Seveso Inspections Series - Volume 2
A joint publication of the European Commission's Joint Research Centre and the United Kingdom Health and Safety Executive

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IMPROVING MAJOR HAZARD CONTROL AT PETROLEUM OIL REFINERIES

KEY POINTS AND CONCLUSIONS

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Mutual Joint Visit on Seveso Inspections
in Petroleum Oil Refineries,
8-10 March 2006, Liverpool, UK

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Editors
A Murray, M Wood, and V Beckett

HSE Environment Agency SEPA ipsc Institute for the Protection and Security of the Citizen MAJOR ACCIDENT HAZARDS BUREAU EUROPEAN COMMISSION DIRECTORATE-GENERAL Joint Research Centre

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Disclaimer: The main purpose of the document is to provide a collection of knowledge representing the state of practice in the EU in the expectation that it will aid Seveso inspectors and inspections programmes in reviewing and improving their performance as appropriate. It is understood that several approaches to controlling this type of major hazard may be equally effective and the document is not offered as a definitive assessment of all possible options in this regard. Moreover, the editors note that where information is provided on a practice applied in a particular country it has been provided with the view that this might be useful descriptive information. However, the document does not intend to represent a complete description of any one country's inspection practices since they often differ internally between regions and sometimes between competent authorities who share Seveso inspection responsibilities.

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Preface

The inspection function has always been considered one of the most powerful and dynamic tools available to Member State authorities for enforcement of the Seveso II Directive. For this reason the European Commission along with competent authorities responsible for Seveso II implementation have long held this area as a priority for EU level technical co-operation. There is a strong, shared commitment to continuing to work together to increase the effectiveness of inspection practices and to ensure a consistent approach to interpreting Seveso requirements through inspections across the Member States.

The Seveso Inspections Series is intended to be a set of publications reflecting conclusions and key points from technical exchanges, research and analyses on topics relevant to the effective implementation of the inspection requirements of the Seveso II Directive. These publications are intended to facilitate the sharing of information about Member States' experiences and practices for the purpose of fostering greater effectiveness, consistency and transparency in the implementation of Article 18 of the Directive. The series is managed by the European Commission's Technical Working Group on Seveso II Inspections (TWG 2), consisting of inspectors appointed by members of the Committee of the Competent Authorities for Implementation of the Seveso II Directive (CCA) to represent Seveso inspection programmes throughout the European Union. The Technical Working Group is coordinated by the Major Accident Hazards Bureau of the European Commission's Joint Research Centre with the support of DG Environment.

The booklet, *Improving Major Hazard Control at Petroleum Oil Refineries: Key Points and Conclusions*, is one of a series of publications that form part of the Seveso Inspections Publication Series. The publication series is one of a number of initiatives currently in place or in development to support implementation of the Directive and sponsored at EU level. In particular, a prime source of content for publications in this series is the Mutual Joint Visit (MJV) Programme for Seveso II Inspections. Launched in 1999, the European Commission's MJV Programme was intended to serve as a vehicle for promoting technical exchange among Member State

Seveso II inspectors. The aim of the programme was to encourage the sharing and adoption of best practices for inspections through a system of regular information exchange. The visits would be hosted by different Member States (hence visits would be 'mutual') and targeted for working inspectors of other Member States (and thereby 'joint' visits) charged with assessing compliance with the Seveso II Directive in industrial installations. The MJV Programme is managed by the Major Accident Hazards Bureau in consultation with the TWG on Seveso II Inspections.

Since 2005 the MJV programme has encouraged visits focusing on topics of specific interest for Seveso inspections as identified by the Technical Working Group. To the greatest extent possible, the conclusions and observations of inspectors participating in these workshops will be published as part of the Seveso Inspections Series.

The mission of the TWG is to identify and recommend actions to promote exchange of information and collaborative research among the Member States for improving the quality and consistency of implementation of Seveso II obligations within the Seveso inspection authorities. The results of these efforts may also be published separately on the Seveso Inspections website, or combined with MJV summaries in the Seveso Inspections Series.

For more information on Seveso refineries inspections, please visit the website http://sevesorefineries.jrc.it that was created as a result of recommendations from this workshop. You may also find useful information on its parent site, http://sevesoinspections.jrc.it and the MAHB website (http://mahbsrv.jrc.it). Together these sites contain useful references to Seveso legislation, its implementation and related risk management and assessment projects.

Executive Summary

This report documents the purpose and arrangements for a Mutual Joint Visit (MJV) on the subject of petroleum oil refineries, which was hosted by the Seveso II Competent Authority in Great Britain between 8-10 March 2006. It represents an output from the meeting in accordance with the Commission's (Draft) Terms of Reference for the Mutual Joint Visit Programme. The document is designed to capture the information and share it in a meaningful way with other inspectors. It includes observations and conclusions from discussions among inspectors and other experts participating in the MJV as well as recommendations for follow-up actions and suggestions for implementing them.

In particular, the MJV emphasised that there was an urgent need for a structured form of knowledge sharing to establish a widespread level of knowledge in a number of areas among both operators and competent authorities, with special attention to such areas as:

- Lessons learned from accidents and near-misses in refineries.
- Accident reporting and investigation strategies specific to refineries.
- Safety performance indicators for use by both industry and competent authorities.
- Inspection findings, plans and strategies.
- How to improve human reliability when operating complex systems.

A number of practical measures for facilitating knowledge sharing in these areas were suggested, including:

- Collaboration on the development of a website for Seveso refinery inspectors and operators whose purpose would be to facilitate information exchange on technical issues.
- Exploration of the potential to share near-miss reports on an EU-wide basis.
- Development of good practice guidance for incident investigation and reporting of refinery incidents.
- Organisation of another special topic workshop relevant to oil refinery safety.
- Development and application of safety performance measurement

'indicators' for use of both industry and competent authorities.

This report is a summary of the presentations and discussions that took place during the Mutual Joint Visit. In addition, several presentations are provided in the Annexes to this document and the information is also downloadable from the MAHB Seveso inspections and Seveso refineries websites at http://sevesoinspections.jrc.it and http://sevesorefineries.jrc.it.

1 Council Directive 96/82/EC on the control of major accident hazards involving dangerous substances.

The Mutual Joint Visit on petroleum oil refineries

Between 8-10 March 2006, the GB Health and Safety Executive hosted the 15th Mutual Joint Visit (MJV) on behalf of the European Commission's Committee of Competent Authorities for the Implementation of the Seveso II Directive (CCA). The Chemical Industries Division of the Health and Safety Executive together with the Environment Agency, and the Scottish Environment Protection Agency make up the Competent Authority for the Seveso II Directive in Great Britain.

This was the second only Phase 2 Mutual Joint Visit. The visit was organised as a workshop on petroleum oil refineries.

Why petroleum oil refineries?

Petroleum oil refineries operate in most Member States of the European Union.[1] In total, European refineries represent a little over 12% of the world's refining capacity. There are 130 refinery establishments currently in operation in Europe taking into account Candidate Countries, Switzerland and Norway (see Annex 2). Of these, the vast majority are top tier sites.

Whilst providing products essential for many national economies, the processing of high volume flammable hydrocarbons presents major accident hazards that may impact on the immediate and wider communities in the event of plant failure and loss of containment. Major accidents on refineries such as Killingholme (UK, 2001), Puertollano (Spain, 2003), Karlsruhe (Germany, 2004), and Texas City (United States, 2005) demonstrate the potential catastrophic (and sometimes fatal) consequences. Regulatory authorities need to assure that refinery operators manage their hazards effectively and continuously strive to reduce risk.

As a defined sector with a great deal of commonality between individual refineries, as well as many refineries having a multinational presence, it is important that Competent Authorities are consistent in their approach to the regulation of European oil refineries. An MJV 'topic' meeting was

considered to be a way of moving towards this objective.

The Mutual Joint Visit programme

The MJV programme is sponsored by the European Commission on behalf of the Committee of the Competent Authorities for implementation of the Seveso II Directive (CCA) and DG-Environment, and is managed by the Major Accident Hazard Bureau (MAHB) of the European Commission's Joint Research Centre (http://mahbsrv.jrc.it). The programme was launched in 1999 to support exchange of information among European Seveso II inspectors on inspection practices and effective accident prevention measures. The programme is sponsored by the European Commission and the Member State competent authorities for Seveso II implementation. At each MJV a workshop focusing on the general procedures and experiences relative to Seveso II inspections ('Phase 1') or special topics ('Phase 2') is held. The programme offers Member States the opportunity to develop together a more sophisticated understanding of what constitutes Seveso compliance and acceptable safety in an inspection context. In particular, it provides a platform for jointly exploring effective approaches to risk control and industrial safety as it relates to different technology and industrial sectors and more generally for reviewing and improving tools and strategies for assessing site safety management. The programme is rooted in the belief that Member States can learn from each other and work together constructively to solve common problems and by doing so increase their technical proficiency and the effectiveness of their respective inspection programmes.

Meeting participants consist of representative of inspectors from EU Member States and Candidate Countries. A number of industry experts are also usually invited to participate in the visits in order to provide an industry perspective and contribute specific expertise, with a view to promoting better communication and transparency between inspection authorities and the regulated community.

The MJV Phase 2 strongly emphasises the dissemination of meeting results so that all Seveso inspectors in Europe may have the opportunity to benefit from MJV technical exchanges. Therefore, this report will be published as part of the Seveso Inspection Series and made freely available to the European Union of Seveso inspectors as well as to other organisations and

Table 1 Themes for the workshop programme

Theme	Topic (or issue, activity, installation etc)	Benefit and/or challenge to industry/regulators	Potential practical output from workshop (for illustration only)
1	Knowing and understanding the health, safety, and environmental regulatory issues.	Identifying common issues and concerns facing industry and regulators, and how we can work together: how collaboration can achieve improvements.	(i) Options for future collaboration on the common issues and concerns identified. (For example, coordinated regulation for each major company in the European refinery sector). (ii) Mechanisms to check the implementation of conclusions to prevent major accidents.
2	Learning from accidents.	How industry and regulators can maximise on lessons learnt to reduce risk, and integrate them into their programmes.	(i) Practical examples and conclusions of refinery accident investigations. (ii) The development of an information exchange network.
3	Assuring refinery process safety performance.	Identifying the underlying causes (precursors) to refinery major accidents and using that knowledge to prevent future accidents.	(i) Guidelines on how to implement meaningful leading performance indicators for major accident safety. (ii) Improved benchmarking across Europe on performance measurement and sharing of consistent measures.
4	Targeting high hazard installations.	How to prioritise, plan and conduct inspection at refinery installations, eg benchmarks in plant operation/design, auditing safety management systems (including company audits), safety integrity levels (SILs) etc.	(i) Guidelines on a general framework for inspection report. (ii) Criteria to define the scope of an inspection. (iii) Main irregularities identified at inspection.

experts with related interests within and outside Europe.

Aims and objectives of the MJV on petroleum oil refineries

The workshop specifically aimed to identify priorities, benchmarks and strategies for risk reduction at high hazard installations and to exchange practical experience relating to intervention techniques and targets, with the objective of generally improving consistency in compliance with the Seveso II Directive across Europe. Examples of the kinds of outcomes that were envisioned include:

- The identification of **common safety issues and common approaches (ie, strategic, methodological, technical, etc) to addressing them**.
- A recommendation to establish a **network** of Seveso 'refinery' regulators that can support each other in preventing accidents and dangerous incidents.
- Recommendations to advance **cooperation** on effective interventions with international/refining companies in order to maximise the impact of these interventions.
- The identification of **tools and mechanisms** essential to supporting these kinds of European partnerships.

Organisation and structure

The format comprised a mix of presentations and case studies interspersed with smaller roundtable discussion groups (consisting of 10-12 delegates). These groups shared and debated information to develop common understandings on the four Workshop themes:

- Learning from accidents.
- Assuring integrity management.
- Inspection strategies.
- Human factors.

A discussion paper on each theme with guiding questions had been

2 Council Directive 96/82/EC on the control of major accident hazards involving dangerous substances.

prepared and distributed to participants prior to the meeting. Each discussion group was chaired and the main points from each discussion were summarised and reported in a follow-up session. Written summaries were also provided to the meeting organisers and much of the information in this report was based on these summaries, as well as presentations and discussions that took place in the meeting itself.

Participation

The workshop was designed for inspectors who enforce the inspection requirements of the Seveso II Directive[2] (Article 18) at petroleum oil refineries. The UK competent authorities and MAHB solicited nominations for participants with the requirement that all participants nominated should:

- have practical knowledge of the installations and activities at refineries and the risks involved;
- have practical experience of applying the Seveso II Directive and associated national law;
- want to participate actively in the workshop; and
- undertake to disseminate the workshop's outputs within their Member State.

There was a significant breadth of delegates present including 29 representatives from 20 European countries (including delegates from Candidate Countries to the European Union (Romania and Croatia), the majority being inspectors of major hazard sites with refineries included in those responsibilities.

In addition, representatives from the refining industry were also invited to contribute an industry perspective and in recognition of their considerable expertise. Moreover, it was clearly recognised that the competent authorities and industry share a strong common interest in improving information exchange on safety problems and lessons learned as well as exploration of leading edge solution. In all there were seven representatives of the industry coming from the UK Petroleum Industry Association, the Council for Clean Air and Water in Europe (CONCAWE), and the European Process Safety Centre.

Additional invitees included a representative of the workforce: **Transport and General Workers Union;** and a Board Member from the United States Chemical Safety and Hazard Investigation Board (US CSB).

A list of delegates can be found in Annex 1.

It was hoped the event would act as a catalyst for European regulators to become more outward-looking and develop its working links with its counterparts in other European Member States – the refining industry is global and often centred outside the UK (Europe).

Outputs

The following chapters summarise the outcome of the presentations and discussions that took place surrounding the four themes addressed at the workshop. The summaries largely highlight common problems and areas where (all) representatives agreed that further work would benefit Seveso inspections and inspectors and help to raise safety standards in the petroleum oil refining industry. In some cases differences in approaches were noted by participants and where available the results of these discussions are also included here for information.

Outputs/recommendations from the workshop

Theme A: Learning from accidents

Objective(s) *How can industry and regulators maximise on lessons learnt from (loss of containment) accidents to reduce major accident risk, and integrate them into their (inspection) programmes?*

Background
In the European Community (EC) there are approximately 130 petroleum oil refineries. Since the implementation of the Seveso II Directive 96/82/EC (ca.2000), 9 major accidents at petroleum oil refineries have been notified to the EC. The need to identify what went wrong and prevent a recurrence is natural but the Seveso II Directive required this also as part of an operator's safety management system *(Articles 7, 9 and Annex III element (c)(vi))*. Accidents provide valuable information for both regulators and duty holders to ensure that lessons learnt minimise the chance of a recurrence with potentially greater consequence.

Member States may also have requirements for the internal reporting and investigation of incidents beneath the thresholds for an EC notifiable accident *(Article 15(1) & Annex VI)*. The investigation process is normally thorough and comprehensive (resource intensive) and examines many aspects, including technical, organisational and managerial factors *(Article 14)*.

Recent major accidents, notably at Texas City (USA) and Buncefield (UK), graphically illustrate the potential on and off-site consequences that such major accidents can produce, and naturally raise public anxiety about the controls on major industrial activities; not least why did an accident happen when a similar incident may have occurred elsewhere?

Common issues of concern
The participants identified a number of common issues of concern around this theme.

A1 Failing to maximise on information available
Much information has been published on lessons learned from accidents but the quality, accessibility, timeliness, and targeting of the information, amongst other factors, substantially affect its usefulness to both operators and the competent authorities.

As a number of presentations illustrated, finding information on comparable situations, whether inspecting a particular process or investigating an incident, always seems to require a large amount of effort. Even if reports of past accidents with aspects relevant to the current problem are identified, extracting the key lessons learned can still be quite cumbersome. In essence, the problem has several aspects: existing databases are often difficult to search, many incident reports with valuable information are not available outside the establishment or the competent authority, and if reports are available, they may not be organised well enough, or searched easily, to give a clear picture of the causal factors and lessons learned.

Participants identified a number of possible activities that could be undertaken to improve the situation.

- Development of a 'good practice' guide would be helpful on incident investigation and structured sharing of knowledge.
- Creation of a simple master directory (with a few key details) of refinery incidents that have taken place worldwide.
- Establishment of an open website for sharing safety information specifically relevant for refineries.
- Development of common criteria for incident investigation and reporting.
- Establishment of a voluntary reporting scheme for refinery incidents occurring throughout Europe.

It was understood that implementation of these suggestions would need further examination to determine which are most currently viable. Progress would most likely require a joint effort from refinery operators and competent authorities. Moreover, in some cases the legal concerns or

3 This also reflects a recent amendment to Seveso II Directive, 2003/105/EC, Article 1.12.

political sensitivities could constrain information sharing.

A2 Near miss reporting
There was a consensus that near miss data was an essential and valuable information source. This issue is strongly related to the issues identified in A1 and shares many of the same characteristics, particularly lack of availability of near miss reports. As a main conclusion it was agreed that a common threshold or definition was needed for identifying interesting and relevant incidents.

The activities suggested in A1 above could in addition be used to also strengthen near miss reporting and accessibility to near miss reports.

A3 Site employees and contractors
Participants generally agreed that refineries faced an ongoing challenge of providing an equal level of protection to all workers on site in proportion to their exposure to risk. A number of incidents have occurred at refineries over the years involving contract workers. As such, a priority should be placed on learning from these events and systemically improving the safety of contractors at refineries.

Patterns of use of contractors should also be explored. Third party employees are carrying out more frontline operational work on refineries. Industry needs to ensure that 'all on site' are afforded the same level of protection.[3]

Theme B: Assuring integrity management

Objectives: *To share experience on evaluating the effectiveness of the [operators] through life management of integrity of important refinery systems on a complex refinery establishment.*

To examine how regulators and industry can implement meaningful performance indicators for major accident safety, and improved benchmarking across Europe on performance measurement and sharing of consistent measures and indicators.

Background

One of the requirements of the operator's safety report is to demonstrate:

'that adequate safety and reliability have been incorporated into the design, construction, operation and maintenance of any installation, storage facility, equipment, and infrastructure connected with its operation which are linked to major-accident hazards inside the establishment.' (Directive 96/82/EC, Article 9(1)(c).)

Few new refineries are being built in Europe. The chemical characteristics of crude oils are not constant. There is a worldwide trend towards exploiting crudes with higher acidity, which has a knock-on effect on the plant maintenance and inspection strategies, particularly towards corrosion. Also operating temperatures and capacities have an effect on corrosion and other failure modes (some plants are being operated at or even above their original operating capacities).

Therefore, the challenge to the refinery operator is to maintain existing (often aged) refinery installations and productivity, perhaps beyond their original design lifetime. This requires decisions on continued operational life (life extension) of refinery plant based on sound plant data generally derived from examination strategies (and increasingly today, based on risk-based inspection (RBI) in the UK). In other Member States, the type of the examination (and frequency) of refinery plant may be prescribed differently.

Measuring and monitoring the overall effectiveness of health and safety programmes and the implementation of risk control systems is an essential part of any safety management system. Operators of major hazard establishments such as oil refineries are required to have such monitoring systems in place. In this context, the use of safety performance measures as a potentially new tool for managing particular risks associated with refinery safety, eg, maintenance failures, ageing plants, was introduced as a topic for

4 Travers, I *Process safety performance indicators. Step-by-step guide to implementing KPIs. Presentation for the European regulators workshop on refineries*. March 2006

discussion in connection with integrity management by several presenters.

As the presenters noted, it is not uncommon for operators to monitor their performance through the use of indicators; indicators are used in the management of many business risks including financial, productivity, and quality. In the field of safety management, the lost-time injury is often used to measure the performance of an operator's safety management arrangements. However, lost-time injuries are often associated with injury caused by failure to manage risks such as working at height, slips, or manual handling. These measures do not reflect the performance of the management of the process safety-related risks that may arise from major accident hazards, which if uncontrolled will manifest themselves in a loss of containment leading to a major fire, explosion or emission of one or more dangerous substances; the consequence of which may impact on many persons both on- and off-site.

Measures specifically designed to measure performance of major hazard controls in an operation are being developed and also applied successfully in some establishments. Yet it is evident that these experiences, and the knowledge and understanding of how to establish and apply measures for specific operations, have not yet been widely shared. It was suggested that both industry and the competent authorities that oversee their efforts have an interest in widespread development and use of this performance measurement technique within the refinery industry.

Common issues of concern

In general the discussions around this theme centred on the difficulty of identifying when critical safety systems are losing reliability at an early enough stage, that is, before safety levels are significantly undermined. As one presentation noted, 'critical systems deteriorate over time often without causing any impact until they fail catastrophically.'[4] Common tools for identifying safety failures, such as audits or analysis of lost-time incidents, have not proved particularly successful for preventive detection of integrity deficiencies. For example, approaches that rely on injury, incident and near-miss data, are actually not preventive enough because these data tend to be lagging indicators of an integrity problem. Not only are measures more specific to major hazards required, but leading indicators that can help detect deterioration in performance before an incident occurs.

The participants highlighted three specific areas of particular concern:

B1 Integrity management
Good practice requires that the integrity of the whole refinery establishment is managed using a structured process, including unit operations, offsite (off plot) facilities, and utility systems. The participants highlighted that maintenance remains the key plant life cycle issue.

B2 Ageing refineries
This trend coupled with changes in crude oil characteristics and working practices is widely perceived as increasing refinery risks as well as the nature of those risks. The participants questioned whether industry and competent authorities are adequately alert to the potential threat(s). They noted in particular that focused attention should be paid to the following areas:

- Succession planning and potential loss of corporate knowledge in the face of organisational change, particularly changes in ownership, reduction of the work force, and early retirement options.
- The importance of maintaining an ongoing high level of competence for identifying and managing critical safety factors within both operators and competent authorities.
- The safety demands associated with the increased reliance of the industry on outsourcing and contract workers for specific types of work, such as maintenance. Operators should interact with suppliers and respond to these demands as an 'intelligent' and responsible customer.

B3 Safety performance measurement
Participants supported spreading knowledge about safety performance measures for high hazard industries and encouraging more widespread development and application of them in the refinery industry. Several observations were made concerning the potential direction of future work as follows:

- There is a particular need for development and application of leading indicators.

- There is already work ongoing in this area in various countries, such as the Netherlands, the United Kingdom and France. The knowledge and experience gained from these and other similar efforts should be pooled and made available to the broad community of refinery operators and inspectors.
- It is recommended to advance stepwise in the early stages of Key Performance Indicator (KPI) development to assure a controlled approach to their implementation.
- In the same vein, the KPIs should be introduced cooperatively rather than coercively based on perceptions of where the most value-added benefits could be achieved. Moreover, they should be tested and calibrated, or re-calibrated, as necessary to ensure that this value-added is in fact realised. This approach provides better assurance that major accident prevention and compliance improvements will be obtained.

B4 Safety critical systems

A clearer definition of what constitutes a 'safety critical system' is required to aid both plant life cycle integrity management and the development of appropriate safety performance measures (KPIs).

As noted in discussions on Theme A, coordinated knowledge sharing and structured good practice would help both operators and competent authorities be more effective in preventive safety management and oversight. Failure to learn from known accidents may cause an operator to overlook the signs of a particular failure (degradation) modes.

Moreover, it was observed that, whilst legal frameworks differ amongst Member States for integrity inspection (eg, goal-setting versus prescriptive measures), they do not take away the need to inspect the plant correctly, using appropriate test methods for the degradation mechanisms, and analysis of the results in order to make appropriate decisions to prevent loss of containment.

It was cited that coordination and communication between competent authorities (eg, regulatory departments, other authorities) is a particular challenge in the oversight of major hazard control at refinery operations.

Theme C: Inspection strategies

Objective(s): *To examine approaches to prioritising, planning and conducting inspection at refinery establishments, for example, inspection toolkits, benchmarks in plant operation/design, auditing safety management systems.*

Background
Article 18 of the Seveso II Directive requires 'Member States to organise a system of inspections, or other measures of control appropriate to the establishment concerned. Such inspections or other control measures shall be sufficient for a planned and systematic examination of the systems being employed at the establishment, whether of a technical, organisational or managerial nature. Unless the competent authority has established a programme of inspections based upon a systematic appraisal of major-accident hazards of the particular establishment concerned, the programme shall entail at least one on-site inspection made by the competent authority every twelve months of each establishment covered by Article 9' (ie, those operators required to produce a safety report - most European refineries are subject to Article 9).

The modern complex petroleum oil refinery comprises a network of unit operations for the processing of crude oil together with the associated facilities of import/export pipelines, road/rail/marine terminals, bulk storage.

Competent authorities will conduct inspections at a sufficient frequency to gain reasonable knowledge of how well duty holders manage the key risk controls at refineries, the failure of which would have significant impact on the local population. This degree of intervention does not in any way constitute a guarantee on the adequacy of an operator's safety management system arrangements.

Common issues of concern
A number of presentations outlined various strategies for organising the inspection programme and conducting the inspection itself. Various presentations highlighted the importance of a systematic approach and the

usefulness of using systematic appraisal methods to prioritise interventions (eg, which establishments are next in line, what part of the establishment or safety programme is subject to inspection) and checklists or lists of questions specific to refineries to improve the thoroughness and precision of inspections.

The follow-up discussion among the participants tended to revolve around the following points:

Inspection strategy is another area where sharing lessons learned among Seveso inspectors from different competent authorities and countries could improve inspector effectiveness. Ongoing information exchange on this topic could especially aid consistency and coordination across boundaries, a particularly important goal with respect to the large presence of multinational refinery operators in Europe. Examples of the types of information that could be shared include:

- inspection findings, eg outcome of Petroplus inspection as presented at the workshop by Belgium;
- inspection plans and models, eg improving the audits of safety management systems at BP Grangemouth presented by a UK representative.

It was also noted that there is considerable variation in approaches to inspection strategies, for example, frequency of inspection and the amount of resources allocated. Clearly, the resources available to competent authorities vary.

However, there were also some common aspects to inspection programmes. Notably, the safety report is used by most participating inspectors as a basis for decision-making and generally focusing on the identification and management of the risk.

Theme D: Human factors

Objective(s): *To examine the role of (and barriers to) human factors and its practical application in improving human reliability in refinery process*

safety management systems.

Background

Human factors is a relatively new area for some companies. The lack of a clear understanding of the issues means that companies often do not include human factors into their safety management system (SMS). Some aspects of human factors have always received attention, for instance training (although often without targeting the competencies required for the control of major accident hazards) but they have rarely been deliberately managed as part of an integrated safety management system or with the rigour that their contribution to the risk requires.

Definitions: **Human factors** can be defined as the 'environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety'. In other words, human factors is concerned with what people are being asked to do (the task and its characteristics), who is doing it (the individual and their competence) and where they are working (the organisation and its attributes), all of which are influenced by the wider societal concern, both local and national.

Reliability is particularly important in the effective management of safety-critical tasks on major hazard plant. For instance, in process operations - the correct identification of pipework, procedures, repair work; in process control systems – the interpreting and responding to (process) information, whether these are completed by site-based workers, or contractors and third party workers.

Human factors appear as key root causes in major accidents worldwide, and the research literature shows that the human factor contribution is increasingly dominant. Up to 80% of accidents may be attributed, at least in part, to the actions or omissions of people; for example, through ‘procedural violations’, ‘inadequate procedures’ and ‘human error’. The lack of effective management of human factors has been a contributory factor in the causes of many major accidents. The literature cites several examples of major accidents where failures of people at many levels (that is, organisational failures) contributed substantially towards the accidents including Piper Alpha, Esso Longford, Zeebrugge, Texaco Milford Haven, Chernobyl and Bhophal.

Despite the growing awareness of the significance of human factors in safety, particularly major accident safety, the focus of many sites is almost exclusively on engineering and hardware aspects, at the expense of 'people' issues.

For example, a site may have determined that an alarm system is safety-critical and have examined the assurance of their electro-mechanical reliability, but they then fail to address the reliability of the operator in the control room who must respond to the alarm. If the operator does not, or is not able to, respond in a timely and effective manner then this safety-critical system will fail and therefore it is essential that the site addresses and manages this operator performance.

Inspection should focus on the reasons for the errors of individuals, which are usually rooted deeper in the organisation's design, decision-making, and management functions.

Common issues of concern

Participants generally agreed that human factors reliability is an important issue in major accident prevention at refineries. However, competent authorities in the different European countries, as well as operators, are at different levels of learning. This variation in competency has implications for:

- the identification of human factors issues in operational situations and in incident investigation (ie, causal analysis);
- targeting the right level in the safety management system. For example, currently the human factors analysis tends to be directed towards the activities of the workforce and often neglects the role of management in ensuring safe operations;
- examining human factors as individual topics rather than as part of a systematic, overall approach; and
- the quality of outputs of human factors analyses.

The participants highlighted the following issues in particular:

D1 Analysis and sharing of lessons learned
Again, promoting the analysis and sharing of lessons learning in human factors-related incidents was noted as an important mechanism for improving and verifying human factors reliability both for operators and competent authorities. It should also be broadly recognised that valuable improvements in human reliability can be achieved without the introduction of complex systems.

D2 Key human performance elements
It was generally agreed that competent authority/industry experience on managing human performance and the nature of human failings is adequately addressed within ten broad topics:

1 Organisational change
2 Staffing levels and workloads
3 Managing human failures
4 Fatigue from shift work and overtime
5 Procedures
6 Training and competence
7 Communications and interfaces
8 Organisational culture
9 Integration of human factors into risk assessments and investigations
10 Human factors in design

Many of these topics are issues that the refining operator's safety management system should address (Article 7 and 9, Annex III).

D3 Absence of structured formal standards, benchmarks and training
The variation in competency noted previously is largely a reflection of the paucity of standardised information and training materials in this field, in particular, targeted to major hazards industries, such as refineries.

D4 Structured knowledge sharing
As mentioned for the other themes, both industry and competent authorities would benefit from structured knowledge sharing concerning how to identify and analyse human factors to reduce major hazard risks in the refinery industry.

Summary and conclusions

Main concerns from the four workshop themes

Learning from accidents: A main concern is the inability to maximise on the information available, due to difficulty in accessing information, and if a relevant document is found, it is quite often difficult to extract the key lessons to be learnt from large amounts of text.

Assuring integrity management: Keeping refinery plant operating beyond the designed life cycle and the difficulty of identifying when critical systems are losing reliability to a point where an incident could occur before it is too late, is the main worry for refinery inspectors in this area.

Inspection: Although there is commonality in the use of safety reports for decision making and identifying risks, there are considerable differences in approach to inspection strategies in organising inspection plans and conducting inspection.

Human factors: Human factors are the root cause of many incidents, however, there is a difference in the level of understanding of human factors amongst member countries.

The concerns raised against the four themes fall into two main areas:

- An inconsistency of approach.
- Different levels of knowledge of inspectors in certain areas.

Underlying both of these is the difficulty in accessing helpful information.

Solutions

The main solution would be to develop a co-ordinated way of sharing information on incidents, process safety performance indicators, inspection strategies, human factors etc. Before this can happen, certain areas may need

Name	*Title*	*Organisation*	*Representation*

to be developed at EU level and guidance produced by Member States, eg, good practice in inspection/investigation at refineries, formal standards around human factors, common criteria for incident investigation/reporting, a process for near miss reporting.

Refinery website

Since the workshop, funding has been secured by the Health and Safety Executive, in collaboration with MAHB, to take forward the development of a website to help inspectors with their inspection/investigation at refineries. Many of the concerns raised can be solved by the production of a website, supported by European refinery inspectors actively providing useful information against the four workshop themes. Over time this website may serve as the basis of a network of refinery inspectors that may generate further joint initiatives.

(This website was subsequently established along with a pilot project. Please see http://sevesorefineries.jrc.it for more information.)

Development work

Near miss information – it is too ambitious to try and develop a European-wide system for the voluntary collection of near miss information in the near future. However, work in this area is being taken forward with the piloting of a voluntary input facility (as part of the Seveso Refineries website) to capture causation information against those incidents investigated that fall below the MARS criteria. The Health and Safety Executive in the UK are also hoping to develop guidance for industry on the collection and utilisation of 'near miss' information at site level.

Name	*Title*	*Organisation*	*Representation*

Annex 1: Delegate contact information

Name	*Title*	*Organisation*	*Representation*
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Mark Hailwood		Landesanstalt für Umweltschutz Baden-Württemberg	Germany

Name	*Title*	*Organisation*	*Representation*
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Mrs Carmen Miclea	Environmental Commissioner	Regional Environmental Commissariat Bucharest - County Commissariat Prahova	Romania
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Mr Manfred Hutter	Chemist	DAA Wallis	Switzerland
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William Mayes	Safety Group Head	ExxonMobil	UK
Ian McPherson	Director, Environment Health and Safety	UK Petroleum Industry Association	UK
Kevin Myers	Director	Health and Safety Executive	UK
Kevin Allars	Head of Chemical Industries Division	Health and Safety Executive	UK
Ron De Cort	Head of Unit - Wales and Western England	Health and Safety Executive	UK
John Sumner	Head of Unit - Scotland and Northern England	Health and Safety Executive	UK
Moira Wilson	Head of Unit - Risk Assessment and Process Integrity	Health and Safety Executive	UK
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Ian Travers	Principal Inspector	Health and Safety Executive	UK
Mike Skellett	Specialist Inspector	Health and Safety Executive	UK
John Wilkinson	Principal Specialist Inspector	Health and Safety Executive	UK
John Murray	Head of Unit - Chemical Industries Strategy Unit	Health and Safety Executive	UK
Mark Bishopp	Principal Specialist Inspector	Health and Safety Executive	UK

Country	*Number*	*Refinery location*	*Refinery operator*	
Janet Etchells		Principal Specialist Inspector	Health and Safety Executive	UK
Alan Graham		Inspector	Health and Safety Executive	UK
Samantha Leech		Inspector	Health and Safety Executive	UK
Richard Potter		Principal Inspector	Health and Safety Executive	UK
Anthony Downward		Inspector	Health and Safety Executive	UK
Andrew Cooke		Inspector	Health and Safety Executive	UK
Malcolm Whyatt		Inspector	Health and Safety Executive	UK
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Collette Fitzpatrick		Administrator	Health and Safety Executive	UK
Paul O'Shaughnessy		Administrator	Health and Safety Executive	UK
Eddie Hanna		Administrator	Health and Safety Executive	UK

Country	*Number*	*Refinery location*	*Refinery operator*

Annex 2: European refineries

Country	*Number*	*Refinery location*	*Refinery operator*
Austria	1	Schwechat	OMV AG
Belgium	5	Antwerp	AB Nynas Petroleum NV
		Antwerp	Belgian Refining Corp NV
		Antwerp	ExxonMobil Refining and Supply Co
		Antwerp (2002)	Fina Raffinaderij
		Antwerp	Petroplus
(Bulgaria)	1	Bourgas	Neftochim
Cyprus	1	Larnaca	Cyprus Petroleum Refining Ltd
Czech Republic	4	Kralupy	Czech Refining Co
		Litvinov	Czech Refining Co
		Kolin *	Karamo Kolin
		Pardubice	Paramo AS
Croatia	3	Rijeka	INA dd
		Sisak	INA dd
		Zagreb	INA dd
Denmark	2	Fredericia	AS Dansk Shell
		Kalundborg (2002)	Dansk Statoil AS
Estonia	Nil		
Finland	2	Naantali	Fortum Oil and Gas Oy
		Porvoo	Fortum Oil and Gas Oy
France	13	Lavera	BP plc
		Reichstatt-Vendenheim	Cie Rhenane de Raffinage
		Dunkirk	ExxonMobil Refining and Supply Co
		Fos sur Mer	ExxonMobil Refining and Supply Co
		Port Jerome	ExxonMobil Refining and Supply Co
		Berre l'Etaing	Ste des Petroles Shell
		Petit Couronne	Ste des Petroles Shell
		Donges	Total SA
		Dunkirk	Total SA
		Feyzin	Total SA
		Gonfreville l'Orcher	Total SA
		Grandpuits	Total SA
		La Mede	Total SA
Germany	16	Vohburg/Ingolstadt/Neustadt	Bayernoil Raffineriegesellschaft GMBH

Country	*Number*	*Refinery location*	*Refinery operator*
		Hamburg *	BP Lubes Services GMBH
		Heide/Grasbrook/Wesseling	DEA Mineraloel AG
		Lingen	Deutsche BP AG Erdol Raffinerie GMBH
		Godorf	Deutsche Shell AG
		Harburg	Deutsche Shell AG
		Ingolstadt	ExxonMobil Refining and Supply Co
		Salzbergen *	H and R Chemisch-Pharmazeutische Spezialaten GMBH
		Harburg	Holborn Europa Raffinerie GMBH
		Karlsruhe (2004, 2004?)	Mineraloelraffinerie Oberrhein GMBH
		Burghausen	OMV AG
		Schwedt	PCK Raffinerie GMBH
		Leuna/Spergau	Total Raffinerie Mitteldeutschland GMBH
		Karlsruhe	Total Raffinerie Mitteldeutschland GMBH
		Gelsenkirchen	Veba Oel AG
			Wilhelmshavener Raffinerie Gesellschaft GMBH
Greece	4	Aspropyrgos	Hellenic Petroleum SA
		Thessaloniki (1999)	Hellenic Petroleum SA
		Aghii Theodori (2002)	Motor Oil (Hellas) Corinth Refineries SA
		Elefsis	Petrola Hellas
Hungary	2	Szazhalombatta	MOL Hungarian Oil and Gas Co
		Tiszaujvaros	
Ireland	1	Whitegate	ConocoPhillips
Italy	17	Ravenna	ALMA PETROLI spa
		Falconara Marittima	API – RAFFINERIA DI ANCONA spa
		Sannazzaro de' Burgondi	ENI spa – Divisione Refining and Marketing
		Taranto	ENI spa – Divisione Refining and Marketing
		Collesalvetti	ENI spa – Divisione Refining and Marketing
		Venezia	ENI spa – Divisione Refining and

CONCAWE members:

BP	ENI	Neste Oil	Repsol (Spain)
CEPSA (Spain)	ExxonMobil	Nynäs	Shell
Chevron	Hellenic Petroleum	OMV	Statoil (Norway)
ConocoPhillips	KPI	Petrogal	TOTAL
DOW	MOL	Preem	

Marketing			
		Priolo Gargallo	ERG RAFFINERIE MEDITERRANEE Spa
		Priolo Gargallo	ERG RAFFINERIE MEDITERRANEE Spa
		Augusta	ESSO ITALIANA Srl Raffineriea di Augusta
		Mantova	IES – Italiana Energia e Servizi Spa
		Busalla	IPLOM spa
		Gela	RAFFINERARIA DI GELA Spa
		Milazzo	RAFFINERIA DI MILAZZO Scpa
		Roma	RAFFINERIA DI ROMA spa
		Sarroch	SARAS spa
		Trecate	SARPOM spa
		Cremona	Tarnoil Raffinazione SPA
Latvia	Nil		
Lithuania	1	Mazeikiai	JSC Mazeikiai Nafta
Luxembourg	Nil		
Malta	Nil		
Netherlands	6	Rotterdam	ExxonMobil Refining and Supply Co
		Rotterdam (2002)	Kuwait Petroleum Europoort BV
		Europoort	Netherlands Refining Co
		Pernis	Shell Nederland Raffinaderij BV
		Amsterdam*	Smid and Hollander Raffinaderij BV
		Vlissingen	Total Raffinery Netherlands
(Norway)	2	Slagen	ExxonMobil Refining and Supply Co
		Mongstad	Statoil Mongstad
Poland	5	Czechowice	Nafta Polska SA
		Gorlce	Nafta Polska SA
		Jaslo	Nafta Polska SA
		Plock/Trezebina	Petrochemia
		Gdanska/Jedlicze	Rafineria Gdanska SA
Portugal	2	Leca del Palmeira	Petrogal
		Sines	Petrogal
(Romania)	10	Pitesti	Arpechim SA
		Ploiesti	Astra SA
		Ploiesti	Petrobrazi SA
		Bacau	Petrolsub SA
		Ploiesti	Petrotel SA
		Darmanesti	Rafinaria Darmanesti SA
		Onesti, Bacau	Rafo SA
		Ploiesti	Rompetrol SA Vega Refinery
		Cimpina	Steaua Romania SA
Slovakia	1	Bratislava	Slovnaft, Joint Stock Co
Slovenia	1	Lendava	Nafte Lendava
Spain	9	Castellon de la Plana	BP plc

		Cadiz	Cia Espanola de Petroles SA (CEPSA)
		Huelva	Cia Espanola de Petroles SA
		Tenerife	Cia Espanola de Petroles SA
		Somorrostro Vizcaya (2002)	Petronor SA
		Cartagena Murcia	Repsol YPF SA
		La Coruña	Repsol YPF SA
		Puertollano, Ciudad Real (2003)	Repsol YPF SA
		Tarragona*	Repsol YPF SA
Sweden	5	Gothenburg*	AB Nynas Petroleum
		Nynashamn*	AB Nynas Petroleum
		Gothenburg	Preem Raffinaderi AB
		Gothenburg	Shell Raffinaderi AB
		Brofjorden-Lysekil	Skandinaviska AB
Switzerland	2	Cressier	Petroplus
		Collombey	Tamoil SA
(Turkey)	6	Mersin	Anadolu Tasfiyehanesi AS
		Narli, Kahramanmaras	Ersan Petrol Sanayii AS
		Aliaga-Izmir	Turkish Petroleum Refineries Corp
		Batman, Siirt	Turkish Petroleum Refineries Corp
		Izmit	Turkish Petroleum Refineries Corp
		Kirikkale	Turkish Petroleum Refineries Corp
United Kingdom	11	Coryton, Essex (1999)	BP plc
		South Killingholme (2001)	ConocoPhillips
		Eastham*	Eastham Refinery Ltd
		Fawley (1999)	ExxonMobil Refining and Supply Co
		Teesside	Petroplus International BV
		Stanlow (2003)	Shell UK Ltd
		South Killingholme	Total SA Lindsey Oil Refinery Ltd
		Dundee*	AB Nynas Petroleum
		Grangemouth (2000)	BP plc
		Pembroke, Dyfed	Texaco
		Milford Haven	Total SA

Source: Adapted from Worldwide Refining Review, O and GJ 2003

Key
* Denotes lubricant and bitumen refineries
(YEAR) denotes refineries where EU reportable major accidents occurred in the last five years (since Seveso II ~ 1999). Source: MARS database

Annex 3: Timetable of the workshop

Day 1 Wednesday, 8 March 2006

	09:30	**Registration** (and coffee etc)
Session 1	10:00	**Introduction** Plenary (Auditorium) *Chair: Kevin Allars, Health and Safety Executive* - Welcome - Liverpool and Redgrave Court (the venue) - Workshop format: Purpose and how it will run - MAHB JRC briefing *(Maureen Wood)*
Session 2		**Keynote lectures** Plenary (Auditorium) *Chair: Kevin Allars, Health and Safety Executive*
	10:30	*Kevin Allars, HSE*: Major hazards, European cooperation and harmonisation – the importance of 'inspection' in assuring MAH prevention
	11:00	*John Bresland, US CSB*: Independent Chemical Accident Investigation by the United States Chemical Safety Board
	11:45	*Bernard Petitpain, TOTAL*: European size merging and safety improvement process: Some considerations by Total Refining HSE manager
	12:30	**Lunch**
Session 3	14:00	**Workshop Theme A: Learning from accidents** *Chair: Ron De Cort, Health and Safety Executive* Plenary (Auditorium) Presentations/Case studies: Participant contributions to share experience *Kevin Allars (UK)*: The Buncefield major accident, 2005 *Raymond Dumont (CH)*: Storage site for gasoline and oil with a capacity of 750 000 m^3. Safe enough? *Astrid Ollagnier (FR)*: The incident at the La Mede refinery, 2005 *Mark Hailwood (GER)*: Corrosion of furnace tubes of a desulphurization unit, MiRO, 2004 *Otto Wientjes (NL)*: Refinery inspection project
	15:15	**Coffee break**
	15:45	**Roundtable Discussion Groups** (Conference Rooms) **Theme A: Learning from Accidents** How industry and regulators can maximise on lessons learnt to reduce risk, and integrate them into their programmes.
	17:00	**Report back**

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17:00 **Report back**

17:30 **Close**

19:30 **Social Evening** (optional): The Racquet Club

Day 3 Friday, 10 March 2006

Session 6 09:00 **Workshop Theme D: Human reliability**
Chair: Moira Wilson, Health and Safety Executive
Plenary (Auditorium)
Presentations/case studies: Participant contributions to share experience, techniques etc
Wilfried Biesemans (BEL): Petroplus Refining Antwerp NV: Use of Article 17 of the Seveso II directive
John Wilkinson (UK): Human reliability at refineries

10:00 **Roundtable Discussion Groups** (Conference Rooms)
Theme D: Human reliability
To examine the role of (and barriers to) human factors (reliability) and its practical application in improving refinery process safety management systems

10:30 **Coffee break**

11:00 **Roundtable Discussion Groups** (cont)

11:30 **Report back**

Session 7 12:00 **The way forward**
Plenary (Auditorium)
Chair: Kevin Allars, Health and Safety Executive
What issues and concerns should regulators and industry focus on? What are the common issues/concerns? How should we move forward? How can we network in practice? How monitor our outcomes? Do we want another event (or carry over untested issues to other MJVs)?

12:30 **Closing remarks**
- Evaluation: Has this event been useful?
- Maureen Wood, MAHB JRC
- Kevin Myers, Director (HSE's Hazardous Installations Directorate)

13:00 **Lunch**

14:00 **Depart**

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