Safely reaching new heights

Lift safety testing for tall buildings.

Abstract

In the swiftly-growing and increasingly prominent tall building market, safe and reliable lifts are essential for normal operation. Prior to entering service, all lifts have to pass safety assessment and professional acceptance tests. Subsequently, they must undergo periodic inspections. Lift manufacturers, developers and operators can ensure professional lift safety inspections through state-of-the-art techniques such as the ADIASYSTEM, a computer-controlled diagnosis system. Compared with the traditional load test which is time-consuming, logistically difficult and potentially causing harm to lift components, especially in tall buildings with high capacity lifts running at high speed, the load-substituting testing system utilises a less destructive technique that ensures greater safety, greater reliability and proper evidence for the most crucial safety aspects.
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1. Introduction

Tall building trends

Humanity has ever strived to build bigger, taller and better. Thanks to recent breakthroughs in building systems and technologies, a startling number of tall building projects are rising around the world, shattering record after record. In 1998, the Petronas Towers stood above all other buildings at 452 metres, but by 2020, it will merely be the 27th tallest in the world. Dubai’s Burj Khalifa, which holds the current height record at 828 metres, will be dwarfed by Jeddah’s Kingdom Tower when it is completed in 2019 with a height of more than one kilometre. In just two decades, the “world’s tallest building” will have more than doubled in height.

Looking East

Skyscrapers are also going global. Up to 1990, North America was the home of the vast majority of the world’s iconic skyscrapers, but since the turn of the century, the balance has shifted firmly eastward. As of 2011, only 27 of the world’s 100 tallest buildings were located in North America, while the Middle East accounted for 24 and Asia accounted for 45 – most of these in China alone. North America’s representation had dropped to just 20 by 2013.

Tall buildings are prestige symbols for their home cities, but beyond that, they fulfil important economic needs as well. Rapidly-urbanising countries such as China are eager to utilise new building technologies to create taller and more efficient projects for their growing populations of increasingly affluent urbanites. For developers, tall buildings represent the best way to maximise return on investment where land availability is limited, as is the case in many fast-developing cities. And these investments have shifted in focus. While nearly all the tallest skyscrapers of the 20th century were office buildings, more than half of the world’s 100 tallest buildings are now mixed-use or residential instead of commercial, reflecting the rising market allure of high-rise luxury apartments.
At a time when an unprecedented number of increasingly tall buildings are being built, lift manufacturers as well as building developers and operators need to tackle the challenges of lift safety in these structures.

Lifts are integral to the safe, reliable and successful operation of tall buildings. The taller the building, the more lifts are required to service it. For instance, it takes 57 lifts to serve the 160-storey Burj Khalifa, the world’s tallest freestanding structure. As is the case with very tall buildings, no single lift runs the full height of the building. As one of a growing number of mixed-use skyscrapers, the Burj Khalifa has different sets of lifts servicing its hotel, office and residential zones.

In tall buildings, lift safety and reliability are absolutely critical for day-to-day traffic as well as emergency egress and firefighter access. In case of emergencies, the Burj Khalifa uses lifts from each of the three use areas to aid egress. It is estimated that evacuation of the building using lifts together with stairs reduces total egress time by 45% compared to evacuation without lifts.

Lifts have only recently been introduced as a crucial part of the emergency egress system in tall buildings. Before the turn of the century, fire and building codes generally barred occupants from using lifts for egress during emergencies. However, this approach was largely abandoned in the wake of the 11 September 2001 terrorist attacks, which laid bare the immense difficulties of evacuating tens of thousands of occupants from the World Trade Centre Towers via stairwells alone.

Building owners and operators need to be aware of the changing expectations for lift safety in tall buildings. These expectations are driven by several factors: the evolving state of the art with respect to lift technology in tall buildings, changes in lift codes and standards as well as safety verification procedures, and public awareness of safety issues. Lift manufacturers, lift maintenance companies and independent inspection organisations also need to keep up with the changing face of lift inspection in order to remain relevant and competitive in the market.

**LIFTS IN BURJ KHALIFA, DIVIDED BY USAGE**

- Hotel and serviced apartment passenger elevators
- Corporate office passenger elevators
- Residential passenger elevators
- Fire service elevators

Source: CTBUH
2. The changing face of lift inspection

Increasingly aligned standards, but differing regulations worldwide

Safety procedures in tall buildings are changing with the times, and we can say the same of lift inspections. The growing complications of lift safety in tall buildings call for a second look at the tests we use.

Lift safety standards worldwide

Lift tests must fulfil the requirements of the latest lift safety codes, directives, rules and regulations. The most influential and well-known lift safety standards worldwide are:

- **EN81 series**, which serves as the national standard across the EU. It has also been used as the basis for the national standards many other countries, including Australia, China, Korea, India, Russia, Singapore, Malaysia and South Africa.

- **ASME A17.x/CSA B44.x standards**, which apply to the United States and Canada respectively

- **JIS A 4302**, the inspection standard for Japan (new national standards also based on EN81 are under preparation)

Recognising the global growth of the market and the need for harmonisation for lifts and escalator standards, an international working group drawn from across the lift industry and several international inspection companies is currently developing an ISO series of standards for lifts (ISO 22559-x).

Inspection laws and regulations

While standards are becoming increasingly aligned, lift safety inspection laws and regulations differ wildly around the world. And they continue to evolve. Countries and regions such as Japan, Hong Kong, Singapore and South Africa currently allow “registered engineers” from maintenance companies to perform inspections, which can lead to conflicts of interest. EU countries have largely liberalised their markets, abandoning governmental inspection regimes in favour of accredited inspection companies in accordance with ISO 17020. Countries in the Middle East – some of the fastest-growing lift markets – are also turning to accredited independent inspection companies. However, one trend stands out as particularly relevant to tall buildings: a number of countries have begun to allow alternative weightless testing methods for periodic inspections in place of traditional load tests.
Traditional load tests: Unfriendly to tall buildings

For decades, the industry depended on traditional load tests to verify crucial lift safety aspects, particularly in the all-important safety gear tests and traction tests. Bulky check weights were the accepted means of verifying the fitness of the lift mounting and setting, as well as the soundness of the complete assembly. Today, more modern methods that provide added value are available, especially in the case of lifts in tall buildings.

With the availability of more modern test methods, load tests no longer serve the best interests of tall buildings. The reason has to do with the problems of mass and speed.

Requirements of lifts in tall buildings

While the basic principles of lifts have never changed, cars must now travel farther as buildings become ever taller. For every additional floor that a lift must reach, the weight of its ropes increases. Thus, the masses transported are much greater. In the Burj Khalifa’s main service lift, which traverses 504 metres, steel ropes will account for about three-quarters of the moving mass.

Greater speeds and forces also come into play where lifts in tall buildings are concerned. Tall buildings are often equipped with high-speed or ultra-high-speed lifts to overcome the longer travel heights and serve the large number of floors more efficiently. These powerful lifts can reach speeds of as much as 60km/h. When combined with the greater moving masses, these higher speeds require much longer braking distances. To compensate, high-speed lifts often have more powerful brakes, and additional features such as an additional tensioning pulley in the pit, tensioning cables below the car and an anti-rebound system to reduce the jumping height of the car in the headroom.

Where load tests pose greater risks

The impacts generated from full load/full speed safety tests can inflict a wide range of deteriorating effects and stresses on cab components, guide rails and the building itself. Traditional full load tests at high speed imply unnecessary stresses to the lift. This is because kinetic energy increases geometrically as speed increases. This means if you double the speed, kinetic energy goes up by a factor of four. Thus, the safety gear must absorb a much higher amount of energy than it would in a shorter building.

In short, traditional full load tests in taller buildings involve greater masses and speeds, and hence greater risk of damage.

Accuracy problems of load tests

Another problem is that load tests are inaccurate in determining the correct deceleration. Safety gear test results are determined by measuring slide marks on rails to see if a lift stops within a permissible range of stopping distances. These results are essentially “pass/fail” and do not yield more meaningful information.
that might predict future problems before they arise. The same is true of load testing for traction tests, which do not provide measurements to help determine the rate of traction degradation between ropes and traction sheave over the long term.

Logistical difficulties due to load tests

Many building owners and operators shun load tests for periodic inspection because they consider the amount of disruption to operations and unpredictable damage to be unacceptable.

High-energy safety gear tests in tall buildings can be extremely noisy, causing unnecessary alarm to occupants and visitors. Transporting bulky check weights into ground-floor lobbies and other lift access areas can also disturb the business environment. In addition, dropped weights can damage floors and other elements of the building interior.

Many building owners and operators shun load tests because the amount of disruption to operations is considered unacceptable.

Managing and handling the check weights needed for load tests can be a logistical nightmare for tall buildings. In a five-storey building, a load test for a four-person lift may only require 375kg worth of weights. In contrast, a skyscraper might have a 20-person lift rated at 1,500kg, which would require 1,850kg worth of weights for a load test. In some cases it may be necessary to move thousands of kilogrammes of bulky weights a great distance from the parking lot into the building. Moving check weights through the city is time-consuming and can result in risks to handlers, significant costs (from truck, driver, parking ticket and fuel) and sustainability impacts.

3. A technological leap for accuracy and reliability

An alternative testing method available since 1990

Given the drawbacks of load tests, many manufacturers, owners and operators looked to alternative test methods made possible by leaps in testing technology. Stakeholders around the world have found that modern weightless testing methods can help them achieve equal or greater safety and reliability for lifts in tall buildings, compared with load tests.

Many important lift markets have responded to this technological shift with legislation that supports the use of alternative weightless tests. Among the changes:

- For more than 20 years, Germany has permitted the statutory load test in compliance with national regulations for both traction as well as hydraulic lifts to be legally replaced by a so-called equivalent no-load method using an empty lift car.

- SS 550:2009 (Singapore) permits balance point checks to be performed using alternative methods to load tests.

- The 2013 edition of the ASME A17.1/CSA B44 (North America) will permit alternative test methods with no load for tests specified under Section 8.6.4.20.

To meet the safety needs of the market and keep pace with the hectic growth of skyscrapers worldwide, lift inspectors need to adopt computerised safety-relevant tests. Such alternative solutions in particular have to provide proper evidence for the most crucial safety aspects that have traditionally been checked by load tests.

The ADIASYSTEM method developed by TÜV SÜD in 1990 was the very first modern weightless testing method world-wide. Since then, its hardware and software have undergone continuous further development. Today, the system is known as a leading technology in this field of application.
ADIASYSTEM: A sophisticated equivalent test method

TÜV SÜD developed ADIASYSTEM to serve as an accurate, inexpensive, convenient and energy-saving alternative method for lift safety testing.

Data logger and travel gauge

The system verifies the free fall with rated load stopping capability of the safety gear. A data logger directly measures the decelerations of the empty car after application of the safety gear. The recorded results of the accelerometer give an accurate prediction of the full load/full speed condition. This is one of the important safety-relevant criteria, which is specified in the codes as the worst-case scenario. In addition, a travel gauge measures distance travelled and the speed of the car.

Pressure gauge

The system is capable of providing accurate and highly reproducible pressure flow measurements to identify faults in hydraulic lifts.

A test method for providing a competitive edge

ADIASYSTEM solves the logistical problems of load tests, replacing the encumbrance of check weights with a lightweight electronic and computerised testing package. Inspectors need only wheel the entire test kit on a trolley from one lift to another, ensuring that business operations will not be disrupted for long. These electronic devices let inspectors gather more precise and extensive measurements than they could with traditional methods, and in less time. The testing process thus saves labour, wear and costs.

The system was introduced in 1990 as the first equivalent no-load test method world-wide to replace the complete scope of load tests on lifts. Over the years, TÜV SÜD has continued to further add to the system’s available testing features, while also improving the accuracy of gauges and user-friendliness of hardware and software.

Traditional full load tests at high speed imply unnecessary stresses to the lift. The weightless testing system enables a reduction in the previously required high testing speed. As the safety gear only needs to absorb a small fraction of the kinetic energy to verify the correct and code-compliant settings, these tests can be considered less destructive.
4. Business benefits

ADIASYSTEM verifies important aspects of lift safety and reliability in safety gear tests, traction tests and other tests, fulfilling the same function as load tests. As such, it contributes significantly to overall lift safety. Because of the reduced logistics and auxiliary costs, it is also a more environmentally friendly method compared with load tests.

With a successful track record of more than 20 years, the test method has proven its worth in over a million safety tests around the world. Through data logging or online measurement with a range of different electronic sensors, the system gathers traceable proof of test compliance and completely replaces the need to use potentially damaging full loads in inspections.

The system also provides a complete documentation trail, ensuring that results are genuine and allowing inspectors to meet quality assurance and traceability requirements. Using these measurements, gradual degradation of systems can be found and corrected before they become a problem.

As independent providers of testing, product certification and system certification, TÜV SÜD’s companies are accredited to offer certification as a Notified Body in several European countries, and as an Accredited Elevator/Escalator Certification Organisation (AECO) in North America.

TÜV SÜD has in-depth experience in lift inspections going back 100 years, and is an active participant in national and international standardisation committees. With over 800 locations worldwide, the company provides maintenance management support services, lift warden training and courses on the Lift Directive, standards and codes in key markets.
5. Conclusion

The trend towards taller buildings, particularly in markets in Asia and the Middle East, calls for realistic and reliable safety tests for lifts used in these buildings. Unfortunately, traditional load tests fall short of the needs of the current and future generations of high-rise buildings. The high masses and speeds involved in load tests for tall buildings can damage lift components and elements. Load tests for lifts in tall buildings are also time-consuming and logistically difficult, may provide limited metrics and inexact results, and are no longer state-of-the-art.

Lift safety legislation in a number of countries permits alternative testing using a computerised electronic weightless testing system such as TÜV SÜD’s ADIASYSTEM. In the context of lift inspection for tall buildings, the solution is superior to load testing because it is:

- less expensive and less time-consuming
- not harmful to lift components and equipment, property or implied workers
- more precise and gathers more extensive and decisive data
- traceable and cannot be falsified
- more environmentally friendly

TÜV SÜD has performed over a million safety tests around the world with this computer-driven universal expert system for lift inspection that serves as a complete replacement for load tests. With the system, lift manufacturers and installers can reliably safeguard installations of new lifts, while owners and operators of tall buildings can achieve greater reliability, accuracy, speed and convenience in periodic safety testing.

The solution has enabled clients to filter out a considerable number of lifts running with faulty safety gear systems. These results exceeded those obtained by traditional inspections by a wide and unexpected margin. Clients can therefore be assured of an appropriate testing method that substantially increases lift safety.
**GLOSSARY OF ACRONYMS**

- AECO – Accredited Elevator/Escalator Certification Organisation
- ASME – American Society of Mechanical Engineers
- CTBUH – Council on Tall Buildings and Urban Habitat
- CSA – Canadian Standards Association
- EN – European Standard
- SS – Singapore Standards
- TRBS – Technical Regulations for Safety in the Workplace

**FOOTNOTES**

[3] Ibid.

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Find out more about TÜV SÜD’s lift and escalator safety solutions

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