LIGHT-WEIGHT FIRE BARRIER MATERIALS FOR AIRCRAFT THERMAL/ACOUSTICAL INSULATION BLANKETS

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INTRODUCTION

Dryden Flight Research Center EC84-31806 Photographed 1984
Remotely piloted Boeing 720 Controlled Impact Demonstration aircraft
burning after failure of anti-misting fuel to prevent a fire. NASA photo


Aluminum skin
Blanket

In a post-crash fire incident the fuselage structure of current commercial aircraft could be burned through after 2 minutes. Increasing this burn-through time will give additional evacuation time.

BURN-THROUGH APPARATUS

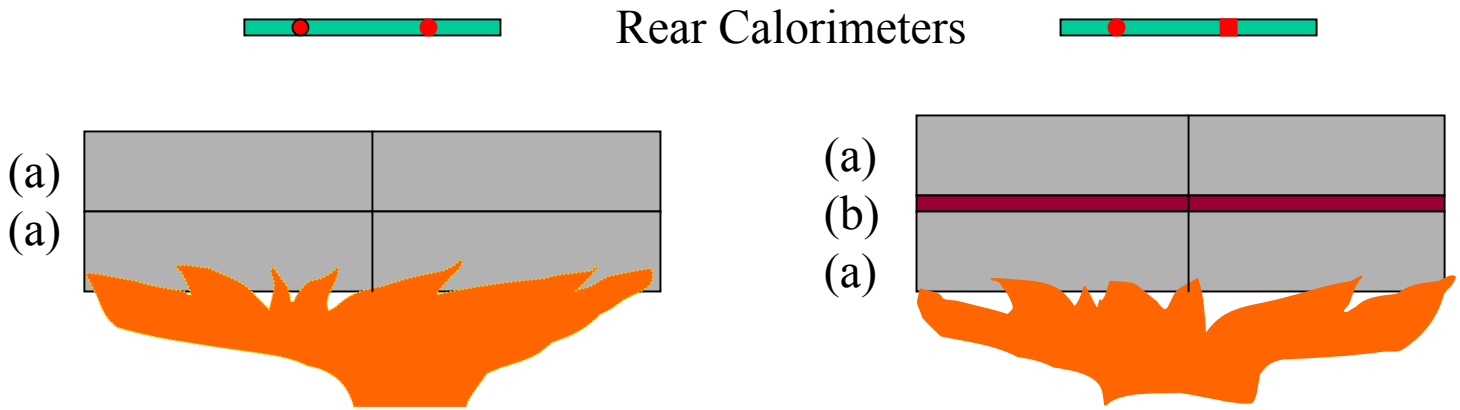
TESTING PARAMETERS

Flame temperature: 1900 F
Room Humidity: 50-55 %
Intake air velocity: 2150 ft/min.
Fuel flow rate: 6 gal/hr.
Front heat flux: 14-15 Btu/s.ft^2

FIRE BARRIER MATERIALS

Materials	Thickness (mm)	Areal Density d_a (g/m^2)
Ceramic fiber paper (Al_2O_3-SiO_2-B_2O_3)	0.4-0.5	75
Ceramic paper (silica glass)	0.15	50
Silica Felt	3-5	50
Alumino silica Fabric	0.5-1	75-150
Oxidized Poly-acrylonitrile Fiber	25.4	~ 250
Pre-oxidized Poly-Acrylonitrile Felt	~ 4	400
Melamine/Aramid Felt	3.8	900
Aramid/inorganic fiber	12.7	170

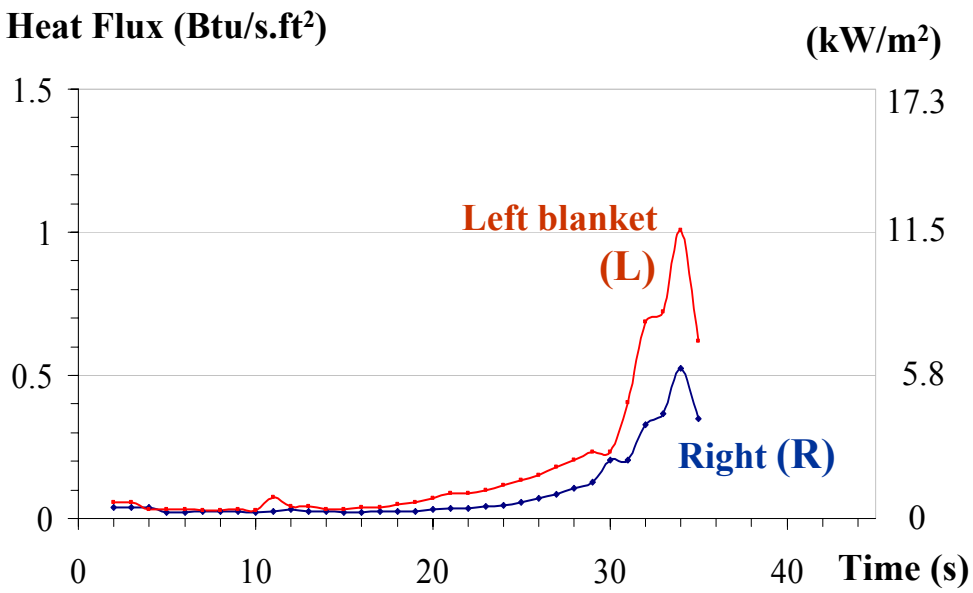
SPECIMEN PREPARATION and TESTING PROCEDURE



(a) fiberglass batting 0.6 pcf, 1 in. thick
(b) fire resistant material.

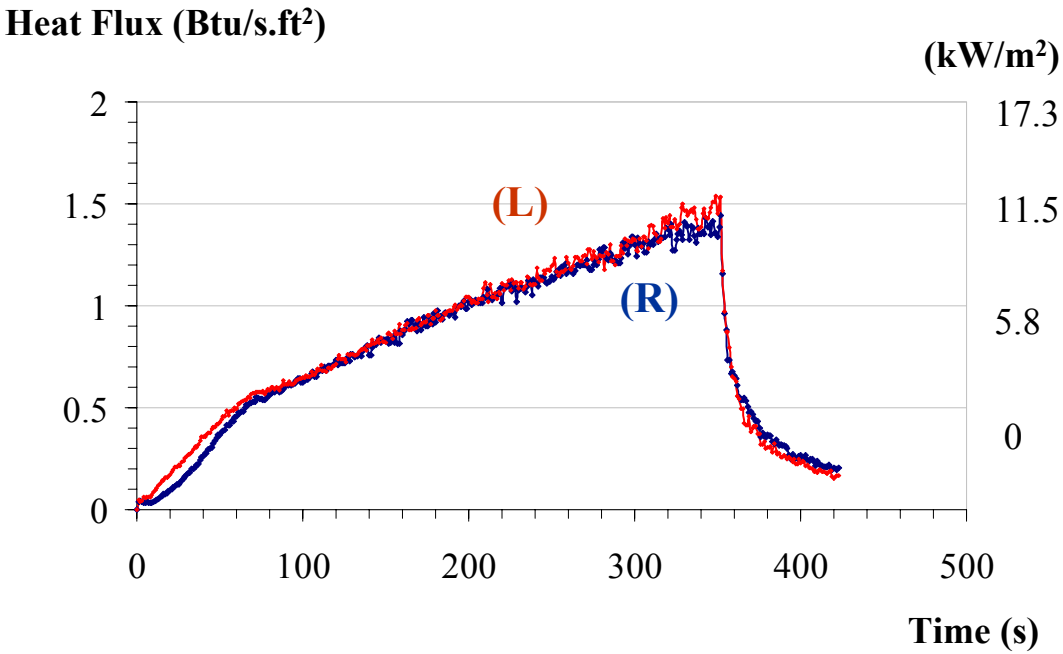
Failure

Burned-through before 4 min.
Rear Heat Flux passes 2 Btu/s.ft^2



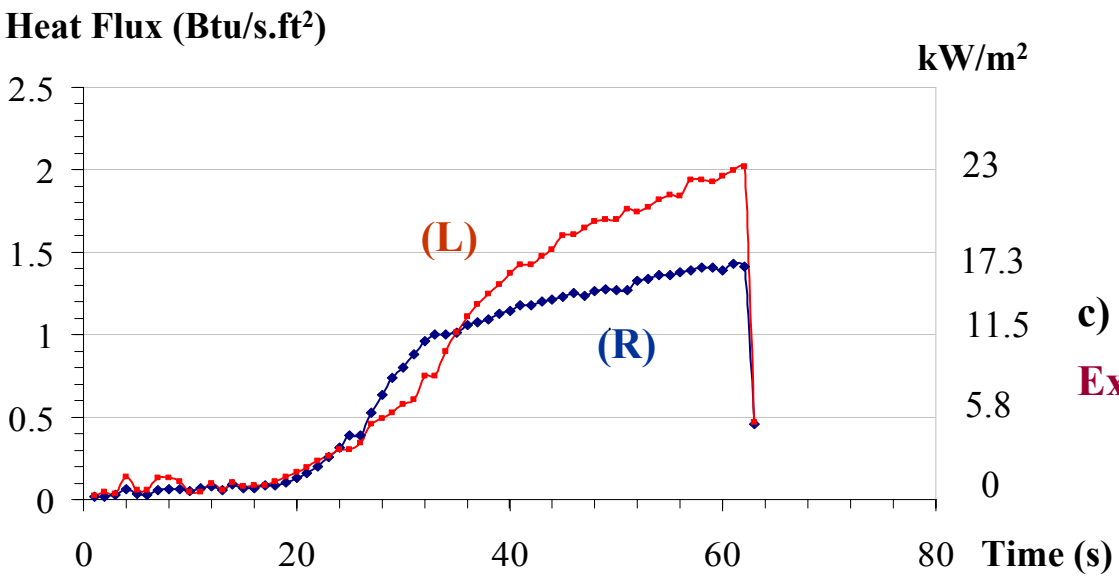
(a) 2 layers of fiberglass 0.6 pcf

Burned through at 29 s



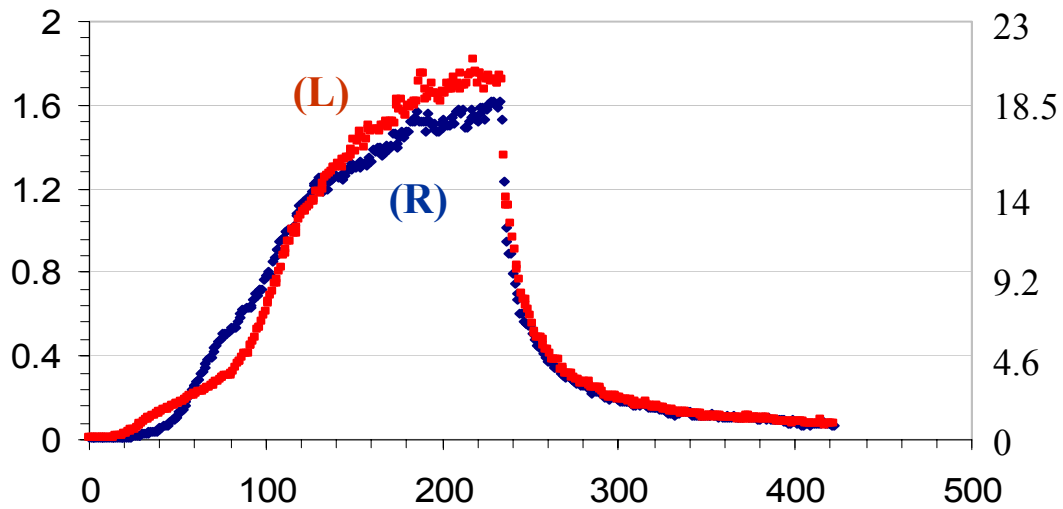
(b) With BAS ceramic fiber paper

Not burned through after 6 min.



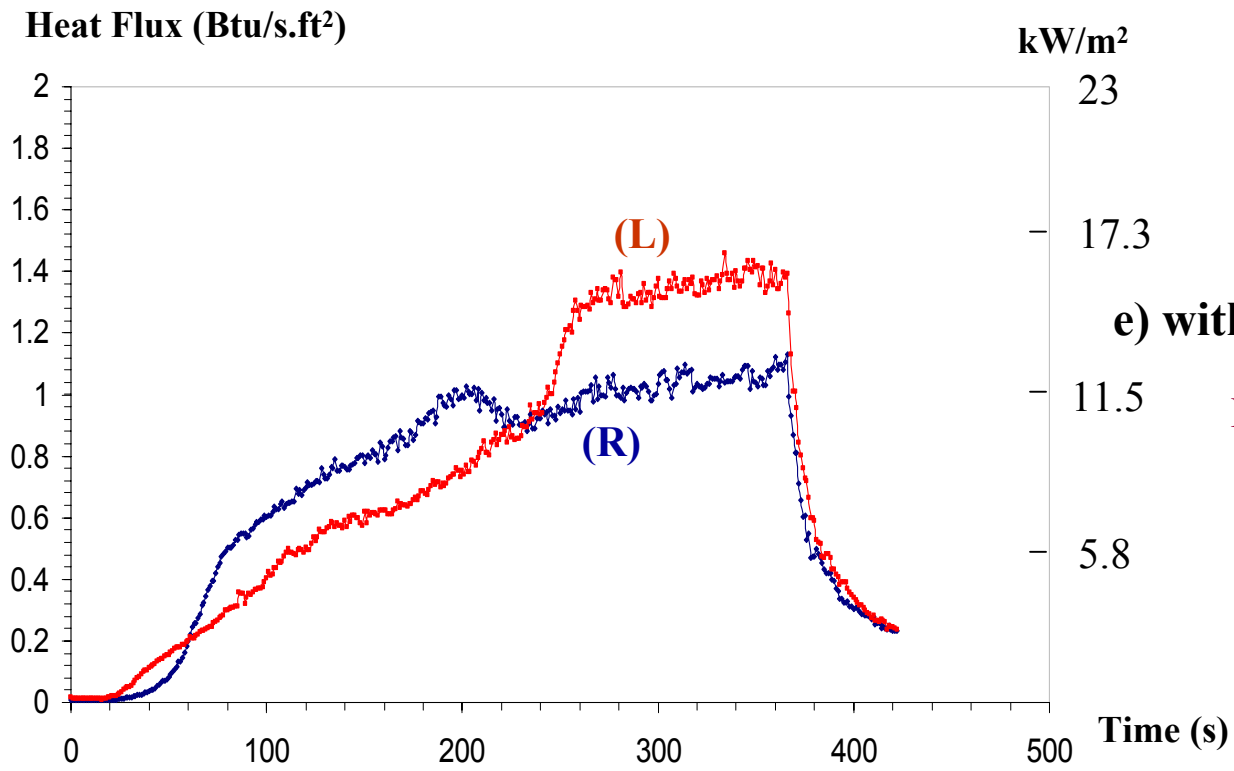
c) With glass ceramic paper

Exceeded heat flux at 60 s



d) With silica felt

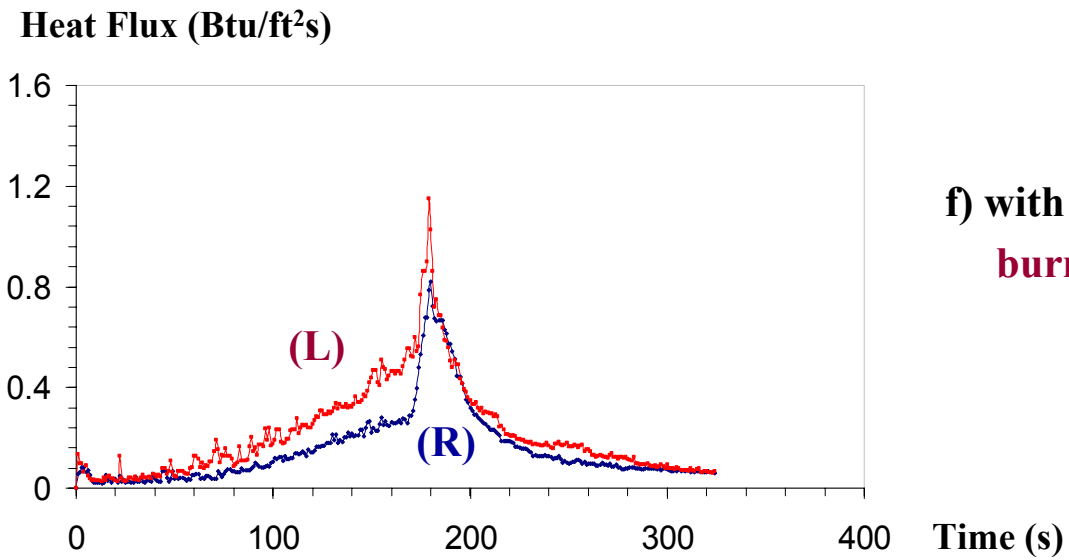
Not burned through after 4 min.



e) with alumino-silica fabric

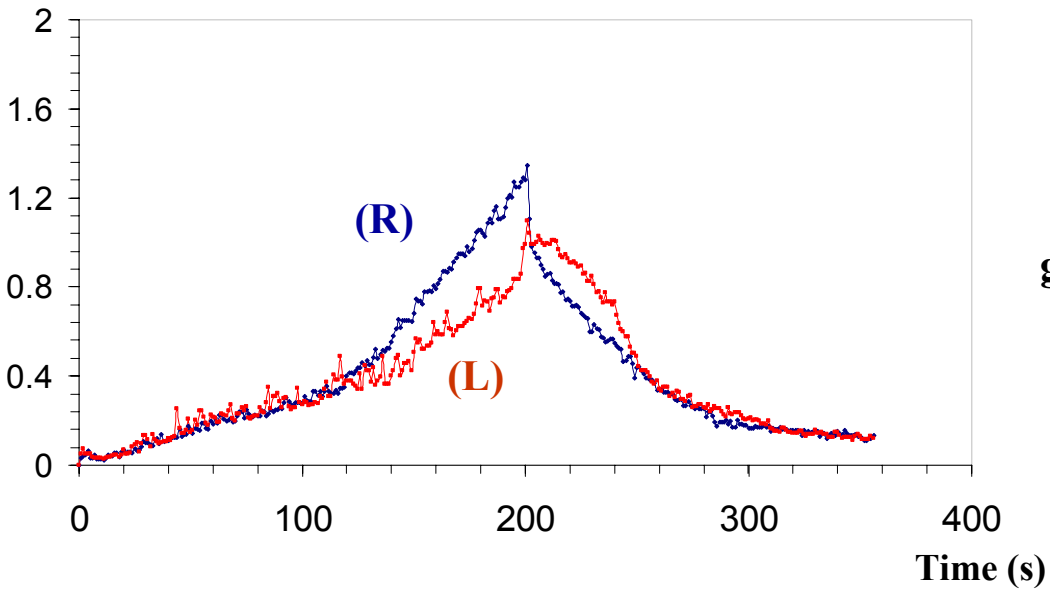
Not burned through after 6 min.

REAR HEAT FLUX CURVE OF BLANKET SAMPLES IN THE BURN THROUGH TEST



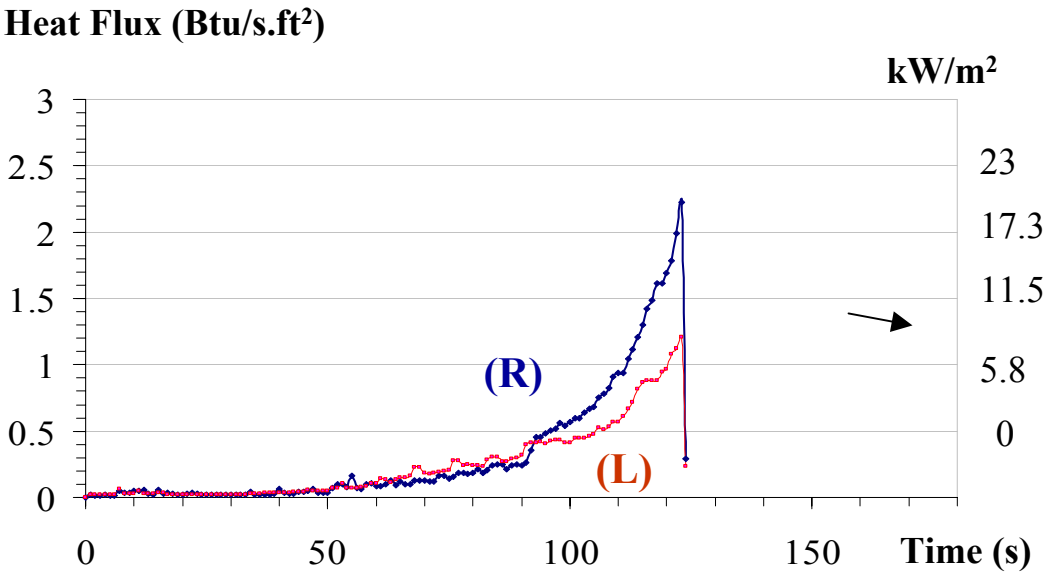
f) with oxidized poly-acrylonitrile fiber.

burned through at 175 s



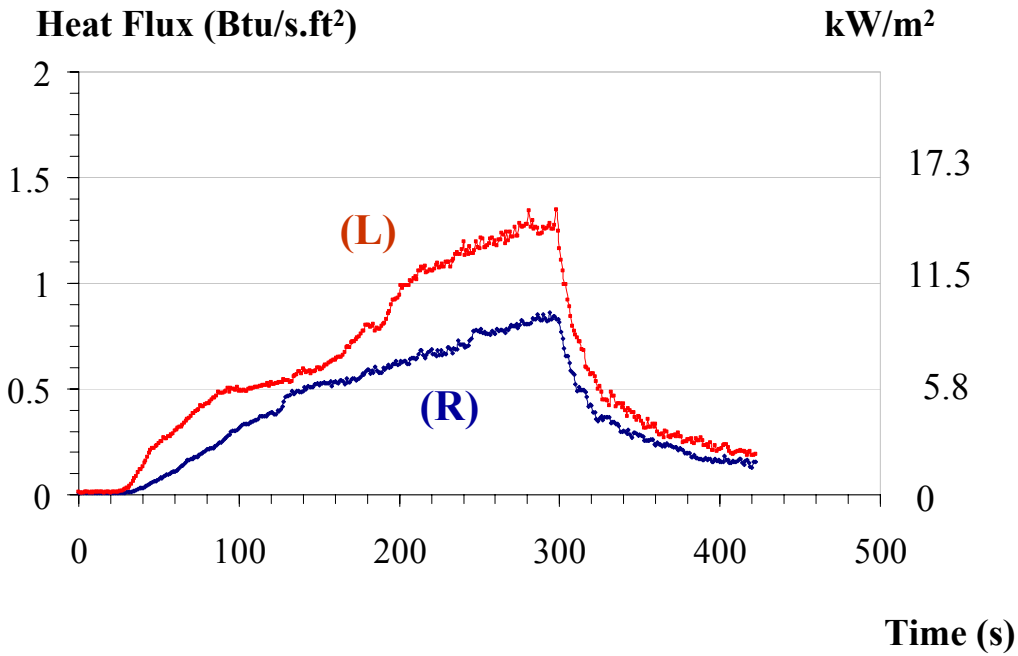
g) with pre-oxidized PAN felt

burned through at 120 and 180 s



(h) With 2 layers of aramid felt.

Burned through at 115 s



(i) with 1 layer of aramid/inorganic fiber

Not burned through at 6 min.

BURN-THROUGH TIME & REAR HEAT FLUX

Materials	Thickness (mm)	Areal Density (g/cm^2)	Burn-through Time
Ceramic fiber paper (Al_2O_3-SiO_2-B_2O_3)	0.4-0.5	75	Not burned through, 6 min. Q_M =1.5 Btu/s.ft^2
Ceramic paper (glass-silica)	0.15	50	Not burned through, 4 min. Q_M = 2 Btu/s.ft^2 at 4 min.
Silica Felt	3 - 5	50	Not burned through, 5 min. Q_M = 2 Btu/s.ft^2 at 5 min.
Alumino silica Fabric	0.5-1	75-150	Not burned through, 6 min. Q_M =1.4 Btu/s.ft^2
Oxidized Poly-acrylonitrile Fiber	25.4	~ 250	Burned through after 175 s
Pre-oxidized Poly-Acrylonitrile Felt	~ 4	400	Burned through in 120-180 s
Melamine/Aramid Felt	3.8	900	Burned through after 120 s
Aramid/inorganic fiber	12.7	170	Not burned through, 6 min. Q_M =1.3 Btu/s.ft^2

A light-weight ceramic fiber/felt/fabric layer can block the flame completely

BURN-THROUGH PERFORMANCE FACTOR

To describe the applicability of the materials in terms of fire resistance.

$$R = \frac{t_b}{d_a} \quad (s.m^2/g)$$

t_b : burn-through time (s)

d_a : areal density (g/m^2)

In terms of burn-through performance, the applicability of a material is higher if the R value is higher.

BURN-THROUGH PERFORMANCE

Materials	Areal Density	Burn-through Time (g/cm^2)	Burn-through factor
Ceramic fiber paper (Al_2O_3-SiO_2-B_2O_3)	75	Not burned through, 6 min. Q_M =1.5 Btu/s.ft^2	4.8
Ceramic paper (glass-silica)	50	Not burned through, 4 min. Q_M = 2 Btu/s.ft^2 at 4 min.	4.8
Silica Felt	50	Not burned through, 5 min. Q_M = 2 Btu/s.ft^2 at 5 min.	6.0
Alumino silica Fabric	75-150	Not burned through, 6 min. Q_M =1.4 Btu/s.ft^2	2.4-4.8
Oxidized Poly-acrylonitrile Fiber	~ 250	Burned through after 175 s	0.7
Pre-oxidized Poly-Acrylonitrile Felt	400	Burned through in 120-180 s	0.4
Melamine/Aramid Felt	900	Burned through after 120 s	0.13
Aramid/inorganic fiber	170	Not burned through, 6 min. Q_M =1.3 Btu/s.ft^2	2.1

SUMMARY AND CONCLUSION

- Burn-through apparatus and the testing of fire barrier materials were presented.
- Ceramic- and polymeric-based materials including alumino-silica and silica paper/fiber/felt/fabric, poly-acrylonitrile, and aramid fiber-based were tested.
- All ceramic-based materials were not burned through after 4 min. Their rear heat flux reached 1.4-2 Btu/s.ft^2 after this period of time.
- A polymer-based fiber material was not burn-through after 6 min. with a back-side heat flux as low as 1.3 Btu/s.ft^2.
- A factor $R = t_b / d_a$ was introduced to describe the applicability of the fire barrier materials in terms of burn-through performance.