A nasty report on FRAME.

When you search the Internet for information on FRAME, you may find a document published at: BRE project reports library: Effect of Local Acts on fire risks. In this publication, the FRAME method is used to analyse a number of generic cases warehouse and car parks to estimate the likely impact of local acts on these buildings with or without sprinkler protection.

A Monte-Carlo analysis was made leading to criticizing the FRAME approach and leading to the conclusion that the FRAME approach is not valid. However, the graphical results of the Monte-Carlo give such weird results that they indicate strongly that FRAME method was not correctly applied by the (anonymous) author(s) of this report.

Reading through the report reveals a number of serious mistakes, indicating that the analysis was not made according to principles and concepts of FRAME and lacks the scientific discipline and care that could be expected from an institution like BRE.

Lack of information research
The first and basic criticism on this report is that the author(s) apparently have made no effort to find more information on FRAME than what was available in the manual or have tried to reach the author. The manual is just a manual: a means to help the user of the method, it is not a dissertation to explain and justify the content of the formulas used. A simple Google search with FRAME and "fire risk assessment method" would lead in a few steps to the FRAME website where more information and the contact data of the author of FRAME.

In the English part of the website, the sub pages already give some explanation on the background of the method, which should be adequate to counter the statement on page 3 of the BRE report that "the functions seems to be arbitrarily chosen to give results that subjectively feel right. The functions are not directly related to statistical data, nor have they been derived as fitted curves describing the response of more complex models."

Only the last statement is true, as it is difficult to fit to models which did not exist at the time FRAME was developed. The author(s) do not distinguish the differences between a (complex) fire model, which only simulates a fire without any judgment on its consequences, and a risk assessment tool that weights cause, effect and probability. Even so, a number of checks have been made by the author to verify that there is no significant contradiction between a number of fire models and FRAME. E.g. the relative values of the fire load factor q and the fire resistance factor F are consistent with the equivalent fire duration concept used in some fire models, e.g. DIN 18230.

The generic warehouse
One set of calculations was made for a "generic warehouse". Looking at the values used on page 4, it seems that the author(s) haven’t seen a warehouse in reality, or at least haven’t read the FRAME manual correctly. The accumulation of the errors made is such that the resulting calculation is unduly pessimistic and only representative for the very poor end of the warehouse collection. If the data have to represent a generic warehouse, a more balanced choice of good and bad aspects should be considered.

Major error 1: the ventilation factor $k$
The ventilation factor $k$ is set at 0.1 %. This value does not reflect the reality, and is far too low: In most general purpose warehouses, the roof and upper sides have rather large translucent plastic and glass parts for natural light, covering about 10 to 15 % of the floor area. The FRAME manual states "Measure the total area of single glazed windows, glass and plastic skylights in the ceiling (roof) and upper third of the walls giving to the outside. Consider that about one third of these surfaces will be open by the effect of the fire and will be used for smoke evacuation." This means that the generic warehouse shall have a ventilation factor $k= 3$ to 5 %, not 0.1 %.

This is a very drastic and erroneous aggravation: in a warehouse with a high fire load and almost no ventilation, the space will be rapidly filled by the smoke of the fire and make it nearly impossible for the fire brigade to make an effective intervention. The conclusion through the FRAME calculation, that the property is probably lost is not illogical, even for a small warehouse.

Aggravating error 2: factor M = flammable contents
The assumption is made that the flame propagation class M is between 4 and 5: this would be acceptable for a warehouse where the whole content is packed in polystyrene / polyurethane packing. In a generic
warehouse, a mixture of metal boxes, carton, wood, plastic is more likely to be found at the surface of the content. According to the manual and software, the value for M for a generic warehouse should be between 2 and 3, not between 4 and 5. This error has also a heavy impact on the results, as the value M is used both in the potential and the acceptable risk calculation.

Aggravating error 3: number of people
The number of people present in the warehouse is indicated to be 1 person per 30 m² floor area, where the manual recommends 1 person per 300 m², which is in reality already an overestimate of a warehouse population.

Aggravating error 4: temperature rise (factor T)
The value for T varies between 100 and 300: the lower value is relevant for sensitive equipment like electronics. Making a calculation with this value means that the content of the whole warehouse is easily damaged. For a generic warehouse, a value in the 250 -350 °C range would be more appropriate.

Aggravating error 5: the activation factors:
Gas heaters inside the warehouse and possible uncontrolled smokers are considered as activation factors; in reality, a large number of warehouses is unequipped, which means that this assumption is not valid for the "generic" warehouse. Who would accept the use gas heaters inside a warehouse with a highly flammable content (flame propagation class M = 4 to 5) ?

Aggravating error 6: normal protection:
assumed is: no organised human presence, no manually operated alert system, no guaranteed notification for the fire brigade, no alarm to the occupants. Fire extinguishers, no hose reels, partial staff training , fire brigade between 10 and 20 minutes. For a "generic" warehouse with people working in it, it would be logical that it complies with the fire precautions at work act, and that fire alarm facilities are available, but maybe without guaranteed notification to the fire brigade.

Aggravating error 7: fire brigade intervention time:
The assumption here that the fire brigade needs 10 to 20 minutes to be at the fire site is inconsistent with the availability of a large permanent public fire brigade. Such a fire brigade is found in urban areas only, where they can be at the fire site in 5 to 10 min.

Thus the value for N is largely underrated, resulting in an unrealistic high value for the risks.

As a result of combining these aggravation errors for the "generic" warehouse", the FRAME calculation yields values to conclude that all these warehouses are inadequately protected both for property and people. A more balanced use of FRAME would result in the following recommendations to have a "good" level of protection:

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- manual fire protection + local alarms for warehouses up to 2000 / 2500 m²
- automatic detection for warehouses in the 2500- 7000 m² range
- sprinklers for larger warehouses , up to 30 - 50000 m²
- larger sprinklered warehouses should be subdivided in compartments.

The car park.
For the generic car park case, the accumulation of aggravating factors is less, so the deviation of the values in the graphs and those to be expected by an experienced user of FRAME are not so outspoken. The following remarks can be made :

Major error 1: Fire load of the content : indicated as 2500 to 10000 MJ/m².
A modern car of 1500 kg weight, 8 m² floor space contains approx. 30 % combustible materials (20 MJ/kg). The useful space for parking is about 50 % of the total floor space of a car park, the rest is for circulation. This gives the following estimate for the fire load 1500 kg x 30 % x 20 MJ/kg / 8 m² x 50 % = 562,5 MJ/m² . The fire load for a car park shall be estimated in the 500 - 700 MJ/m² range, not at 2500 MJ/m² or more.

Aggravating error 2: factor M for flame propagation: the range selected is M 1 to 4;
The surface of a car is still for a large extent metal / glass, i.e. incombustible or M=0. For the parts in plastic, rubber at the outside of the car, an aggravation to M =1.5 is reasonable.

Aggravating error 3: number of people between 0 and 1 per 8m²:
It is totally unrealistic to assume that there should be more people in a car park than in an office (1 pers./10 m²). Didn’t any bell ring? Considering 2 persons per car, 1 car per 20 m² (parking + circulation space) and 10 to 20 % of the car users near their cars, a density of 1 person per 50 to 100 m² is more realistic.

Aggravating error 4: normal protection:
Assumed is: no organised human presence, no manually operated alert system, no guaranteed notification for the fire brigade, no alarm to the occupants. Fire extinguishers, no hose reels, no staff training, fire brigade between 10 and 20 minutes.

The assumption "no organised human presence" is inconsistent with the provision for people present in the car park. Eventually, two types of calculation can be done: a car park in idle time with no people, and a car park at rush hours, with a threat to people, but at the same time human presence for alarming. It seems not logical that in a generic car park there is no provision for fire alarms (I do not know such car park without fire alarm push buttons) and that in an urban area (where car parks are) it would take 10 to 20 minutes to get the fire brigade on site.

Aggravating error 5: building fire load: 100 MJ/m²
most car parks are made of steel/concrete only which can justify a 0 MJ/m² building construction fire load.

Through the accumulation of these aggravation errors, the author(s) of the report provoked too severe results, as is clear from their graphs on page 12. Without these aggravations, a FRAME calculation will result in acceptable values for R1 (persons) for even very large (7000 m²) above ground open car parks. Property protection will be a problem though.

For underground car parks, FRAME is quite severe, sprinkler protection or smaller car parks with strong smoke venting will be needed to reach an adequate level of protection according to FRAME. This is not always requested by the authorities. Recent fires in underground parking have shown that these fires are difficult to control and extinguish, which is an indication that the FRAME approach is justified. (Alan Brinson of EFSN will be glad to supply the examples of such underground car park fires).

The FRAME analysis.
The report gives on page 9 some considerations on FRAME. Through the Monte-Carlo analysis it was found that the uncertainties in the results are in the 10 - 20 % range, arising for input uncertainties. As is indicated above, the input range was arbitrarily chosen by the author(s) of the report.

The question can be asked, how far the uncertainty is depending on the input range chosen by the calculator, and what is more important, what is the margin of error that is allowed at the input side to obtain "unsafe" conclusions at the output. The validity of FRAME can only be questioned if the results of a FRAME calculation would diverge considerably from the content of fire codes on the unsafe side: e.g. if FRAME would accept a 5000 m² compartment where the code would only allow 3000 m².

An other point is that inexperienced user of FRAME can put in so much "safety margins" in his input that unrealistic conclusions can be formulated. This may be a quest for a better manual, and or training for the user, or for an "input review" by an experience fire safety engineer.

The conclusions given on page 9 are of little or no value, they either state the obvious such as:
- the risk is significantly lower with sprinklers present.
- The risks increase with the floor area

Or they are erroneous:
- compartment height has little influence on the risk: this is not true, but linked to the "no ventilation" assumption. Fire safety experts will agree that in compartments without ventilation, the fire risk is considerably higher than in ventilated spaces.
- Risk scores higher than 1 as obtained are basically the result of unduly pessimistic chosen factors as is supposed on page 10.
It is true that a constant error would just change the risk score by a multiplication factor, but FRAME uses basically a logarithmic scale, which means that multiplying a score by 2 means that the "absolute risk" as the author(s) call it is multiplied by 100. This requires due care at the definition of the input data.

The FRAME software contains the following disclaimer and warning:
Everybody uses this program and the FRAME method on his own and only responsibility. In no event will the author be provide any warranty either expressed or implied to the user. The user assumes the entire responsibility for the application of the method, its appropriateness, reliability and correctness of the data used, and for the conclusions derived from its application.

This program is only suitable for use by a person skilled in fire protection as complement and support of his professional judgement formed through learning and experience.

When a person, researcher or scientific, makes a calculation which yields weird results as it was here, the first thing he should do it submit his input data to an experienced person, instead of blaming the calculation method for the results.

On page 10, a test calculation for a domestic dwelling room was carried out. The results were all less than 1 indicating adequate protection for the risk. And the author(s) continue, referring to statistics that people die in fires, to indicate that FRAME is wrong. The first instruction for FRAME is that the basis of the calculation is a compartment, not a room. FRAME is not conceived for dwelling rooms. The author(s) misuse the method to make their point.

Fire statistics in dwellings show an uneven distribution of "bad luck" through the population: The majority of the victims are elderly people, children, persons asleep and the inhabitants of old and poor quality houses. This is also demonstrable by a FRAME calculation for an old style (masonry /wood) house with a stove, no home detectors and poor electrical circuits, even if this already out of the normal scope of FRAME.

Conclusion

As the author of the FRAME method, I can only conclude that this BRE report has not respected the prerequisite constraints, principles and instructions given with the software and manual. This is not the kind of work that can be expected from a renowned institution as the Building Research Establishment. The content of the report is damaging and the publication should be corrected or withdrawn.
Ing. Erik De Smet