement is signed and received by Factory Mutual Research. Continued Approval will depend upon satisfactory field experience and periodic Quality Audit Inspections.

VII MARKING

7.1 The manufacturer shall mark each roll or packing container with the manufacturer's name and product trade name. In addition, the roll or container must be marked with the Factory Mutual Research Approval Mark and the words "Subject to the conditions of Approval as a (roof cover or adhesive, as applicable) when installed as described in the current edition of the Factory Mutual Research Approval Guide".

7.2 Markings denoting Factory Mutual Research Approval shall by applied by the manufacturer only within and on the premises of manufacturing locations that are under the Factory Mutual Research Facilities and Procedures Audit Program.

7.3 The manufacturer agrees that use of the Factory Mutual Research name or Approval Mark is subject to the conditions and limitations of the Factory Mutual Research Approval. Such conditions and limitations must be included in all references to Factory Mutual Research Approval.

VIII MANUFACTURER'S RESPONSIBILITIES

8.1 To assure compliance with his procedures in the field, the manufacturer shall supply to

the roofer such necessary instruction or assistance required to produce the desired performance achieved in the tests.

8.2 The manufacturer shall notify the Factory Mutual Research of any planned change in the Approved product, prior to general sale or distribution, using Form 797, Approved Product Revision Report.

IX QUALITY AUDIT INSPECTION AND RE-EXAMINATION

9.1 Re-examination and manufacturing inspections will be conducted periodically on the Approved products at Performance Roof Systems - Imperbel Group manufacturing locations in Perwez and Beersel-Lot, Belgium to determine that the quality and uniformity of the materials have been maintained and will provide the same level of performance as originally Approved.

TESTS AND REPORT BY:

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