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**CONFERENCE OF THE PARTIES
TO THE CONVENTION ON THE TRANSBOUNDARY
EFFECTS OF INDUSTRIAL ACCIDENTS**

**Workshop on the Facilitation of the Exchange of Safety
Management Systems and Safety Technologies**

4-5 November 2002
Chisinau (Republic of Moldova)

# BACKGROUND PAPER

Submitted by the open-ended group to prepare the workshop 1/

## Introduction

1. In accordance with articles 15 and 16 of the UNECE Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) the Parties shall: (i) exchange reasonably obtainable information at the multilateral or bilateral level; and (ii) consistent with their laws, regulations and practices, facilitate the exchange of technology for the prevention of, preparedness for, and response to the effects of industrial accidents. Furthermore, according to article 18, para 5, of the Convention, "the Conference of the Parties shall, at its first meeting, commence consideration of procedures to create more favourable conditions for the exchange of technology for the prevention of, preparedness for and response to the effects of industrial accidents".

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2. The Conference of the Parties agreed to further consider the issue of facilitating the exchange of safety technologies at its second meeting in 2002 on the basis of the outcome of a workshop on these issues (ECE/CP.TEIA/2, annex VIII, Decision 2000/7, para 2 and annex IX, Part Two, sub-para 7.1.2).

3. This document contains a background paper for the Workshop on the facilitation of the exchange of safety management systems and safety technologies, drawn up by an open-ended group to prepare the workshop, on the basis of a report commissioned by the UNECE. 2/

## Background

4. Some of the countries in central and eastern Europe face significant challenges in their transition from centrally planned to market-driven economies. At the same time, the existing industrial base represents a potential transboundary hazard due to obsolete and inefficient technologies and management practices.

5. There is a large legacy of environmental damage caused by inefficient use of natural resources and generally low prioritization of environmental issues relative to other factors in the production process. The process of transition is one that brings a number of financial hardships, and with it comes severe restrictions to investment in environmental remediation and protection. Therefore, a process of prioritization is absolutely essential, as are methodologies for the efficient transfer of expertise and technology in a cost-effective and timely manner. It is difficult, if not impossible to derive an accurate estimate at the extent of environmental damage and the cost of rectifying such damage. Environmental, including health, damage costs are generally externalized and there are limited regulatory pressures to internalize their costs through preventative approaches. Notwithstanding, the potential costs in ecological and health terms (regardless of their financial implications) of a catastrophic accident requires that the management process which is put in place is also cumulatively and progressively working towards prevention as opposed to crisis management alone.

6. Ultimately, the transfer of safety and other efficient and effective will rduce the risk of major international incidents. However in the interim period there are severe financial constraints to the updating of existing technologies. Therefore, some financially sound process is required that would deliver both improved safety and environmental performance and production efficiency. This will also contribute to regional stability, as it is possible to envisage a scenario where a transboundary incident may aggravate an already volatile security situation between bordering nations.

7. The need to invest in systems to address existing problems in countries with economies in transition and reduce the risk of future problems is undermined by an often overriding public and state desire to achieve immediate economic gains as they transform from centrally planned to market driven economies. It is also important to note that alongside the financial difficulties exist a range of other constraining factors, including lack of institutional capacity, a shortfall in expertise and political uncertainty or unrest, all of which act to destabilize or detrimentally affect strategic programmes for environmental protection.

8. Despite this, there is evidence that poor and potentially hazardous environmental performance discourages potential investors, a fact that is being recognized throughout industry and government. However, it is important to realize that investment is only part of the story: in the absence of training and a robust institutional framework, the benefits of investment are unlikely to be optimized, and in some cases may dissipate entirely in a short period of time. Therefore, the transfer of any technological capacity (be it safety technology, clean technology, expertise and so on) must be much more than merely the transfer of hardware. It needs to include knowledge, expertise and creativity embodied in people and within the frameworks in which they work. It must also occur at a number of different levels (e.g. site, local government bodies, regional government bodies, and central government) in order to ensure that a self-sustaining capacity and capability is created.

## I. DEFINITIONS OF INDUSTRIAL ACCIDENTS, TRANSBOUNDARY EFFECTS AND SAFETY TECHNOLOGIES

### Industrial accidents

9. Within the context of this paper, an industrial accident can be defined as uncontrolled and unforeseen development in a process that involves hazardous substances and that has the potential to cause transboundary impacts (taking into consideration limitations regarding the scope of the Industrial Accidents Convention as noted below). Therefore, operational discharges and emissions that are legally permitted and unknown or non-permitted chronic discharges (e.g. leaching of contaminants from on-site waste disposal areas) are not included in the scope of this paper or in the Industrial Accidents Convention. It should also be noted that the Industrial Accidents Convention itself does not apply to the following activities:

- Nuclear accidents or radiological emergencies.
- Accidents at military installations.
- Dam failures, with the exception of the effects of industrial accidents caused by such failures.
- Land-based transport accidents (except in the case of emergency response to such and on-site transportation accidents).
- Accidental release of genetically modified organisms.
- Accidents caused by activities in the marine environment, including seabed exploration or exploitation.
- Spills of oil or other harmful substances at sea.

10. Industrial accidents may include, but are not limited to, unplanned discharges that arise from fire, explosion and equipment breakdown caused by human error, design faults, engineering failures and natural disasters.

11. There are a number of possible causes of industrial accidents, and these can be subdivided into the pre-operational, operational, and end-of-life factors, each of which may

include software and hardware failures and human error elements (e.g. at any stage in the design, use, construction, maintenance and decommissioning of the plant):

(a) Pre-operational factors:

- Inadequate test specifications for equipment
- Poor quality control
- Poor manufacturing practices
- Inappropriate or inadequate materials
- Improper handling of equipment
- Second-rate components
- Incomplete or incorrect set-up, installation or final testing

(b) Operational factors

- Inappropriate use.
- Inadequate training of operators.
- Unexpected interaction with other systems or system components.
- Wrong design standards.
- Inadequate design margins.
- Use for incorrect application.

(c) End-of-life factors

- Material wear, corrosion or friction.
- Ageing.
- Misalignment.
- Inadequate preventative maintenance.

**Transboundary effects**

12. Transboundary transfer of hazardous substances may occur via two principal vectors (or pathways): (i) discharge to the atmosphere, and (ii) discharge to water.

13. Ultimately, substances contained in the atmosphere or in surface and groundwater are normally transferred to soils, sediments or other biotic or abiotic solid materials through physical, chemical and biological processes. This transfer may occur at great distance from the point of source entry into the environment (i.e. the site of the industrial accident), leading to transboundary contamination and pollution of land in addition to that of air and water resources, causing transient, temporary, chronic or permanent effects.

14. Transboundary impacts may include one or more of the following:

Air

- Changes in ambient air quality.
- Release of any toxic or hazardous air pollutant.
- Changes in noise levels and level of vibrations.

Water

- Changes in water quality or quantity (surface water and groundwater).
- Change in quality of coastal waters.
- Change in quality and quantity of riverine, estuarine and coastal sediments.
- Release of toxic or hazardous water pollutants.

Climate

- Microclimatic changes (e.g. temperature, rainfall and wind).

Soil

- Changes in soil acidification, nutrification or other contamination.
- Changes in deposition or erosion.

Landscape, historic monuments or other physical structures

- Changes in land use.
- Decreased aesthetic appeal or changes in visual amenities.
- Changes in historical, archaeological, paleontological, architectural or cultural assets.
- Changes to present or future uses of natural resources.
- Impacts on ecologically sensitive areas or areas of special environmental value.

Human health and safety

- Changes in human health and safety.
- Changes in disease incidence.
- Changes to well being and quality of life.

Flora and fauna

- Changes in migratory patterns.
- Disturbance of habitat.
- Decrease in biological diversity.
- Impacts on threatened species.
- Changes in species composition.

**Safety technologies**

15. Safety technologies can be defined in two complementary ways:

(a) A technology or management system or procedure that reduces the risk of an accident occurring;

(b) A technology or management system or procedure that reduces the environmental, ecosystem and human health damages should an accident occur.

## II. INDUSTRIAL ACCIDENTS CONVENTION AND TECHNOLOGY TRANSFER

16. Developed by the United Nations Economic Commission for Europe (UNECE), the Industrial Accidents Convention applies to the prevention of, preparedness for and response to industrial accidents capable of causing transboundary effects, including accidents caused by natural disasters. It is also concerned with international co-operation in the form of mutual assistance, research and development, exchange of information and exchange of technology in these areas.

17. The Parties to the Industrial Accidents Convention recognize that industrial accidents can have severe and long-term impacts on human health and well being, and the state of the environment and related ecosystems. Major accidents also have the potential to cause inter-generational impacts and therefore the prevention of such will contribute to the creation of a workable sustainable development strategy. Equally important, industrial accidents have the potential to cause impacts across national borders. Therefore regional and national protection of environmental and human health no longer lies within the control of individual nations and co-operation is required to ensure that preventative, preparedness and response measures are properly and appropriately coordinated.

18. International cooperation is the central tenet on which effective action before, during or after an industrial accident is based. By cooperative measures, appropriate policies and co-ordination and reinforcement of action at all levels in the areas of preventative, preparedness and response measures are enhanced. Naturally, cooperation is aided by the existence of frameworks of bilateral and multilateral agreements.

19. Hazardous activities applicable under the Industrial Accidents Convention are defined in two ways. Firstly with reference to hazardous substances present at or above threshold quantities noted in annex I to the Industrial Accidents Convention, and secondly with reference to two location criteria adopted by the Conference of the Parties at its first meeting. According to these criteria, hazardous activities located within 15 kilometers from the boarder (for activities involving substances that may cause a fire or explosion or involving toxic substances that may be released into the air in the event of an accident) and/or located within catchment areas of transboundary and boarder rivers, transboundary or international lakes, or within catchment areas of transboundary groundwaters (for activities involving substances falling under categories of very toxic, toxic, and dangerous for the

environment listed in Part I of annex I to the Convention) are covered by the Industrial

Accidents Convention. Industrial activities are *not*, therefore, defined by sector (although certain sectors *are* specifically excluded) or according to the operation's size.

20. The Industrial Accidents Convention is comprised of thirty-two articles, and thirteen annexes. Articles and annexes of particular relevance to the transfer of safety technologies are summarized below, with supplementary comments as appropriate.

(a) *Article 1* contains definitions. It is important to note that the Industrial Accidents Convention does not define safety technologies. The definition of safety technologies and the concept of associated exchange or transfer mechanisms is examined in subsequent sections of this paper.

(b) *Article 3, paragraph 2* states that the Parties to the Industrial Accidents Convention should develop and implement policies and strategies for reducing the risks of industrial accidents by means of exchange of information, consultation or other cooperative measures. Such steps should avoid unnecessary duplication of existing efforts at national and international levels. Further cooperative measures, including the development of technology transfer strategies, should therefore complement and be readily integrated with existing schemes as far as is practicable.

(c) *Article 3, paragraph 4* states that Parties to the Industrial Accidents Convention should take appropriate legislative, regulatory, administrative and financial measures to implement the Convention. Therefore, this implies that certain aspects of the technology transfer process may be regulated and enforceable under national law.

(d) *Article 7* sets out guidelines for establishing policies on the siting of hazardous activities. Activities should be sited with the objective of minimizing the risk to the population and environment of all affected Parties. The implementation of appropriate safety technologies clearly has implications for the degree of flexibility in the siting of hazardous activities. This is related to both the transfer of safety technologies and the commercial availability of such technologies (i.e. simply stated, it is not possible to transfer a non-existent technology).

(e) *Article 8* relates to emergency preparedness. The implementation of, and limits to, safety technologies will influence the nature of emergency plans. Contingency measures will need to take into account the likely outcome of safety technology implementation (e.g. application of certain technologies may reduce the risk of atmospheric releases, but increase the risk of discharge to water or land).

(f) *Article 9, paragraph 2* states that whenever possible and appropriate the public in the areas capable of being affected should have the opportunity to participate in relevant procedures with the aim of making known its views and concerns on prevention and preparedness measures. This policy is in keeping with the theory of stakeholder participation and empowerment, and may lead to indirect and direct involvement of the general public in the choice of safety technologies and their application.

(g) *Article 14* addresses the issues of research and development and notes that Parties to the Industrial Accidents Convention should initiate and cooperate in the conduct of research into, and in the development of, methods and technologies for the prevention of, preparedness for and response to industrial accidents. Parties should actively encourage and promote scientific and technological cooperation, including research into less hazardous processes aimed at limiting accident hazards and preventing and limiting the consequences of industrial accidents.

(h) *Article 16* is of the greatest direct relevance to the transfer of safety technologies, and deals with the exchange of technology. It states that the Parties to the Industrial Accidents Convention should, consistent with their laws, regulations and practices, facilitate the exchange of technology for the prevention of, preparedness for and response to the effects of industrial accidents, via the promotion of:

(i) The exchange of available technology on various financial bases;

(ii) Direct industrial contacts and cooperation;

(iii) The exchange of information and experience;

(iv) The provision of technical assistance.

These mechanisms should be undertaken through the facilitation of contacts and cooperation among appropriate organisations and individuals in both the private and public sectors that are capable of providing technology, design and engineering services, equipment or finance.

(i) *ANNEX I* defines threshold quantities of hazardous substances for the purpose of defining hazardous activities within the context of the Industrial Accidents Convention. Part I specifies threshold quantities for categories of substances, while Part II specifies threshold quantities for specifically named compounds. Where a compound named in Part II falls within a category in Part I, the threshold quantity set out in Part II is applied.

(j) *ANNEX III* allows for consultation between the Party of origin and affected Parties concerning the transboundary effects of the hazardous activity in the event of an industrial accident, and measures to reduce or eliminate its effects. The consultations may relate to:

(i) Possible alternatives to the hazardous activity, including the no-action alternative, and possible measures to mitigate transboundary effects at the expense of the Party of origin. This implies that the affected Parties may have some influence as to the choice, nature and implementation of safety technologies;

(ii) Other forms of possible mutual assistance for reducing any transboundary effects. This may involve the transfer of technology or expertise where appropriate from the potentially affected Party to the Party of origin.

(k) *ANNEX IV* states that the following measures may be carried out, depending on national laws and practices, by Parties, competent authorities, operators, or by joint efforts:

(i) The creation and implementation of general or specific safety objectives;

(ii) The adoption of *legislative provisions or guidelines concerning safety measures* and safety standards;

(iii) The identification of hazardous activities that require *special preventive measures,* possibly including a licensing or authorisation system;

(iv) The evaluation of risk analyses or of safety studies for hazardous activities and an action plan for the implementation of necessary measures;

(v) The provision to the competent authorities of the information needed to assess risks;

(vi) The application of the *most appropriate technology* in order to prevent industrial accidents and protect human beings and the environment;

(vii) The undertaking, in order to prevent industrial accidents, of the appropriate education and training of all persons engaged in hazardous activities on-site under both normal and abnormal conditions;

(viii) The establishment of internal managerial structures and practices designed to implement and maintain safety regulations effectively; and

(ix) The monitoring and auditing of hazardous activities and the carrying out of inspections.

This annex recognizes implicitly that the process of developing capacity is greater than the mere transfer of hardware, although this *is* a significant factor in the process. Other elements are also essential including a policy framework, risk analysis and assessment, training, and the continuous development of human resource potential.

(l) *ANNEX XI* states that, pursuant to Article 15, the exchange of information between Parties should include the following elements, which can also be the subject of multilateral and bilateral co-operation:

(i) Legislative and administrative measures, policies, objectives and priorities for prevention, preparedness and response, scientific activities and technical measures to reduce the risk of industrial accidents from hazardous activities, including the mitigation of transboundary effects;

(ii) Measures and contingency plans at the appropriate level affecting other Parties;

(iii) Programmes for monitoring, planning, research and development, including their implementation and surveillance;

(iv) Measures taken regarding prevention of, preparedness for and response to industrial accidents;

(v) Experience with industrial accidents and co-operation in response to industrial accidents with transboundary effects;

(vi) The *development and application of the best available technologies* for improved environmental protection and safety;

(vii) Emergency preparedness and response;

(viii) Methods used for the prediction of risks, including criteria for the monitoring and assessment of transboundary effects.

21. A key issue in the Industrial Accidents Convention and other related agreements is the new and emerging emphasis on prevention relative to impact mitigation. In this respect there are important parallels to be drawn with the change in environmental paradigms between the 1980s and 1990s. The 1980s were characterised by the polluter pays principle and the promotion of end-of-pipe clean-up technologies to treat problems once they had occurred. The 1990s are characterised by prevention from the outset, involving risk analysis, anticipation, management systems, monitoring mechanisms, ongoing impact assessment and clean technology. The former represents an opportunistic crisis management approach that could be either low cost or high cost and potentially bankrupting if the unexpected and extreme occurs. The latter represents a responsible, systematic and risk-averse approach and involving by front-end investment, R&D and hazard assessment. The parallels between these concepts of clean technology and safety technology are explored further below, drawing out the policy lessons the first set suggest for the latter and the potential benefits of integrating the two concepts to achieve environmentally proficient and hazard free production.

## III. SAFETY TECHNOLOGIES AND SAFETY MANAGEMENT

22. The concept of safety technologies and safety management covers a wide range of alternative approaches that run in parallel to the concepts behind clean and cleaner technologies, pollution prevention and recycling. However, the focus of these similar ideas is different in that they target the risk of uncontrolled developments in the process rather than waste minimization *per se*. For example, they may include one

or more of the following characteristics at particular sites (U. S. Environmental Protection Agency, 1992):

(a) Good "housekeeping" measures:

- Improving operational procedures to reduce the risk of fire, explosion or other uncontrolled releases. This could include the method of materials handling, preventative maintenance of plant, and improved worker training programmes (from line operator to senior management);
- Segregate wastes (e.g. potentially hazardous mixtures such as oxidising agents and organic compounds);
- Effective supervision, and production planning and scheduling to reduce risk of cross-contamination in multi-product plants;
- Just in time ordering of materials to minimize the requirement for on-site storage of hazardous materials (also cost saving through reduced inventory);
- Rotation of chemical stock to reduce risk of material degradation or destabilization;
- Proper labeling of materials;
- Purchase of pure feeds:
- Use of properly designed tanks and vessels only for their intended use;
- Installation of overflow alarms for all tanks and vessels;
- Installation of secondary containment areas;
- Floating roof tanks for control of volatile organic compounds;
- Storage of containers so as to allow for frequent inspection for corrosion or leaks, and to minimize risk of tipping, puncturing or breaking;
- Distance between incompatible chemicals to be maximized;
- Insulation of electrical circuitry and regular inspections for potential sparking risks;
- Cleaning of process equipment immediately after use.

(b) Process and plant design measures:

- Minimization of the number of process steps (e.g. process simplification);
- Elimination or reduction of the production of unwanted potentially hazardous intermediate products or by-products;
- Improved reactor design to minimize undesirable reactions that produce potentially hazardous substances or create potentially hazardous conditions;
- Changing to less hazardous materials, for example materials that are not considered hazardous within the scope of the Industrial Accidents Convention. This may be possible in certain circumstances (e.g. feed materials to certain industrial plant), but may have cost and production efficiency implications. Changes in feed materials may also change the environmental impact of the plant through the life cycle of the operation,

and this may need to be considered;

- Maximization of process equipment dedication (i.e. reduce changes in batch processes);
- Modification or changes to equipment. This option can involve either replacing existing equipment, introducing new equipment at a new operation or modifying existing equipment to optimise the safety aspects of the production process. This option may incur greater capital costs than those above, but may bring savings indirectly through reduced liabilities. Examples include the use of high efficiency recovery systems for potentially hazardous vapours and low spark-risk electrical control systems.

(c) <u>Control and monitoring systems</u>

23. Control system efficiency can be attributed to a combination of the following interrelated factors:

- Measurement accuracy, stability and repeatability (precision);
- Sensor locations;
- Controller response action;
- Process dynamics;
- Control element characteristics and location;
- Overall system reliability;

24. Instrumentation should be selected that enables the control system to consistently and accurately measure the real process conditions. In the absence of such a control system, precise control of many industrial processes is not possible.

25. When choosing a control system or device, some of the following questions may need to be considered:

- How reliable is the device and what are the consequences of device or system failure?
- Is a redundant backup control device or system required considering the consequences of system failure? Is an alternative power supply required should the device or system lose its primary power source?
- How robust is the control device or system? Will it continue to work and give accurate measurements should the process environment change unexpectedly? Should an alternative construction material be considered?
- Are replacement devices or systems readily available? What are the inventory requirements for component parts or complete devices or systems?
- Is the device or system intrinsically safe considering the process environment in which it will be placed (e.g. can it cause ignition of flammable substances through sparking)?

- What are the maintenance implications of the device or system: could it be maintained routinely or are there significant implications for the process (e.g. extended downtime)?
- What special operator training is required (if any) in the use and maintenance of the device or system?
- What are the implications of human error for the control device or system: could control mechanisms be overridden by operators?

26. Examples of a monitoring system include the installation of improved early warning detectors or monitoring systems to identify: (i) changes in vessel pressure; (ii) changes in liquid levels; (iii) changes in temperature; (iv) changes in pH; and (v) presence of low concentrations of potentially hazardous substances in the ambient air (e.g. by continuous emissions monitoring).

27. Any monitoring system should be real-time and connected to a safety system that can automatically, quickly and safely shut the process or plant down. This may require the application of fuzzy-logic control (that simulates human responses to changes in a system and that deal more effectively with complex systems that traditional "true/false" control systems can not handle).

(d ) Maintenance

28. Maintenance is also an essential part of safety management. There are different types of maintenance, as indicated below:

- Breakdown maintenance – crisis management;
- Conditional or indicative maintenance – relies on the detection of problems in their early stages, often through intuitive recognition of problems by experienced workers;
- Preventative maintenance – maintenance on a regular basis, particularly important for early warning systems and other control devices or systems that might only operate periodically;
- Predictive or reliability maintenance – monitors the performance of plant and directs maintenance based on changes in performance (e.g. when performance falls below a certain predetermined level of acceptability). This method allows the likely time of failure to be predicted and the maintenance regime to be adjusted accordingly.

(e) Safety management

29. Based on the recommendations in Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances ("Seveso II Directive"), the following issues should be addressed by the safety management system:

- Organisation and personnel – the roles and responsibilities of personnel involved in the management of major hazards at all levels in the organisation. The identification of training needs of such personnel and the provision of the training so identified. The involvement of employees and, where appropriate, subcontractors;

- Identification and evaluation of major hazards – adoption and implementation of procedures for systematically identifying major hazards arising from normal and abnormal operation and the assessment of their likelihood and severity;

- Operational control – adoption and implementation of procedures and instructions for safe operation, including maintenance, of plant, processes, equipment and temporary stoppages;

- Management of change – adoption and implementation of procedures for planning modifications to, or the design of new installations, processes or storage facilities;

- Planning for emergencies – adoption and implementation of procedures to identify foreseeable emergencies by systematic analysis and to prepare, test and review emergency plans to respond to such emergencies;

- Monitoring performance – adoption and implementation of procedures for the ongoing assessment of compliance with the objectives set by the operator's major-accident prevention policy and safety management system, and the mechanisms for investigation and taking corrective action in case of non-compliance. The procedures should cover the operator's system for reporting major accidents of near misses, particularly those involving failure of protective measures, and their investigation and follow-up on the basis of lessons learnt;

- Audit and review – adoption and implementation of procedures for periodic systematic assessment of the major-accident prevention policy and the effectiveness and suitability of the safety management system; the documented review of performance of the policy and safety management system and its updating by senior management.

## IV. PARALLELS BETWEEN "CLEAN TECHNOLOGY" CONCEPTS AND SAFETY TECHNOLOGIES

30. The following section examines the concepts that underlie clean technological industrial strategies, and makes a case for the integration of clean technologies (for environmentally proficient production) and safety technologies (for accident risk reduction).

**The principles of clean technology**

31. The concept of clean technology is best explored with reference to economic performance, resource usage and environmental impact (Clift, 1995). Consequently, clean technology is not necessarily synonymous with "state-of-the-art" by virtue of the fact it must
be able to compete on economic terms in a commercial arena with existing technologies. There is often a significant gap between what is technically viable and what is economically affordable and considerable (R&D) effort is devoted to reducing that gap.

32. Clean technology is an integral component of (and often considered synonymous with) waste minimization 3/ and pollution prevention and has principally been employed within the process industries. Ideally, the "cleanliness" of a technology should also take into account the environmental performance of upstream suppliers and downstream users and disposers of products, although this is often difficult to determine, and the boundaries of the investigation are instead restricted more closely to the process in question. Waste minimization can be further defined as any technique, process or activity which either avoids, eliminates or reduces a waste at source, usually within the confines of the production unit, or allows re-use or recycling of the waste for benign purposes (Crittenden and Kolaczkowski, 1995).

33. Waste minimization (at least as defined in the manufacturing industry) is not concerned with, in most cases, action after waste has been generated (e.g. incineration, detoxification, thermal, chemical or biological decomposition, stabilization dilution or transfer of waste constituents from one medium to another (Crittenden and Kolaczkowski, 1995)). Instead, a waste minimization "hierarchy" is used (Crittenden and Kolaczkowski, 1995), namely (in order of decreasing priority):

**Elimination → Source reduction → Recycling → Treatment → Disposal**

34. A number of generic (cross-sectoral) strategies are adopted within an overarching management system to facilitate waste minimization (Crittenden and Kolaczkowski, 1995):

a) Improved plant operations (predictive and preventative maintenance, better handling procedures, separation of waste streams to facilitate in-process recovery and volume reduction);

b) Alterations to process technology (modernization, modification, better control of process equipment). This approach is more capital intensive so it is often considered to be more appropriate for new plants rather than via retrofitting of existing plants;

c) Recycling, recovery, re-use of waste products;

d) Changing raw materials;

e) Product reformulation.

35. To expedite the development of a waste minimization programme, all waste management costs including storage and transport must be identified and allocated to the source of waste generation rather than general operating overheads. This can be carried out during a rigorous assessment, including analysis of the causes of waste generation,

including poor

handling or operational procedures; description of the source, quantity, composition and hazardous properties of waste generated at each stage; definition of temporal variations waste characteristics; description of current waste disposal practices and the identification of the true current costs of handling, storage, treating, transporting and disposal of wastes. This can then lead to the development of a waste minimization programme.

36. As many processes do not run at full efficiency capacity - simple changes and improvements are often an effective first step in the implementation of waste minimisation. The "fear" of clean technology as being unaffordable and ineffective in producing environmental benefits could be circumvented by this route. Part of the solution may be - via a waste audit - to identify the true costs associated with wastes.

37. Where there are a number of competing clean technologies, they can be ranked according to the reduction in the hazards associated with the waste outputs, treatment/disposal costs, future liability, safety hazards and input material costs. 4/ The means of determining the cleanliness of a particular technology relies heavily upon the assessment of resource usage and environmental impact using life cycle inventory (LCI) and life cycle assessment (LCA) methodologies. The former attempts to calculate all the environmental burdens associated with providing a particular service to society. It accounts for all energy and material flows throughout the life cycle and is the only tool that considers the whole lifecycle necessary to provide the service, to avoid the shifting of environmental burdens from one part of the system to another. LCI can also be used to identify those changes in a product’s life cycle offering the most significant environmental improvement.

38. By comparison, LCA uses the inventory data to assess the potential environmental impact of waste generation, resource consumption and energy requirements throughout a site’s life cycle (Young and Vanderburg, 1994). LCA can therefore, be defined as a process to evaluate the environmental burdens associated with a product, process or activity by identifying energy and materials used and wastes released to the environment (and the impact of resource usage and waste release on the environment), and opportunities to effect environmental improvements. The cycle includes extraction and processing of raw materials, manufacturing, transportation and distribution, use, re-use, maintenance, recycling and final disposal. LCA is unlike an Environmental Impact Assessment as it addresses the “off-site” issues of up- and downstream effects. LCA has a wider application to the concept of cleaner production and clean technology, by ensuring that changes to one part of the process train do not cause larger detrimental impacts elsewhere in the process. Therefore LCA should be used to guide process selection and design (Clift, 1996). However, incorporation of LCA into these processes is still at an early stage, even ignoring the need to integrate with risk assessment procedures and conceivably safety technology choice.

## V. TRANSFER OF SAFETY TECHNOLOGIES

39. Clean technology transfer can be defined as “the transfer of the capabilities to effect and sustain best-practice environmental performance” and therefore safety technology transfer could be defined as “*the transfer of capabilities to effect and sustain best-practice in*

*preventing and limiting the effects of major industrial accidents*". There is a distinction between capacity and capability. Capacity refers to the set of resources and skills possessed at any one time to operate on a day-to-day basis, while capability as a concept captures the dynamic potential to improve safety performance over time through innovation and mastery of technology and management practices. However, before these issues are examined, it is important to understand the principles behind safety technologies beyond the generic definitions noted previously.

40. The analysis so far suggests four points that merit consideration with respect to technology transfer and safety technologies.

(a) There is a need to develop parallel policy towards prevention, on the one hand, and the mitigation of effects on the other;

(b) Policy can draw on the prior experience of efforts to promote the prevention of pollution rather than to treat symptoms of pollution incidents once they occur. A range of policy targets and mechanisms therefore need to be in place to establish the incentives and frameworks that best promote the preventative rather than reactive approach;

(c) On account of (i) commitments and obligations within Agenda 21 for more advanced industrialised countries to transfer technologies and capabilities from the industrialised to the developing countries and (ii) the inherent necessity for joint action in transboundary pollution crises and accidents, the issue of technological and managerial collaboration between neighbouring states is crucial;

(d) For technological and managerial collaboration to be effective in terms of the production and implementation of hazard prediction schemes, preparedness and action plan implementation, there exist three key pre-requisites: (i) a jointly developed action plan based on the principles of consultation, participation and shared effort; (ii) similar level of technological and managerial expertise and the respective capacity to innovate and advance practice; (iii) training programmes and less formal capability mechanism for optimising the 'learning' possibilities from technological/managerial collaboration on transboundary hazards.

41. The Rio Declaration on Environment and Development was signed by 178 countries in 1992. In the context of technology development and diffusion, this document stressed the need for sustained economic development to link with environmental protection, and for developing countries to have greater access to financial and technological resources. Agenda 21, as the action plan of the Rio Summit, promotes a 'bottom-up' approach by placing emphasis on the role of NGOs, people and communities, combined with "the importance of adequate information, the need for adequate cross-cutting institutions; and the complementarity between regulatory approaches and market mechanisms for addressing development and environmental needs" (Grubb *et al*, 1993).

42. The relevance of concerns about corporate social responsibility to future global industrial activity and the sustainable economy has been underlined by a number of Principles and Resolutions that emerged from the 1992 Rio Earth Summit (UNCED) and

Agenda 21. For example, Principle 10 of UNCED promotes the disclosure and dissemination of information on environmental performance. Principle 16 of UNCED calls for the increased incorporation of economic instruments in environmental protection. Agenda 21 also ‘requests’ industry to contribute to the development and transfer of clean technology and the building of local capacity in environmental management in developing countries.

43. The potential of clean technology transfer to combine economic growth with the protection of the environment in developing countries was recognized in Agenda 21. The concept can of course also be extended to safety technologies. The Agenda contains two programmes which promote the transfer of clean technologies: first, through the encouragement of inter-firm co-operation with government support to transfer technologies which generate less waste and increase recycling; and second, through a programme on responsible entrepreneurship, encouraging self-regulation, environmental research and development, world-wide corporate standards, and partnership schemes to improve access to clean technology. These issues are similarly relevant to accident prevention strategies and safety technologies.

44. While there is a growing body of literature covering the development and diffusion of technology in the industrialized country context (Byers, 1986; Irwin and Vergragt, 1989; Rice, 1988; Rothwell, 1992), little research has been undertaken on mechanisms which would ensure the effective transfer of clean technology to firms in developing countries. Environmental degradation resulting from industrial activity is more closely related to production efficiency and capacity to innovate than to firm size, ownership, location or regulatory regime (Warhurst, 1992; Lagos, 1992; Loayza, 1993; Acero, 1993). This means that environmental degradation tends to be greatest in low-productivity operations with obsolete technology, limited capital, inefficient energy use and poor human resource management. Conversely, those companies that have the resources and capacity to innovate are able to harness technological and organizational change to reduce both the production costs and environmental costs of their operations. Environmental regulation and related public pressures are increasingly important determinants of the newly emerging environmental drivers of corporate strategy (Rothwell, 1992).

45. Industrial accidents and related safety problems are associated with ineffectual management, inefficient human resource development and obsolete or poorly maintained technology as well as than the absence of decreed safety procedures, regulations and penalty systems.

46. Technology transfer involving the building up of managerial innovative capacity and improving human resource development could have a significant impact on accident outcomes, safety issues and environmental problems. The source of this innovative capacity is principally the industrialized countries. This suggests that in order to improve accident prevention and safety management in less developed countries, and the ability to comply potentially with newly emerging finance conditionality relating to hazard management, there needs to be a transfer of the technological and managerial capabilities required to improve production efficiency, risk assessment, hazard mitigation and innovation. Appropriate funding mechanisms and science and technology infrastructure also need to be in place to stimulate and foster such transfers. Therefore, effective mechanisms required to ensure that a real transfer of hazard prediction and safety management capability takes

place is an issue.
Historically, literature and policy about technology transfer has concentrated on the supply of plant and equipment and the skills involved in operating them. Consequently, the innovative capacity of recipients is undeveloped and they remain purchasers and operators of imported plant, equipment and procedures.

47. The research argues that if innovative capability (in its broadest sense) and production efficiency is key to improved accident prevention and safety management, then technology transfer will only contribute to the successful diffusion and absorption of technology if mechanisms embrace a number of factors. First, the knowledge, expertise and experience required for managing technological change - of both an incremental and radical nature. Second the development of human resources to implement organizational changes to improve overall production efficiency and accident prevention and safety management throughout the plant and facility.

48. The capacity to innovate and manage technological and organizational change is fundamental to achieving and maintaining best-practice environmental and social performance, accident prevention and safety management and the internalization of external social and environmental damage costs. Following the liberalization of investment regimes in many developing countries where obsolete equipment and limited capital and skills are endemic, foreign investment may provide an opportunity for the transfer of the skills and technical resources necessary to improve performance in their research. It is argued here that this recent trend towards joint ventures and other forms of strategic alliance between foreign, multinational firms and domestic producers can provide an effective vehicle for the transfer of the technology and human resources essential for more collaborative accident prevention and safety management. This transfer process although not automatic, can occur where one or more of the firms demonstrate the capabilities required for best-practice processing and management techniques.

49. The transfer of accident prevention and safety management production technology and the managerial skills required to maximize its ability to deliver good performance may be one of the more cost-effective ways to improve productivity, environmental management and safety. There is considerable scope for improving the efficiency (and, therefore, hazard management and environmental performance) of production through technological and organizational change. However, many developing countries have a limited institutional capacity for the regulation of environmental impacts and scarce resources for monitoring and enforcement. The lack of financial, technical and human resources may preclude the large, well-trained staff required for the effective monitoring and enforcement of conventional command and control approaches to accidental and safety hazards.

50. Alongside economic liberalization, many countries in transition are constructing new legislative frameworks designed to improve environmental and social responsibility. This provides an opportunity to design policy approaches for effective environmental protection and safety management which reflects local institutional capacities and which avoids some of the inefficiencies and rigidities that are now becoming apparent in the policy approaches adopted by industrialized countries. Although successful in focusing attention on environmental performance, these regulatory approaches have tended to discourage innovative responses to the environmental imperative by prescribing technologies for

pollution control and safety management. Rather than seeking innovative ways to reduce environmental damage costs and accidents, regulations instead have assumed the technology and organization of production (and therefore the associated external damage costs) to be static. Therefore, they have focused on the distribution of this fixed damage costs among stakeholders e.g. companies, state and workers. Approaches to regulation which promote pollution control through Best Available Technology (BAT), for example, are based on the assumption that emissions and waste materials are an inevitable part of production and that the environmental impacts of these emissions can be most effectively controlled through add-on clean-up technology rather than the prevention of a waste stream through process re-engineering. BAT controls have proved very effective at reducing pollution after their initial application, but they create a situation of technology lock-in where a company has little incentive to find alternative, innovative, ways to comply with environmental performance standards. There is also no guarantee that once items of BAT are in place environmental and safety performance will continue and improve over time. Although add-on controls can have relatively low capital costs, retrofitting tends to increase production costs by reducing process efficiency and offering little flexibility for further improvement. As regulatory standards change, so new techniques (involving further capital costs) are required to achieve the permitted levels of discharge and safety threshold levels.

51. Furthermore, and equally pertinent to the issue of the financial resources available in developing and transitional countries, command and control regulatory frameworks require a large, well resourced and experienced staff to conduct monitoring and enforcement rules. The financial burden that this style of regulation imposes on corporations and on the state has led to calls for radical policy reform in several industrial countries (e.g. the debate over Superfund in the United States). In developing countries, where the lack of financial and technical resources for monitoring and enforcement is often more pronounced, adopting a model of regulation that is resource-intensive, as well as overly rigid in the options it provides for pollution prevention and safety management, is likely to be both economically inefficient and environmentally ineffective. While clear, well enforced environmental legislation is certainly required, economic liberalization and the emergence of new environmental stakeholders at all levels, from the global to the local, represent a broadening of the available instruments with which to achieve environmental and safety goals. At a time where the state in both industrialized and developing countries is less and less able to afford the policing efforts that would be required to ensure compliance with command and control legislation, economic liberalization provides an opportunity to attain cleaner and safer production through new investment, technological innovation and the transfer of the capacity to manage technological and organizational change to achieve and sustain best-practice. There is some suggestion that this is already occurring.

52. The emergence of alternative market-based regulatory instruments in the form of, for example, environmental conditions attached to credit and insurance or environmental barriers to market access, may prove an effective regulatory tool with which to promote improvements in environmental and social performance and international competitiveness. The same is relevant for safety performance. A good environmental and safety record is increasingly important in securing financial backing and may be a factor in gaining access to newly liberalized investment regimes. Increased scrutiny of projects from investment, credit, and insurance companies, the trend towards harmonization of national environmental and

safety standards, and the emergence of voluntary standards and codes of conduct at the global level (e.g. ISO 14000, Berlin Guidelines, the Industrial Accidents Convention etc.) are combining to make clean process and best-practice standards the *sine qua non* of market access and project approval. Demonstration of technological and managerial strategies for environmental and safety best-practice are increasingly required by banks and financial institutions that finance investment projects.

53. The importance of managerial capability to the successful diffusion of best practice safety techniques is especially relevant in the context of new industrial developments in newly liberalizing economies. Investment in environmental control technology or cleaner production techniques or safety innovations and accident warning systems are, by themselves, an insufficient condition for achieving and sustaining best practice management. The acquisition, assimilation, and operation of innovative production processes in an efficient, safe and clean manner is dependent on the capacity of management to understand, adapt, and master the process, and not solely on the technical specifications of plant and equipment. Innovative technological hardware does not by itself ensure a high level of environmental, social and safety performance, and efforts to achieve best-practice need to address the building of managerial capacity alongside the development of innovative technologies.

54. Technology transfer can take a number of routes:

(a) Collaborative R&D between venture partners.

(b) In exchange for equity participation in a project.

(c) Build and operate contract.

(d) Construction only contract.

(e) Licensing or franchise agreement.

(f) Open-market transaction.

55. These transfer processes may have associated with them a number of “clauses”, for example:

(a) Long-term management contracts.

(b) Use of supplier’s education and training package.

(c) Use of local technical institutes and suppliers.

(d) Restrictions on ability of the purchaser to change/adapt the technology.

(e) Requirement to use the same supplier for future transfers.

(f) Maintenance contracts.

56. Training is an integral part of the transfer process and should be made available for those operating the new technology, and prior to operation of the technology adequate skills must be gained. The technology supplier or the purchaser may provide training and certification. In either case, training may be via hands-on experience or classroom instruction or some combination thereof. The training period and its timing relative to commissioning of

the technology should be decided on a site-specific and technology-specific basis. Where appropriate the training should be supplemented by training. The level of post-commissioning support and training is defined in part by the nature of the relationship between vendor and purchaser, and also by separate agreement as required. Research on technology transfer (Warhurst, 1996) suggests that training and parallel knowledge transfer over and above the hardware transaction requires its own contractual agreement and should usually be costed in order to optimise the quality of supply.

57. It is clear therefore that technology transfer is a much more sophisticated process than the physical transfer of hardware, and it can capture a wide range of related activities.

**Notes:**

1/ The open-ended group to prepare the workshop on the facilitation of the exchange of safety management systems and safety technologies chaired by a representative of Germany. Experts from France, Romania, the Russian Federation, the Republic of Moldova and Ukraine also participated in its work.

2/ The report entitled “Development of a draft procedures for the facilitation of the exchange of safety technology in the UNECE region within the Convention on the Transboundary Effects of Industrial Accidents” was prepared by Mr. Paul Mitchell and Mr. Alyson Warhurst (United Kingdom).

3/ Waste minimization is also sometimes termed waste reduction, clean or cleaner technology, cleaner engineering or cleaner processing, pollution prevention or reduction, environmental technology, or low and non-waste technology.

4/ It is also possible in many instances to measure the extent of prior experience in industry, capital cost, changes in operation and maintenance costs, the effect on product quality, implementation period and ease of implementation.