THE REVISED 3rd EDITION OF THE CHEMICAL INDUSTRIES ASSOCIATION "GUIDANCE FOR THE LOCATION AND DESIGN OF OCCUPIED BUILDINGS ON CHEMICAL MANUFACTURING SITES"

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The publication of the third edition of the CIA's "Guidance for the location and design of occupied buildings on chemical manufacturing sites" marked a significant revision of the previous version. The revision was produced by a working group drawn from experts in the field and representatives of the UK Chemical and Oil Industries, and continues the British chemical industries leadership in this area.

Although some sections of the previous edition – for example those dealing with toxic gas releases – remain largely unchanged, other sections have been significantly revised from previous versions. For the first time, the revised guidance sets out the principles against which companies should judge their occupied buildings policies – and performance – and has a new section on managing occupied buildings, helping to ensure that standards are maintained throughout the working life of a building. The issue of occupancy – when does a building become occupied? – has been discussed in much greater detail and now has a section devoted to the issue. The section dealing with approaches to assessment, either hazard based or risk based, has been re-written and (hopefully) clarified. The way the "10^{-4} rule" should be interpreted has been significantly clarified and the use of exceedance curves has been highlighted as a way to ensure that significant events with a frequency just below 10^{-4} are not excluded from consideration. The use of Individual Risk and Aggregate Risk is discussed - the first to determine when action is required and the second to determine priority and "how much is enough?" The guidance also now includes an example of a site's approach to occupied building risk assessment, which – whilst not an "approved template" – should assist companies and their advisors in knowing what an acceptable assessment should cover.

The paper discusses these changes to the guidance and some of the discussions which led to their adoption. It also considers how companies should now approach assessment of both new and existing buildings, and what changes may need to be made to existing assessments as companies revise them over the next few years.

INTRODUCTION

The revised, third edition of Chemical Industries Association's (CIA's) "Guidance on the location and design of occupied buildings on chemical manufacturing sites" was published in October 2010. The publication of the 3rd edition followed 2 years work by a group of experts in the field and representatives from UK chemical companies, undertaking a thorough revision of the previous edition. The working group assembled by the CIA set out to bring the previous document up to date: the previous document was written in the mid- to late 1990s and then subject to a relatively minor revision in 2002–3. That second edition concentrated on removing some errors, (very) briefly discussing the issue of occupancy, and adding an expanded section dealing with protection against toxic gas. The third edition has been a much more thorough revision, reconsidering every existing section and adding new sections which either deal with questions (from regulators and users of the guidance) not adequately addressed previously, or which discuss ideas and possibilities not familiar 15 years ago. The revision also aimed to make the guidance clear, revising sections which may have been difficult to use up to now.

However, the group also set themselves the task of not making changes to the document which would make existing Occupied Buildings Risk Assessments (OBRAs) no longer valid. The group recognised that a competently produced OBRA was certain to be a useful document, even if there had been changes in knowledge, techniques and in available material since the last edition. The aim was to produce a document which should be easier to understand and which extended the guidance rather than overturning anything already in place. Similarly, although the guidance is used around the world by companies of all sizes, the aim was to write guidance which would be of use to medium sized chemical companies: providing them with enough information to enable their engineering staff to be "intelligent customers" in this area. The working group were not trying to provide a textbook on occupied buildings (OBs) but aimed to set out achievable standards and provide signposts to more detailed technical work. The bibliography has therefore been much extended.

OCCUPIED BUILDINGS PRINCIPLES AND POLICIES

Previous editions of the guidance suggested that companies should have a policy on occupied buildings but did not specify what the policy should contain and did not

explore the principles which companies should use in writing their policy. The thinking behind these principles was discussed (in a previous paper, Coates & Patterson, 2009) by analogy with the six-step risk reduction strategy embedded in the UK Control of Substances Hazardous to Health (COSHH) regulations. The working group reduced the six detailed steps to three broader steps and these principles are spelled out in paragraph 1.5 of the first section of the revised document: *The protection of people on chemical manufacturing sites should adopt the following principles*:

- *Wherever possible, locate people away from chemical processing and storage unless their presence is required for safe, effective operations.*
- *Control the risks during storage and all operational phases by efficient and effective process safety management.*
- *Ensure that the on-site buildings are located and designed to minimise the risks to the occupants by:*
  - *(a) carrying out an appropriate risk assessment for the buildings, and*
  - *(b) applying the results of the risk assessment to the design and continued operation of the buildings.*

In common with other safety management systems the priorities are remove, reduce, and then protect. The guidance makes the first priority removing people from the hazards: the second priority proper and effective process safety; and only then protection of people in buildings. To make this work, the new guidance makes it clear that companies should embed these principles in a clear written policy setting out: how they will assess the risks to people in OBs; the standards they will use to make the assessments and which they will apply to those buildings; and the way occupied buildings will be managed. The policy should also cover the company's use and management of temporary buildings on site.

OCCUPANCY

For the first time the document addresses the issue of occupancy directly, indeed section 2 of the new edition deals specifically with this issue. Occupancy has raised a lot of questions, often from the regulators, and was only briefly mentioned in the appendix dealing with toxic gas protection in the previous edition. The questions usually revolve around "is this structure an occupied building or not?" and hence "should it be included in the OBRA?" However the question "How do we allow for the occupancy of a building in calculating the risks to people in the building?" has also become important. The new section offers guidance on what types of buildings should be included and which types it is reasonable to exclude; and on how much occupancy is needed before a building should be included, making it plain that both numbers of people and duration need to be allowed for. However, it also makes it plain that these factors should be part of a site's OB policy, and something a site should be able to explain & defend to their regulators.

The occupancy figure – the proportion of time an employee spends in a building – is one of the factors in the assessment calculation for calculating Individual Risk (IR) in OBRAs. The figure for individual occupancy is normally taken as the time spent working on site which in the UK is most often taken as 1920 hours a year. As a proportion of an individual's time this gives 0.22 for a 40 hour weekly shift. However, the guidance, mirroring concerns voiced by HSE, warns of "salami-slicing" risk as a way of allowing higher risk to appear acceptable. The guidance is based on IR but accepts that, for those circumstances where an operator may be continuously present in a building on every shift – for example control room operators where the control station is continuously occupied – the occupancy figure may need to be increased especially in calculating the benefits of any proposed improvement.

The other note of slight caution is where operators may take their breaks in the same building that they work in. In this case, the occupancy can also be greater than 0.22.

SPECIAL CONSIDERATIONS

In addition to consideration of occupancy, some additional situations are now included which require special consideration within OBRA:

(i) Intermittent hazards: for example a jetty, where a jetty building provides weather protection (for example) for the operator who needs to be present during unloading but where the building is only occupied when the hazardous activity (unloading) is being carried out.

(ii) Occupied buildings within buildings: internal buildings that are occupied, whilst the remainder of the building is not. OBRA techniques should be applied to the areas which are intended for occupancy; the response of the building surrounding the occupied building should also be evaluated, as it may impact on the occupied area.

(iii) Internal process monitoring rooms: rooms, often on the first floor of batch processing plants built around the 1960s, to allow manual control of plants and reading of pneumatic instrumentation. Such rooms are generally not continuously occupied but may have grown in importance, now being used to house the front-end of more modern, electronic process control equipment. Operators can often use these rooms to make batch records and carry out control functions on what has become semi-automated plant. However operators will also – probably for the majority of their time – be working on and around the plant. This type of room should be avoided in new design, and the function located away from the process hazards.

Where such rooms are present within existing process plants or reactor houses the first principle to be adopted is that such rooms should, at the very least, not offer additional risks to those using them. The design should be examined to ensure that no

additional risks (compared to the plant as a whole) have been added by, for example, using significant amounts of glass in the room's construction. If this is achieved and the risks from the process operations have already been reduced to as low as reasonably practicable it has been argued that the control rooms should not have to offer additional protection: why should the risks be significantly different either side of a door? If this principle were to be accepted then no further assessment would be required. The guidance accepts that in some cases this approach may be acceptable but makes it clear that if it is decided not to include existing internal monitoring rooms in the assessment, the reasons should be recorded. This implicitly makes it clear that such a decision should be capable of being justified to the regulators.

However, the guidance also makes it clear that the approach of not including the building in the risk assessment only applies if the operators' room is used for normal monitoring duties and not used for taking rest breaks, meetings, as an office etc. These additional activities should be undertaken elsewhere, or the monitoring room should be formally included in the occupied buildings risk assessment and appropriate risk reduction measures applied.

ASSESSMENT METHODS

The revised guidance presents a hierarchy of assessment approaches, of which the simplest is again referred to as the "hazard approach". This requires the calculation of the severity of the hazardous effects which then determines the design specification for the building, such that it will protect the occupants. This approach is more usually applied to new buildings, where there can be less constraint on design and planning options, than for an existing building.

If this is the case, then a risk based approach can then be used. The guidance explains a simple risk-based method, used for screening and/or lower hazard situations. However, where this may not be conservative, for example where there are a number of similar threats to a building, then a more detailed exceedance curve approach is recommended.

The choice of assessment methods is described in the flowchart in Appendix 1, with further explanation of the risk-based approaches within the flowchart in Appendix 2.

The revised guidance has also included benchmark data (Appendix 3) which are often applied to the Hazard-based method. Where hazard consequences are below these benchmark levels, no specific building safety measures are required.

EXCEEDANCE CURVES AND THE "10^{-4} RULE"

The figure of 10^{-4} has been widely used in occupied buildings risk assessments as a frequency below which incidents, principally vapour cloud explosions, can be ignored. The origin, derivation and use of this figure is discussed in the new edition, making it clear that the figure has some validity and can continue to be used. However, the use of the 10^{-4} figure can make an implicit assumption that buildings will reduce the vulnerability of their occupants to 1% of the figure outside of the building, and therefore needs to be treated with care. It should, in new assessments or when assessments are revised, be subject to further checking to be certain that the conclusions it leads to are robust. The further checking is also important to ensure that there are no incidents which, alone or when summed, fall just below the 10^{-4} cut-off but which mean that significantly higher levels of overpressure could be experienced by an OB than that given by the 10^{-4} cut-off.

The principle method of carrying out these further assessment is by the use of exceedance curves. The construction and use of these curves and a more detailed discussion of the "10^{-4} rule" is given in the accompanying paper by Kieran Glynn (Glynn, 2011).

INDIVIDUAL AND AGGREGATE RISK

The previous versions of the guidance have had very specific statements that the guidance does not deal with societal risk and that the decisions in the guidance on the adequacy of protection are based on considerations of Individual Risk (IR). This is in line with UK legislation and the guidance of HSE's "Reducing Risks, Protecting People" document (R2P2) which applies the As Low as Reasonably Practicable (ALARP) test to IR. The new edition continues this clear guidance: decisions on the protection levels required in occupied buildings should be based on IR and the ALARP demonstration should be based on getting the IR of any person in an occupied building to the lowest reasonable level. Also the guidance does not deal with societal risk in its general sense, especially as it explicitly does not deal with issues to do with off-site populations.

However, this leaves two significant issues to be dealt with, even in relation to on-site populations: given that there are often a number of buildings which need to be brought up to standard, which ones have the highest priority? and: when deciding what needs to be done to a building, how do we apply the cost versus benefit judgement of the ALARP test to buildings containing very different numbers of people? Both of these are dealt with by invoking the idea of "Aggregate Risk" (AR), the sum of the risks to all the people in the building, measured over their exposure time in the building. AR is used as a specific measure of risk to a specific population and in this sense is not the same as societal risk, though it could be argued simply to be a subset of societal risk. However societal risk is a more general term, often (even usually) meaning the risks posed by any particular risk or set of risks (for example the set of risks from a major hazard site) to the whole population who are or might be exposed to those risks. Whilst AR should allow for all the risks which impinge on a particular building, AR is used in the guidance only to signify the

aggregation of the risks to the particular set of people who use the building over the period that each person occupies the building.

Used in this way aggregate risk provides answers to both of the questions posed above. Which buildings have priority? Assuming that any buildings found to have unacceptable risks will be dealt with promptly, the buildings with the highest AR should be dealt with first. In the same way, the change in the AR when a particular improvement is made will provide the benefit side of the cost-benefit equation when judging which changes are justified. This argument is illustrated in the guidance by the following examples:

- **Example where IR is the appropriate measure.** There are two buildings on a site. Building A has a single occupant whose level of IR is in the unacceptable region. Building B has 100 occupants and level of IR for the most exposed individual is in the tolerable region. The AR for building B is greater than building A. In this case IR is the appropriate measure (as this is in the unacceptable region) and building A should be the highest priority.
- **Example where AR is used for prioritisation.** There are two buildings on a site with similar levels of IR which are both in the tolerable region. Building C has a single occupant and building D has 100 occupants. The level of IR is slightly greater in building C than in building D. Prioritisation on IR would indicate that the building with the single occupant is the highest priority whereas AR would "correctly" prioritise the building with 100 occupants.
- **Occupancy value for IR calculation.** The HSE cautions against incorrectly defining the time any one individual spends carrying out a high risk task, compared with the situation where someone is always there performing the task. The hypothetical person to be defined should represent the worst case for occupancy of the task (which may in fact be carried out continuously). Taking this caution into account, the following examples show calculation of occupancy values for various sorts of building occupation.
  (a) On operating sites, working patterns such as job rotation may mean that no particular individual spends their entire time on site in a single building. Nevertheless where a building is occupied 24/7 or during office hours the standard assumption for calculation of occupancy for IR should be that a hypothetical person may spend all of their time on site within the building. Given a typical UK shift pattern, this would amount to around 1920 hours per year (or an occupancy probability of 0.22. (If non-shift personnel regularly take breaks or meals in the same building they work in, then their exposed hours may exceed their nominal working hours).
  (b) Where a building is only occupied for a defined period of time (e.g. a canteen which is only open for 2 hours/day and has no occupants outside this period) the individual risk calculation should be based on the number of occupied hours per day for the most exposed person (i.e. the person who spends the longest duration in the building). The occupancy probability need not exceed 0.22.
- **Occupancy value for AR calculation.** For buildings with multiple occupants (e.g. office buildings) consideration should be given to the overall risk by considering the number of occupants present at various times e.g. day, night, weekend. Companies should clearly document and justify decisions they make on occupancy probability in any calculation.

Example: Calculate the AR for a building which has 100 occupants during office hours and 20 occupants outside office hours.

$$AR = F \times 0.22 \times 100 \times V + F \times 0.78 \times 20 \times V$$

F – Frequency of the event
V – Vulnerability (probability of fatality given the event)
0.22 – Probability of the event occurring during office hours
0.78 – Probability $\underline{(1 - 0.22)}$ of the event occurring outside office hours.

TEMPORARY BUILDINGS

Temporary buildings have become an area of significant concern since the accident at Texas City, (Investigation Report, 2005) where most of the deaths were in and around a number of temporary buildings parked on vacant ground near the centre of the explosion. They are also an area where technology has moved on since the first edition and is another area which the new edition deals with in greater depth. When the first edition was written temporary buildings almost always meant timber framed, relatively lightly constructed "Portacabin" type units. Now steel-framed, window-less units have been developed which give much higher levels of protection for the occupants. These are more expensive than conventional units, though costs have fallen in recent years and costs are continuing to fall. Because of these changes the section dealing with temporary buildings has become Section 5, rather than an appendix, in the new document.

Sites should have a clear written policy dealing with temporary buildings, either as part of their overall occupied buildings policy or as a stand-alone policy document. The policy should be supported by a permit system to control where and for how long temporary buildings will be allowed on site. The permit system needs to have a firm review period to stop buildings starting as temporary but becoming, by default, permanent site fixtures. Although the first choice should be to locate temporary buildings in non-hazardous areas wherever possible, the guidance accepts that it is acceptable to locate buildings in areas with significant hazards provided an OBRA has been carried out, the building offers suitable protection, and the

risks can be shown to be at ALARP level. The benefits of locating protected buildings closer to a hazard, especially on more congested sites, can be justified if the analysis shows that the costs, in travelling time for example, make this location acceptable. This is an area where changes in equipment technology, as better items become available and costs fall, mean that what satisfies the "reasonable practicability" test changes – though in a sense this cuts both ways. A location previously unsuitable for a temporary building may be acceptable using a modern strengthened design; but a location where a standard building passed the ALARP test because of the high cost of a protected building, may now fail the ALARP test as costs have fallen.

Two other points should be made on temporary buildings, one on location and one on occupancy. A location may be justified during a shut down when hazardous materials have been removed from a plant and hazardous activities have ceased. However, start-up is always a higher risk period and this location may well be quite unacceptable during re-commissioning: the acceptability of a location may well change through the life of a project. Then there is a danger that the risks in occupied buildings may be significantly understated if the occupancy is "salami-sliced" over a year. It is not acceptable to reduce annual risk figures by only allowing the time a temporary building is on site, for example dividing by 25 if a temporary building is only on site for 2 weeks. Doing this could "use up" all a person's hazard exposure in the 2 week period and essentially assumes they face no significant risks for the rest of the year. The justification for any given location must be made as if the temporary building and the people in it were exposed to the appropriate hazards throughout the year, even if the actual period on site is relatively short.

MANAGEMENT

Another new section of the document covers the management of occupied buildings, an area not discussed in earlier editions of the guidance. The working group, especially those members involved in the management of chemical sites, felt that this was an omission which needed to be covered, if the proper value was to be obtained from the time and money made in the production of OBRAs. These assessments can be produced by external "experts" – consultants or head office staff – and then largely ignored as staff responsibilities, management structures and even ownership changes. They can gather dust, except as something to produce when the regulator asks for it.

The guidance recommends that normal Management of Change (MoC) procedures should be applied to occupied buildings. Sites should ensure that the MoC system covers changes to the use and occupancy of buildings and any physical changes to a building which could affect its integrity. The MoC system overall should ensure that the risk assessment for process changes, or changes to plant or equipment, consider any effects the changes might have to OBs. However, given the creeping incremental nature of many changes to buildings and occupancy, the new guidance also recommends that sites should have both a periodic, normally annual, inspection of the buildings, and a periodic review of the full OBRA. The inspection needs to check for changes to occupancy and for changes to the buildings which could affect their continued suitability for use. Changes of concern could range from simple replacement of a window, where normal glass may have been used, to the removal or breaching of fire walls as occupancy changes.

For COMAH/Seveso sites the periodic review is probably most usefully tied to the five-yearly COMAH/Seveso Safety Report review required for top-tier sites. This COMAH review should include a review of site's major hazards which form the most significant input to the site's OBRA. Non-COMAH/Seveso sites should use a similar time period to review that their existing OBRAs remain valid and up to date. It is important that sites remember that the aim should always be not only to check that there have been no changes which make the OBRA no longer valid or adequate, but also to search for further cost-effective risk reduction measures and to ensure that the ALARP demonstration remains current.

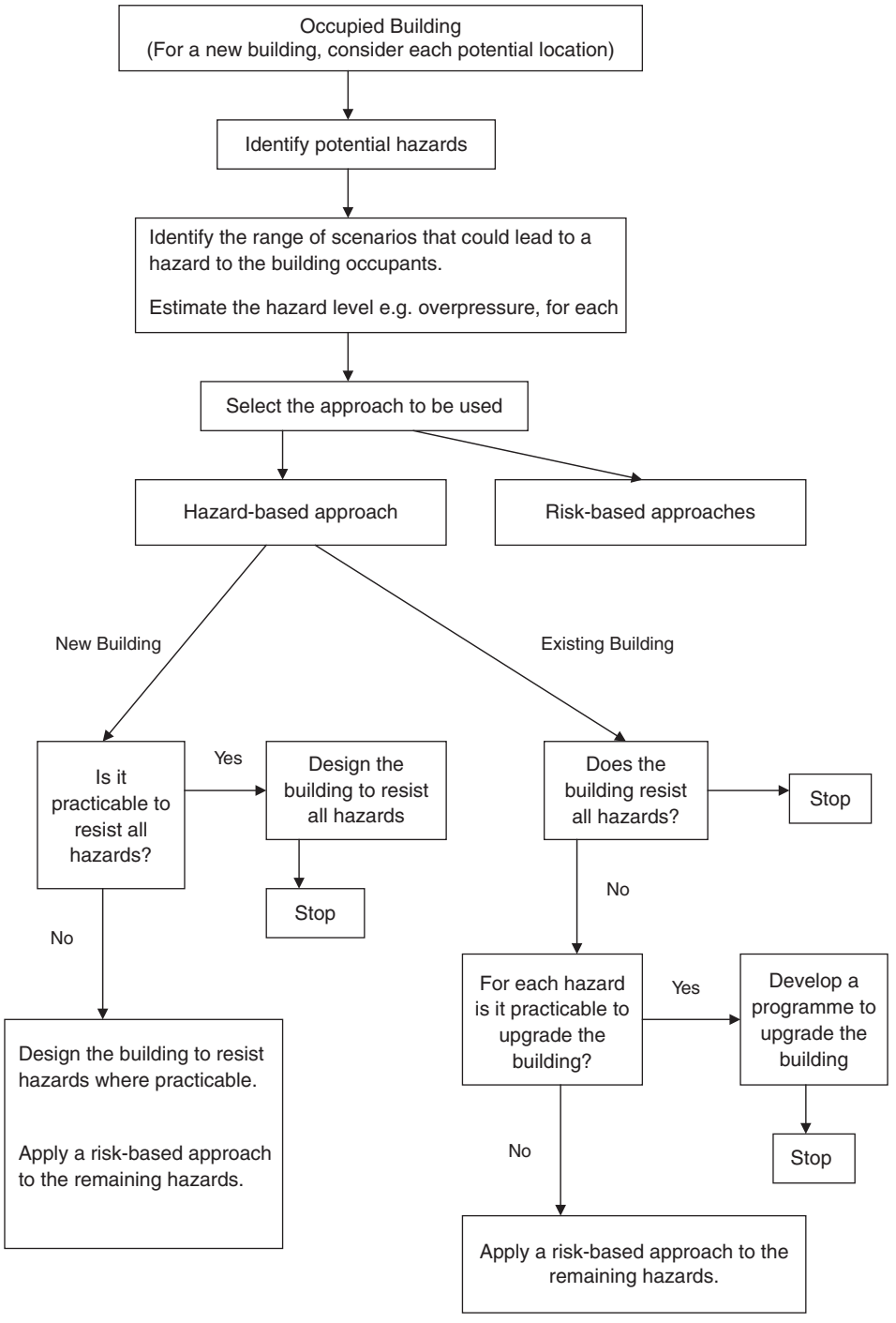
CASE STUDY

The inclusion of a case study in the guidance, based on a real OBRA of a UK site though not a simple reproduction of that study, is not intended to provide a "do it this way" template. It is intended to provide a demonstration of the steps which one company took to produce an OBRA (an OBRA which was subsequently accepted as adequate by the UK regulators); show the methods they employed; and illustrate some of the choices the site made during the production of and following the completion of the OBRA. The site has a number of major hazards on site and several of these could contribute to a vapour cloud explosion. This led the site to the use of exceedance curves and to making significant decisions on which improvements were justified both to control and administration buildings.

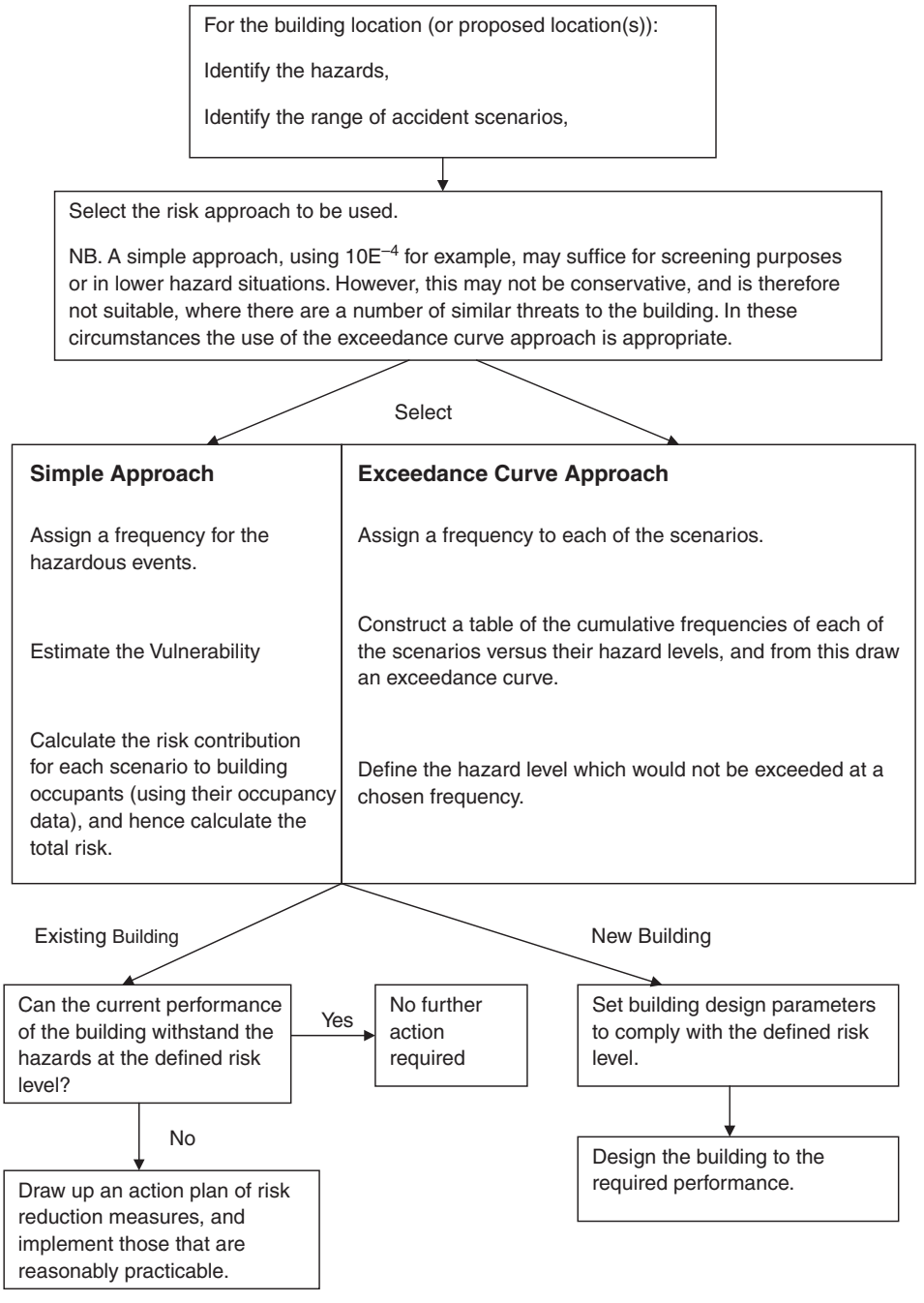
CONCLUSIONS

As will be clear the guidance has been very substantially re-written and hopefully brought in line with current thinking, without making existing assessments immediately out of date. Existing OBRAs should be reconsidered against the new guidance as they become due for revision and reassessment. The available techniques for OBRA have been extended and the matters which need to be considered laid out more clearly. The new techniques and considerations will need to be taken into account as OBRAs are revised – without ever losing sight of the fact that our primary duties are to keep people out of harms way and to reduce the risks of all of our operations as far as we can, for the benefit of the whole of society, on or around our sites.

APPENDIX 1: OVERVIEW OF OCCUPIED BUILDING ASSESSMENT APPROACH



APPENDIX 2: OVERVIEW OF RISK-BASED APPROACH TO BUILDING ASSESSMENT



APPENDIX 3: BENCHMARKS

Hazardous effect	Benchmark value: Below this no specific building safety measures are required	Basis
Explosion overpressure (PIP STC010108, 2006)	30 mbar	Overpressures below 30 mbars are insufficient to cause structural damage or significant window glass hazards
Thermal radiation	6.3 kW/m^2	Radiation levels below 6.3 kW/m^2 are taken as "safe escape" (1% fatality 90 seconds exposure)
Flammable gas	LFL	Buildings outside LFL will not experience ingress of flammable gas above flammable concentrations
Toxic gas concentration	EPRG 3	Buildings outside EPRG 3 will not experience concentrations of concern from toxic gas ingress

LFL Lower Flammable Limit

EPRG 3 Emergency Response Planning Guideline 3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

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