SCHIPHOL AIRPORT FIRE SAFETY: A BENCHMARK ON FIRE PREVENTION AND SAFETY MANAGEMENT

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Key words

Fire safety, airport terminal, benchmark, safety management, fire prevention, high reliability organizations

Abstract

Introduction
Schiphol Airport belongs to the four busiest airports in Europe. Over 46 million passengers and 1.5 million ton cargo per year are handled nowadays. The Schiphol airport terminal is the central building of landside and is complex because of its functional interferences and large dimension in volumes and surface. With some airport terminal fires in mind (e.g. Düsseldorf, 1996) fire safety is an important aspect in the safety modernization program of Schiphol. The question is how Schiphol airport Terminal fire safety efforts score compared (benchmarked) to other comparable complex buildings?

Theory and method
To compare several complex buildings on fire safety, an evaluation framework needs to be developed. Subsequently, the benchmark was performed with the multimodal public transportation and transfer terminal in the Dutch city of Utrecht and with the airport terminal of Düsseldorf International airport (Germany).
Each of these three cases (Schiphol, Utrecht and Düsseldorf) was studied on two main aspects: fire prevention and safety management. The benchmark for both fire prevention and safety management was performed in three steps:

1. analyzing relevant documents
2. interviewing key officials
3. observing the building (or plans , Utrecht) and its use

Results
The results indicate that the developed fire prevention framework and safety management framework are very useful for scoring the fire safety of complex buildings.
All three considered cases prioritize safety over security in case of an emergency. In the airport terminals, retail is located in the middle of the halls whereas in Utrecht, retail will be located in the side walls of the building. All three objects have a sprinkler installation and a fire notification system. All three operate an evacuation installation; however Utrecht is not implemented in the safety organization yet (must still be build). In all three object operate a

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smoke-heat distraction system. Regarding safety management, Schiphol and Utrecht developed a dedicated policy aimed at continuous improvement, involving a system for granting permits, monitoring and sanctioning. However, not all aspects of their safety management systems are fully implemented yet.

Conclusion
Analyzing both the safety prevention and organization gives a broad insight in the total of fire safety in a complex building. To this end, the two developed evaluation frameworks for fire prevention and safety management were very useful. The interaction between these aspects still can be developed in a more consistent way.

Discussion
The results are based upon three objects that vary with regard to its history: Düsseldorf has been newly built recently, Utrecht is to be built and the Schiphol airport Terminal exists for decades. Still, the benchmark shows the main fire safety concepts of the three cases, which can be used for themselves as for other complex buildings as well.

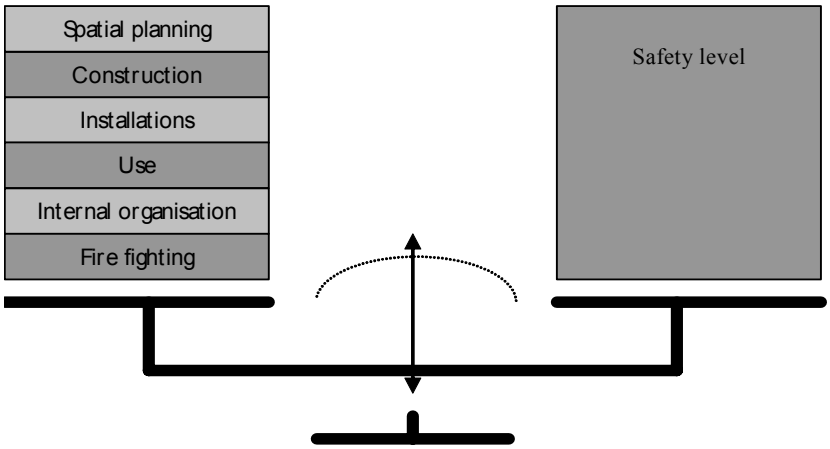
Introduction

For complex buildings such airport terminals, prescriptive fire safety rules are absent in The Netherlands. Instead, a performance-based approach needs to be applied to design and manage safety. In the end, the performance-based approach should result in safety level which is as least as safe as is intended by the pre-scriptive rules.

The problem however with the performance-based approach is that it concerns tailor-made applications. Various such applications are difficult to compare. To compare various performance based approaches, we developed two frameworks regarding fire safety. Fire safety can be realized in the design of the building and in it's management:

- Fire prevention: the building-related fire enhancement to reduce the probability on fire or to minimize the fire consequences
- Safety management: the managerial enhancements to reduce the probability on fire or to minimize the fire consequences

Figure 1: Fire safety



Spatial planning, construction, inventory and use and installations are part of the fire prevention framework. The internal organization, use and fire fighting are incorporated in the safety management framework. Both fire prevention and safety management should add to a minimum required safety level. Various safety enhancements from both frameworks could realize this minimum safety level.

In this paper, we present both safety frameworks and their applications to three complex buildings:

- Schiphol airport terminal (The Netherlands)
- Düsseldorf airport terminal (Germany)
- Public transport transfer facility Utrecht (The Netherlands)

In section 2 the research approach is presented. In section 3, the two fire safety frameworks are developed. In section 4, the fire prevention framework is applied to the three complex buildings. In section 5, to the same three buildings, the safety management framework is applied. In section 6, we draw conclusion regarding the developed frameworks and their application.

Research approach

Two reference documents were developed, one for fire prevention and one for safety management.

2.1 Fire prevention framework

The fire prevention framework was based upon the Dutch building directive 2003 for new buildings (Bouwbesluit) [VROM, 2003]. This building directive inhabits fire safety prescriptive measures. However, these are not applicable to a large and complex building such as an airport terminal. For such types of buildings, article 1.5 and chapter 2.22. in the directive provides a safety performance-based approach. The owner should prove his solution is at least as safe as it is realized following the prescriptive measures. The way the owner full fills the required safety level, is up to him. The reference for assessing the fire prevention of the three benchmark objects consists of the following aspects:

a) Building and it's surroundings: such as fire and smoke compartments, escape routes and possibilities, construction integrity, materials and accessibility and water supplies
b) Installations: such sprinklers, heat smoke distraction and fire alarm ~~and~~ installations.
c) Inventory and use: fire safe materials, activities and interior design

These three main categories were subdivided in 6 benchmark aspects for fire safety. For these 6 aspects including:

- (The restriction of) fire risky situations
- (The restriction of) fire development including fire alarm
- (The restriction of) fire extension (fire compartments)
- Fire resistance of the construction
- Safe escape
- Fire suppression related to the building (such as sprinklers)

A checklist was developed in which these 6 main categories were further detailed in way that we could specify the quality of to these categories belonging components.

The specification/application of the fire prevention framework is done by:

- Studying documents
- Interviewing key actors: the designer of the fire prevention concepts, the designer and the safety manager.
- A site tour

2.2 Safety management framework

The safety management framework is based upon:

- The Dutch directive for chemical industries which is a translation of the EU Seveso guidelines [VROM, 1999]

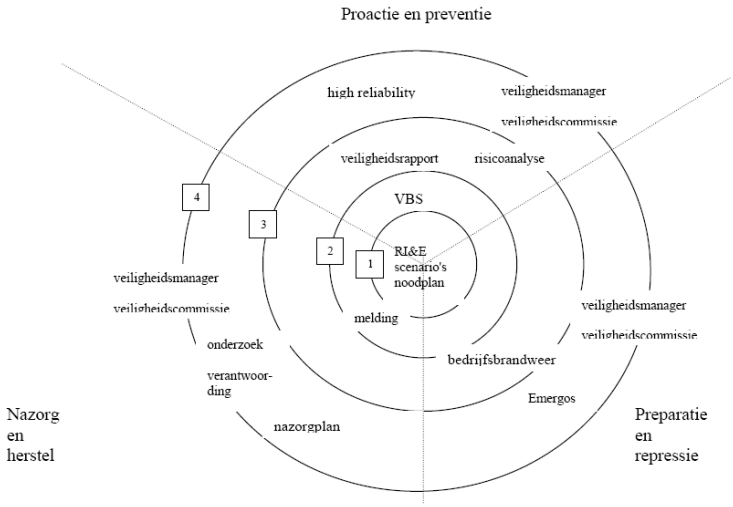
- Emergos: checklist for company emergency organizations [TNO, NIFV and KIWA, 2002]
- Theory of High Reliability Organizations
- The ICAO Safety Management Manual [ICAO, 2006].

The safety management framework is formulated based upon the processes that need to be managed. Four levels are distinguished:

- Level 1: Basic (no Safety management system: only complies with minimum legal safety requirements)
- Level 2: Safety management system: The organization has a safety management system in which the plan-do-check-act loop works. This level is comparable to the level of small chemical industries in The Netherlands.
- Level 3: Safety case: The organization has a safety management system and conducts safety cases to assess safety. This level is comparable to the level of large chemical industries in The Netherlands.
- Level 4: Excellent: the organization has a full-working safety management system and encompasses all the three levels before. This level is comparable to the level of nuclear industries.

Figure 2 below shows the main elements of each of the levels. Still needs to be translated in English)

Figure 2: Safety management framework



These four levels are further detailed in a checklist that was applied in the benchmark. The level of safety management coincides merely with the scores on the following aspects:

- Safety management system
- Risk inventory and assessment
- Accident analysis
- Company's emergency response plans
- ER education and training
- Fire brigade and in-company occupational safety

The application of the safety management framework is done by:

- Studying documents
- Interviewing key actors: the safety and health manager, the chief of (airport) fire brigade and the manager of the company emergency response organization.
- A site tour

These two frameworks were applied to Schiphol and two other complex buildings. To this end, the Schiphol airport Terminal was characterized from a fire safety (prevention and management) point of view.

Based upon this activity, safety experts of AAS and researchers chose 2 benchmark objects: Flughafen Düsseldorf International (Germany) and Public Transport Transfer facility Utrecht (Netherlands) as benchmark objects. The main categories of benchmark criteria were:

Table 1: Benchmark aspects.

Main category	Aspects
Building	1-roof concept, multiple functions, safety versus security, multi modal transportation and multiple exits and entrance, construction activities
Public	Number of visitors,, multiple languages, unfamiliarity, goal of the attendance, various organizations
Risks	Vulnerability, risk assessment, public
Organization	Incident management, high reliability, 24/7 (24 hours, 7 days a week), safety management system

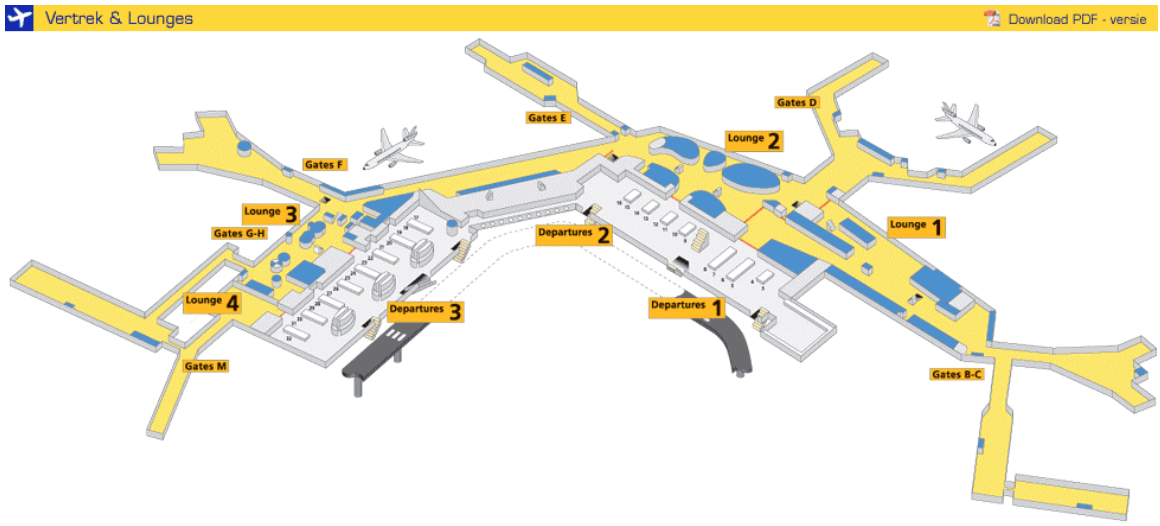
Most characteristics of Düsseldorf and Utrecht are similar to Schiphol. Both Düsseldorf and Utrecht however deviate in 1 aspect from Schiphol. The Düsseldorf airport Terminal is a totally new building, opened in 2003. After the 1996 airport terminal fire in Düsseldorf, from 1997-2003, almost 400 million euro were invested in the new airport terminal. The public transport transfer facility of Utrecht is in its final design stage and does not exist yet. However, because we compare the object in a conceptual manner rather than as part of an audit, both objects are relevant for the benchmark.

For efficiency reasons, the fire prevention and safety management framework were applied in coordination to each of the benchmark objects. This means for example that fire prevention specialists and safety management specialists visited the Düsseldorf airport Terminal together. First, we applied the frameworks to Schiphol, followed by Utrecht and finally to Düsseldorf. This sequence had to do with the availability of the persons in charge of fire safety aspects of the objects.

2.3 Schiphol airport Terminal, Düsseldorf airport Terminal and Transport Terminal Utrecht
In this section, we briefly described the three benchmark objects.

Schiphol airport Terminal
In the Netherlands, Schiphol Airport is main international hub for international and intercontinental flight. In 2006, 46 million passengers about 1.5 million tons of cargo is handled.
For the future Schiphol aims at handling 65 million passengers per year. The main part of the airport for passengers handling is the Schiphol Terminal. The Schiphol Terminal is the responsibility of Amsterdam Airport Schiphol (AAS). The picture below shows the map of the Schiphol Terminal. There are 3 departure halls (1, 2 and 3) and 8 piers (B, C, D, E, F, G, H, and M) and 61 gates which form the connection between the landside and airside. The train station is a tunnel below the Terminal building.

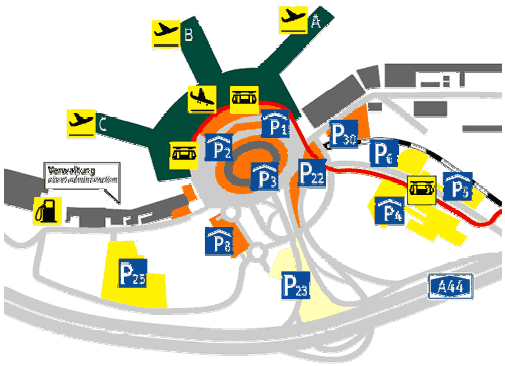
Figure 1: Site map of Schiphol airport Terminal [AAS, 2007].



In such a large and complex building with many (foreign) passengers, many organizations employing a great variety of activities, fire safety is elementary. To this end, Schiphol runs an extended fire safety (re)construction program called Continuity and Fire Safety Program (C&BT-program). This more than 100 million euro program consist of 26 fire safety projects in the Terminal and runs to the year 2010.

Düsseldorf airport Terminal
Nowadays and in the future, Düsseldorf handles about 18 million people year and 97.000 tons cargo. The main part of the airport for passengers handling is the Terminal. The picture below shows the map of the Düsseldorf Terminal. There are 3 departure gates (A, B and C) and 1 hall for arrivals. The train station is in a tunnel below the Terminal building.

Figure 2: site map Flughafen Düsseldorf [Flughafen Düsseldorf International, 2007]



Transport Terminal Utrecht
Terminal Utrecht handles about 13 million passengers in 2020. The terminal is a multi level building over about 16 rail platforms. Trespassers using the terminal from east to west are separated from travelers. On the Terminal several office buildings are developed. Adjacent to the Terminal, a large indoor mall (Hoog Catharijne) and a conference building (Jaarbeurs) are situated.

Figure 3: impression Terminal Utrecht [Gemeente Utrecht, 2007]

Now that we presented the fire prevention and safety management frameworks we will present its application to the three benchmark objects.

Fire prevention
The table below summarizes the relative results on each of the 6 aspects (most left column) for Schiphol, Utrecht and Düsseldorf (upper row) [NIFV and NHL, 2007] (in which for Schiphol the C&BT program is completely realized, hence the future situation). In the cells, the score of Schiphol Airport is presented relative to the Dutch Building directive, multimodal transfer facility Utrecht (still in design) and Düsseldorf International Airport.

Table 2: Benchmark results fire prevention

	Schiphol .... than Building directive 2003	Schiphol ... than	
Reference		Utrecht	Düsseldorf
Restrict fire risky situations	Better	equal	Equal
Restrict fire development including fire alarm	equal	Better	Worse
Restrict fire extension (fire compartments)	better	Equal	Equal
Fire resistance of the construction	better	Better	Better
Safe escape	Equal	Equal	Equal
Fire suppression (building related)	Better	Equal	Equal

Based upon this table, Schiphol scores:

- better than the Dutch minimum fire safety requirements: the main reasons therefore are that the occupancy level is below maximum, the sprinklers installation and 60 minutes fire resistance time of the construction instead of the minimum requirement of 30 minutes and the multiple building related fire suppression equipments.
- a bit better than the to be realized Public transport facility in Utrecht: the reason is that material class in Schiphol is less flammable than is Utrecht and the fire resistance of the construction.
- equal to the airport Terminal of Düsseldorf: Düsseldorf is better than Schiphol because it has an advanced smoke distraction system in the terminal and smoke hoods above retail shops and the overall use of fire resistant materials in the airport terminal Schiphol is better than Düsseldorf because its construction is 30 minutes more fire resistant.

Safety Management

The table below summarizes the results on each of the 6 aspects for Schiphol, Utrecht and Düsseldorf [NIFV and NHL, 2007] (in which for Utrecht the intentions as described are realized and today's situation is continued in the management organization of the terminal):

Table 3: Benchmark results safety management system

	Schiphol on VMS-level	Schiphol ... than	
Reference		Utrecht	Düsseldorf
Safety management system	2	worse	better
Risk inventory and assessment	1	equal/ worse	better
Accident analysis	3	Worse	Unknown
Company's emergency response plans	3-4	Equal	better
ER education and training	3	better	Equal
Fire brigade and in-company occupational safety	3	better	Equal

Based upon this table, we conclude that Schiphol scores

- About level 2 to 3 on the safety management levels: risks are not analyzed using scientific methods such as TRIPOD or the bowtie technique. The safety management system is concept ready, but needs to be implemented
- A bit less than Utrecht: Utrecht uses scientific methods and techniques to assess risk and to analyze accidents
- Better than Düsseldorf. Düsseldorf has no safety management system at all.

Discussion

The two self-developed frameworks for evaluating fire prevention and safety management proved to be very useful for scoring the safety of complex buildings. In addition, the frameworks facilitate a comparison between various complex buildings: comparing Schiphol with a new built Terminal (Düsseldorf) and a to be built public multimodal transfer facility (Utrecht).

We had to deal with a variety of information. For Schiphol, we had access to all relevant documents and we could speak every official we needed for the research. For Utrecht, in particular documents regarding the safety management were not constipated yet. In Düsseldorf, safety management for the terminal did not exist at all.

At Schiphol, we visited the airport Terminal and conducted 6 in-depth interviews. Regarding the Transport Terminal Utrecht, a site visit was of coarse not possible. Still we conducted 6 in-depth interviews as well. For Düsseldorf, we did the site visit, however, we only had two relevant safety documents available for analysis and instead of in-depth interviews we were given two fire safety presentations and discussions afterwards.

Apart from these methodological aspects, we are convinced that the fire prevention and safety management framework are useful tools for developing and evaluating fire safety of complex buildings. To better balance fire safety, hints for more integration between fire prevention and safety management could be useful. Such hints might become available when applying the presented frameworks more often and publishing the results in international journals and conferences on safety.

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