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The Gaylord Texan Hotel and Convention Center

Protecting Atrium area with 210 foot high glass domed ceiling. The size of the atrium area alone is approximately 87,143 sq. ft. This atrium is part of a Hotel and Convention Center in Texas.

The Gaylord Texan Hotel and Convention Center

Location: Grapevine Lake Dallas Texas

Industry:
Atrium

Products used
6 x VESDA LaserPLUS

High ceiling atrium present a great number of challenges to any smoke detection technology as far as detection reliability is concerned.

The VESDA system has been used in large open area applications around the world for many years. One example is the use of VESDA detectors to protect part of a large Hotel and Convention Center in Texas, USA. The central part of this building complex is an atrium with a 210 ft (64 m) high glass domed ceiling.

The fire hazards in this environment are related to day-to-day activities associated with the normal operation of the business such as food preparation, potential electrical and plant faults, facility maintenance and occupant related causes.

Losses due to an event of fire in such environment could be quite catastrophic; therefore a reliable and very early smoke detection system is crucial for the business continuity of the hotel. A total of six VESDA LaserPLUS detectors are currently installed to protect the atrium and surrounding areas. The size of the atrium area alone is approximately 87,143 sq. ft (8,100 sq. m.).

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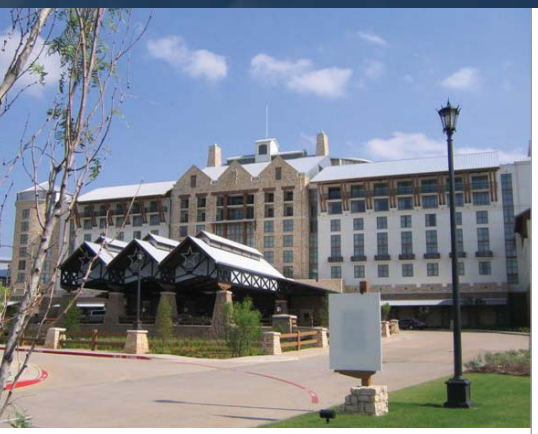


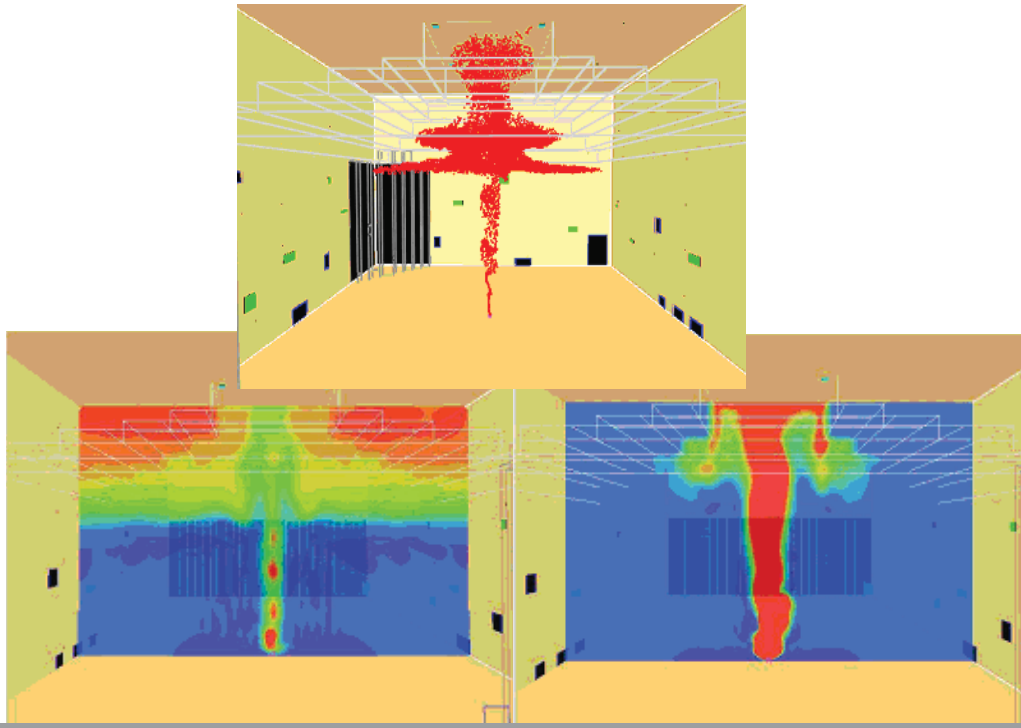
The Gaylord Texan Hotel and Convention Center at Grapevine Lake Dallas Texas

Performance-Based Design

According to the Uniform Building Code, which calls for a 5 to 10 MW fire to actuate the building's smoke evacuation system, the smoke detection system is required to detect smoke within 5 minutes from the start of a fire. The specified fire size is very large and in many cases it's unfeasible to generate such test fires within the areas requiring protection. This obstacle can be overcome with the aid of computer modelling and real smoke tests for early and Very Early Smoke Detection systems such as VESDA.

In order to assess the system design and the effectiveness of the VESDA detectors' location and sampling holes in such environment, a set of computer simulations have been carried out to illustrate smoke movement in the atrium, detection performance and overall protection in accordance with performance-based fire safety system design methodologies[1]. The computer model also takes into account the phenomenon of stratification, which usually occurs in high ceiling enclosures.

Stratification occurs when the smoke or hot gases flowing from the fire fail to ascend to the smoke detection points mounted at a particular level above the fire due to the loss of buoyancy [2]. This phenomenon has a great impact on the performance of ceiling mounted smoke detection systems as well as other detection technologies such as projected beam detectors. This is a complicated issue requiring in-depth fire engineering analysis. The following picture illustrates smoke particles movement in the atrium under the influence of stratification.



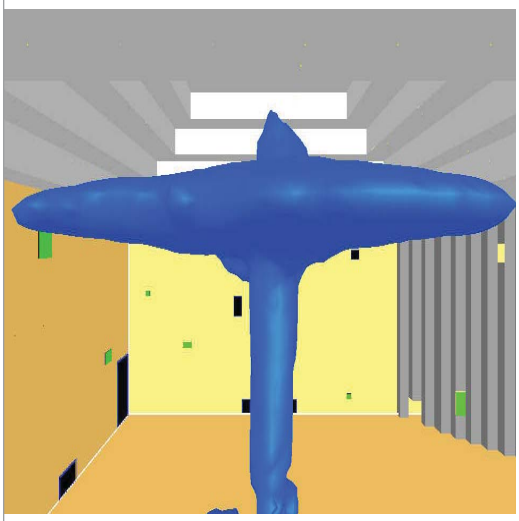
1. *Refer to Xtralis technical report 09982 and Applications Engineering Report aeReport number AB2003012 for detail analysis.*
2. *NFPA 72 National Fire Alarm Code 1999 Edition.*

The effectiveness of the smoke detection system could be determined by factors such as stratification due to the level of temperature variation, fire size and fire growth rate and sampling hole locations.

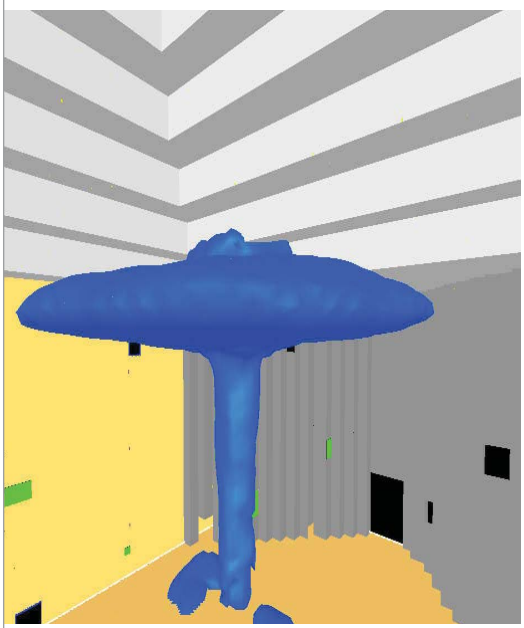
A large number of computer simulations were constructed in order to understand the VESDA system performance in such a challenging environment. Liquid pool fire, standard sofa and timber fires are used in the simulations and the fire sizes ranged from 100 kW to 5 MW. Ventilation conditions are also characterised and different forced ventilation configurations were taken into account. A total of four different fire locations are assessed.

Considering the hot climate conditions during the months of summer in Texas, two different stratification conditions were simulated involving temperatures varying from 68°F to 140°F (20°C to 60°C). With stratification effects taken into account, two solutions with additional VESDA detectors were evaluated.

The following two pictures illustrate temperature profiles with and without stratification after 150 seconds from the start of a 5 MW fire at the central point of the atrium.



The two pictures below show smoke particles movement for fires starting at two different locations; one near the center and the other near the wall.



The following table provides a summary of the simulation results. Note that other parameters such as the Cupola Exhaust Fans operation are not displayed in the table.

Fire		Smoke detected within 300sec		
Size (MW)	Stratification condition	Existing	Solution 1	Solution 2
5	1	Yes	Yes	N/A
5	No	Yes	Yes	N/A
0.5	1	No	Yes	No
0.5	2	Yes	Yes	No
0.5	No	Yes	No	N/A
0.5	No	Yes	No	N/A
0.5	1	No	Yes	No
0.5	1	Yes	Yes	Yes
0.5	1	Yes	Yes	Yes
0.5	1	Yes	Yes	Yes
0.1	1	No	Yes	No
0.5	2	No	Yes	No
1	1	No	Yes	No

Atrium Conditions and Protection

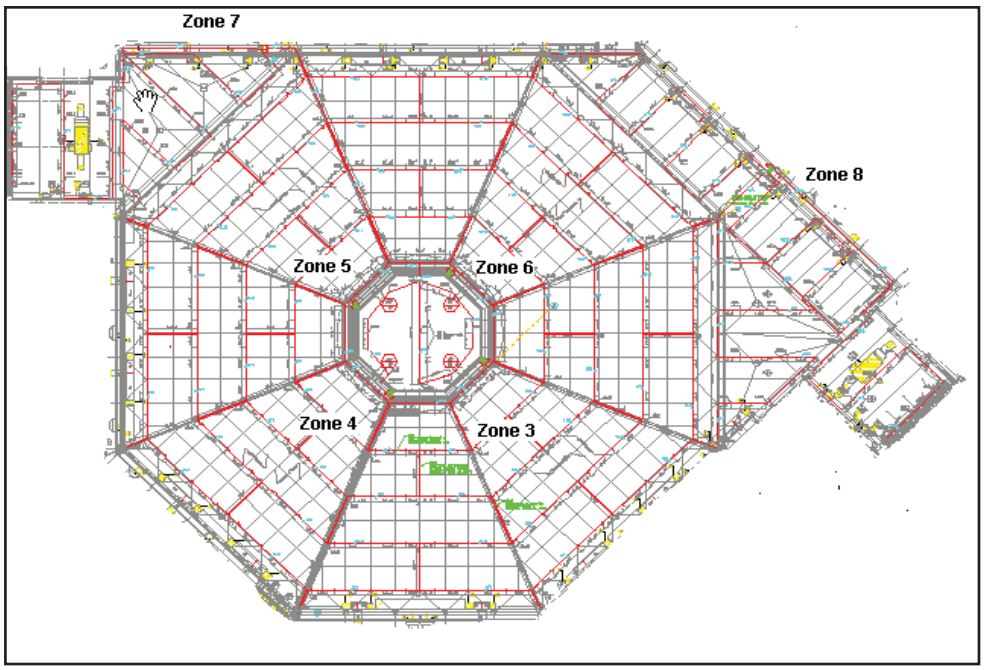
The atrium area is hexagon-shaped. There are four cupola exhaust fans installed on the Cupola part of the ceiling structure with a total ventilation capacity of nearly 100 m^3/s. As for air conditioning in the atrium, approximately 60 to 70 m^3/s (estimated) of fresh air is supplied into the atrium.

The following table shows the normal environmental conditions in the protected area:

Parameters	Value (Average)
Temperature	68°F
Relative Humidity	55%

Detectors Zones 3, 4, 5 and 6 cover one quarter of the ceiling area each. One of the pipes from Zone 7 covers the central part of the dome. Zone 8 covers areas away from the glass ceiling area.

So when a fire starts in the middle of the atrium, it is expected that either Zone 3, 4, 5 or 6 will activate earlier depending on the actual movement of smoke. When stratification is minimal, Zone 7 should activate early as well. Due to the position of Zone 8, it will activate later than others.



Smoke Tests

For the purpose of validating the computer modelling developed by Xtralis, smoke tests were conducted on 11th December 2003.

Representatives from the Hotel's management, fire contractor and Xtralis were present. The smoke test involved a total of six radiant heaters, as well as a certain amount of smoke cartridge to represent a fire size in the order 25 to 26 kW at the start of the fire. The smoke source was positioned on a platform, 3.28 ft (1.0 m) above the floor in the center of the atrium. The smoke test was conducted between 16:15pm and 17:10pm.

On the same day, a representative average background level recorded before the smoke tests was 0.016 %/m (0.005 %/ft).

The smoke level measurements from the VESDA detectors are shown in the plots on the following pages, in the order of time to activation. (Zone 6, 7, 5, 3, 4, 8).

Note the smoke plume and the level of buoyancy. The smoke is moving towards the middle and Zone 6 coverage areas.

Performance Assessment

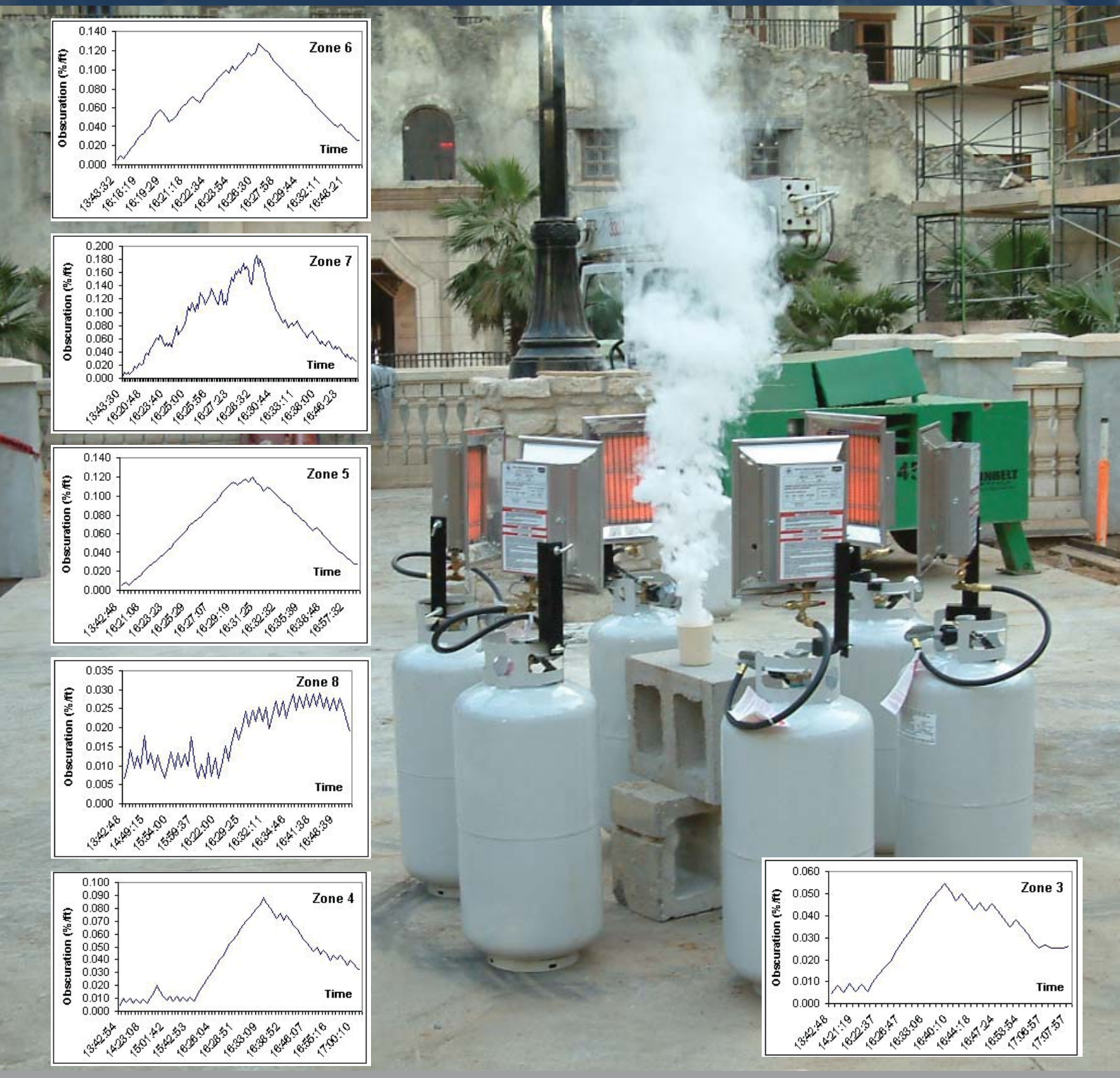
Using the smoke test results, the effectiveness of the detection performance can be assessed. The following table illustrates the status of Alert, Action and Fire 1 alarms recorded from the smoke tests. The smoke thresholds are configured such that Alert = 0.0125 %/ft (0.04 %/m), Action = 0.022 %/ft (0.07 %/m) and Fire 1 = 0.03 %/ft (0.10 %/m).

Again, detector activation time is tabulated in time sequence; Zone 6 responding first and Zone 8 responding last. Zones 5, 6 and 7 all issued Alert within 5 minutes.

Zone #	Alert	Action	Fire 1	Peak Smoke Level (%/ft)
6	3' 05"	3' 15"	3' 29"	0.1278
7	3' 56"	5' 25"	5' 48"	0.1859
5	4' 52"	6' 51"	7' 35"	0.1194
3	7' 37"	10' 20"	12' 33"	0.0544
4	8' 36"	9' 55"	11' 04"	0.0881
8	10' 39"	14' 36"	NA	0.0291

The following relay functions are suggested to respond to a fire event.

Relay	Function
Alert	Supervisory signal in the Siemens panel
Action	Actuates the smoke control process
Fire 1	Activates the building fire alarm system through the Siemens panel


Zone 6
Obscuration (%/ft)
Time
Zone 7
Obscuration (%/ft)
Time
Zone 5
Obscuration (%/ft)
Time
Zone 8
Obscuration (%/ft)
Time
Zone 4
Obscuration (%/ft)
Time
Zone 3
Obscuration (%/ft)
Time

Validation of Simulation Results

It is difficult to simulate fires in such environment to represent the exact smoke growth and environmental conditions. However a trend can be derived when the sequence of all activation events is considered.

The following table provides a summary of the results of different simulation scenarios versus the actual smoke test. In this case, only simulations with the smoke source at the center of the atrium are included. The results are presented in an ascending order from the zone that responds quickest to that responding latest for the actual smoke test and each simulation scenario.

Test										
	A	B	C	D	E	F	G	H	I	J
6	7	7	6	7	7	7	6	Fire	7	5
7	4	6	3	4	4	4	3	size	6	6
5	5	5	5	5	5	5	8	is	5	7
3	3	3	4	3	3	3	5	too	8	8
4	6	4	8	6	6	6	4	small	NA	NA
8	8	8	7	8	8	8	7		NA	NA

This table indicates that the trend from simulation results agrees with the actual smoke test results in that zones 5, 6 and 7 are the first ones to respond and zone 8 is the last. This also agrees with the expected results based on the original design.

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Conclusions

It is a great challenge to provide reliable smoke detection in high ceiling environments such hotel atria, sport stadiums and airport buildings. Early and very early smoke detection is paramount considering egress time requirements, smoke travel from the source to detection points, dilution, high airflow and stratification. VESDA's active air sampling technology provides unparalleled performance in such challenging environments.

Large number of landmark buildings such as this one has a very unusual and innovative design and layout creating equally unique detection challenges. Also conducting real smoke tests to show compliance with "deemed-to-satisfy" fire protection solutions is not always feasible. Therefore, a performance-based design solution involving computer modelling and real smoke tests designed for early and very early smoke detection should be used instead.

To ensure effective smoke detection in a high ceiling atrium, the occurrence of the phenomenon of stratification in these environments needs to be analyzed and addressed.

For a fire size of 5 MW and above, the existing VESDA pipe network design can detect smoke within 5 minutes in simulated stratification conditions with temperature varying from 68°F to 140°F (20°C to 60°C). The actual smoke test results indicate the effectiveness of the VESDA system in providing very early smoke detection in a high ceiling atrium.

VESDA LaserPLUS

Further Information

Xtralis provides advisory services on early and very early warning smoke detection and system performance-based design. Contact your nearest Xtralis office or distributor for further information.

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