

# **HSE Comments and Actions on the Independent Review**

**“HSE’s Risk Analysis and Protection-Based  
Analysis Approaches for Land-Use Planning”**

**July 2005**

## **Introduction**

The independent review of HSE's risk analysis and protection-based analysis approaches for land-use planning (LUP) concluded that; '*HSE's risk analysis methodology was generally fit for purpose, being neither excessively conservative nor excessively non-conservative*'.

It also concluded that '*there were circumstances where a protection-based analysis was appropriate but the reasons for resorting to this approach were not always well defined*'.

The report also made eleven specific recommendations that included;

- amendment to methodologies,
- better definition of terminology,
- performing research,
- improvement of documentation of completed analyses.

HSE agrees with many of the conclusions and recommendations in the review, and has already acted upon some of them. In certain instances HSE had already identified issues of concern and had begun the process of addressing them before the review was completed.

However, there are a few recommendations on which HSE does not concur and there are others that we will not be taking forward. We wish to explain our position so that interested parties will be able to study the review and our response in context. This document has therefore been written to outline HSE's response to the review and present any resultant courses of action where appropriate.

It should be noted that the review covered methodologies used by HSE under our current LUP system whereby we provide advice on the basis of individual planning applications. There is a wider ongoing debate on whether the risks to proposed developments should be considered in a more collective way, and a cross-government task group is currently looking at such specific land-use issues. A more collective approach might mean that, rather than provide specific advice for individual development proposals, advice is provided on general land use in the vicinity of Major Hazard Installations (MHIs) and Major Hazard Pipelines (MHPs). This could ensure that overall risks did not increase as development was introduced.

## **Layout of this Document.**

The summary and conclusions of the independent review document are split into four main headings each with its own overall conclusions and recommendations:

1. Review of HSE's risk analysis methodology
2. Review of HSE's protection based approach
3. Review of assumptions used
4. Review findings relating to Bulk LPG storage.

By the nature of the topic area, this is a complex subject and the recommendations and their presentation reflect this. This document has therefore been designed to mirror the independent review layout, so that comparisons between the two are made easier, with HSE's

comments, and actions where appropriate, being presented after each conclusion or recommendation.

A Glossary of the acronyms used in this document has been provided at the end.

# 1. HSE's Risk Analysis Methodology

## Overall conclusion

*On the basis of the reviews conducted, it is concluded that HSE's risk assessment methodology is generally fit-for-purpose. No evidence was found that would indicate that HSE's methodology is either excessively conservative or excessively non-conservative.*

## HSE Comment

HSE welcomes this overall conclusion on its LUP risk assessment methodology. Despite this conclusion, HSE intends to continue to review and improve its performance; a review of the models and methodologies commonly used by HSE's Hazardous Installations Directorate's Methodology and Standards Development Unit (MSDU<sup>1</sup>) in setting land-use planning consultation distances has recently been completed. **(insert link to P5 on IFRLUP web page)**. Taking the findings of that review into account along with Recommendations 1 to 4 here, and other internal developments, MSDU has been considering the advantages of a more streamlined approach to LUP assessments.

The basis of such streamlined assessments would be as stated here:

The hazardous substances consent entitlement should form the basis of LUP assessments.

Relevant factors would include:

- The particulars of the consent for the site.
- Any constraints due to conditions of consent.
- Other matters not constrained by the consent:
  - Any road tanker loading/unloading operations (These need to be included despite there being no restriction on the frequency of this activity due to consent).
  - Certain permanent features of the site (e.g. where the hazardous substance location is clearly within a building).
  - Certain prevention, control or mitigation measures that are enforceable under the relevant statutory provisions (e.g. valves and other devices specifically provided as safety related systems).
  - On site pipelines.

It is HSE's view that the assessment method adopted should be no more than 'fit for purpose'. Where a protection-based analysis assessment is known to be appropriate then this should be the method of choice. Where a quantified risk-based assessment (QRA) is used this should be streamlined so that standard 'components' are utilised whenever possible. HSE also considered whether the degree of caution employed in the MSDU methodology for LUP risk assessment was appropriate.

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<sup>1</sup> MSDU has since been renamed Risk Assessment and Process Integrity unit.

The conclusion of that consideration was that, overall, each of HSE's LUP assessments is cautious, but not overly cautious. This does not mean that caution has been built in to every component of the analysis. A 'cautious best estimate' is the objective.

In terms of event frequencies, HSE uses historical accident data to inform our assessment of how often an accident may occur. We then note the assumption that the installations are operated in such a way that a major accident is no more likely than historical data suggests.

HSE cannot take site specific factors which may change over time into account in its assessments. If it did it would necessitate HSE constantly needing to review and re-assess risks. To avoid this problem and also be cautious, HSE uses generic frequencies and probabilities that reflect the view that operations are at least as good as historical data suggests.

Assumptions and uncertainties associated with the use of consequence analysis models still need to be treated with sufficient caution to ensure that HSE's assessments are neither unjustifiably optimistic nor overcautious.

MSDU's methods and assumptions are generally consistent with the concept of a cautious best estimate approach. However, assessment methodologies based mainly on consent 'entitlement' and constraints do not assess the residual risk from actual operations but the risk envelope arising from the entitlement.

It is also important to recognize that the degree of analysis appropriate for risk assessments used by HSE for LUP purposes is quite different from those required of duty holders for regulatory compliance with COMAH.

## **Specific Recommendations**

### **Recommendation 1**

*If in the future HSE seeks to apply QRA to types of plants more complex than those currently analysed using QRA, HSE consider supplementing the 'top down' approach to the identification of hazards with other methods.*

### **HSE Comment**

HSE does not agree with this Recommendation. HSE believes that the use of fault tree analysis and other bottom-up methods introduces a level of complexity and requirement for data that is generally beyond what is appropriate for LUP assessment under an 'entitlement' regime. However, where consent is subject to conditions, MSDU already applies an appropriate range of analytical techniques.

This Recommendation should not be interpreted as equating what is required for LUP assessments, undertaken by HSE, with what is required from the duty holder for regulatory compliance.

### **HSE Action**

This Recommendation is noted, but no further action is proposed.

## **Recommendation 2**

*HSE consider whether events resulting in unintended releases from vents (such as vessel overfill during transfers from road tankers) should be included in risk analyses for sites storing chlorine or other pressurised liquefied gases.*

### **HSE Comment**

HSE acknowledges that releases from vents are not considered explicitly, but 'holes in the vapour space' of vessels are included in assessments involving liquefied toxic gases. HSE believes that these amount to the same thing in terms of consequences.

Consideration of such releases is likely to be very site specific and not subject to plant conditions controlled by consent. It is likely to depend on technical measures such as pressure/level control, or the presence of scrubbers. The operating procedures and staff training may also be important factors.

At chlorine installations, for example, the level of protection is specified in standards (e.g. two bursting discs, expansion tank, scrubber, etc.) In this case it is suggested that explicit consideration of vent releases would add little or nothing to off-site risks.

### **HSE Action**

HSE (MSDU) will determine whether the 'release from vents' scenarios, under various circumstances including tanker off-loading, are significantly more likely than the 'holes in the vapour space' scenarios that are currently employed in this area of assessment.

If the 'release from vents' scenario is found to be significantly more likely than HSE's current assumed scenario then further research will be considered on its likelihood and consequences.

## **Recommendation 3**

*In the case of sites storing or using water reactive materials (such as sulphur trioxide), HSE consider whether the risk analysis should include scenarios where water is inadvertently added to the dangerous substance (for example, where water may be used for cleaning of tanks or equipment).*

### **HSE Comment**

The independent review raises two events to be considered:

- Water is added to a vessel containing a water-reactive substance.

HSE agrees that this event is suitable for consideration, but believes that it may be eliminated from an LUP assessment of a specific site due to extremely low probability.

- Water is used to clean out a vessel containing residual water-reactive substance.

This event involves a specific failure by the site to comply with good practice. An assumption of good practice is intrinsic to HSE's approach to LUP assessments, it being based on residual risk.

Either event may involve a breach of the Health and Safety at Work, etc. Act 1974 (HSW) under some circumstances. The points covered in this Recommendation seem more appropriately considered during a hazard analysis by the operator, and via regulatory compliance work by HSE, than as part of an LUP assessment. LUP assessment is generally based on a standard scenario list derived from the consent particulars (and current/future development nearby) rather than details of the actual plant on the day.

This Recommendation also raises questions about the wider principle of residual risk in LUP. The risk considered in LUP assessments is defined as the residual risk which remains after all reasonably practicable preventive measures have been taken to ensure compliance with the HSW Act (1974) and its relevant statutory provisions. The degree of caution in HSE (MSDU) assessments for LUP has recently been considered and found appropriate (see the HSE response to the general conclusion).

## **HSE Action**

HSE (MSDU) will include consideration of the first event in the next review of methodology for SO<sub>3</sub>, oleum and other water reactive substances, when the full range of foreseeable events (not just those described above) will be considered before the representative set of events is chosen to form the basis of the further analysis. The review of this methodology is not a current priority but links to other recommendations from the IFRLUP project on development of the 'REACTPOOL' model & water-reactives methodology.

In relation to the second event, for the reasons outlined in the 'comment' section, HSE does not believe it to be a relevant consideration under its LUP remit and intends no further action.

## **Recommendation 4**

*HSE perform further investigations into the significance of hazards arising from undesired chemical reactions and, if necessary, develop a means of including such hazards in a risk analysis.*

## **HSE Comment**

HSE already takes this into account on a case specific basis. Indeed reactions producing toxic gases due to inadvertent mixing of some compounds with acids already form the basis of assessments in some cases (e.g. the use of cyanide in electroplating baths). Some substances

(e.g. ethylene oxide) are known to undergo decomposition/polymerisation and are assessed accordingly.

The possibility of thermal runaway in a reactor or other process vessel is included in site-specific assessments. Toxic combustion products are included in fire scenarios. Substances produced during loss of control of an industrial chemical process have also been assessed. However, guidance for assessors on undesired chemical reactions is limited.

## **HSE Action**

HSE (MSDU) has already commissioned a study to identify and describe the scope for such events to result in a major accident, and assess the likelihood and consequences of a range of representative examples. The results from the study may be used to further inform this process.

Some work has already been carried out in Europe on the subject of substances generated following loss of control (e.g. EUCLIDE: a study on the emission of unwanted compounds linked to industrial disasters' V. Cozzani & S. Zanelli, EUR17351EN, European Commission, Luxembourg, 1997). HSE will consider conducting a review of this work to determine whether there are any implications for LUP assessment, although this is currently not a priority.

## 2. HSE's Protection-Based Approach

### Overall Conclusion

*The reasons for adopting a protection-based method, the terminology associated with the method, and the basis for the selection of events, are not clear.*

### HSE Comment

HSE does not disagree with this conclusion. Prior to the completion of the independent review process, HSE instigated an internal review of the methodology for carrying out a protection-based assessment. This has now been completed, with the following conclusions:

The protection-based approach as employed by HSE is based upon the description in the 3<sup>rd</sup> report of the Advisory Committee on Major Hazards (ACMH3):

“Ideally, the separation should be such that the population would be unaffected whatever accident occurs. For hazardous installations, however, such a policy is not reasonably practicable. It seems reasonable to aim for a separation which gives almost complete protection for lesser and more probable accidents, and worthwhile protection for major but less probable accidents.”

In its decision as to when to use the protection-based approach HSE is guided by the DETR Circular 04/2000 Para A4, which states:

“where it is beneficial to do so, HSE's advice takes account of risk as well as hazard – that is the likelihood of an accident as well as its consequences;”

Even given this, in many cases where a hazard-based approach is adopted, there is some understanding of the likelihood of the range of events that may have effects beyond the site itself. This information can be used to formulate a consistent basis for decision-making, taking into account both consequence and likelihood in an appropriate manner.

As part of the LUP process each site with hazardous substance consent needs to be assigned three safety zones around it, to allow the land-use planning consultation to be undertaken. To determine the extent of these zones each site has to be assessed. There are three assessment options are available for this purpose:

- Protection-based assessment
- Risk-based assessment (Quantified risk assessment, QRA)
- Generic assessment

Generic assessment is particularly designed for assessment of sites with deemed consent, and the hazardous substances are described by their generic category (e.g. toxic, flammable). So for most other types of site the choice is between a protection-based assessment and QRA.

Factors that need to be considered are:

- Dominating events are clearly identifiable.
- The maximum hazard range of the dominating events.

- The influence of ambient conditions (particularly wind direction) on the extent and severity.
- The effort required applying QRA.
- The degree of uncertainty that would be associated with the results of a QRA.

For all types of installation an initial hazard analysis is necessary.

The protection-based assessment methodology is most appropriate for installations with clearly identifiable dominating events, where the hazard ranges are generally no more than a few hundred metres, and the extent of the consequences of events are easily defined.

Even where a QRA is considered to be more appropriate, a protection-based assessment may be selected until the QRA methodology is developed, tested and implemented.

Three possible methods have been identified for any type of installation.

- Selection of a single/pair of representative hazard(s)

The full ranges of events are considered. Types of events that are capable of causing a major accident beyond the site boundary are listed along with qualitative descriptions of consequences and likelihoods. Some hazards are screened out on the grounds of insignificant consequences or extremely low likelihood. Further analysis is then required to determine whether any of the remaining hazards are dominant. To facilitate this, 'worst case' and 'average' consequences are calculated. These then become our "maximum credible accidents". The next step is to decide whether 'worst case' or average conditions are appropriate. It is then necessary to consider whether the selected event is appropriate for all three LUP zones:

The inner zone, where a high proportion of fatalities may be expected.

The middle zone, as analysed.

The outer zone, where additional protection is given to sensitive populations.

If a single event analysis gives appropriate consequence distances, relative to the 'complete' and 'worthwhile' protection criteria described in the 3<sup>rd</sup> report of the ACMH 3<sup>rd</sup>, then this is adopted.

- Selection of representative events from a consequence/frequency matrix

This method uses the same qualitative analysis of possible events as above but ascribes cautious frequencies to the resulting consequences. Order-of-magnitude estimates are generally sufficient for base frequencies. A house resident may be chosen to represent the middle zone population. The necessary levels of harm and frequencies are adjusted as appropriate for the other zones. The resulting distances to the frequency/consequence pairs are plotted on a matrix allowing the qualifying events to be grouped and the maximum consequence distances from the groups to be chosen. This limited set of event consequences is then applied to the actual conditions at any site to determine the extent of the LUP zones.

- Selection of representative events from a consequence/cumulative frequency analysis

This method requires a similar amount of information as needed for a QRA. The consequences and frequencies for each event are listed in order of consequence range along with the cumulative frequency. Once the analysis is performed over a range of example installations it becomes possible to identify appropriate events for each LUP zone, which can be used to assess individual installations from then on.

Though all these methods are acceptable the assessment method adopted should be no more than 'fit for purpose' and also depends on the quality of the information that is available.

## **Specific Recommendations**

### **Recommendation 5**

*The terminology used in relation to protection-based analysis ('worthwhile' protection, 'unlikely but foreseeable', etc) is better defined.*

### **HSE Comment**

These terms are qualitative in nature and descriptive of the end that is to be achieved. It is the combination of the level of harm and the frequency of that harm being experienced that is important. These will be determined in combination for any particular hazard, and depend on the method adopted.

### **Recommendation 6**

*The relationship between the two levels of protection stated in the aim and the three LUP zones defined by the analysis is described.*

### **HSE Comment**

For each of the possible methods to be adopted it is necessary to describe the level of harm and the frequency of that level of harm being experienced for each of the three LUP zones.

### **Recommendation 7**

*HSE develops internal guidance for Inspectors on selecting events for use in protection-based analyses*

### **HSE Comment**

This has been taken forward by the internal HSE review, detailed earlier, which describes a process involving three possible methods for selecting the events. The selection process

occurs before any site is assessed. For any particular type of hazardous installations, where a protection-based assessment is appropriate, there will be a specific conclusion describing the events (1-3) to be chosen and the corresponding level of harm to be used. These events are then analysed and the results used for setting the three zones around any qualifying installation.

### **Recommendation 8**

*Where protection-based analysis is used for installations of a given type, the reasons for adopting a protection-based approach, together with the rationale for selecting the event or events used in the analysis, are documented in such a form that the information could be released to interested parties outside HSE as required.*

### **HSE Comment**

To a certain extent this is already the case. A full description of the methodology for LPG installations is contained in published reports and the MSDU information system.

### **HSE Action**

A full description of HSE (MSDU) methodology is contained in the MSDU information system. Technical details, and selected examples, of HSE's approaches to land-use planning are also to be published on its website in a document entitled 'HSE's Land-Use Planning Methodology Technical Reference Document'.

### **Recommendation 9**

*HSE continues to perform research into risk analysis methods so that some of the reasons for using a protection-based approach can be resolved.*

### **HSE Comment**

HSE already has a range of research activities ongoing or planned in this area, where the results are deemed to be beneficial to itself and its stakeholders. For example, HSE has recently developed a risk-based assessment technique for certain large-scale flashfire hazards through the application of recent research results. This work is beneficial to both HSE and its stakeholders as it is likely to contribute to reduced CDs whilst still maintaining an acceptable level of protection for the public. HSE believes that the wording of this Recommendation fails to acknowledge the current requirements placed on HSE (DETR Planning Circular 04/2000) to apply protection-based approaches in LUP assessments unless it is 'beneficial' to apply a risk-based approach.

## **HSE Action**

HSE have carried out a general review of protection-based methodology.

The general conclusion is that a number of schemes are possible for identifying the representative event or events. The scheme that is most appropriate for a type of installation will depend on the complexity of the type of installation, the extent of uncertainty associated with the understanding of risks from the type of installation, and the need to do no more than what is 'fit for purpose'. Where beneficial a risk based approach will be adopted.

## **Recommendation 10**

*With regard to the specific protection-based approach used for bulk liquefied petroleum gas (LPG) storage, it was noted that the choice of event for the analysis was influenced by the frequency of the Boiling Liquid Expanding Vapour Explosion (BLEVE) event currently assumed by HSE. It is recommended that:*

*The estimate of this [BLEVE event] frequency is updated and, depending on the outcome of this revision that the selection of the event used in protection-based analyses of bulk LPG installations is revisited.*

## **HSE Comment**

This matter has received extensive consideration by MSDU in the past, including the consideration of frequency data and the use of fault tree analysis. As a consequence of this, HSE believes that:

- The result is very sensitive to site specific assumptions and the problem is complex due to concurrent and stochastic aspects.
- The use of a cautious estimate is legitimate.
- A protection-based assessment is appropriate.

## **HSE Action**

MSDU will continue to take account of any new data or analysis concerning the frequency of this event, and the contributing factors, to ensure that the representative event(s) remain appropriate.

### **3. Assumptions used**

#### **Overall conclusions**

*All of the assumptions reviewed were found to be appropriate and / or in keeping with the approach taken by most risk analysis practitioners, with one exception. The assumption questioned is that relating to the amount of LPG in a vessel when it undergoes a BLEVE, for which a recommendation has been made.*

#### **HSE Comment**

The one assumption questioned in the report relates to the amount of LPG assumed present in a tank when it undergoes BLEVE. An internal review of HSE's protection-based methodology has been carried out and the conclusions described earlier in this document. In the case of bulk LPG storage establishments the review found that the use of a protection-based analysis was currently justified. This was on the grounds that the level of harm resulting from a major accident at its worst would far exceed that of a 'dangerous dose', the current harm criterion for a risk-based assessment method, and there was still considerable uncertainty concerning the frequency of such an event, and how it could be assessed, at any particular installation.

#### **Specific Recommendations**

##### **Recommendation 11**

*It is recommended that: the assumptions relating to the amount of LPG in a vessel when it undergoes a BLEVE are revisited. This is particularly important if the BLEVE event is going to continue to be used for protection-based analysis of bulk LPG storage installations. It is believed that the amounts currently assumed by HSE could represent an underestimate in some cases.*

#### **HSE Comment**

As detailed previously, prior to the completion of the independent review, HSE (MSDU) instigated a review of its protection-based methodology. As part of that review a typical small LPG installation was used as the example for the application of three types of methodology. In all three cases the results were similar, which in MSDU's opinion demonstrates that the existing approach and assumptions are fit for purpose.

#### **HSE Action**

This Recommendation has been addressed as part of the review of the protection-based methodology. No further action is proposed.

## 4. Findings related to bulk storage of LPG

### Overall conclusions

*The level of harm arising from many of the major accidents at a bulk LPG establishment would be considerably worse than a 'dangerous dose', justifying the use of a protection-based approach. However, this objection could be dealt with by using a risk-based analysis with fatality as the harm criterion. Another reason for the adoption of a protection-based approach for bulk LPG storage is that there is considerable uncertainty associated with the likelihood of some of the events that may occur, particularly the probability of ignition of flammable clouds and the frequency of a BLEVE. Further research in these areas is recommended (Recommendations 9 and 10). It may be that, as an interim position, protection-based analysis is retained, but with the use of an event other than the BLEVE, to generate the LUP zones. The assumption used in the current analysis methodology relating to the amount of LPG in a vessel when it undergoes a BLEVE is questioned. A recommendation has been made (Recommendation 11).*

### HSE Comment

The overall conclusions from this specific review of bulk storage of LPG repeat those reported under the protection-based approach review in Section 2. They also repeat the conclusions reached in Section 3 on the assumptions employed by HSE when performing land-use planning assessments. Readers are referred to the HSE comments in Sections 2 and 3.

## Glossary

**ACMH** – Advisory Committee on Major Hazards

**BLEVE** – Boiling Liquid Expanding Vapour Explosion

**CD** – Consultation Distance. This is the distance, from an MHI or MHP, inside which HSE must be consulted about proposed developments.

**COMAH** – Control Of Major Accident Hazards Regulations 1999

**DETR** – Department of the Environment, Transport, and the Regions

**HSE** – The Health and Safety Executive

**HSW** – the Health and Safety at Work etc Act 1974

**IFRLUP** – the Implementation of the Fundamental Review project

**LPG** – liquefied petroleum gas

**LUP** – land-use planning

**MHI** – Major Hazards Installation

**MHP** – Major Hazards Pipeline

**MSDU** – the Methodology and Standards Development Unit of HSE. This unit has recently been renamed, and is now known as Risk Assessment and Process Integrity.

**QRA** – quantified risk assessment, risk-based analysis approach