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Lifts (elevators) — Study of the use of lifts for evacuation during an emergency

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National foreword

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Lifts (elevators) — Study of the use of lifts for evacuation during an emergency

Ascenseurs — Étude de l'utilisation des ascenseurs pour l'évacuation lors d'une situation d'urgence

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Contents

Page

Foreword

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In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 25743 was prepared by Technical Committee ISO/TC 178, *Lifts, escalators and moving walks*.

Introduction

This Technical Report has been prepared in response to a request for an investigation into the implications of the use of lifts[1] (elevators) for the evacuation of persons during various types of building emergencies. There has been considerable debate over recent years with regards to the hazards and risk associated with using lifts for evacuation. There is clearly a need to determine what hazards and risks exist and what can be done to the building and lifts to minimize these risks if lifts were to be used.

The purpose of this Technical Report is to investigate the risks to persons using lifts to evacuate a building during an emergency.

Lift engineers and firefighters were involved in the production of this Technical Report. It is fully recognized that lift engineers are not experts in building design or fire engineering; therefore, this Technical Report does not attempt to resolve issues in these areas. It aims to make clear to those persons involved in building design and fire engineering the issues that need to be addressed. Not all of the issues set out in this Technical Report need to be addressed in all building designs.

There are many reasons why a building can need to be evacuated, such as a fire, explosion, chemical or biological attack, flooding, storm damage or earthquake. Not all of these are relevant to every building and other possible risks are so unlikely to occur that they can be disregarded. It is the responsibility of the building designer(s) to determine whether a particular risk is sufficiently great to require addressing.

If, for example, a small office block is being designed for a mid-town area, it is within the realms of possibility that it can be subjected to an explosion or chemical attack (as a result of terrorism). It is not, however, very likely to be the case unless there exists some particular reason to make it attractive or susceptible. In most cases, the risk of these events is probably so low as to make it unnecessary for them to be addressed.

If a building is intended to be the headquarters of the military, this increases the likelihood of it being subjected to some form of attack. It is, in that case, necessary to consider the effect of an explosion in or close to the building or a chemical agent being introduced into the building.

A building constructed in an area where earthquakes do not normally occur need not have provisions made for such an event.

If a building is intended to be located in the centre of a city to form a prestigious landmark, consideration of all the possible events that might occur can be essential.

It is the responsibility of the designer of the building to determine by risk assessment or other methods what events reasonably need to be addressed. Once this is done, the chart provided in Figure 1 can be used to see what needs to be considered, if lifts are to play a part in any evacuation strategy.

A lift or lifts can allow disabled persons to evacuate a building in relative ease, but if it is thought that lifts can play a role in general evacuation, it is possible for them to make a significant contribution to reducing the general evacuation time. This depends on the building size, number of lifts, etc.

This Technical Report does not concentrate on the evacuation of disabled persons, but instead highlights and addresses the hazards and risks to which all users can be exposed if lifts are used for evacuation.

Even if it is thought that lifts can play a part in a general evacuation, it could prove to be uneconomic. It is not suggested that lifts should replace stairs or that using lifts instead of stairs will increase evacuation times in many building designs.

1) Hereinafter, the term “lift” is used instead of the term “elevator”. In addition, the term “lift” is also used instead of the terms “lifts, escalators and moving walks”.

Lifts (elevators) — Study of the use of lifts for evacuation during an emergency

1 Scope

This Technical Report investigates and highlights the main risks associated with using lifts (elevators) for the evacuation of persons in various types of emergency.

The types of emergency under study arise from fire, flood, earthquake, explosion, biological or chemical attack, gas leakage, lightning or storm damage in the building being studied or a building adjacent to it.

The purpose of this Technical Report is to provide a process for making decisions relevant to the design of lifts and buildings, in order to determine if a given design can enable the lifts involved to be used with an acceptable level of safety.

It is not intended that all buildings be designed for all risks and, consequently, it is not intended that all lifts incorporate all features mentioned. It is the responsibility of the building designer to determine events that are likely to occur, given the building's importance, function, occupancy, status, location, use, size, etc.

It is not the responsibility of, nor is it possible for, lift manufacturers to determine whether or not a lift can be used safely as a means of evacuation in a given building. It is the responsibility of other parties to make this decision. The lift manufacturer can only advise on the capabilities of a particular lift design or the status of the lift at a particular point in time.

The philosophy adopted in this Technical Report can be applied to any building, be it large, small, new or existing. In practice, its application to existing building designs can prove to be difficult and uneconomic in many instances.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
building management system
BMS
system capable of making intelligent decisions based on information sent to it

2.2
building management
persons or organization responsible for ensuring the day-to-day safe, efficient running of the building and for ensuring that the building is safely evacuated in line with the evacuation strategy in an emergency

2.3
emergency command centre
room, area or location within or outside the building, where those responsible for evacuation receive information, issue instructions and manage events as they unfold

2.4
fire compartment
fire separated area
area within a building bounded by walls, floor and ceiling, constructed from fire-resistant material, such as to provide resistance to fire for a defined period

2.5
hazardous area
floor or area in the lift well where, due to heat, smoke, gas, etc., the environment is considered dangerous to persons

2.6
required evacuation time
time measured from start of the lift evacuation service to completion of the evacuation of a floor or number of floors

2.7
safe area
floor of the building where it is known that heat, smoke, etc. are not present and where it is safe for people to exit a lift car

3 Abbreviated terms

B	building-related
BL	building- and lift-related
BMS	building management system
L	lift-related
TSR	technical solution required
TSRB	building technical solution required
TSRL	lift technical solution required
TSRBL	building and lift technical solution required
ETA	estimated time of arrival

4 Use of the decision chart

4.1 General

The chart in Figure 1 should be used to study a particular building design. Where reference is made to adjacent buildings, the intention is to consider the effects of incidents in the adjacent buildings on the building design under study.

Steps 1 to 8 of the chart contain various numbered boxes. The numbers do not run in any particular sequence and are provided for reference only. Certain boxes contain a series of upper case letters and a number, e.g. TSR16B. These are inserted at points where some form of design provision needs to be made. TSR stands for “technical solution required”. The number is the reference of the technical solution and the last letter gives an indication of who needs to address it. “B” is used to indicate that the issue is building-related. “L” is used when the issue is lift-related and “BL” where both are involved and a joint solution is required.

Possible technical solutions have been identified for lift-related issues and these have been further studied using the ISO 14798 risk methodology. Where a building solution is required, this has been left to those responsible for building design, although some pointers are given to assist in the thought process.

An explanation of each TSR is given in Annex A and a summary of the points is given in Annex B.

4.2 Example of use of the decision chart

In the decision chart, Figure 1 a), box 1, states: Emergency detection system or building management detects problem in building A or an adjacent building B — TSR00B.

This TSR assumes that either some system has detected an emergency or the building management has detected it. In the case of building management, it is likely that they are observing an event or have had the situation reported to them.

TSR00B indicates that a technical solution is required to detect emergencies and B indicates this is not a lift issue, but a building issue, to be solved by the building designer. The solution in low-risk buildings can be a building management procedure to deal with the situation or a simple detection system. In high-risk buildings it can be a very sophisticated detection system. It is the responsibility of the building designer to determine the level of sophistication required to address the given building risk. There is no need for building A to have a system which is also monitoring building B. Building B would have its own system and in the event of a fire, staff in building A are likely to see the adjacent building being evacuated or to see the fire.

Box 178 asks “Is the emergency a fire in building A?” and references TSR41B. Building A refers to the building design being studied, but this building can be put at risk by events in an adjacent building. In the decision chart, an adjacent building is referred to as Building B.

TSR41B indicates that this is an issue to be addressed by building design. Some means should be provided to enable building management to tell if the emergency is a fire in their building.

If it is assumed that the emergency is not a fire in the building being studied (building A), then one moves to box 174: Is it some other emergency in building A? — TSR16B.

If the answer to this is yes, box 12 is next. This explains that an explosion, terrorist attack, gas, biological attack, water, structural failure, lightning strike or storm has occurred in the building and that it is possible for it to affect the building structure.

These emergencies are deliberately selected because their outcome covers almost all possible emergencies. Other emergencies, while not mentioned by name, are addressed. For example, a lorry crashing into a building can, in the worst-case scenario, result in damage to the building structure and possible structural failure.

After box 12, comes box 28b (TSR11B). TSR11B indicates that this is another building design issue. It is the responsibility of the designer to decide if the building is of sufficient importance to make detecting events that affect the building structure essential. If no provision is made to monitor the structure, this decision cannot be made by persons other than those observing the structure.

If the event is assumed to be an earthquake then box 31 is relevant; it states: Building management or instruments detect(s) problem and, if over magnitude X, BMS instructs lifts to shut down at defined parking locations away from potential danger area. If event over Y, shut lift down immediately — TSR14BL.

TRS14BL indicates that there are both lift and building issues to be addressed. It is the responsibility of the building designer to determine how and where to monitor the structure.

Once a means is provided, it is the responsibility of the designer to also decide how sophisticated the lift reaction should be to this event. If the lift system can only be sent one signal from the monitoring system to indicate that an event has taken place, the lift is only able to make one response. This can be to stop the lift in flight which means that there is a high probability of passengers being trapped. If a monitoring system is able to indicate to the lift the magnitude of the event, then other reactions are possible “at a magnitude X, take lift to a floor and wait”, “at a magnitude Y, stop lifts” and so on.

The lift maker needs to make the lift respond in the desired manner, but it is the responsibility of the building designer to determine for the building what amount of structural movement is an issue requiring a reaction from the lift system.

Box 33 says: Check equipment displacement, make slow speed check run, guide alignment, etc. — TSR15L.

TSR15L indicates that these are tasks to be managed by the lift designer. Unless some reasonable degree of self-monitoring is provided on the lift, it is dangerous to allow it to continue to operate when the building has undergone a large shock.

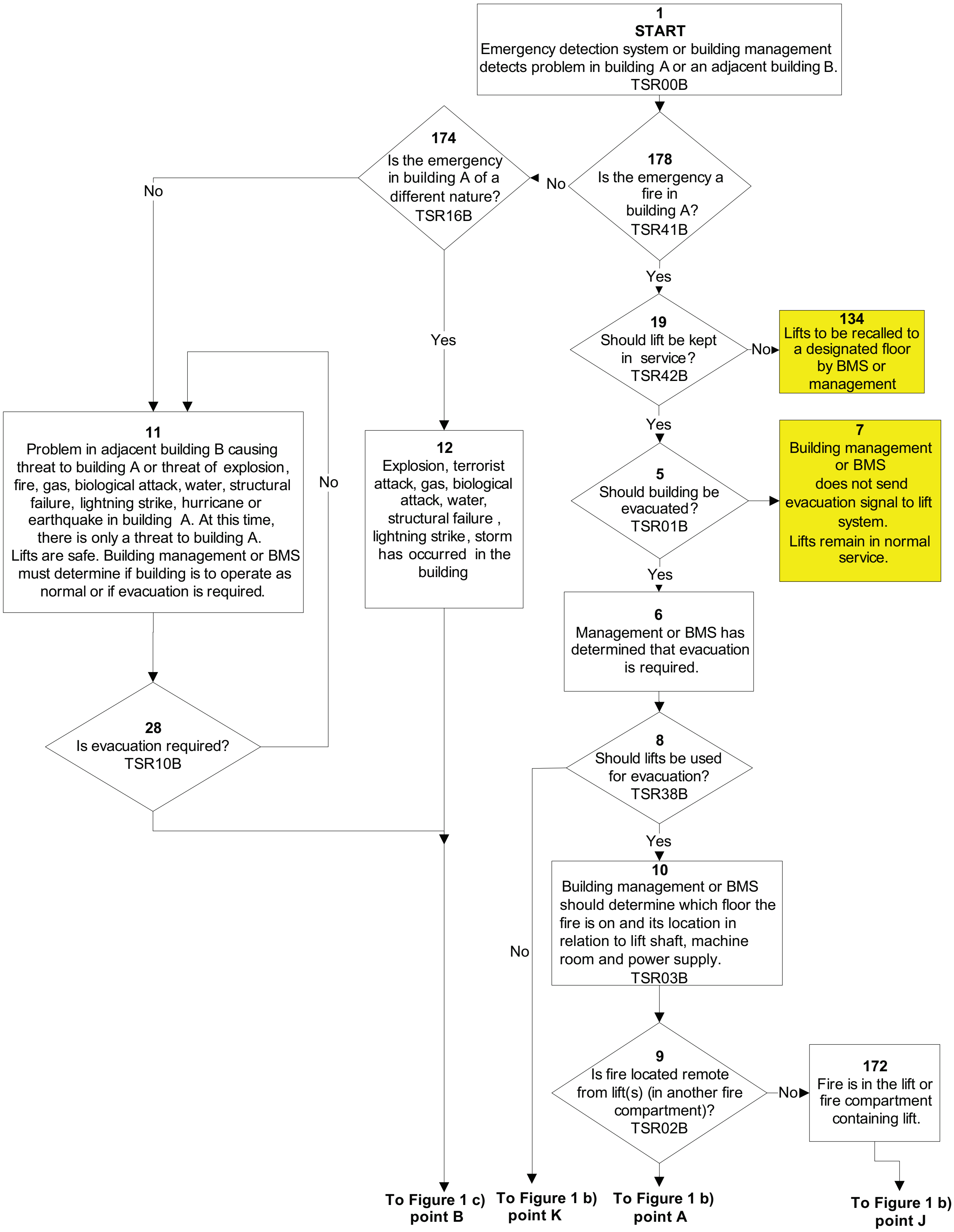
The lift system should determine if it is safe to move the lift. If it is assumed that these self-checks have concluded that the lift should not be operated in the normal manner, then box 147 says: Recover car to closest floor or raise alarm for trapped passengers. Signals and voice information for passengers trapped in lift car. Notify BMS and management — TSR07L.

After checks are made, box 143 asks: Can lift be used safely?

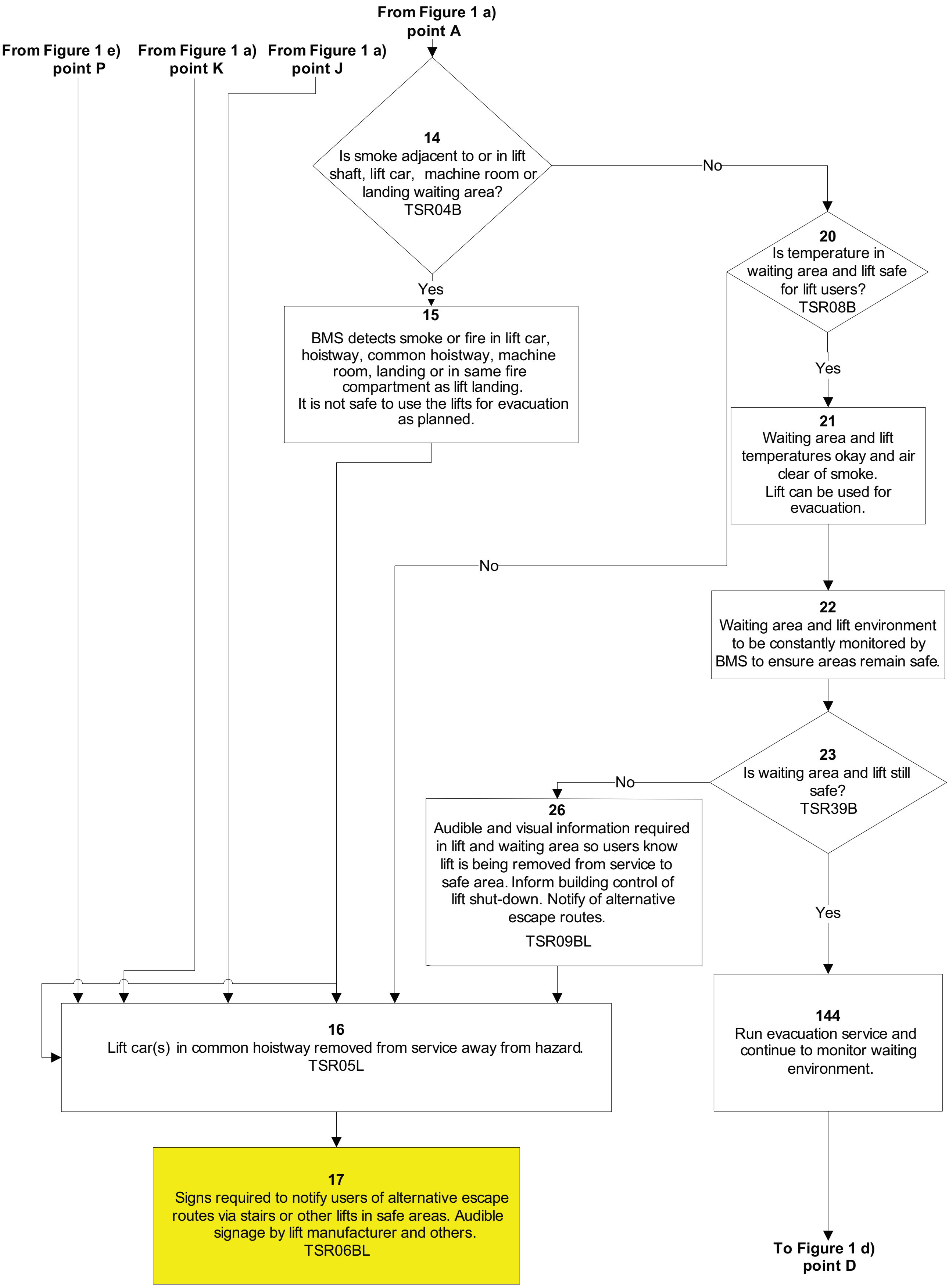
This clearly indicates the design requirements for the lift maker in terms of signal, etc. and response of the lift.

When using the chart, it is important to always work through the particular scenario from the beginning of the chart. If this is not done, it is likely to become misleading and lead to wrong conclusions.

Annex A provides additional information for each (TSR).



a) **Decision step 1**



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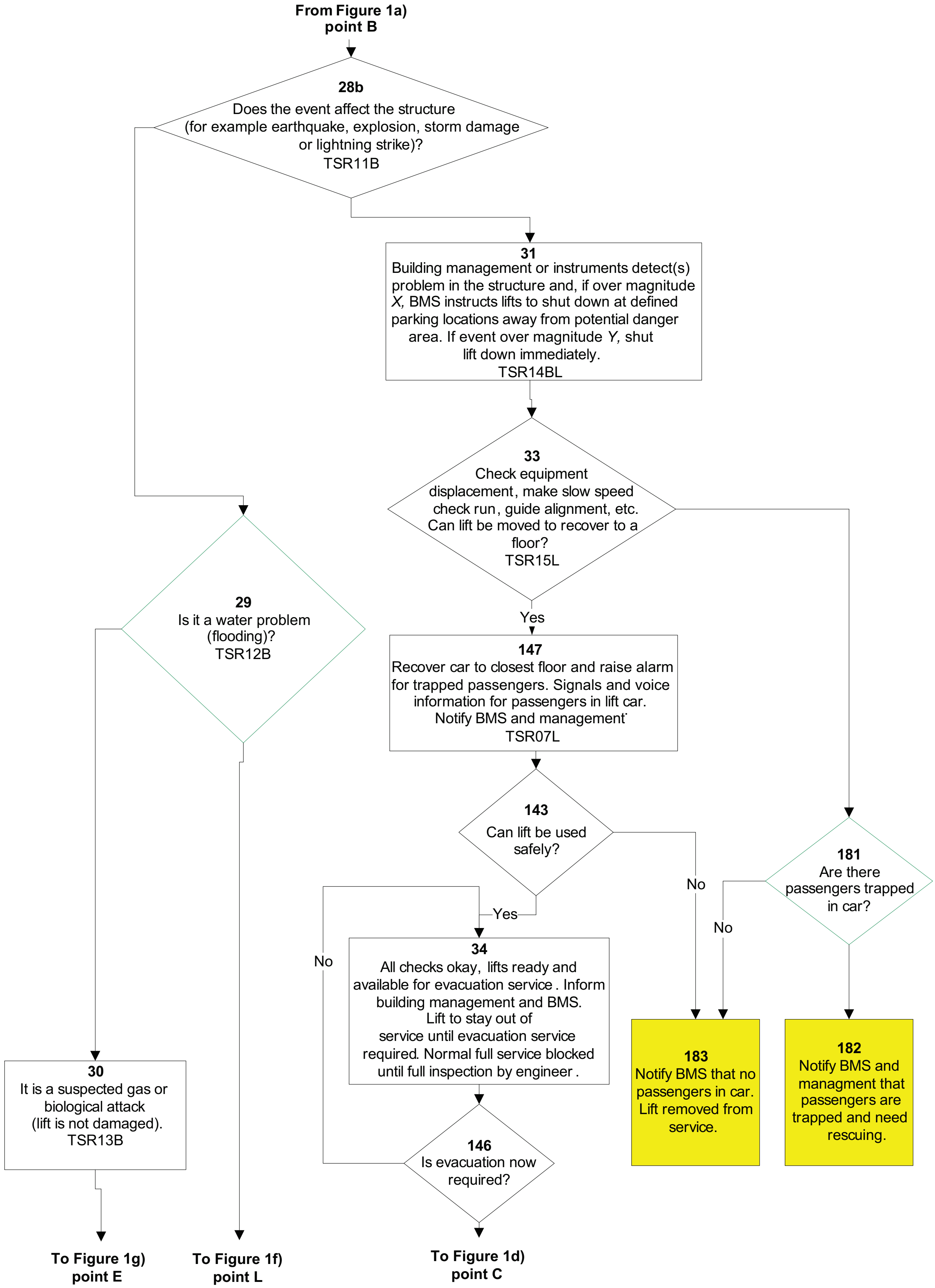

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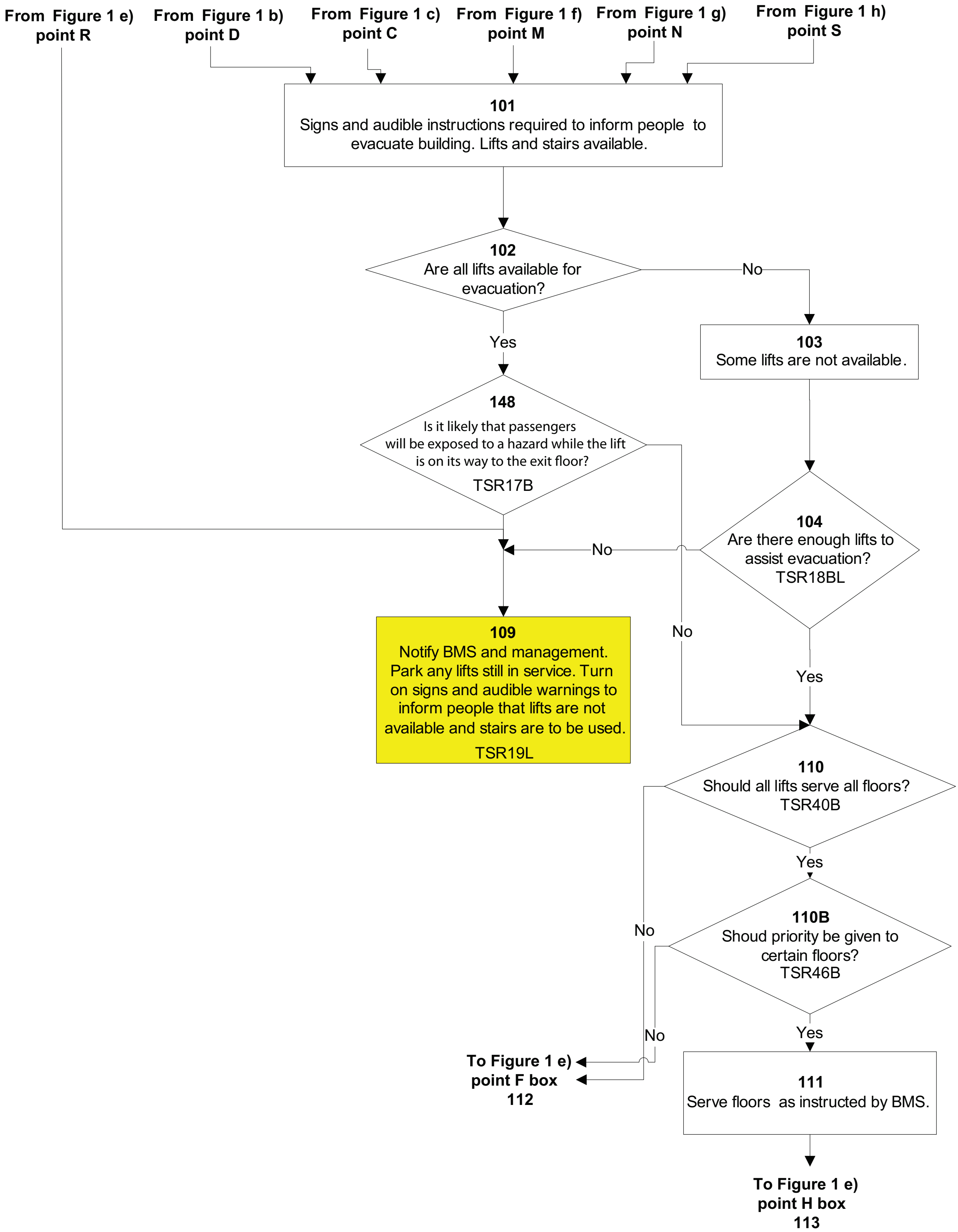

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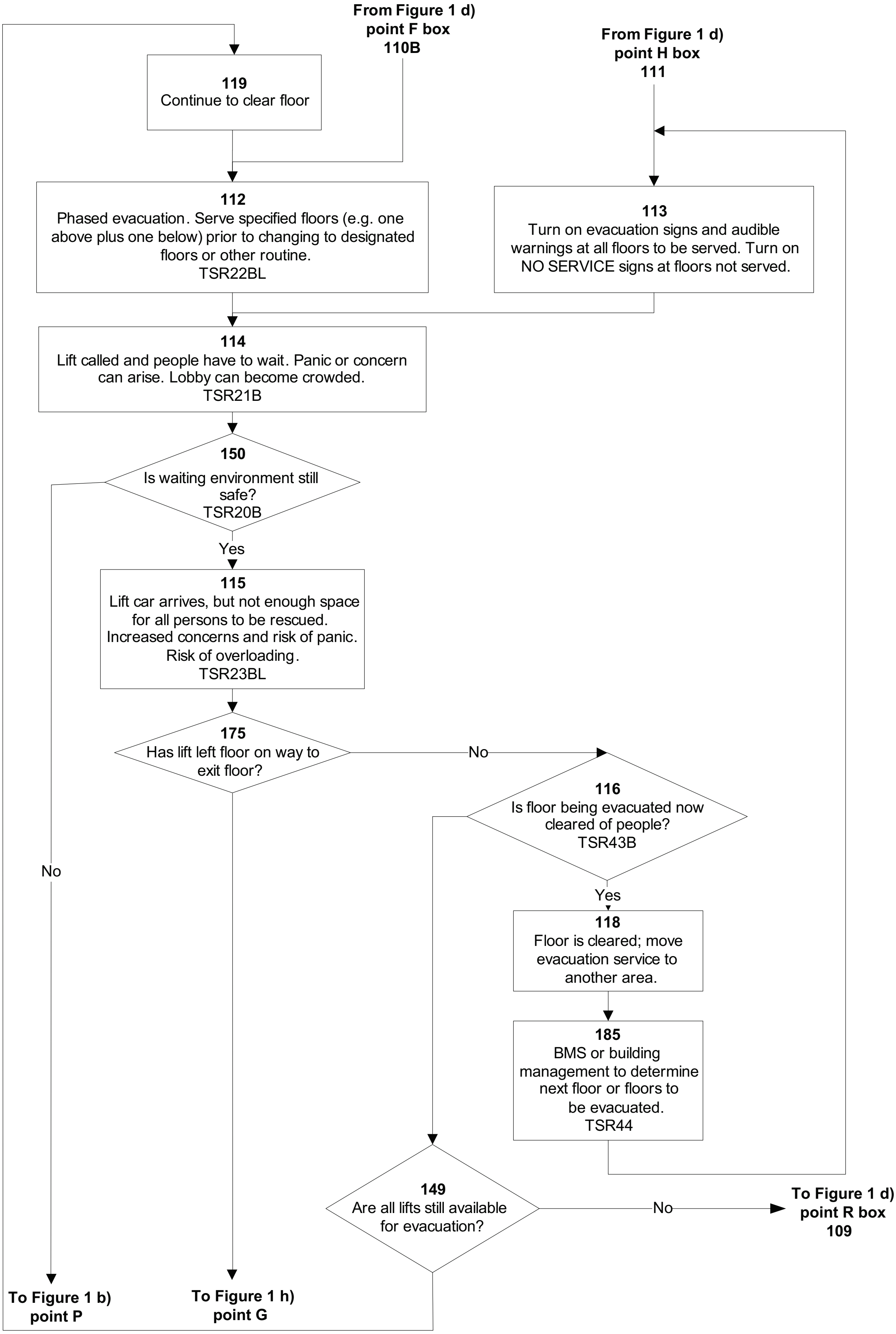

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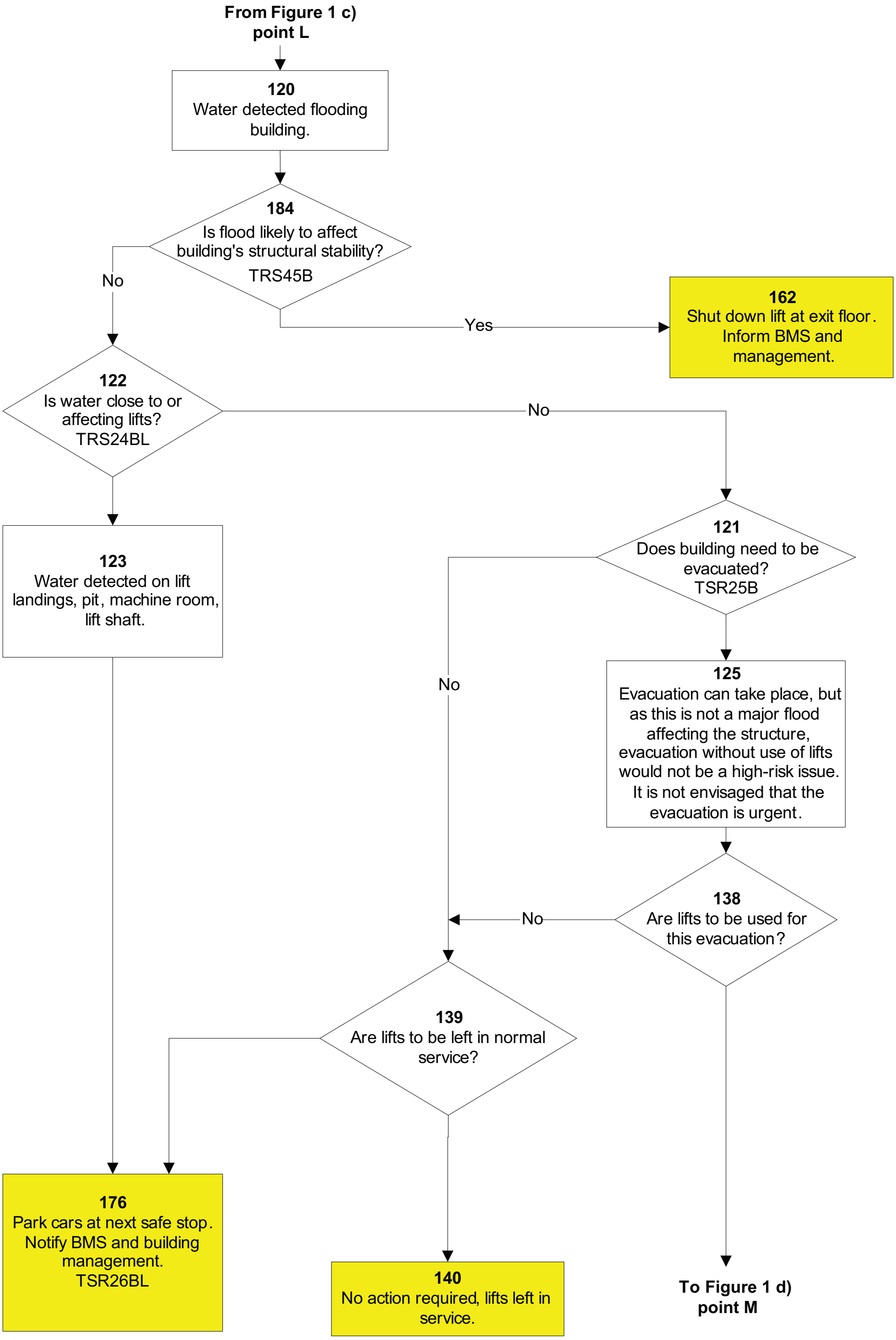

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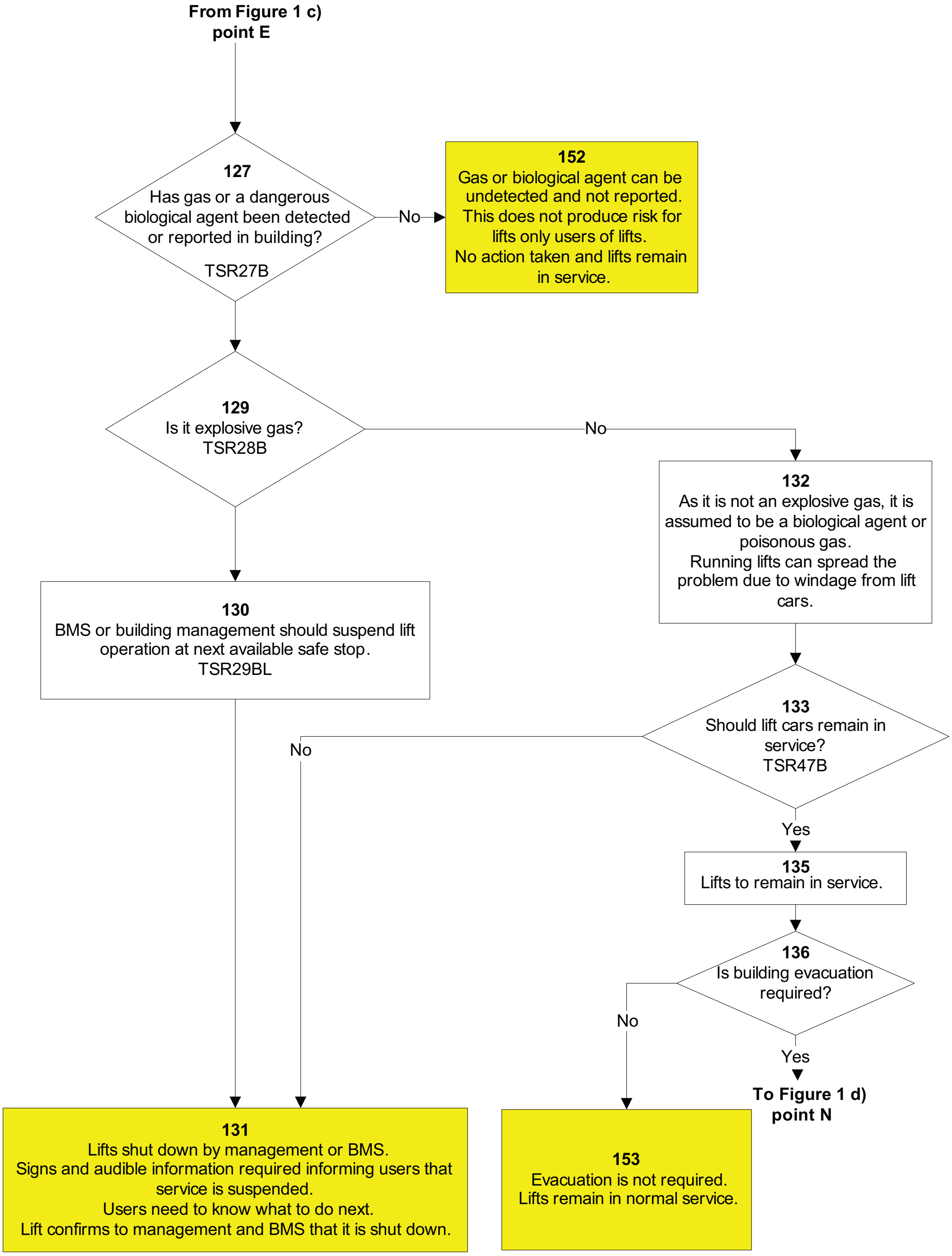
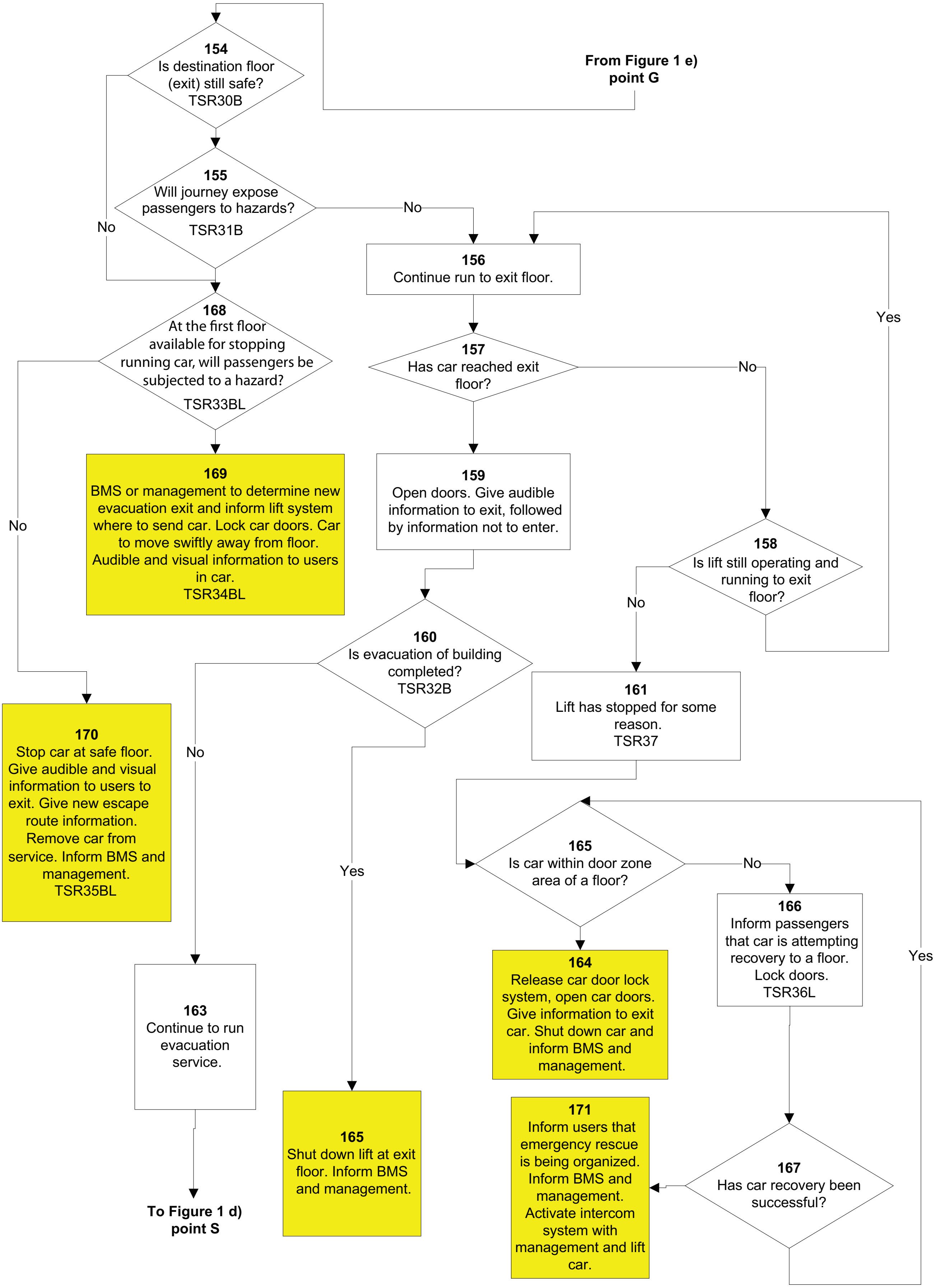


g) Decision step 7



h) Decision step 8

Key

BMS building management system

ETA estimated time of arrival

TSRB building technical solution required

TSRBL building and lift technical solution required

TSRL lift technical solution required

NOTE Building A is the building being designed or studied; building B is an adjacent building that can cause a threat to building A.

Figure 1 — Decision chart

Annex A
(normative)

Further explanation of technical solutions required

A.1 Explanation of technical solutions required

A.1.1 TSR00B, Figure 1 a), box 1, states: Emergency detection system or building management detects problem in building A or an adjacent building B.

It is the responsibility of the building designers to determine the method of emergency detection. In small, simple buildings, this can be left to the building management. In complex buildings, a sophisticated detection system can be employed in all areas of the building. This sensing can include the detection of fire, heat, smoke and structural vibration.

The more sophisticated the detection system employed, the more precise the level of information available to make decisions and the more meaningful these decisions are. If a sophisticated system of information gathering is used, it should also be determined how this can be best displayed or used. A small amount of information can be simply displayed using lights on a console, but where complex information is gathered, this probably needs to be fed to an intelligent BMS, which should determine exactly what is going on.

It is the responsibility of the building designer to determine the decree of sophistication required, taking into account the importance of the building, the type of occupancy, etc. It is important to remember that if the type of emergency cannot be determined with any accuracy, it is not possible to make sound decisions regarding what lifts should do.

Lifts only do what they are told; therefore, if the lift is required to respond in different ways to different types of emergency, the lift system needs to be informed of the type of emergency taking place.

Information to confirm whether or not the problem is in an adjacent building is likely to be gathered by persons observing what is going on in an adjacent building or by information passed on by the emergency services, the public, etc.

If the problem is in an adjacent building, lifts in the building being considered for evacuation are not directly in jeopardy. This does not mean that they are safe to use, but it is reasonable to assume that they would operate if required to do so.

Assuming the issue is not in an adjacent building, it is understood to be in the actual building, but the type of emergency needs to be determined by some means.

A.1.2 TSR01B, Figure 1 a), box 5, asks: Should building be evacuated?

This is not a decision to be made by lift engineers, but by other experts and those responsible for building management. Those tasked with making such decisions need to be provided with clear information from building systems or other sources that lets them know what is going on, where it is happening and how serious it is. In some emergencies, it can be better not to evacuate the building, i.e. to minimize the spread of harmful substances. If the building is not to be evacuated, it needs to be determined what action, if any, is to occur. Are the building occupants to be informed, are the lifts to remain in use or are lifts to be moved to a particular location?

If the building is not to be evacuated, box 7 indicates that the lifts remain in normal service.

If the building is to be evacuated, it needs to be determined if lifts should be used (see box 8, TSR38B).

A.1.3 TSR02B, Figure 1 a), box 9, asks: Is fire located remote from lift(s) (in another fire compartment)?

"Remote" means in another fire compartment. The fire detection system needs to determine not only that there is a fire, but the temperature and presence of smoke in relation to the lift. In high-risk buildings, it can be advantageous to also determine the rate of spread of fire and its direction. Persons responsible for the design of the building and its power supply need to determine the type of sensing equipment required to properly monitor the conditions of these items.

A.1.4 TSR03B, Figure 1 a), box 10, states: Building management or BMS should determine which floor the fire is on and its location in relation to lift shaft, machine room and power supply.

It is essential to know the exact location of the fire in relation to the lift. It can be the lift itself that is on fire. Unless it can be established with certainty that the lift is safe, it should not be used.

A.1.5 TSR04B, Figure 1 b), box 14, asks: Is smoke adjacent to or in lift shaft, lift car, machine room or landing waiting area?

It is vital that the location of smokes in relation to the lift shaft, machine room, lift car and landing areas be known. This means that these areas need to be properly monitored by building systems in order to detect smoke.

It is the responsibility of the specialist in this field to determine the design of the detection system. The type of detection selected should then be reported to the lift manufacturer to enable the fitting of similar devices to the lift car. If detection devices are required in lift machine room areas or lift shafts, the type and location should be specified by the appropriate specialist and not the lift manufacturer, as these devices should form part of the total detection system and not part of the lift.

Information from these detection systems should be fed to a BMS and a manual control point located in an emergency command centre, if provided.

A.1.6 TSR05L, Figure 1 b), box 16, states: Lift car(s) in a common hoistway removed from service away from hazard.

On receipt of a signal (automatic from a BMS or manual from an emergency command centre), lifts are to advise passengers to leave the car using signs and audible warnings. There should also be signs on landings and audible warnings to advise users not to enter lifts. Lift doors are to close at slow speed with an audible warning. Any stationary lift is to run to a floor chosen and instructed by a BMS or the building management.

Any lifts running should be allowed to complete their journey to a safe area or predetermined location. On arrival, no further movement is to take place unless instructed by a BMS or the building management using a manual override signal.

Lift Door Open buttons should remain in operation, but the doors should normally be closed while the lift is parked. Other parties need to design the BMS to enable it to automatically select a safe floor (see definitions) to which the lift is to run. They should also design the building signs and information required on the landing where the lift is. These should be activated at the time of incident.

NOTE These are not lift signs, but building signs.

Lift designers are to ensure a lift door nudging system is employed to get the doors closed as quickly as possible.

A.1.7 TSR06BL, Figure 1 b), box 17, states: Signs required to notify users of alternative escape routes via stairs or other lifts in safe areas. Audible signage by lift manufacturer and others.

Very clear visual and audible information/instructions need to be given on each landing to inform users that the bank of lifts or lift is NOT available for evacuation.

It is necessary to inform those wishing to evacuate, where they should go and what they should do. The design of this information and its location in relation to the lifts is critical. The system needs to be dynamic in nature so as to accommodate changes in the situation. In addition to information provided at the lifts, similar information should be given on routes to the lifts, thus avoiding persons having to retrace their steps if the lifts are not operating.

If potential lift users are directed to other lifts, these should also be suitably designed for evacuation use and put to evacuation service by the building management or BMS.

Building designers need to design the signs and information with great care so as to ensure they are clear, unambiguous and conspicuous.

A.1.8 TSR07L, Figure 1 c), box 147, states: Recover car to closest floor or raise alarm for trapped passengers. Signals and voice information for passengers trapped in lift car. Notify BMS and management.

It has been determined that the lift can be damaged by a large shock to the building. As soon as it is established that safe use is not possible, the lift should be moved at slow speed and parked at the closest floor to its current location.

The BMS or building management should be alerted to the lift condition automatically.

If it is not possible to recover the car and passengers are trapped, they should be informed by signs and audible messages that the alarm has been raised and they will be rescued.

It needs to be possible for passengers to speak to the building management by way of an inter-communication unit. It is the responsibility of the management to have the ability to remotely deactivate the car door locking system (see TRS34BL), if they believe this can be an advantage for the trapped passengers.

A.1.9 TSR08B, Figure 1 b), box 20, asks: Is temperature in waiting area and lift safe for lift users?

The temperature in any waiting area and lift car needs to be continuously monitored to determine that it is safe and remains safe. When an unsafe condition is detected, the information should be sent to a BMS and to the management. The BMS should determine what is to be done and send the appropriate signals to the lift.

It is the responsibility of the experts in the field to determine what temperatures humans can reasonably be exposed to. Based on this information, suitable sensors should be selected and their location determined.

NOTE A waiting area and a protected lobby are not and cannot be the same thing. This TSR deals with the area selected by the building designer for persons to wait for lifts, whatever the safe area is described as.

A.1.10 TSR09BL, Figure 1 b), box 26, asks: Audible and visual information required in lift and waiting area so users know lift is being removed from service to safe area. Inform building control of lift shutdown. Notify of alternative escape routes.

Clear and concise, audible and visual information needs to be given in the lift stating that the car is to be removed from service. Passengers should be advised not to attempt to exit the car as it is to run express to a safe area.

Building control is to be informed by the lift that it is being removed from service and is making a safe run to a particular floor. On arrival, the lift informs control that it has arrived. If the lift fails to arrive within a certain number of minutes, building control is to be sent an alert by the lift system.

On arrival at the safe floor, the lift doors should open and then close. No further lift movement is to take place, but Door Open buttons should remain in operation. Building management should be able to bring the car back into service by a manual override if they think it appropriate. All other potential users of the lift are to be informed of alternative lifts and evacuation routes. The lift designer is to design the lift signs and control system to suit. Those parties responsible for the building design are to design signs to advise of alternative evacuation routes; it is the responsibility of other parties to design the detection systems and of the BMS to respond to changes in the situation instantaneously. All information needs to be clear and concise.

A.1.11 TSR10B, Figure 1 a), box 28, asks: Is evacuation required?

It is the responsibility of those in charge of decisions to have as much information and in as close to real time as possible, as the conditions in the building or lift can change over time. The threat of an attack can eventually become an actual attack. In large buildings, an evacuation can take some time and it should not be assumed that continued use of a particular lift or lifts is guaranteed.

If conditions change, new information is required for users and lifts can need to be removed from or brought back into evacuation service.

A.1.12 TSR11B, Figure 1 c), box 28b asks: Does the event affect the structure? (For example, earthquake, explosion, storm damage or lightning strike.) (All pose a risk of structural damage.)

All these events are detectable by measuring the vibration of the building structure. It is the responsibility of specialists in this field to determine how this is to be done, assuming it is to be done. The information from monitoring systems can either be fed into a BMS that automatically sends out an appropriate signal to the lifts, or the information can be displayed on a display panel to inform the building management of the situation. If the condition is not one of those described by box 28b, box 29 is considered.

A.1.13 TSR12B, Figure 1 c), box 29, asks: Is it a water problem (flooding)?

Flooding from rivers, etc. can be very dangerous to building structures and the potential loss of life can be great, but such flooding can be observed and reported by persons in the building or reported on local radio. For this reason, no monitoring system needs to be envisaged. Local flooding can, however, result from a failure of pipes and tanks, etc. and the damage can be considerable. Using the lifts to evacuate able-bodied persons should not be necessary, as it is unlikely that any evacuation would have to be swift. Even if able-bodied persons use the stairs, it can still be necessary to use the lifts for others and, in such a case, it is important to know the lifts have not been affected by water.

A.1.14 TSR13B, Figure 1 c), box 30, states: It is a suspected gas or biological attack (lift is not damaged).

The presence of an explosive gas or a biological agent in the building does not itself damage the lift. The risk is that operating the lift can cause gas to ignite or, in the case of a biological agent, it can help to spread it around the building.

If an explosive gas is present in the building, the risk of ignition from operating the lift is no more or no less than that which comes from operating any other electrical plant in the building. The only difference is that, if the power to items such as air conditioning is turned off, it does not trap people as would turning off the power to the lift.

Unless the circumstances are very unusual, it is assumed lifts should be allowed to stop normally at the end of their journey and then be parked. Building management or the emergency services should be able to turn the power off if they think it is an advantage.

In the case of a biological agent, the best strategy should be determined. In some instances, it would be best to stop the lifts because this would slow down the rate at which the biological agent spreads. The decision to act in relation to lifts should be left to the building management or emergency services. If they decide to remove lifts from service, they should be able to give a simple instruction by operating a key switch or button to cause all lifts to park at an agreed parking floor or to run the evacuation service.

A.1.15 TSR14BL, Figure 1 c), box 31, says: Building management or instruments detect(s) problem in the structure and, if over magnitude X, BMS instructs lifts to shut down at defined parking locations away from potential danger area. If event over magnitude Y, shut lift down immediately.

If a shock to the building structure is detected, the lifts should be stopped at the first available floor, assuming the level of shock is not greater than a value X_{gn}. If the shock is greater than a value Y_{gn}, then the lifts should be stopped immediately. It is the responsibility of the building designer to advise the lift manufacturer of the values of X and Y.

If the lift is stopped immediately because the shock is greater than Y, it is likely that passengers will be trapped between floors and they should therefore be informed that, once the shock has passed, they will be rescued. Once the shock has passed, any car with trapped passengers should automatically raise the alarm (see TSR15L).

A.1.16 TSR15L, Figure 1 c), box 33, states: Check equipment displacement, make slow speed check run, guide alignment, etc. Can lift be safely moved to recover to a floor?

In this case, the lift is either stalled between floors with trapped passengers, stalled between floors without passengers or at a floor level.

If the lift is between floors with trapped passengers, automatic recovery (see TSR15BL) of the car should not be attempted as the condition of the lifts is not yet known.

Some heavy items of equipment could have become displaced and fall on the car if it were moved. Due to this, the alarm should be raised automatically to notify building management of the situation. Any building management system should be informed that the lift is out of service.

If there are no passengers in the lift car, a number of further checks can be made to determine if further use is possible. In addition, a remotely operated camera or a series of cameras can be used to allow a lift engineer to remotely inspect the installation, the main points being the correct location of the car and counterweight in the rails, the position of the machine in the machine room, displaced machine steels and separator beams. It is also possible to fit displacement sensors to the machine and other critical items to ensure their location is within limits. Any devices used for displacement measurement should, in addition to informing the lift system of the situation, inform any BMS.

If passengers are trapped, feedback from monitors and remote visual inspection by means of cameras can determine if it is safe to recover the car. If it is safe, the car should automatically be recovered to the nearest safe floor.

If there are no passengers trapped, the car can be moved the entire length of the hoistway to ensure it clears everything and that all operating signals for the drive and controls are working.

If all appears to be well, the lift car should then make a slow speed travel throughout the hoistway and, if all is well, should either be removed from service at a selected floor, preferably the main floor, or be put into service at substantially reduced speed, half speed, assuming the normal full speed is greater than 2,5m/s.

A.1.17 TSR16B, Figure 1 a), box 174, asks: Is the emergency in building A of a different nature?

Once it is determined that the emergency is not a fire, it should next be determined what other type of emergency exists. If it is not a fire or any other type of emergency, it is assumed to be a false alarm.

A.1.18 TSR17B, Figure 1 d), box 148, asks: It is likely that passengers will be exposed to a hazard while the lift is on its way to the exit floor?

Lifts are apparently available for use, but, if they are used, it is possible for them to pass through an area where a hazard, such a smoke, exists. To determine this possibility, the location of the lift needs to be known and compared with information from sensors in the lift shaft, as well as other building information. This information needs to be combined in a BMS that determines if lifts can run without passing through hazardous areas.

A.1.19 TSR18BL, Figure 1 d), box 104, asks: Are there enough lifts to assist evacuation?

If a considerable number of lifts are not available for some reason, it can be better to remove all lifts from service rather than have too few. If users are told the lifts are not available for use, most people can make their way from the building via emergency stairs. If too few lifts are in service, delays can result that can be dangerous or cause panic.

A limited lift service should be run for the evacuation of disabled persons with lifts being driven by attendants.

A.1.20 TSR19L, Figure 1 d), box 109, states: Notify BMS and management. Park any lifts still in service. Turn on signs and audible warnings to inform people that lifts are not available and stairs are to be used.

It has been determined that lifts should be removed from service for some reason. It is possible that the lift system has been instructed by the building management to remove lifts from service. A building management system or the lift control system could have detected a problem. Irrespective of the reason, the lifts should be removed from service in an organized manner.

Signs and audible information should inform lift passengers and those waiting on landings that the lifts are being removed from service. People need to be informed by building signs of the location of other lifts or stairs that should be used.

Where possible, lifts should park at the main floor unless there is good safety reason not to do this.

The building management and any building management system should be informed that lifts are being removed from service and the floor at which they are parking. Once parked, they should inform the management and BMS that they are parked and indicate the reason they were removed from service, e.g. smoke detected, high temperature or smoke in well. This information can be useful to the building management or any rescue teams who wish to put a lift back into service.

A.1.21 TSR20B, Figure 1 e), box 150, asks: Is waiting environment still safe?

The environment in which people wait for the lift needs to be constantly monitored. In an emergency, such as a fire, the conditions can change over time. Smoke density or temperature can rise to the point where it is no longer safe for people to wait.

A.1.22 TSR21B, Figure 1 e), box 114, states: Lift called and people have to wait. Panic or concern can arise. Lobby can become crowded.

It is not possible to service all floors at once; therefore, priority should be set by the building management system or a predetermined programme be run. In either case, signs and information need to be given on the floors being served along with an approximate time of arrival. Information needs to be given on the floors not being served to indicate that evacuation service starts in (approximately) a certain number of minutes or that NO service is provided. Information on alternative routes or action to be taken also needs to be provided on the floors where service is not being provided.

A.1.23 TSR22BL, Figure 1 e), box 112, states: Phased evacuation. Serve specified floors (e.g. one above plus one below) prior to changing to designated floors or other routine.

The order of evacuation needs to be determined based on the number of persons needing evacuation from the building, the number of lifts available and the scenario in progress. This is complex and the situation is likely to be dynamic, with the number of lifts available changing along with changes in the emergency itself.

Lift engineers can calculate the number of persons that can be moved for a given set of circumstances, but the first thing to determine is the number of persons to be evacuated within the required evacuation time. It is the responsibility of fire engineers and other experts to determine these figures. It should also be determined what the likely proportion of wheelchair users will be.

The following are priority examples:

a) If, for example, the building has 30 floors and is served by a single bank of lifts, it can be reasonable to assume that persons below floor 10, other than those with a disability, can walk down emergency stairs. Assuming the emergency is in fact a fire on floor 17, the lifts can be instructed to manage floor 18 and 19 first, then floor 16 and 15, then all floors above 19, followed by all floors below 15.

b) If, for example, the building has 80 floors with 4 banks of lifts, the first bank serves the ground floor to floor 20. The second bank serves the ground floor non-stop to 21 and all floors to floor 40. The third bank serves the ground floor non-stop to floor 41 and all floors to floor 60. The last bank serves the ground floor non-stop to floor 61, then all floors to floor 80.

If the emergency affects floors 65 to 70, these floors are covered by the fourth bank of lifts.

Assuming that building sensors have not detected problems or hazards in the fourth bank of lifts that serve floors 61 to 80, they can be used to evacuate persons from floors 65 to 70.

The lifts can start by serving floor 70, 69, then 68 and so on down to floor 65. Persons on floors 71 to 80 and floors 64 to 61 can be told to use the stairs down to floor 60, where they can then use lifts to take them to the ground floor. Any persons unable to use the stairs can be served by one of the lifts once the floors with the emergency have been cleared.

The third bank of lifts serving floors 41 to 60 can provide service starting from floor 60 and working down to floor 41. As floor 60 not only has its normal residents, but also persons coming down from above, one or two cars can be instructed to give priority to floor 60 and run a shuttle service between floor 60 and the ground floor.

Floors 40 to 21 can be evacuated by their lifts starting at floor 40 and working down to floor 21. Persons on the first floor and up to floor 20 can be told to use the stairs.

Cleary, the possible combination and best way to serve the building is dependent on many factors, such as the building layout and size, the number of persons to be handled and the type of emergency in progress. The lifts can be made to operate in almost any sequence, but it is the responsibility of those designing the evacuation strategy, not the lift manufacturer, to determine this sequence.

This evacuation strategy also needs to take into account what to do when the number of lifts available is less than the maximum.

In summary, small simple buildings require only simple routines that are easy to determine. Large, complex buildings require sophisticated and complex building management software capable or making decisions based on many factors. Lift engineers should be consulted to explain what is possible, but they should not be asked to determine what is required. It is the responsibility of other parties to do this.

A.1.24 TSR23BL, Figure 1 e), box 115, states: Lift car arrives, but not enough space for all persons to be rescued. Increased concerns and risk of panic. Risk of overloading.

Lifts arriving without space to spare can be the cause of panic among those who have waited some minutes for its arrival. This situation should be avoided wherever possible. Car load sensors need to be accurate devices, such that if a car has the capacity, it can stop for more passengers. Where this occurs, a voice message should tell people to enter. Only when a true full load (100 %) exists should lift cars run to the exit floor non-stop.

Where the risk of overloading is thought to be high, the machine, drive, ropes, brake and all items related to the ability of the lift to support a load should be selected for an increase in duty load of 125 %.

This means a 16-person lift car should have equipment suitable for a 20-person lift, but the size of the lift car should be selected for 16 persons only. As the machine and brake would be chosen on the basis of a 20-person lift, they include the normal ability to support an additional 25 % overload. This means the installation is in fact capable of handling safely 25 persons in the 16-person car.

A.1.25 TSR24BL, Figure 1 f), box 122, asks: Is water close to or affecting lifts?

Water can be coming from the operation of a sprinkler system, the burst pipe of tank, hose discharge, etc. The presence of water on a landing can be detected by a number of methods. One such method is the provision of sensors in the floor outside the lift. If it is a sprinkler discharge, this can also be detected at the sprinkler.

The presence of water in the lift pit and on the car roof can also be detected.

If water is present and flooding is the only emergency, a decision needs to be made as to whether it is best to remove the lifts from service. Floods from building water supplies are not likely to be life-threatening and the building can be evacuated using the stairs and unaffected lifts as there is no need to rush.

Lifts that are affected need to be removed from service and this should be done in an orderly manner without trapping passengers, if at all possible.

A.1.26 TSR25B, Figure 1 f), box 121, asks: Does building need to be evacuated?

There can be occasions when building management or the authorities advise against evacuating the building even though there is an emergency. It depends on the circumstances, type of emergency and information available.

If a bomb warning is received in a high-security building, evacuating staff to waiting areas outside the building while it is being searched can expose them to greater risk. Much depends on the source of the bomb warning and level of building security. The bomb can actually be planted outside the building rather than inside and persons can then evacuate into its blast path.

If the building is thought to contain some form of virus brought in by terrorists, it can be desirable to keep people in the building until the situation is under control. This is preferable to allowing them to leave and possibly spreading the virus.

Provision should always be made to allow the building management or authorities to override any automatic evacuation signal that is generated by a smart system. Irrespective of the systems employed, the evacuation decision cannot be made by a lift system; therefore, it is the responsibility of other experts in this field to determine what risks require evacuation and the type of evacuation (partial or full) needed.

A.1.27 TSR26BL, Figure 1 f), box 176, states: Park cars at next safe stop. Notify BMS and building management.

Lifts need to be removed from service and this should be performed in an organized manner to avoid trapping passengers.

It is the responsibility of those designing the evacuation strategy to determine the parking locations for lifts. Lifts can be run to the main floor, parked at their location or sent to special parking locations. In most circumstances, it is likely to be best to park the lifts at the main floor of the building.

During the operation, passengers should be informed that the car is travelling to a particular floor, to then be removed from service. The information should be both visual and audible. It should also advise passengers to exit on arrival. Signs on landings and audible information should tell passengers exiting the lift where to go and what to do.

Persons waiting on any landings need to be informed that lifts are being removed from service and told what to do and where to go.

If a car is to be parked at a main landing, then, subject to information on the condition of the main landing, it should park with its doors open. This allows emergency personnel entering the building to see that the lift is empty. If the car is to be parked at other floors, the doors should be closed and only the car Door Open button should remain operable.

In large buildings, where lifts are likely to be parked high up in a building, provision should be made in the form of remote control cameras to allow the inside of each lift to be viewed.

Such cameras need wide-angle lenses to ensure the entire car floor area is visible to users of the camera (security staff, emergency teams, etc). This provision enables staff to quickly check to see if anyone is in a lift.

A.1.28 TSR27B, Figure 1 g), box 127, asks: Has gas or a dangerous biological agent been detected or reported in building?

Whilst the detection of gas or biological agents is not impossible, it can prove difficult and costly. It is the responsibility of experts to determine if such sophistication is justified for the particular building.

If an automatic means of detection is not provided, it should be assumed that such an event can only come to light if reported in some way to the building management.

Even if it is left to the building management, the information can still be put into an intelligent building management system manually by the building management to determine what to do next.

A.1.29 TSR28B, Figure 1 g), box 129, asks: Is it explosive gas?

It has been determined by some means that an explosive gas or toxic gas has entered the building. In these circumstances, it can be advisable to shut down lift operation.

A.1.30 TSR29BL, Figure 1 g), box 130, states: BMS or building management should suspend lift operation at next available safe stop.

While the situation is serious, it is probably better to allow lifts to complete their journey before removing them from service.

Operating the lifts or any other electrical equipment is likely to be hazardous in these situations and running lifts only moves air and anything it contains around the building.

A.1.31 TSR30B, Figure 1 h), box 154, asks: Is destination floor (exit) still safe?

The destination (exit floor) needs to be continuously monitored during an evacuation to ensure lifts are not sent to an area that has become hazardous over time.

A.1.32 TSR31B, Figure 1 h), box 155, asks: Will journey expose passengers to hazards?

If the car is likely to run through a hazardous area while making its journey to an exit floor, the journey should be terminated at the first available safe floor. The term hazard means the presence of smoke, heat or any other hazard at a level that is likely to cause harm.

Those persons tasked with designing detection systems for smoke and heat should not just consider detecting if such things are present, but at what level or intensity they are. Passing through smoke for a few seconds as the lift car runs at speed is not itself hazardous. It all depends on the intensity of the smoke and/or chemicals it contains. In small- to medium-sized buildings, it can be sufficient for the building designer to plan for the detection of smoke and heat and determine that, once a sensor is triggered, lift service is suspended. In larger buildings, it can be advantageous to measure the intensity instead of simply looking for the presence of a hazard. It is the responsibility of the building designer to make this decision and determine the equipment required. Behaviour of the lift on receipt of a signal is easy to organize once the required reaction of the lift to a signal is achieved.

A.1.33 TSR32BL, Figure 1 h), box 160, asks: Is evacuation of building completed?

Determining the completion of the evacuation of the building is vital. It is difficult to know how this can be determined with any amount of certainty unless reports are obtained direct from each floor confirming that everyone has left. The lifts can do a number of simple things that indicate that there appears to be no one left to be evacuated. Cars can wait at a floor with doors open to see if a car button is pressed or if a load can be detected entering the car, but these are crude measures and do not answer the question with any certainty.

Cameras can be provided on landings and floors to allow building staff to view floors. Unless it can be determined with certainty that all persons have been evacuated from a floor, the lifts serving that floor cannot be redirected to new floors to serve. The most obvious way to resolve this issue is to have fire wardens on each floor, who notify management or the BMS when they have checked the situation. Cameras can be a back-up for this.

A.1.34 TSR33BL, Figure 1 h), box 168, asks: At the first floor available for stopping running car, will passengers be subjected to a hazard?

Once lift cars have started their journey to an exit floor, the condition of the lift shaft and adjacent areas needs to be continuously monitored. If conditions deteriorate and the car needs to make a stop, the system needs to know if the first available stop is safe. If it is not, the lift needs to either travel further or, if this can take the lift into serious danger, stop and reverse to a safe floor.

All lift stops should be controlled stops and this means allowing the lift to slow down and stop in the normal manner. Information on the conditions of floors needs to be measured in real time, as lifts travelling at speed need to react as soon as possible.

A.1.35 TSR34BL, Figure 1 h), box 169, states: BMS or management to determine new evacuation exit and inform lift system where to send car. Lock car doors. Car to move swiftly away from floor. Audible and visual information to users in car.

If the exit floor becomes unusable, it is the responsibility of the BMS or management to determine a new evacuation exit and inform the lift system where to send the car.

The exit floor can become unusable at any time during the evacuation and cars can be running towards this floor when a signal is received saying it is no longer safe. Cars already running need to slow down at the first safe floor, but if no safe floor exists in the path of the car, it needs to stop and reverse. During this operation, car doors should remain closed and locked to prevent passengers from attempting to exit. If passengers manage to open a car door, the car is unable to move away from the floor. As the floor is hazardous, this produces serious problems for passengers if they are allowed to exit.

Having stopped, the car should be moved swiftly away from the floor to the first available safe stop.

Audible and visual information to users in the car is vital to avoid confusion and panic. This information should explain where the car is going and what to do on its arrival.

A.1.36 TSR35BL, Figure 1 h), box 170, states: Stop car at safe floor. Give audible and visual information to users to exit. Give new escape route information. Remove car from service. Inform BMS and management.

A new floor has been selected at which to stop a car because its original destination floor has become unsafe or the car is about to pass through a hazardous area.

When the car stops, audible and visual information needs to be given to users to exit. They also need to be informed by the building systems of a new escape route. Once the car has been stopped, it should be removed from service. The BMS and management should be informed of the status and location of the lift car.

A.1.37 TSR36L, Figure 1 h), box 166, states: Inform passengers that car is attempting recovery to a floor. Lock doors.

A car is attempting to recover itself to a floor after stopping for some reason. When a car stops, it is a natural reaction for passengers to try to pull the car door open if they fail to open. For this reason, car doors should be shut and locked during normal operation. The doors should remain locked until it is determined that the car is recovered to a floor or cannot be recovered. During any recovery or attempted recovery, passengers need to be informed of what is going on by both audible and visual information.

Recovery of the car can fail and in this situation it needs to be possible for the building management or BMS to remotely unlock the car door.

A.1.38 TSR37L, Figure 1 h), box 161, states: Lift has stopped for some reason.

The lift has stopped for some reason and it needs to be determined if it is close enough to a floor for the doors to open or if it is already at a floor. If it is not close enough to a floor to open its doors, it should attempt a recovery and, during this process, the car and landing doors should be closed and locked, and passengers should be informed that a recovery is taking place.

Recovery of the car can fail and in this situation it needs to be possible for the building management or BMS to remotely unlock the car door.

A.1.39 TSR38B, Figure 1 a), box 8, asks: Should lifts be used for evacuation?

The decision to use lifts in an emergency situation is not one that can be made by the lift manufacturer. It is the responsibility of the building management, using information from the BMS or displays, combined with any other information available at the time from local reports and other sources, to make the decision.

If it is decided that lifts are not to be used for some reason, the lifts should be removed from service in an organized manner (see box 16, TSR05L). If it is thought that lifts can be used, in order to be sure they can be used safely, more information can be required to make the final decision.

Building management makes the final decision, but its suitability is, to a great extent, dependent on the quality of the information they receive. Information needs to be rapidly and clearly displayed in a suitable format and location, e.g. shut down lift, lift safe.

A.1.40 TSR40B, Figure 1 d), box 110, asks: Should all lifts serve all floors?

Some form of evacuation service is required, but it is the responsibility of the specialists involved in developing the evacuation strategy to determine, during the building design, the order in which floors are served.

A.1.41 TSR41B, Figure 1 a), box 178, asks: Is the emergency a fire in building A?

This is not something the lift system is capable of determining. It is the responsibility of the building designer to decide how this is done. The obvious way is through a fire detection system, but the information can be obtained from persons in the building who have seen the fire or by the presence of smoke, etc. It is for this reason that, even if a sophisticated detection system is employed, it is still essential for some form of manually activated signal to be available to those responsible for making decisions in the building.

A.1.42 TSR42B, Figure 1 a), box 19, asks: Should lift be kept in service?

At this stage, there can be obvious reasons why the lift should not be left in service. There can be a report of fire or smoke coming from the lift, for example. If the lift is to be removed from service, a manual signal should be sent to the lifts to recall them to a designated floor. If there is no obvious reason to remove them from service, the system should be allowed to continue in normal operation until the BMS determines what should be done.

A.1.43 TSR43B, Figure 1 e), box 116, asks: Is floor being evacuated now cleared of people?

This is a very difficult thing to determine. Lifts can certainly be allowed to wait at a floor to see if someone else arrives, but how long should they wait? Allowing a lift to wait is a pure waste of the lift's capacity to evacuate others. It is important that persons not be forgotten on a floor. The only way to be certain of this is to have some form of fire warden allocated to each floor whose job it is to inform those responsible for the evacuation that the floor is clear and no longer requires service. This is a building management issue and not a lift design issue. It is the responsibility of other parties responsible for the evacuation strategy to determine how this problem is resolved.

A.1.44 TSR44B, Figure 1 e), box 185, states: BMS or building management to determine next floor or floors to be evacuated.

This issue needs to be addressed in the building evacuation strategy. Having evacuated the floor(s) with the highest priority, it can be best to continue with the evacuation of floors above the event using lifts while those floors below the event evacuate entirely by stairs. The best solution depends on the size of the building, the number of lifts provided and the type of event taking place. This is not a lift design issue, but a fire engineering issue (see TSR27B).

A.1.45 TSR45B, Figure 1 f), box 184, asks: Is flood likely to affect building's structural stability?

Flooding caused by rivers, etc. can be very serious and can sweep foundations away. Basements can also be flooded and passengers in a lift are at risk of drowning if they are in the lift when it enters a flooded basement. Where basements or other areas are at risk of submersion, due to proximity of a river for instance, sensors should be provided to detect rising water levels. When rising water is detected, a signal should be sent to the lift system. Lifts should then be prevented from entering the flooded area and preferably removed from service. Rising water is itself unlikely to cause structural damage and this type of emergency is therefore not normally life-threatening.

Flooding where rivers wash building foundations is much more serious and, where such a risk exists, early warning of flooding is vital. A strategy should be put in place to enable the earliest possible risk of such flooding to be detected. This is primarily a building management issue. Once risk of flooding is identified and assuming time permits, the lifts should be allowed to assist in an evacuation until the depth of water or condition of the structure makes the risk unacceptable.

Once it is determined that lifts should no longer be used, the management should be able to send a manual signal to the lifts to cause them to finish their current journey before being removed from service at a designated area, preferably one or two floors above the buildings ground level.

A.1.46 TSR46, Figure 1 d), box 110B, asks: Should priority be given to certain floors?

If lifts are not to serve all floors, some form of priority needs to be determined. This is not a lift design issue but one for those developing the evacuation strategy for the building.

A person trapped above a fire is likely to be at greater risk than those below a fire. If the emergency is related to the structure of the building, it is likely that everyone is exposed to the same risk although the problems of escape are greater for those higher in the building as it takes them longer to descend. This is a complex issue and can only be determined on a building-by-building basis, taking into account the emergencies the designer wishes to manage with the assistance of lifts.

A.1.47 TSR47B, Figure 1 g), box 133, asks: Should lift cars remain in service?

If a poisonous substance is present in the building, it can be advantageous to stop lift operation rather than run them for evacuation service. Management or civil authorities can determine that the building is not yet to be evacuated. It is the responsibility of the building designer to determine what is to be done in such circumstances. If lifts are not to be used, they should be removed from service in an organized manner.

A.2 Summary

It is clear from this study that the greatest number of issues to resolve relates to the design of the building and not the lifts.

If the building design issues are addressed, it should be possible in certain building designs to reduce evacuation time and permit disabled persons to evacuate safely using a lift.

A.3 Additional points

Lift reliability is clearly an important issue, but if the lift system has features, such as self-rescue, that minimize the risk of trapping, the main issue remaining is that of being able to handle the evacuation without causing confusion.

In a single building with a single lift, it is unlikely the building is of any great size and loss of lift service during an evacuation is likely to have only a small effect on the outcome.

In a large building with many lifts, the result of one lift being out of service is again minimal and should be anticipated in the overall design. It is not unreasonable to expect that in a building with 10 lifts, one can be out of service, if for no other reason than planned maintenance, planned repair or safety inspection. This should be anticipated.

Loss of a bank of lifts is much more serious, but is only likely to occur due to loss of power supply. For this reason, it is vital that secondary (emergency) supplies be provided, which have enough capacity to run all the lifts at full speed with full load.

Lifts and their emergency supplies need to be the subject of regular and comprehensive maintenance to ensure they operate when required as required.

Annex B
(informative)

Summary of requirements

Table B.1 shows the relationship between the various emergencies and the TSRs.

Table B.1 — Relationship between the various emergencies and TSRs

TSR	Fire	Flood	Gas or biological attack	Explosion	Adjacent building incident
TSR00B	√	√	√	√	√
TSR01B	√				
TSR02B	√				
TSR03B	√				
TSR04B	√				
TSR05L			√		√
TSR06BL			√		√
TSR07L				√	√
TSR08B	√				
TSR09BL	√				
TSR10B					√
TSR11B		√	√	√	√
TSR12B		√	√		
TSR13B			√		
TSR14BL				√	√
TSR15L				√	√
TSR16B		√	√		√
TSR17B	√	√	√	√	√
TSR18BL	√	√	√		√
TSR19L	√	√	√	√	√
TSR20B	√	√		√	
TSR21B	√	√	√	√	
TSR22L	√		√		
TSR23BL	√	√	√	√	
TSR24BL		√			
TSR20B	√	√		√	
TSR25B		√			

Table B.1 (*continued*)

TSR	Fire	Flood	Gas or biological attack	Explosion	Adjacent building incident
TSR26BL		√			
TSR27B			√		
TSR28B			√		
TSR29BL			√		
TSR30B	√	√	√	√	
TSR31B	√	√	√	√	
TSR32BL	√	√	√	√	
TSR33BL	√	√	√	√	
TSR34BL	√	√	√		
TSR35BL	√	√	√	√	
TSR36L	√	√	√	√	
TSR37L	√	√	√	√	
TSR38B	√				
TSR39B	√				
TSR40B	Free				
TSR41B	√	√	√	√	√
TSR42B	√	√	√	√	√
TSR43B	√	√	√	√	√
TSR44B	√	√	√	√	√
TSR45B	√	√	√	√	√
TSR46B		√			
TSR47B	√	√	√	√	√
TSR48B	√	√	√	√	√

Annex C
(informative)

Lift design limitations

There are a number of factors that prevent a conventional lift from operating reliably during a fire.

While lift machines and other large items of equipment can appear robust, they frequently contain electronic components necessary for monitoring and other critical safety functions. This extensive use of electronics places severe limitations on temperature that cannot be easily or economically overcome in the design of the lift.

Many components are required to be type-tested and changing their temperature operating range results in the need for redesign and testing. For this reason, changes are not realistic or practicable.

Electronic equipment is normally widely distributed throughout the lift installation. The electronic components can be imbedded in larger components located within lift equipment that is within a conventional machine room or within a defined space in the lift well, on the lift car or on landings.

All such equipment is susceptible to damage from high temperatures, but a greater concern is reliability.

The critical limit is set out below to assist fire engineers in understanding what they need to address in the design of a building to ensure dependable lift operation.

The normal ambient temperature limit for any area containing lift equipment is 40 °C.

It can be seen from the above that the limit for equipment in general is 40 °C and, where continued lift use is critical, provisions need to be made in the building design in the areas related to lifts, to control temperature to these limits. If this is not possible, detailed discussion needs to be made with the particular lift contractor to establish what increase in temperature, if any, can be tolerated.

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