Rubb Technical Report #9301

FIRE PERFORMANCE OF RUBB BUILDINGS

INTRODUCTION

Architectural fabric structures are in wide use throughout the United States and Europe. These structures range in application from relatively simple exhibition tents and site shelters to complex aircraft hangars and large industrial buildings. While there are many positive features to these structures, one of their chief benefits is their ability to be quickly delivered and erected for short to intermediate time frames. Once the structure is no longer needed, it can be readily disassembled and shipped elsewhere for other uses. This feature gives the customer and local planning officials much more long term flexibility than building a fixed base structure.

While many people refer to these structures as "tents", products such as Rubb's building range are, in actuality, fully engineered structures. These buildings have a framework that is designed in full compliance with building code requirements with respect to wind, snow and seismic loads. The major features that separate a Rubb structure from more conventional buildings are the design of it's connections, the quality of it's hot dip galvanized steel framework and the fact that it is fully clad with a flexible membrane. The PVC coated polyester membrane has a life expectancy of twenty years in most environments, can be easily removed when required and is fully reusable. The zinc coating of Rubb's steel frame and all fasteners ensure that connections do not rust together and therefore make the buildings very easy to dismantle and recover even after years of use in one location.

Rubb has been a leader in architectural fabric structures both in the U.S. and internationally for many years. With manufacturing plants in the United States, Great Britain and Norway, we have provided thousands of structures worldwide. One of the main concerns that arises when these buildings are under consideration is their performance in fire situations. The purpose of this technical document is to describe the fire performance characteristics of the PVC coated polyester fabric used in Rubb structures. This discussion will review our compliance with existing regulations, actual case histories and discuss some of the positive aspects that our membranes offer versus other cladding materials.

PAST PROJECTS

The track record for approval of our product by local fire officials has been very positive. This is evidenced by the fact that Rubb buildings have undergone extensive review by numerous code authorities, industrial risk insurers and well known government and corporate organizations. Rubb buildings have been approved for use as aircraft hangars and fuel tank storage enclosures for commercial airlines and U.S. and NATO military forces. Recently Rubb supplied a large commercial aircraft hangar for use at Boston's Logan International Airport. After a thorough review of the fire characteristics of the building; Massachusetts Port Authority Fire Officials, United Airlines Fire Protection Specialists and United's risk insurer's did not even require the structure to be equipped with an overhead sprinkler system. Instead, they chose an underwing AFFF foam system that optimized the chances of saving the aircraft in a fuel fire situation.

Rubb has provided structures at a large number of Department of Energy sites around the country. We are supplier of warehousing to port facilities and industrial users around the world. In fact, Rubb buildings have been approved for use in cities such as New York and Los Angeles which are noted for their tough fire regulations. Rubb buildings are also in use in a wide variety of applications ranging from large painting facilities at shipyards to construction site enclosures to an interim library facility at a major university. In these instances, the fire performance of the membrane has been viewed to be, at the least, acceptable and in many cases a benefit.

FIRE PERFORMANCE CHARACTERISTICS

The material that Rubb uses in it's structures consists of a woven polyester base cloth that is coated with a PVC compound on both sides. The PVC is formulated with flame resisting compounds that remain with the material for the life of the fabric. These membranes meet the self extinguishing requirements of UBC and

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BOCA codes and therefore are treated as approved membranes.

In a fire situation, the membranes will not propagate or spread flame or contribute fuel to the fire. Instead, the material simply melts away from the flame or heat source. When out of reach of the flame or heat, the material immediately self extinguishes. This means that the membrane is basically a "self venting" system. This self venting feature allows heat and smoke to escape from the structure and allows fire department personnel immediate safe access to the flame source. Likewise, potential damage to the building's contents and the structure itself is minimized.

Other concerns regarding our structures involve the use of sprinklers. One concern is that due to the self venting membrane, interior temperatures will not be able to reach high enough levels necessary to activate structure sprinkler systems. However since the membrane melts at approximately 350° F, this is not an issue. Another concern is whether the structure can safely support the weight of sprinkler piping and associated surge loads. The truth of the matter is that these loads are usually minimal compared to the environmental forces that the building is designed for. Additionally, the Rubb structural frame is very rigid and deflects minimally under loads so that standard sprinkler components and connection methods can be used. Rubb can supply reference lists of various customers who have installed sprinkler systems to meet insurance and or code mandated requirements. However, the majority of Rubb buildings are not sprinklered.

BUILDING CODE CLASSIFICATION

Most Rubb projects in the United States fall under the jurisdiction of either BOCA, Southern or UBC codes. These codes are similar in their treatment of membrane structures. Section 604.2.2 of the 1990 BOCA code, states that membranes shall be either noncombustible or flame resistant conforming to NFPA 701. The 1991 UBC code section 5502 (b) states that membranes shall be either noncombustible or flame retardant conforming to UBC standard 55-1.

BOCA code classifies a noncombustible frame supported structure covered by an approved membrane as type 2C construction. This would apply to Rubb buildings since the frame of a Rubb building is noncombustible and since the membrane meets the NFPA 701 criteria. The UBC code is slightly confusing on the issue of classification since their methodology differs from BOCA. By UBC standards as written, Rubb buildings would be classified as type V-N construction. Rubb is currently seeking clarification from ICBO on the section 55 standards as we believe they should be properly classified as type II structures.

COMBUSTIBILITY

A major issue related to treatment of membrane structures by code is the definition of combustibility. UBC states in section 415 that noncombustible materials are those of which no part will ignite and burn when subjected to fire. This is typically determined by UBC Standard 4-1 test which is equivalent to ASTM E136-79. UBC also references standard 42-1 for flame spread rating, this is the same test as ASTM E-84. BOCA is very similar in that both the ASTM E136 and E84 tests are mentioned. By these standards, the membrane materials used by Rubb would technically be defined as combustible. However a review of the ASTM E136 reveals that it is simply not intended to apply to Rubb type membrane materials. Paragraph 1.1 of the ASTM E136 test specifically states:
"This test method covers the determination under specified laboratory conditions of combustion characteristics of building materials. ***It is not intended to apply to laminated or coated materials."***

The standard goes on to further state the Significance and Use of the test:

"3.1 While actual building fire exposure conditions are not duplicated, this test method will assist in indicating those materials which do not act to aid combustion or add appreciable heat to an ambient fire."

"3.2 Materials passing the test are permitted limited flaming and other indications of combustion."

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And in the final commentary on the test it is stated:

"X1.6 Test Limitations - At present there are a number of limitations in the test method and its application that should be recognized."

"X1.6.4 The test method is not suitable or generally satisfactory for materials that soften flow, melt or otherwise flow from the measuring thermocouple."

Thus a full examination of the complete ASTM E-136 79 test method and accompanying commentary reveals that ASTM E-136 79 (UBC 4-1) is simply not appropriate or intended to be applied to the coated fabrics used in Rubb structures.

In discussing alternative definitions of combustibility, we have based our conclusions on the performance of our coated materials in other related tests. These tests are primarily the ASTM E84 flame spread tests and NFPA 701 large and small scale tests. The ASTM E84 test being equal to UBC 42-1 and the NFPA 701 test being similar to UL 214, UBC 55-1, California State Fire Marshall Tests and Federal Standard 191 Method 5903. Many authorities view these tests as being the most appropriate to assess the actual performance of PVC coated materials in real fire situations.

ASTM E84-81 and ASTM E84-84 test results for Rubb materials show flame spread ratings in the range of 10 to 20, fuel contributed values of zero and smoke developed values of approximately 400. These methods give the material a class I rating by UBC and BOCA standards. Class I being the best possible rating.

The NFPA 701 and similar tests measure the time that it takes a material to self extinguish after a flame source is removed, the char length created by the flame and whether flaming drips fall from the test specimen and continue to flame after they reach the floor of the tester. The NFPA 701 test is considered to be the most applicable test for membrane structures. Conclusive test results of Rubb materials tested to NFPA 701 large and small scale tests reveal that our material meets all applicable standards.

To conclude, Rubb PVC polyester membrane materials:

1. Have a class I flame spread rating.
2. Do not support combustion, propagate flame or contribute fuel to a fire.
3. Immediately self extinguish when a flame source is removed.

As stated above, the significance of the ASTM A136 combustibility test is to determine those materials that do not act to aid combustion of an appreciable heat to an ambient fire. By all these measures, Rubb materials clearly are noncombustible.

OTHER RELATED TESTS

A test which is commonly used to classify the fire retardancy of roof coverings is ASTM E 108 (UBC 32-7). One portion of this test is commonly referred to as a burning brand test. This test is intended to duplicate the conditions present when a burning ember from an adjacent structure or other type fire falls onto the roof of the building in question. The test results are generally stated as Class A,B or C with class A being the highest resistance to fire penetration. In tests of 28 ounce material manufactured by the Seaman Corporation of Wooster, Ohio, a class C rating was received. This test revealed once again that the PVC material did not support combustion or propagate flame. In these tests, the fabric material immediately beneath the burning brand did experience melting, however the brands did not fall through the sample and therefore the material passed the test.

Despite this rating, the PVC membrane should not be relied upon as a fire resistant covering. The simple fact of the matter is that the PVC covering will not function to prevent the dissipation of large amounts of heat or flame. In some instances, this may be considered to be a disadvantage, in other cases it is of great benefit.

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CASE HISTORIES

The behavior of PVC coated membrane materials in actual fire situations is well documented. In these situations, the material demonstrates very similar characteristics to the results demonstrated in NFPA 701 and similar tests.

A fire in a Rubb supplied warehouse in Portland, Maine is a good indicator of the PVC membrane's actual fire performance. In this instance, a propane forklift experienced an engine fire while the warehouse crew was on their lunch break. The heat from the fire caused a pressure buildup in the truck's propane tank. This pressure buildup triggered the opening of a valve that began expelling propane from the tank. The propane then ignited creating a large torch-like flame that melted a hole in the roof of the unsprinklered structure. Seeing the smoke from an adjacent lunch shed, the crew alerted the fire department which arrived on the scene to witness the propane exhaust itself and extinguish the fire.

The warehouse, which was filled with tapioca flour, experienced absolutely no structural damage from the intense heat. The roof was repaired by Rubb personnel within two hours at a cost of approximately two hundred dollars. Both fire personnel and the warehouse owner considered the performance of the Rubb building to be outstanding. What could have been a very serious loss of property was minimized by the ability of the structure to immediately vent heat and smoke. It should be noted that this self-venting capability also precluded the need for fire fighting personnel to be put at risk of climbing on the roof to vent smoke and heat.

As part of this technical report, we have included several items which relate to the topics discussed. Foremost among these is an article by Richard Seaman, president of the Seaman Corporation. Seaman is perhaps the foremost supplier of PVC coated membrane structure fabrics is the U.S. today. The referenced article was published in the January/February 1984 edition of Building Standards. This article not only details the history of applicable fire standards in this country, but also gives several appropriate case histories.

CURRENT THOUGHT

Today, many fire officials admit that membrane materials many times offer advantages over more fire resistive materials such as concrete block or metal cladding. The ability of the building to "self vent" is a benefit in many respects. For one thing, it reduces the need for automatic smoke and heat venting that is mandated by code for many building types. The immediate release of heat and smoke reduces the opportunity for structural fatigue and failure and damage to stored materials.

Another important feature is related to the fact that even if the membrane does not melt away, it can be quickly cut away to allow immediate access to the structure's interior. The fire can be fought from outside the structure without the need to put personnel at risk of falling through collapsing roofs or being trapped inside a burning building.

Some building code authorities have even begun to view such membrane coverings as being functionally equal to having no covering at all, thus avoiding the need to install costly fire resistive construction and expensive fire suppression systems. For example, NFPA 30 Flammable and Combustible Liquids Code has issued a temporary interim amendment (TIA) that reads as follows:

"2.5 Storage Tank Buildings. A storage tank building is a roofed structure that contains tanks and that limits the dissipation of heat or dispersion of flammable vapors or restricts fire fighting access and control and shall be installed in accordance with this section. A tank installation that has a canopy or roof that does not limit the dissipation of heat or dispersion of flammable vapors and restrict fire fighting access and control shall be treated as an outside above ground tank in accordance with Section 2-3."

CONCLUSIONS

From their full compliance with NFPA 701 and related tests, the membrane materials utilized by Rubb have met the appropriate standards of

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applicable building code requirements. Our structures have gained approval for use in difficult regulatory climates both in the U.S. and abroad. They have proven their safety in actual fire conditions and there are valid arguments that these self venting buildings offer many advantages over more traditional construction. These advantages must be weighed with regard to specific conditions at a given site with adequate consideration given to the need for proper side yards, sprinkler or hose bib connections, etc. Ultimately, the final decisions related to the use of membrane structures fall to the discretion of the local fire official. It is essential to the interests of life safety that all parties be fully aware the characteristics of the membrane structure early in the planning process so that proper decisions can be reached.

We hope that this information has been helpful. Below we have enclosed a summary of the fire results for our membrane materials. Additional test results and references are available upon request.

Rubb PVC Coated Polyester Fabric Membranes have the following test results:

- NFPA 701 Large and Small Scale Tests - Pass
- UL 214 - Pass
- California State Fire Marshall Tests - Pass
- Federal Test Standard 191 Method 5903 - Pass
- UBC 55-1 (Similar to NFPA 701) - 1993 Pass
- ASTM E 84 Flame Spread - Class I - Pass
- ASTM E 84 Smoke Developed - 400 - Pass
- ASTM E 84 Fuel Contribution - 0 - Pass
- ASTM E 108 - Class C rating in 1993 burning brand test
- ASTM E136 - Not applicable for coated fabrics

Rubb membranes are approved membranes per the definition set forth by UBC and BOCA codes.

For additional information, industry references or for a copy of the latest Rubb video that details the fire suppression system in a Rubb supplied commercial aircraft hangar, please contact:

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