Information Sciences Letters
An International Journal

http://dx.doi.org/10.18576/isl/121226

Determining the Best Woven and Non-Woven Floor Covering (Carpets or Rugs) Commonly Used In Jazan Region, According To Their Resistance to Burning

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Received: 30 Sep. 2023, Revised: 24 Oct. 2023, Accepted: 25 Nov. 2023.
Published online: 1 Dec. 2023

Abstract: There are more than 60% of homes, institutions, care homes, hospitals, hotels, reception places and transportation have carpets and rugs covering the floors. The quantity of fire damages and the ignition of these floor covering may hurt people and children living in these places causing death when exposing to them for long time. Among the used carpets are those with volatile organic elements (VOC 'S) containing toluene, benzene, formaldehyde and other chemicals, some of which have already formed substance (EPA 'S), which is included in the list of highly dangerous substances, In this article identify the best woven or non-woven floor coverings used in the Jazan region according to their resistance burning to fit the functionality safely by using methenamine tablet test. Eleven samples of different types of pile and construction were used and conclude that when the woven or non-woven floor coverings are exposed to an ignition source, the mixed pile from polyester and polypropylene fibers and the pile of 100% polyester passes the methenamine test, while the floor coverings with 100% polyacrylic and 100% polypropylene did not Pass the test, as there is a direct correlation at the level of significance at the 0.01 between ignition time (s)and both pile thickness (mm) and Total sample thickness (mm), There is also direct correlation at the level of significance at the 0.05 between Total sample weight g/m2 and Average sample weight g/400cm2 and therefore there is a huge risk in using these types in places, so we must take preventive measures against the dangers of fires, and achieve the possibility of controlling them in the event of their outbreak and putting them out as soon as possible with minimal losses, using floor covering that passes various fire tests according to standard specification (ASTM D2859). Our findings indicated that polypropylene and polyester mixed-pile floor coverings and 100% polyester floor coverings are preferable more than manufactured floor coverings made of 100% polypropylene or 100% polyester.

Keywords: Floor Covering, Carpet, Rug, Burning, Methenmine.

1 Introduction

In recent years polymers have become versatile and widely accepted materials in almost every conceivable application. Many of these applications involve the possibility of exposure to fire hazards. Upon exposure to a sufficient heat source and sufficient atmospheric oxygen, these materials catch fire and bum. However, the rate of combustion varies from polymer to polymer. The overall fire hazard is therefore a function not only of the fire performance of a polymer, but also the degree of exposure of the polymer to fire.[1]

In the early era of this century, it was known that floor coverings (carpets /rugs) play an essential and key role in the development and spread of fire. This attention has led to written systems that assess the behavior of floor ores/materials in various fire tests [2,3].

Over the past 50 years, scientists and industrialists have shown increasing interest in the behavior of textile products combustion, which has led to agreement on specific specifications for flammability of textile materials/ores. Both consumers and producers must be aware of the role played by all textile products, whether they relate to woven and non-woven floor covering, clothing or furnishings in fires to expand personal safety and reduce human damage and

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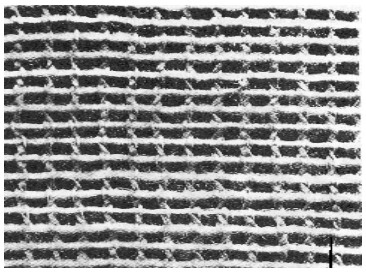
economic loss. This is believed by some that burning with fire is the main risk of fatality, while in fact the smoke

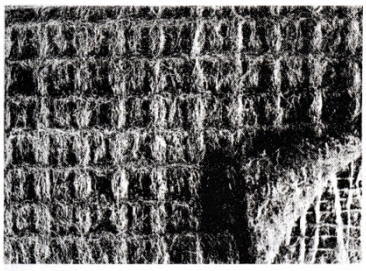
emitted is more deadly than fire when fires break out. The initial attempts were used to test the (Tunnel test) to predict the evolution of the spread of flames, although initially used, it cannot give the necessary fire combustion to divide the floor coverings in terms of the spread of flames in them; because this device was originally designed for the testing of the ceiling and wall covers, and therefore other devices were used as a methenine testing device (used in the study) according to the standard specifications (ASTM D2859) and radioactive plate testing device to test the flammability resistance of floor covering. The methods used to produce textile floor covering vary into:

First: woven floor coverings, which are divided into manual furnishings such as Clem production style, Sumac and hand-made carpet and mechanical furnishings, such as the way the pile works using metal slats (toweling), the way the carpets work face-to-face, the Axminster carpets, the knitting/ tricot carpets, the velour pile yarn carpets, two kinds of warp fabric (velvet) are used, first is used to make the floor and the other to make the pile and one or more wefts to seal [4].

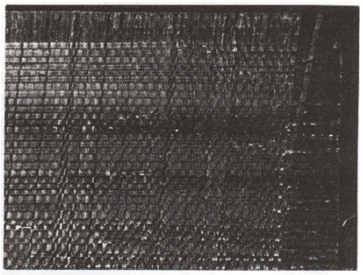
Second: Non-woven floor covering of this type with flap-like. It is a constructive installation consisting of a screen of natural or manufactured filaments, short or continuous that are cohesion with each other in a mechanical or thermal or chemical method. The first and second background some types of floor coverings vary whether woven or non-woven as in **fig1** in fig (1-a) the second background consists of jute, but in fig (1-b) the second background consists of fibers, in fig (1-c) Second background for floor covering mix between fibers and jute, in fig (1-d) Second background for floor covering Sponge rubber backing. [5-9]



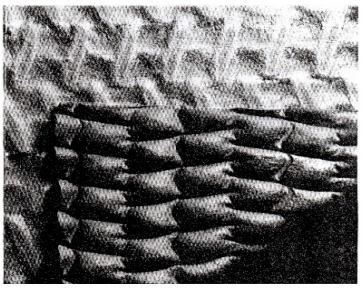
(a) Second background jute



(b) Second background fibers



(c) Second background mix jute



(d)Second background Sponge between fibers and rubber backing

Fig1. The second background styles for carpers

2 Literature Review

Every year, uncontrolled fires result in significant property damage and fatalities. Put simply, fire is the result of intricate chemical and physical reactions brought on by heating various materials to their respective points of ignition. There are several stages or states that can be used to depict the growth and development of a fire, including ignition, fire growth, fully developed fire, decay, and finally extinction. Numerous risks, typically in the form of heat energy and combustion products, are produced at every stage of a fire's development and could endanger both life and property. Generally speaking, ignitability, flame spread, heat release, smoke production, toxicity, and corrosivity are the terms used to describe the fire hazards connected to a material. However, a material's potential for fire depends not only on its inherent properties but also on the surroundings in which it occurs, including the material's orientation, ventilation rates, and the layout of the enclosed space. The same material or component may present different fire hazards depending on its end use. [6]

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For the safety of people residing in buildings and other structures, regulations governing the flammability of building materials and products are essential. When exposed building materials and products are involved in fires that claim lives, new test procedures and regulations are frequently implemented to address the issue. Tests for flammability vary from small-scale room corner testing to those in which the sample is ground into a powder before testing. Test methods can vary depending on a number of factors, such as the relative scale of the test specimen, the intensity and characteristics of the fire exposure, and the precise measurement of flammability parameters being taken into consideration. It has been demonstrated that some current regulatory test methods do not classify a particular type of building material or product in a way that is consistent with full-scale tests that replicate real-world conditions because of specific details like specimen orientation and fire exposure intensity. Other test procedures have been developed as a result of these failures for particular products or applications. Because of this, a variety of tests are employed to categorize goods and building materials according to their flammability or response to fire. [7]

3 Experimental

Materials

Experimental work focuses on measuring the combustion of test samples. This test method is applicable to all types of floor coverings, regardless of the manufacturing method, whether woven or non-woven, or whether they are made of natural or synthetic fibers, and also regardless of the quality of the floor coverings, Either jute or rubber.
The test was carried out on 11 samples with different specifications (Table 1). These samples are the most prevalent in the Jazan region, Saudi Arabia.

Table 1: Specifications of samples.

Sample number	Pile Material	pile thickness (mm)	Total sample thickness (mm)	Total sample weight g/m^2	Average sample weight g/400cm^2	type of background' carpets
1	64% Polypropylene 36% Polyester	9	11	1900	76	jute
2	60%Polypropylene 40% Polyester	8	10	1900	76	jute
3	75% Polypropylene 25% Polyester	10	12	2500	100	jute
4	85% Polypropylene 15% Polyester	10	12	1800	72	jute
5	50% Polypropylene 50% Polyester	8	10	1900	76	jute
6	100% Polyester	9	11	2100	84	jute
7	100% Polyester	7	9	2100	84	jute
8	100% Polyester	6	8	2000	80	jute
9	100% Polyester	8	10	1350	54	jute
10	100%Polypropylene	10	12	1975	79	jute
11	100% Polyacrylic	11	13	2574	102.96	jute

* pile thickness (mm), Total sample thickness, Total sample weight g/m2 and Average sample weight g/400cm^2 average for every 8 samples of each carpet type.

4 Methods

1. Sampling and number of test specimens

Samples are processed according to the standard specifications so that 8 pieces are taken from each sample with area (9 x 9 +/- 0.1 inch) and we make sure there are no excess filaments on the surface of the sample and the direction of the pile is vertical and the sample is adapted at room temperature and there is no moisture. [8]

2. Procedure

The sample is placed horizontally on the assigned place in the device and then the metal ring is placed with a diameter of 8

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inches and thickness of 0.25 inches on the test sample and the methenmine disc is placed in the center of the sample **Fig 2**.and then ignited from the top of the disc so that the ignition source does not reach the sample directly. The sample is accepted if the combustion does not extend to 1 inch from the edge of the metal ring in any direction and for the sample to pass the test, 7 of the eight pieces must pass the test. [8]

Fig 2: determination center of the sample.

In sample (1) pile fibers is 64% Polypropylene 36 %Polyester, pile thickness 9 mm, Total sample thickness 11mm, Total sample weight 1900 +/- 10% g/m2 and Second background is jute. Sample size is 20x20cm .

The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .Fig 3.

		
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 3: combustion behavior of a sample 1.

In sample (2) pile fibers is 60% Polypropylene 40% Polyester, pile thickness 10 mm, Total sample thickness 11mm, Total sample weight 1900 +/- 10% g/m2 and Second background is jute. Sample size is 20x20cm .The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .**Fig 4**

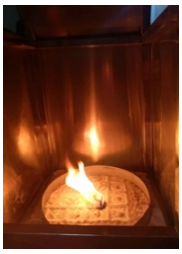		
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 4: combustion behavior of a sample 2.

In sample (3) pile fibers is 75% Polypropylene 25 %Polyester, pile thickness 10 mm, Total sample thickness 12mm, Total sample weight 2500 +/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .

The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .

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Fig 5

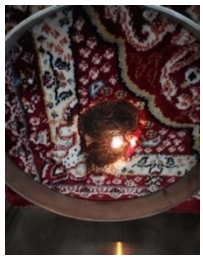	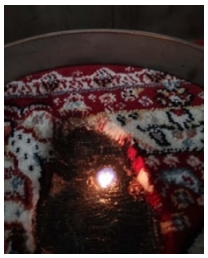	
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 5: combustion behavior of a sample 3.

In sample (4) pile fibers is 85% Polypropylene15 %Polyester, pile thickness 10 mm, Total sample thickness 12mm, Total sample weight 1800 +/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .
The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .

Fig 6

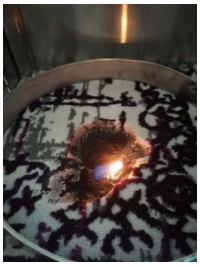	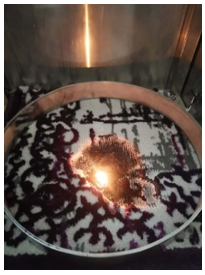	
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 6: combustion behavior of a sample 4.

In sample (5) pile fibers is 50% Polypropylene50 %Polyester, pile thickness 8 mm, Total sample thickness 10mm, Total sample weight 1900 +/- 10%g/m2 and Second background is jute. Sample size is 20x20cm.The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight
times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers

Fig 7

		
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 7: combustion behavior of a sample 5 **.**

In sample (6) pile fibers is 100% Polyester, pile thickness 9 mm, Total sample thickness 11 mm, Total sample weight 2100 +/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that

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melting of the pile fibers occurred, and then charring of the fibers .**Fig 8**

		
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 8: combustion behavior of a sample 6**.**

In sample (7) pile fibers is 100% Polyester, pile thickness 9 mm, Total sample thickness 11 mm, Total sample weight 2100 +/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile .**Fig 9**

		
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 9: combustion behavior of a sample 7.

In sample (8) pile fibers is 100% Polyester, pile thickness 6 mm, Total sample thickness 8 mm, Total sample weight 2000 +/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .
The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .**Fig 10**

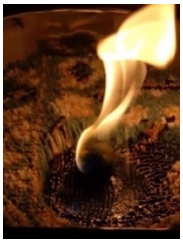	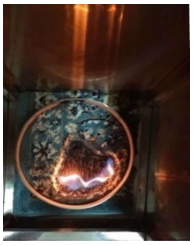	
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 10: combustion behavior of a sample 8.

In sample (9) pile fibers is 100% Polyester, pile thickness 10mm, Total sample thickness 12 mm, Total sample weight 1350 +/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .
The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .

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Fig 11

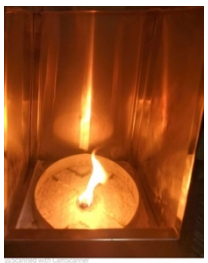		
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig11: combustion behavior of a sample 9.

In sample (10) pile fibers is 100% Polypropylene, pile thickness 10mm, Total sample thickness 12 mm, Total sample weight 1975+/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .
The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .

Fig 12

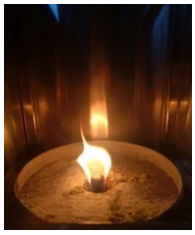		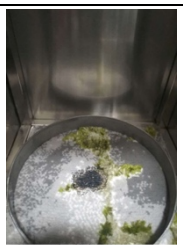
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig12. combustion behavior of a sample 10

In sample (11) pile fibers is 100% Polyacrylic, pile thickness 11 mm, Total sample thickness 13 mm, Total sample weight 2574+/- 10%g/m2 and Second background is jute. Sample size is 20x20cm .
The test begins by placing the disc in the middle of the sample completely, then it is ignited from the top, and the ignition continues until the flame ends, and then the burning distance is measured from the metal ring. This test was repeated eight times on the same sample, where it was observed that melting of the pile fibers occurred, and then charring of the fibers .

Fig 13

	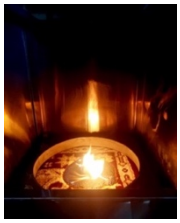	
The flame continues	**melting of pile fibers**	**The ignition is completely off**

Fig 13. combustion behavior of a sample 11

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Table 2. Average Time of ignition.

Sample number	Pile Material	ignition time (average for 8 sample) (s)
1	64% Polypropylene36 %Polyester	58
2	60% Polypropylene40% Polyester	50
3	75% Polypropylene25 %Polyester	94
4	85% Polypropylene15 %Polyester	72
5	50% Polypropylene50 %Polyester	64
6	100% Polyester	83
7	100% Polyester	76
8	100% Polyester	62
9	100% Polyester	49
10	100% Polypropylene	100
11	100% Polyacrylic	126

Table 2: shows that the longest ignition time is for sample No. 11, followed by sample No. 10.

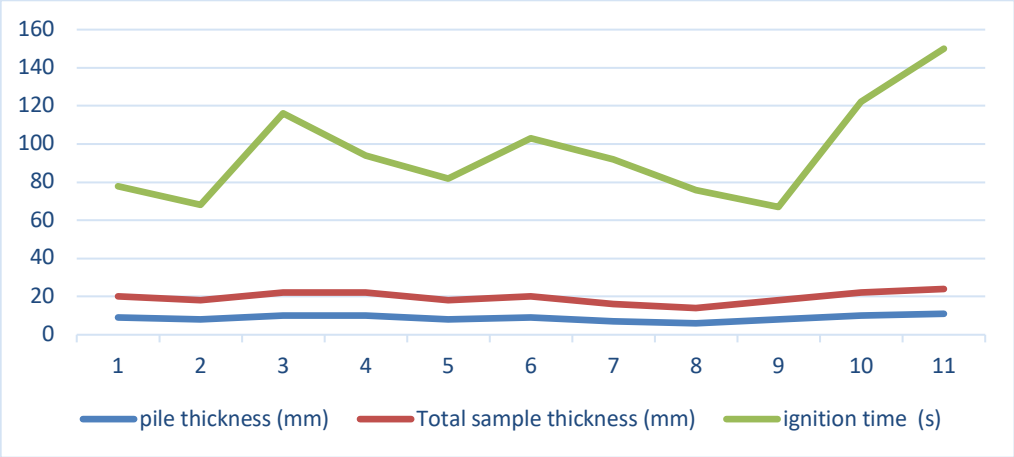

Fig 14: explain the relationship between pile thickness, sample thickness and ignition time

Figure 14 shows that the greater the thickness of the sample, the greater the thickness of the sample, and thus the longer the ignition time

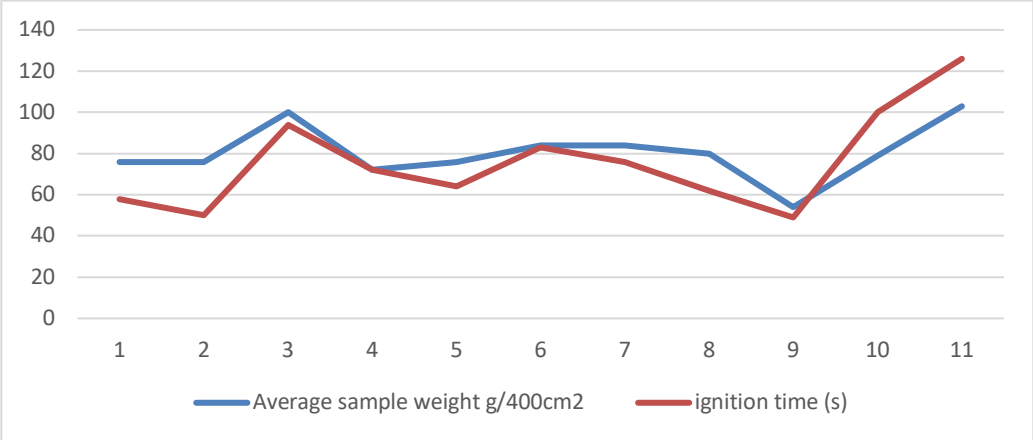

Fig 15: explain the relationship between Average sample weight g/400cm2 and ignition time and shows that the greater sample weight Took more ignition time.

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SAMPLES PASS

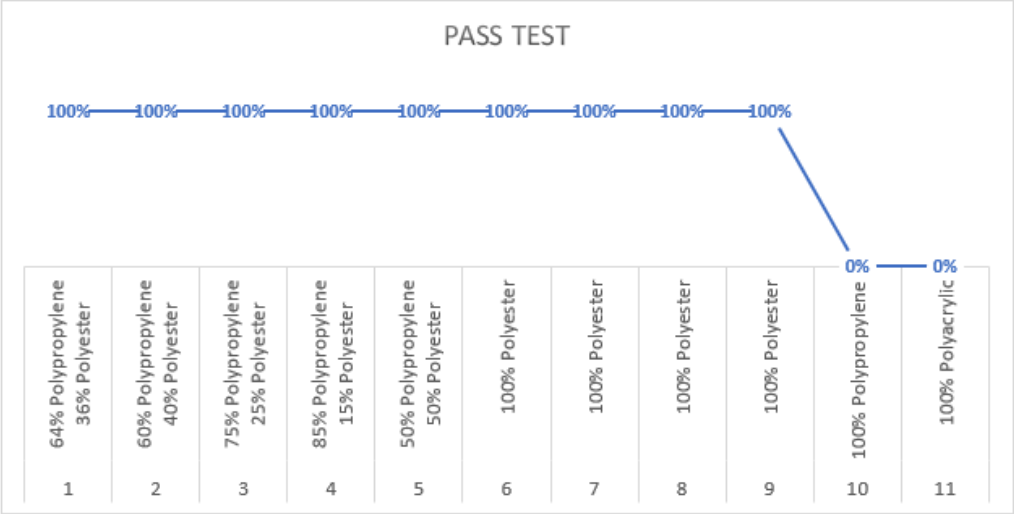

Fig: 15 explain kinds of fibers carpets it's pass Methenamine test.

Table 3. Correlations.

		pile thickness (mm)	**Total sample thickness (mm)**	**Total sample weight g/m^2**	**Average sample weight g/400cm^2**
ignition time (s)	Pearson Correlation Sig. (2-tailed)	.698* .017	.698* .017	.795** .003	.795** .003
	N	11	11	11	11

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

There is a statistically significant relationship at the 0.01 level between ignition time (s) both Total sample weight g/m2 and Average sample weight g/400cm2. While There is a statistically significant relationship at the 0.05 level between ignition time (s) both pile thickness (mm) and Total sample thickness (mm).

5 Results and Discussion

The test was conducted on samples of different synthetic materials and with different mixtures of synthetic fibers. Samples No. 6- 7- 8- 9 had a pile of polyester filaments with a jute background and different heights of the pile and a total weight (g / m2) were different, and also samples No. 1-2-3-4-5 with a mixed pile of polyester and polypropylene with a jute background and with different pile heights and a total weight (g / m2) were also different, sample No. 10 had 100% polypropylene filaments, and sample No. 11 of 100% of polyacrylic filaments/bristles, as shown in the table of specifications of test samples No. (1).
It was concluded that there are no woven or non-woven floor coverings made of natural fibers such as cotton, natural wool, or the mixed pile of natural and synthetic bristles in the market.
And by conducting the methenamine test on the samples, the results were divided into four sections:

First: All samples with a mixed pile of polypropylene and polyester with different mixtures have passed the test, as the combustion area did not exceed the permissible limit in the standard specification.

Second: All samples of 100% polyester material have passed the test, as the area of combustion did not exceed the permissible limit in the standard specification.

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Third: All samples with a pile of 100% of polypropylene did not pass the test, as the area of combustion exceeded the permissible limit in the standard specification.

Fourth: All samples with a pile of 100% of polyacrylic propylene did not pass the test, as the area of combustion exceeded the permissible limit in the standard specification.

Fifth: It is also evident that the ignition time increases with sample weight, As the larger sample weight (Table 1) took a longer ignition time (Table 2) as in sample (11), So conclude that there is a direct relationship between increasing the sample weight and increasing the ignition time.

Sixth: Additionally, it is clear that the ignition time rises with sample weight because, as in sample (11) the larger pile thickness (Table 1) required a longer ignition time (Table 2). We can therefore draw the conclusion that there is a direct correlation between an increase in pile thickness and an increase in ignition time.

We conclude that when the woven or non-woven floor coverings are exposed to an ignition source, the mixed pile of polyester and polypropylene fibers and the pile of polyester passes the methenamine test, while the floor coverings with 100% polyacrylic and 100% polypropylene did not Pass the test and therefore there is a huge risk in using these types in places, so we must take preventive measures against the dangers of fires, and achieve the possibility of controlling them in the event of their outbreak and putting them out as soon as possible with minimal losses, using floor covering that passes various fire tests according to standard specifications In this field both by use.

As shown in table 3 There is a direct correlation at the level of significance at the 0.01 between ignition time (s)and both pile thickness (mm) and Total sample thickness (mm), There is also direct correlation at the level of significance at the 0.05 between Total sample weight g/m2 and Average sample weight g/400cm2

6 Conclusions

Since floor coverings cannot be dispensed with in most places such as homes, care homes, hotels, means of transportation...etc., the Methenamine test according to Standard (ASTM D 2859) was used to test samples of woven floor coverings commonly used in Jazan region to measure How safe it is to be used if exposed to a simple ignition source (such as cigarette butts and matches)
It was concluded that the most commonly used floor coverings are made of synthetic fibers 100% polypropylene, 100% polyacrylic, 100% polyester, a mixture of polypropylene and polyester with different mixtures.
The result of the test was that the manufactured samples of pile made of 100% polypropylene and 100% polyacrylic did not pass the test, while the manufactured furnishings with pile of 100% polyester, blended of 64% polypropylene and 36% polyester, 60% polypropylene and 40% polyester, 75% polypropylene and 25% polyester of 85% polypropylene and 15% polyester, 50% polypropylene and 50% polyester passed the methenamine test.
Our findings indicated that polypropylene and polyester mixed-pile flooring and 100% polyester floor coverings are preferable more than manufactured coverings made of 100% polypropylene or 100% polyacrylic according to the methenamine test.

Recommendation
It is preferable to use the specifications of textile floor coverings that obtained the lowest combustion results in the Methenamine test according to Standard (ASTM D 2859) to increase safety coefficients in residences and hotels...etc.

Author Contributions
The author conceived the work, prepared the samples and performed the experiments, conducted the sequence alignment and drafted the manuscript. The author read and approved the final manuscript.

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Funding
This project number RUP-2. was supported by the Deputyship for Research& Innovation, Ministry of Education in Saudi Arabia.

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Availability Of Data And Material

The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest Statement

The authors declare no conflicts of interest. Ethical approval There is no need for ethical clearance since it is a review article.

Ethical Approval

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Acknowledgment

The author extend her appreciation to the Deputyship for Research& Innovation, Ministry of Education in Saudi Arabia for funding this research work through the project number RUP-2.

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