

Safety guidelines and good practices for tailings management facilities



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Foreword

Since the early 1990s the United Nations Economic Commission for Europe (ECE) has committed itself to the prevention of, preparedness for and response to industrial accidents, especially those with transboundary effects in its region. The 1992 ECE Convention on the Transboundary Effects of Industrial Accidents helps protect human beings and the environment against such accidents by preventing them as far as possible, by reducing their frequency and severity and by mitigating their effects. Issues related to the prevention of accidental water pollution are addressed in close cooperation with the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

Industrial accidents at Tailings Management Facilities (TMFs) may indeed lead to accidental water pollution. TMFs store large amounts of mining waste which are generated as a by-product when extracting minerals. As such, they can pose serious threats to humans and the environment, especially in case of their improper design, handling or management. Thus, a failure may result in uncontrolled spills of tailings, dangerous flow-slides or the release of hazardous substances, leading to major environmental catastrophes. The devastating effects on humans and the environment of such incidents as well as their far-reaching and severe transboundary consequences have been demonstrated by major past accidents in the ECE region, such as the dam break of a tailings pond at a mining facility in Baia Mare, Romania, in 2000 and, more recently, the aluminium sludge spill in Kolontar, Hungary, in 2010 or the 2012 accident at the Talvivaara Mining Company in Finland.

The effective and safe disposal of mining wastes presents technical and environmental challenges. Each facility is unique, so a tailor-made and sound approach is needed to ensure that the TMF is safe, environmentally sound and economical. Although TMFs are operated with increasing care in many ECE countries, the safety of their operations and their afterlife needs further improvement. This should also be seen in the light of the challenges posed by climate change, which may increase the probability of industrial accidents caused by natural disasters, such as earthquakes and flooding that pose a major risk to TMFs.

I hope that these guidelines will be useful in supporting policymakers and the business sector in enhancing awareness and the sharing of experience and good practices among the competent authorities, operators and the public, and for the better harmonization of the regulations and requirements concerning the safety of TMFs in the ECE region.

I look forward to the successful implementation of the guidelines across the ECE region, in particular by Parties to the Industrial Accidents and Water Conventions, so as to limit the number of accidents at TMFs and the severity of the consequences for human health and the environment if such accidents should occur.



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Background and acknowledgements

In 2006, the Conference of the Parties to the Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) and the Meeting of the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) mandated the Joint Expert Group on Water and Industrial Accidents to draw up safety guidelines and a summary of good practice for tailings management facilities.

The guidelines were developed by the Joint Expert Group on Water and Industrial Accidents, with the support of the United Nations Economic Commission for Europe (ECE) secretariat. The Joint Expert Group was co-chaired by Mr. Gerhard Winkelmann-Oei (Germany) and Mr. Peter Kovacs (Hungary). To support the work of the Joint Expert Group, an international steering group was established, consisting of the following members: Ms. Anahit Aleksandryan (Armenia); Mr. Pavel Danihelka (Czech Republic); Mr. Wilhelm Coldewey (Germany); Mr. Klaus Freytag (Germany); Mr. Gerhard Winkelmann-Oei (Chair, Germany); Mr. Peter Kovacs (Hungary); Mr. Lars-Ake Lindahl (Sweden); Mr. Philip Peck (Sweden); Mr. Yuriy Shestak (Ukraine); Mr. Fritz Balkau (United Nations Development Programme); Ms. Christina Stuhlberger (United Nations Environment Programme); and Mr. Wolfhart Pohl (World Bank). The members of the steering group actively contributed to the drafting of these guidelines.

The resulting guidelines, as presented in this booklet, were endorsed by the Conference of the Parties to the Industrial Accidents Convention at its fifth meeting (Geneva, 25–27 November 2008) and by the Meeting of the Parties to the Water Convention at its fifth session (Geneva, 10–12 November 2009). Both bodies encouraged Parties and other ECE member States to disseminate the guidelines for use by the appropriate authorities.

At its seventh meeting (Stockholm, 14–16 November 2012), the Conference of the Parties to the Industrial Accidents Convention requested publication of the guidelines in a more attractive and user-friendly form. This document responds to that request and presents such an updated version of the 2008 publication, *Safety guidelines and good practices for tailings management facilities*.

Authorities, tailings management facility operators and the public are invited to apply these guidelines and good practices, which are intended to contribute to limiting the number of accidents at tailings management facilities and the severity of their consequences for human health and the environment.

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Terminology

In this publication, a **tailings management facility** (TMF) is intended to encompass the whole set of structures required for the handling of tailings including the tailings storage facility, tailings dam(s), tailings impoundment, clarification ponds, delivery pipelines, etc.

Tailings are the fine-grained waste material remaining after the metals and minerals recoverable with the technical processes applied have been extracted. The material is rejected at the “tail end” of the process with a particle size normally ranging from 10 μm to 1.0 mm.

A **tailings storage facility** is a facility used to contain tailings. This can include a tailings dam (impoundment and pond), decant structures and spillways. A tailings storage facility can also be open pits, dry stacking, lakes or underground storages.

A **tailings dam** is a tailings embankment or a tailings disposal dam. The term “tailings dam” encompasses embankments, dam walls or other impounding structures, designed to enable the tailings to settle and to retain tailings and process water, which are constructed in a controlled manner.

A **tailings impoundment** is the storage space/volume created by the tailings dam or dams where tailings are deposited and stored. The boundaries of the impoundment are given by the tailings dams and/or natural boundaries.



PART A
INTRODUCTION, PRINCIPLES
and RECOMMENDATIONS



Chapter A.1 – Introduction

1. There is a growing body of evidence and understanding that environmental degradation of transboundary watercourses and/or international lakes can be caused by unintended large-scale transboundary movement of hazardous materials as a result of tailings management facility (TMF) failures.
2. Such failures of TMFs have contributed to transboundary pollution via mass movement of wastes (generally tailings containing heavy metals and hazardous and/or toxic compounds) in the form of suspended solids and dissolved materials.
3. Pollution of such waterways and the related damage or risk to human health, infrastructure and environmental resources has the potential to have a negative effect on relations between neighbouring countries.
4. Such risks are posed by all TMFs, whether active, idle/inactive, neglected, temporarily or permanently closed, abandoned or orphaned. There is particular concern regarding the large number of neglected, abandoned or orphaned TMFs where active monitoring or maintenance is not undertaken.
5. A TMF represents a large capital investment and an integral part of mining and mineral processing activities. Its proper operation is a key factor in the overall successful operation of a mining project and its industrial processes.
6. The overall importance of TMFs to both the economic viability and social and environmental acceptability of any mining enterprise are often underestimated. Due to the fact that there is no direct financial return from the cost of design, construction, operation and rehabilitation of the tailings storage facility, it may be tempting to assign insufficient managerial and financial resources to the design, operation, management and/or closure of tailings dams.
7. Assigning low priority to the safety of TMFs has been shown to be a seriously flawed approach, as neglect of tailings dams has often been shown to be a major or significant contributing factor to the poor international record of tailings dam failures and incidents.
8. As accidents such as the tailings spill accident at Baia Mare, Romania, in January 2000 have shown, failures and incidents at TMFs can have far-reaching consequences for the environment and environmental services, to human health and to the social acceptance of mining activities.

9. Such failures and incidents can lead to significant costs for a company for items such as emergency response, clean-up and repairs, disruption of operation, claims for damages, lawsuits and legal costs, unscheduled closure activities and the loss of the company's share value. As such, accident costs almost universally exceed the costs a company would incur to ensure proper and adequate levels of safety and control to prevent such incidents.

10. The failure of a tailings dam in any part of the world has the potential to rapidly impact the social acceptance and regulatory frameworks for all other operations of the company concerned and also for the mining industry in general. Industry reputation is an important prerequisite for the promotion of mining within national development strategies. Moreover, the negative impacts of such industrial accidents can be severely exacerbated when transboundary effects are involved.

11. Such damage to industry reputation and national development strategies is a recurring theme in international circles, and is exemplified by the increased awareness being raised throughout the world by the European Commission (through its Mining Waste Directive),¹ the United Nations Environment Programme (UNEP), the International Council on Mining and Metals (ICMM), the Mining, Minerals, and Sustainable Development Project (2001), the World Mines Ministries Forum, the World Wildlife Fund and the World Summit on Sustainable Development (2002). Such organizations and forums are urging the mining and industrial sectors towards safe, sustainable development, which places a high priority on the increased safety of tailings dams.

12. Such organizations and forums also recognize the economic importance of the extractive industries to both national and local economies, including economies at all stages of development. Moreover, it is recognized that mining may constitute a first significant channel of foreign direct investment in some host countries and that in such instances the industry can serve a central role as a foundation for economic and social development.

13. The operation phase for a TMF can last many decades. Both mining and minerals processing are under constant evolution. Practices vis-à-vis design, operation and maintenance — as well as regulation — of TMFs may evolve significantly during the life of a TMF.

14. Experience regarding the long-term behaviour and stability of TMFs after closure is still limited. In the context of tailings dams, the long term is defined as 1,000 years, or more. While knowledge is constantly increasing, the majority of

¹ Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries.

tailings dams closed and remediated to date (2013) were closed less than one or two decades ago. As such, practice can be expected to continually evolve.

15. The potential for both chronic pollution and the acute risk associated with mine tailings deposits can be very long term. There are a significant number of cases where the remains of tailings and waste from mining operations conducted several centuries — or even millennia — ago still produce pollution in amounts that are harmful to the environment. This emphasizes the importance of proper operation and closure of today's tailings dams and waste dumps if unacceptable risks or negative impacts are to be avoided in the future.

16. However, many national jurisdictions lack relevant regulations regarding issues related to idle/inactive, neglected, temporarily or permanently closed, abandoned and orphaned sites.

17. In recognition of the above, a substantial body of work has been performed by the global mining industry, the geotechnical and geotechnical-related science community, international dam safety organizations, intergovernmental agencies and others to generate guidelines for the building and operation of safe TMFs and their subcomponents, in particular, tailings dams.

18. In recognition of all of the above, in the context of the risk of accidents contributing to transboundary pollution affecting watercourses and international lakes, the Parties to the ECE Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) and the ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) decided to draw up safety guidelines and good practices for tailings dams. These take the form of a set of recommendations that will assist national authorities and operators in ensuring an adequate safety level at TMFs and an acceptable level of risk posed by such facilities.

19. The Joint Expert Group on Water and Industrial Accidents under the Industrial Accidents and the Water Conventions established a steering group with recognized expertise on tailings dams and transboundary accidents to draw up the present guidelines. In drafting the guidelines, the steering group took into account input from authorities, operators of TMFs, financing institutions and non-governmental organizations (NGOs) during a workshop on safety of tailings dams held from 12 to 14 November 2007 in Yerevan.

20. The steering group based the guidelines directly on the body of work produced by the global community of dam safety scientists, professional bodies and intergovernmental agencies, and notably the work of the European Commission, the International Commission on Large Dams (ICOLD), UNEP, ICMM and others. Regulating bodies such as the European Commission have

also produced guidelines, directives and regulations that influence TMF design and operation, and major financing bodies have developed safety assurance and design guidelines for their investments. Finally, a number of international instruments and guidelines on industrial accidents, chemicals management, environment impact assessment and public information on environmental risk are pertinent to the design and operation of TMFs.

21. The following are the recommendations and the key elements of the ECE guidelines and good practices for TMFs designed to prevent incidents at TMFs, with a key focus on tailings dams, and to limit the potential for negative impacts on the environment, human health and infrastructure. They are based extensively on accepted and published good practice procedures to ensure conformity with international standards. Security concerns (e.g., sabotage, destructive acts) and workers' safety are not within the scope of these guidelines; nevertheless, these concerns should also be taken into account at all stages of the life cycle of TMFs.

Chapter A.2 – Safety principles for tailings management facilities

22. Governments should provide leadership and create minimum administrative frameworks to facilitate the development, safe operation and decommissioning of TMFs.

23. The operators of TMFs have the primary responsibility for ensuring the safety of TMFs and for formulating and applying safety management procedures, as well as for utilizing technology and management systems to improve safety and reduce risks.

24. Within the general scope of the relevant guidelines and good practice principles, TMFs should be planned, constructed, operated and closed applying a case-by-case or site-by-site approach, taking into account varying climate and hydrology, topography, geology, tailings properties and other conditions.

25. Only competent — properly certified (in accordance with the national legislative, regulatory and safety management norms) — personnel should be engaged in the planning, design, construction, operation/management and closure of TMFs, and the relevant competences should be described in the operation and management plan (see chapter A.3, recommendations to tailings management facility operators).

26. A systematic approach to managing TMF safety should be acknowledged by all stakeholders, and the high-quality “planning-construction-operation-closure-rehabilitation” life-cycle approach should be ensured in all cases.

27. Understanding of processes in the life cycle of a TMF should be developed at the planning and design stage of the TMF, and should be further refined through practice and simulations.

28. The safety of TMFs depends especially on the individuals responsible for TMF planning and design (and approval), construction companies, operators, government and commercial inspectors, rescue services and professionals in closure and rehabilitation. Therefore, such persons should be adequately trained and qualified as well as certified, when required.

29. TMFs should be operated in accordance with the construction, safety and environmental norms of the country concerned, taking into account internationally established best practice, and on the basis of an operating and management plan (operation manual) evaluated and accepted by the relevant competent authority, as appropriate.

30. TMFs should be classified based on a risk assessment, taking into account parameters as specified in Part B of these guidelines.

31. Land-use planning, hydrological and geological considerations should be taken into account when evaluating optimum TMF siting and intended post-operational use.

32. For TMFs that pose a potential risk to neighbouring communities and land uses due to their size or the presence of hazardous materials, the provision of information to and involvement of these communities and individuals, in accordance also with internationally recognized procedures, should be ensured for the purpose of drawing up an emergency plan that the community understands, aimed at mitigating the effects of possible accidents.

33. Projects for TMF construction that have the potential to cause adverse environmental impacts across borders should be notified and consulted between Governments of neighbouring countries, and the ECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) and its provisions regarding the performance an environmental impact assessment should be applied.

34. TMFs should be operated in accordance with the provisions of the ECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention). Where

the subject of concern is of transboundary nature, the principles of the Almaty Guidelines on Promoting the Application of the Principles of the Aarhus Convention in International Forums should apply.

Chapter A.3 – Recommendations

35. These guidelines constitute a minimum set of requirements to ensure a basic level of safety for TMFs. They highlight aspects to be considered to achieve an acceptable level of safety through applying different policies, measures and methodologies. Nevertheless, owners and operators are encouraged to apply additional procedures and safeguards in accordance with local assessments to achieve the highest practical level of performance of their TMF.

36. These guidelines should also be applied in the context of relevant national requirements and existing international guidelines, recommendations and standards concerning TMFs, and using internationally accessible information sources.

37. Below are policy, administrative and legal recommendations to the ECE member countries, competent authorities and TMF operators. Guidelines and best practices on the technical and organizational aspects of TMFs are set out in Part B.

Recommendations to member countries

38. ECE member countries should identify competent authorities at national, subnational and local levels that are provided with the necessary human resources and professional competences for the tasks foreseen in these recommendations.

39. ECE member countries should adopt and enforce adequate legislation for ensuring the safe construction, operation, maintenance and closure of TMFs, including legislation for handling abandoned and orphaned sites from past activities. They should also make appropriate institutional arrangements through, inter alia, the establishment of a coordinating mechanism comprising the key actors concerned.

40. ECE member countries should ensure, if they have not already done so, the elaboration and maintenance of national inventories of operational as well as closed, abandoned or orphaned TMFs that may constitute a risk to human health or the environment. National inventories of closed, abandoned or orphaned TMFs should consider both current impacts and risks of future negative effects (accidents, spills and leaks).

41. ECE member countries should share experience and information on good practice for TMF safety in all the phases of the TMF life cycle on a regular basis.

Recommendations to competent authorities

42. The competent authorities should ensure that all the relevant authorities involved in TMF safety should cooperate with each other, preferably within an integrated system in which one authority plays a coordinating role.

43. The competent authorities should notify their counterparts in neighbouring countries about the TMFs in their country that could cause transboundary effects in the event of an accident.

44. The competent authorities should introduce an authorization and/or a licensing procedure to permit the construction of a TMF.

45. The competent authorities should evaluate and approve the design, operations and management plans (operation manual) drawn up by operators.

46. The competent authorities should verify and endorse the TMF monitoring performed by the operator (or his agent) so that it fulfils established quality standards.

47. The competent authorities should ensure that TMF operators develop internal emergency plans for TMFs with significant risks, and that they provide necessary information to the public and to the relevant authorities, and cooperate with the relevant authorities on preparing external plans.

48. For TMFs with significant risks to outside communities, the relevant authorities should develop external emergency plans in association with operators, community groups, local authorities and rescue services, and apply these plans off-site in the event of accidents (see, for example the APELL process discussed below in chapter B.5, external emergency planning).

49. The competent authorities should ensure that the internal and external emergency plans are reviewed and tested periodically and, where necessary, revised and updated.

50. The competent authorities should apply methodologies for risk identification and assessment of closed, abandoned or orphaned TMFs using a step-by-step approach, starting with a basic screening of sites, whereby resources are gradually directed towards the sites with the highest risk.

51. Based on the risks identified, the competent authorities should make plans for risk reduction measures and/or monitoring (early warning) for closed, abandoned or orphaned TMFs.

52. The competent authorities should ensure (i.e., organize or arrange) training of inspectors on an ongoing basis so that the inspections are performed effectively. In addition, non-mining professionals dealing with environmental impact assessment and land-use planning for mining projects should be trained on tailings issues.

53. The competent authorities should encourage and engage in a “train the trainers” programme at existing educational institutions, so that trainers attain the necessary capacity for training company and government staff. Where possible, use can be made of international training programmes offered by various national and United Nations institutions.

54. The competent authorities should ensure meaningful public participation and easy access to information in accordance with the relevant provisions of the Industrial Accidents Convention, the Water Convention and, in particular, the Aarhus Convention (see recommendations to member countries, above).

Recommendations to tailings management facility operators

55. All TMFs should have an operation and management plan (operating manual) that is available to all personnel, local inhabitants, government inspectors and other relevant stakeholders. All documents relating to planning, design and construction should be maintained in an accessible way, with records kept permanently for future reference.

56. TMF operators should monitor the TMF in accordance with the operation and management plan, as approved by the competent authorities.

57. TMF operators should draw up and implement internal emergency plans and apply them on-site whenever a tangible risk that a major accident may occur has been identified, when an uncontrolled event occurs that could lead to a major accident, or when a major accident has occurred. TMF operators should review, test, revise and update the internal emergency plans periodically, and always when there has been a change in the mine operation and management.

58. The TMF operator should notify the competent authorities in the event of emergencies that have occurred on the site.

59. TMF operators should cooperate with the competent authorities and local communities in preparing external emergency plans.
60. TMF operators should train their personnel and reinforce and update their safety knowledge, in particular with regard to how to identify potentially harmful events and/or circumstances.
61. TMF operators should implement safety audits for their facilities and promote the use of environmental management systems based on international standards.

PART B

TECHNICAL and ORGANIZATIONAL ASPECTS



Chapter B.1 – Pre-construction and construction

Licensing

62. There should be a system of licences dependent on the risk assessment for the TMF. The assessment should be done by the operator and evaluated by the competent authorities. The risk assessment will be done on the basis of the operation and management plan (operating manual) drawn up by the operator. (More information can be found below in the section on hazard identification and risk assessment.)

63. The licensing procedure should differentiate between:

- (a) The basic authorization procedure;
- (b) Authorizations involving public participation;
- (c) Authorizations involving environmental impact assessment and public participation.

64. The complex procedure set out in subparagraph 63 (c) above should be applied to TMFs where:

- (a) The waste facility contains waste considered hazardous (e.g., according to the recommended classification and threshold quantities under European Union (EU) Council Directive 91/689/EEC);² or
- (b) The waste facility contains substances and preparations classified as dangerous (e.g., according to the recommended classification and threshold quantities under EU Council Directive 67/548/EEC³ or Directive 1999/45/EC⁴); or
- (c) A failure or incorrect operation can give rise to a major accident.

² Of 12 December 1991 on hazardous waste.

³ Of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.

⁴ Of the European Parliament and of the Council of 31 May 1999 concerning the approximation of the laws, regulations and administrative provisions of the Member States relating to the classification, packaging and labelling of dangerous preparations

Environmental impact assessment and land-use planning

65. An environmental impact assessment (EIA) should be considered as a precondition for construction and operation of a TMF (see the recommendations in the section on licensing above). The EIA should address the potential physical impact of the TMF on the environment and should be open for the general public and interested or affected persons to comment and provide input on the assessment, and to object to it if there are any legal grounds to do so.

66. The EIA should address:

- (a) *Location criteria*: climate, general topography, regional geology, seismic hazard, environmental sensitivity, hydrology (groundwaters and surface waters) and local geomorphology;
- (b) *Tailings criteria*: geochemical character of the tailings and the physical and geotechnical character of the TMF;
- (c) *Site criteria*: downstream infrastructure, cadastral boundaries, potential underlying mineralization, site topography and hydrogeology;
- (d) *Management*: tailings deposition method, water balance, method for managing storm events and monitoring;
- (e) *Closure*: completion criteria, intended post-operational land use and long-term physical, geotechnical and biological stability, as well as ecosystem rehabilitation, if appropriate;
- (f) Evaluation of “zero” option/non-implementation of the project.

Hazard identification and risk assessment

67. Before licensing the construction of a TMF, a risk assessment should be performed. There are different ways to conduct a risk assessment, and standard procedures are described in literature. To a lesser or greater extent they all include the five steps outlined below. These steps need to be taken by the applicant and the results should be evaluated by the competent authorities. This process also involves a sixth step, which is an evaluation of the acceptability of risks.

Step 1: Hazard identification

68. The applicant needs to evaluate possible hazards such as:
- (a) The toxicity and eco-toxicity of tailings material;
 - (b) Hazards to the aquatic environment arising from effects other than the toxic effects of tailings material (e.g., pH, chemical oxygen demand, salinity, dispersed material);
 - (c) Flood hazards due to the free liquid in the tailings dam;
 - (d) Hazards due to the physical/mechanical properties and behaviour of the stored solid material (slurry transport and/or liquefaction phenomena) in the event of an accident;
 - (e) Hazards resulting from soil contamination by tailings/sludge.
69. The hazards identified will decide the level of ambition needed in the further assessment.

Step 2: Accident scenarios

70. The applicant should describe scenarios of possible failure modes and identify all potential causes. The scenarios need to consider: (a) the impact of possible natural phenomena at the TMF location (e.g., excessive rain, snowfall or snowmelt, earthquakes, landslides, avalanches); (b) failures of already built structures (e.g., other dams) situated upstream, whose failure could cause domino effects; and (c) causes related to the design, management and control of the TMF, including human error.
71. In the scenario description, records of accidents and near-misses at similar TMFs should be considered. No plausible scenario should be excluded.

Step 3: Identification of potential receptors

72. In this step the applicant needs to identify who and what can be affected assuming possible scenarios (failures). Aspects for consideration relate to the environment (water, soil, and biota), human health and living conditions, economic losses (damage to infrastructure or property). Special attention should be directed to scenarios that can cause damage in a transboundary context.

Step 4: Safety measures

73. The applicant needs to describe safety measures aimed primarily at the prevention of potential scenarios (causes of failures) as identified in step 2. Secondly, measures aimed at limiting the consequences/impact, should a failure still happen, should be described. The latter will include measures for

preparedness (warning, alert and alarm systems) and emergency response plans. Cooperation between TMF operators, competent authorities and local authorities (the community) is recommended for emergency planning.

Step 5: Impact assessment

74. The applicant needs to assess the impact/effects of possible scenarios on the potential receptors, as identified in step 3. In doing so, the safety measures proposed under step 4 should be considered and an evaluation should be made as to how they limit the potential impact/effects.

Step 6: Risk assessment and evaluation

75. Finally, the applicant should also assess the probability of principal scenarios (potential failures) as described in step 2, taking into account the proposed safety measures and their reliability. In doing so, site-specific or generic data should be considered and if no such data are available expert judgement should be applied. In some cases it will be possible to quantify the probability of the scenario, e.g., return periods for flood events; in other cases, it will only be possible to discuss low and high probabilities in general terms. The resulting risks are a combination of the probability that a certain scenario will take place and the potential impact if it does. The different scenarios (failure modes) studied can be presented in a matrix with probability on one axis and impact on the other.

76. In this step, the applicant should also make a judgement if the risks related to the different scenarios are to be considered acceptable. Such acceptability assessments will distinguish risks potentially ranging from low probability and low impact to high probability and high impact. It is useful to make a division into three classes of risk: green — acceptable; yellow — conditionally acceptable; and red — unacceptable.

77. If all the risks associated with the planned TMF are deemed acceptable (i.e., they fall into the green class of risk) the applicant can go ahead with his application, including the safety measures proposed in step 4 or otherwise. In other cases, stricter design and operational criteria, more frequent monitoring and/or other risk reduction measures should be evaluated and proposed, as relevant. If there are no economically feasible or technically available measures to reduce the risk to an acceptable level, an objection should be raised to the construction of the TMF. Under such circumstances, an alternative location for the TMF may be a feasible solution.

78. The final decision about the acceptability of risks will be part of the licensing procedure, and should involve the competent authorities and other stakeholders (e.g., involved community representatives, the public, etc.)

Dam safety

79. While planning and designing a safe TMF, particular attention should be directed to:

- (a) The tailings pond, for which the following parameters need to be assessed accurately:
 - (i) The stability of the tailings (or other deposited material such as water treatment sludge);
 - (ii) The geological situation;
 - (iii) The hydrogeological situation;
 - (iv) The hydrological situation;
 - (v) The geophysical situation.
- (b) The tailings dam, for which the following parameters need to be assessed accurately:
 - (i) The slope stability of the dam;
 - (ii) The strength and stability of the foundation for the dam;
 - (iii) The stability of the tailing material (induced liquefaction);
 - (iv) Erosion to the dam (suffusion and outside erosion);
 - (v) Water recovery systems;
 - (vi) Emergency spillways;
 - (vii) Slope sliding;
 - (viii) The tailings delivery system to and on/around the TMF with regard to:
 - a. Safety;
 - b. Environmental protection.

80. The dam-raising method should be chosen with regard to the local conditions (e.g., seismicity, tailings composition, severe climate). Special attention has to be given to quality control and site supervision during the starter works construction phase of the TMF.

81. Additional impoundments should be designed to contain inflow from emergency outlets.

82. Hazardous substances and process water should be reused as far as technically possible (recycling) and, in case it is not possible to recycle hazardous substances, they should be neutralized before they are discharged into the TMF.

Chapter B.2 – Operation and management

Management

83. The TMF should be operated and managed on the basis of an operation and management plan (operation manual) and waste management plan (if such is not part of the operation manual) evaluated and approved by the competent authorities, which is developed in the planning phase and periodically reviewed and updated. The aim of the plan(s) is to effectively manage the risks and hazards at the TMF (or waste facility) in order to stay within the green risk class (see para. 76 above).

84. The operation manual should contain:

- (a) A description of the tailings delivery system to and on/around the TMF (i.e., with regard to safety and environmental protection considerations);
- (b) A description of all monitoring procedures/mechanisms for inspection: sampling locations; sampling frequency; and checklists and compliance parameters, such as minimum capacity/freeboard, pore pressure, groundwater level, functioning of the drainage system, surface water diversion, dam movement and slope stability;
- (c) Procedures for reporting on non-compliance and failures;
- (d) Corrective actions to be applied in the event of non-compliance;
- (e) An internal emergency plan;
- (f) Assessment parameters for the effectiveness and suitability of the operation manual.

85. Any changes to the operation manual should be subject to its performance analysis, which should be documented.

86. The performance of the TMF should be assessed and described during significant seasonal events and the data gathered should be used for rehabilitation planning.

87. In the event of TMF drainage potential, in particular acid rock drainage, the management plans should primarily be developed to prevent or reduce the production of acidic drainage, and secondarily to collect and treat the contaminated water to meet permit conditions or relevant emission standards.

Education and training of personnel

88. The life-cycle approach to TMFs requires that personnel in a variety of different professions and institutions have a common understanding and knowledge of the technical and managerial aspects of TMFs, and use complementary professional procedures in their work. This complementarity may require a certain level of training (and retraining) of various persons in different institutions.

89. The personnel concerned should be identified along the lifecycle “planning-construction-operation-closure-rehabilitation” chain.

90. A variety of different professions are involved, including engineers and managers, planners, regulators, environmental and safety specialists and monitoring and auditing staff. It is important to appreciate the importance of the two-way training — informing mining engineers of issues in environmental and safety management and, conversely, giving environmental personnel the insights needed to deal with TMF issues.

91. The following are among the subjects where adequate skills need to be built through training programmes and on-site experience:

- (a) Technology and future trends in TMF design;
- (b) On-site procedures for safe operation and risk management;
- (c) Standards and regulations for TMFs and for safety and environmental performance;
- (d) Management systems and tools, including corporate social responsibility;
- (e) Measurement of operational and environmental quality;
- (f) Environmental (including basic hydrology) and health issues;
- (g) Safety and environment auditing of the site and its facilities;
- (h) Reporting, both internally and for public information;
- (i) Communication.

92. The inherent uncertainties surrounding all potentially hazardous TMFs require special skills in risk assessment and management, risk communication and reporting.

93. Inspectors should have knowledge of the relevant design principles and the current regulations. However, they also need to develop a good understanding of operational and risk management practices for TMFs. As such facilities do not generate a revenue stream for the operating company, there is a considerable risk that they may therefore be neglected. More details on training of inspectors can be found in the next section.

94. Where TMFs are located in populated areas, communication and negotiation skills need to be built up to ensure that the public stakeholders are properly informed about (and involved in) decisions relevant to their interests. These interests often centre around social, environmental and economic issues for the local community, which must be understood by managers and designers in particular, but also by inspectors and consultants.

95. Numerous avenues are already available for building the necessary broad-based competencies, especially through existing national education institutions and mining schools; nevertheless, it is often very useful to first launch a “train the trainers” programme to bring all relevant staff up to a common level of understanding. Looking beyond existing national institutions, a number of online or correspondence courses are becoming available, and various United Nations agencies have published self-learning manuals and train-the-trainers packages in subjects relevant to TMF management. Increasingly, international institutions and professional conferences also play a valuable role in promoting information exchange and learning. Wherever possible, training should focus on active, hands-on methodologies as the most effective means of training adults.

Education and training of inspectors

96. TMF inspectors should be trained in:

- (a) New technologies in TMF management;
- (b) Standards and procedures;
- (c) Corporate (environment and safety) management methods and tools, and corporate auditing;
- (d) Monitoring and auditing standards for operations;
- (e) Risk assessment and risk communication;
- (f) Communication with operator personnel and the local community.

97. The training resources should be evaluated and augmented as necessary to provide the complete range of subjects and skills required for life-cycle TMF inspection.

98. The training should be based on lessons learned and include simulations, practice, drills, role play, field exercises and discussion of case studies. It should be an ongoing process and not an ad hoc activity. Extensive material is available from national institutions, industry associations and United Nations agencies to support such events and programmes. Study tours of practices in other countries are also extremely valuable.

99. The training should be spread over time and be subject to reinforcement, revision and follow-up, with refresher courses provided at regular intervals.

Chapter B.3 – Facility inspections

100. Facility inspections should be performed by the competent authorities at all phases of the life cycle of the TMF, and should ensure that TMF operators are taking all the necessary steps to manage the safety of a TMF throughout its lifecycle without posing any risk to the environment or human health. The inspectors should verify in particular if the TMF is managed in accordance with the applicable legal and regulatory standards, as well as with the approved operation manual and waste management plan, as follows:

- (a) *During the pre-construction and construction phase:* verification of the location for the waste facility; verification of assumed factors affecting design in the field; construction of the tailings dam;
- (b) *During the operation phase:* verification that the physical stability of the waste facility is ensured and that pollution or contamination of soil, air, surface water or groundwater are prevented; verification of regular monitoring of immission and emission measurements; verification if failures were properly reported and proper corrective action was taken;
- (c) *During closure and after closure:* verification that the physical stability of the waste facility is ensured; verification of the rehabilitation process, including its proper documentation.

101. If the management of the TMF does not follow the operation manual and/or waste management plan, the inspection authority should urge the operator to introduce corrective actions within a specified period, and if this is not done, to take back the operation permit.

Chapter B.4 – Identification, assessment and management of abandoned sites

Assessment of and priority tasks for abandoned sites

102. Abandoned or orphaned sites should be regularly inspected by the competent authorities depending on the risk posed by the site as assessed in the initial screening.

103. The initial screening should include a walkover survey concentrating on TMF features such as the containment dam, the beach, the water management system and the hydrographic catchment area, as well as the vulnerability factors for nearby or downstream communities and land use, and any important natural areas requiring special protection.

104. Public access to sites which present significant risks to persons and animals should be restricted.

105. The components, structures and parameters to be specifically considered for inspection and screening in the event of any unusual sign or event should include the following:

- (a) The geomorphological situation and catchment area (TMF and upstream geologic structure, inflowing streams, size and topography of the TMF catchment area, expected frequency and magnitude of flood events);
- (b) The dam crest (materials used, irregularities, depressions, signs of erosion);
- (c) The slope geometry (height, angle, berms);
- (d) The containment dam slope condition (materials, vegetation, signs of erosion, seepage, slumping, active mass movements such as slumping, sliding or rotational failures);
- (e) The lagoon condition (size relative to TMF, depth, geometry, vegetation, alien deposits such as litter);
- (f) The water management system (existence and condition of drainages, by-passes, decantation plant, contingency/emergency spillways, pumps);
- (g) Monitoring equipment (inter alia, trigonometric points, survey targets, piezometers/standpipes);
- (h) Historic incidents and accidents.

106. Depending on the result of the screening, the sites should be labelled from green to red classes of risk (“low risk”, “intermediate risk” and “high risk”).

107. Sites should be prioritized for a further detailed assessment based on the initial risk assessment. This assessment should lead to the development of a risk management strategy, which in some cases may be limited to monitoring, while other sites may require immediate action due to a non-negligible probability of failure in the short term. The detailed assessment should include:

- (a) Research on existing documentation;
- (b) Detailed site surveys;
- (c) Potential spot investigations;
- (d) Rough calculations on the probabilities of a specific set of identified failure modes.

108. Starting with the highest risk sites, all risk sites should undergo appropriate investigation and data generation measures (e.g., topographical surveys, modelling, etc.). For each of them, specific risk management programmes should be designed, tendered and contracted within a reasonable time frame. These risk management programmes will in some cases include plans for a full site remediation, while in other cases monitoring will be sufficient. Programmes can be divided in phases, where the more acute risks are dealt with in the short term, and site remediation may come at a later stage.

Management of abandoned sites

109. The competent authorities should make an attempt to locate the responsible party (former operator, landowner) for abandoned or orphaned sites and take legal action to force them to properly manage the site. In the event of long legal processes, the competent authorities should take the necessary action to maintain the sites in order to avoid unacceptable risks.

110. The management system for abandoned or orphaned sites should include the organizational structure, responsibilities, procedures and resources for determining and implementing the accident prevention policy, as follows:

- (a) *Organizational structure*: competent authorities should be nominated to carry out the assessment and monitoring of abandoned or orphaned sites. They should be allocated adequate staff, technical means and budget to accomplish their mandate;

- (b) *Identification and evaluation of hazardous sites:* closed, abandoned or orphaned sites should be known and catalogued in an inventory containing their location and key characteristics, and they should be labelled accordingly;
- (c) *Monitoring and maintenance:* the sites should be monitored and maintained and remediation measures should be undertaken as a priority for those sites where risks are unacceptable (e.g. failures are likely or very likely to happen).

111. Experience has shown that removing or re-engineering of sites will in most cases be very costly and should only be undertaken where appropriate risk reduction measures fail.

Note: Further guidance in dealing with abandoned sites, including the administrative machinery needed to address the management of such sites, can be found in the 2005 United Nations publication, *Identification and Management of Contaminated Sites — a methodological guide* (see general source list, para. 140).

Chapter B.5 – Emergency planning

112. Emergency plans should be established for each TMF for phases of construction, operation and closure. The appropriate emergency plan needs to be established prior to the issuing of permits for construction, operation or closure. Hence, they should be drawn up within the periods set by local or international rules.

113. Emergency plans should be established, tested and revised by the TMF operator (internal plans) and by authorities (external plans), in particular:

- (a) Prior to the commencement of operations;
- (b) If an accident or emergency situation occurs at the site or other similar sites;
- (c) When the emergency service organization or its senior personnel are changed;
- (d) After new technical knowledge in the area of TMF management becomes available or when new risks are identified;
- (e) If operational changes, mismanagement, structural problems, equipment modification or natural events result in a threat that design limits will be exceeded;
- (f) At regular intervals, as determined in the emergency plans themselves.

114. Among other things, the plans should evaluate downstream inundation hazards resulting from floods or dam failure, and upstream conditions that might result from major land displacements or increased flood flows. If applicable, the emergency plans should include inundation maps for the flows resulting from design floods, possible dam failures or emergency releases.

115. Where there is a series of dams on the stream, analyses should be made considering the potential for progressive “domino” failure of the dams. To evaluate the effects of dam failure, maps should be prepared delineating the area which would be inundated in the event of failure. Analyses should be made to determine conditions which could be expected to result in slow, rapid or practically instantaneous dam failure.

116. The emergency plans, both internal and external, should include:

- (a) The scope and objective of the emergency plan;
- (b) The responsibilities of each member of the organization (chain of responsibility and authority for actions to be taken);
- (c) Evaluation of emergency scenarios, risks, potentially affected areas, etc.;
- (d) Organization of communication and notification procedures;
- (e) Available equipment for interventions;
- (f) Procedures for emergency response for each of the emergency scenarios determined;
- (g) Procedures for remediation.

Internal emergency planning

117. Internal emergency plans should be developed for each specific site and situation. Emergency plans should be tested and evaluated through periodic drills, as defined in each plan.

118. Prior to development of an internal emergency plan an analysis should be made to determine the most likely mode of dam failure under the most adverse conditions and the resulting peak water outflow following the failure. The analysis should also identify any chemical substances or other potentially polluting materials that might be released in the event of a TMF failure.

119. Internal emergency plans should contain estimations of the amounts and types of equipment needed to deal with polluting or dangerous releases, as well as the construction materials and equipment needed for emergency repairs of the TMF based on the structure, foundation and other characteristics of

the dams. The plan should also foresee measures for clean-up of any material that might be released from a TMF.

120. Internal emergency plans should be compatible with external emergency plans of the competent public authorities, and should be activated in a coordinated fashion in the event of a major accident.

121. Plans for notification of key personnel, local authorities and emergency services and the public must be an integral part of the emergency plan and should be prepared for all types of dam failure conditions.

122. The internal emergency plans should be part of the company's operating and management plan (operating manual), and should be regularly reviewed by senior management. Corporate personnel responsible for emergency management must be clearly identified to all staff on the site, and on-site personnel must receive adequate training in emergency procedures and incident reporting.

External emergency planning

123. External emergency plans should be prepared and implemented by the relevant authorities, conform to local needs and vary in complexity in accordance with the type and degree of occupancy of the potentially affected area. Where a TMF is identified as a substantial risk in such plans, the internal and external emergency procedures must be compatible.

124. The local community should be given the opportunity to participate in the preparation and revision of the external emergency plans, and to partake in any exercises that might be carried out. The local community should be entitled to comment on the external plans within reasonable time frames, and due account should be taken of these comments.

125. It should be ensured that in border areas the contingency plans of two regions of neighbouring countries are compatible with each other and include contact details to allow proper notification of any emergencies that might occur. Ideally, the local communities and the competent authorities of such neighbouring countries are given the same rights to participate in the preparation and revision of the compatible external emergency plans.

Note: It should be recalled that the United Nations-approved process of "Awareness and Preparedness for Emergencies at the Local Level" (APELL process) has been developed to guide the preparation of external emergency plans. A version of APELL specific to mining has been developed jointly by UNEP and the mining industry.

Emergency planning for abandoned sites

126. The competent authorities should develop emergency plans for abandoned and orphaned sites, considering the above elements and criteria for internal and external emergency planning. Before developing the plans, the existing plans and responsibilities should be verified, as follows:

- (a) Regional emergency response frameworks, such as civil protection, fire brigades and flood response;
- (b) Emergency response plans for a coordinated regional/transboundary response;
- (c) Clear command structure and management of interfaces between the authorities concerned;
- (d) Models of scenarios for mining accidents and their integration into the community emergency plans.

PART C

REFERENCES



References to documentation on mining and tailings

127. A large amount of literature is available on tailings and tailings management. Some of the more relevant works have been selected here, with an emphasis on sources that offer access to readily available online documents and references, as these are often more accessible to readers with limited financial resources to purchase books.

128. Where possible, relevant United Nations documents have been highlighted, as these have often been subject to extensive international review prior to publication.

129. Finally, a number of reference works published by industry or professional associations have been included.

130. Some of the sources below provide links to the primary references, but not to the full documents themselves.

Note: Even the sources below that are not fully up to date can still provide valuable insights, information and further links. All Internet references cited below were last accessed on 21 January 2013.

General sources of information

131. The Mining Association of Canada has a useful website (www.mining.ca).

132. ICOLD (www.icold-cigb.net) is an international NGO that provides a forum for the exchange of knowledge and experience in dam engineering. It has published authoritative bulletins concerning tailings dams.

133. The EU Reference Document, *Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities*, is available from the EU Integrated Pollution Prevention and Control Bureau.⁵

134. Directive 2006/21/EC of the European Parliament and Council of 15 March 2006 on the management of waste from extractive industries sets out rules for waste resulting from the extraction, treatment and storage of mineral resources and the working of quarries.⁶

⁵ Available from www.eippcb.jrc.ec.europa.eu/.

⁶ See www.eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006L0021:EN:NOT.

135. Authorities in Australia, Canada and South Africa have published guideline documents on tailings management. Relevant regulations from these countries are available from the relevant national institutional websites.

136. ICMM has produced a range of publications, which are available on its website.⁷

137. References on cyanide can be found on the website of the International Cyanide Management Code (www.cyanidecode.org).

138. For safe handling of cyanide and other chemicals during minerals processing, the Organization for Economic Cooperation and Development *Guiding Principles for Chemical Accident Prevention, Preparedness and Response* are especially useful.⁸

139. Reference works on emergency preparedness and response can be found on the UNEP APELL website.⁹ Publications include the useful handbook on APELL in the mining sector¹⁰ and a handbook on *Hazard Identification and Evaluation in a Local Community*.¹¹

140. UNEP and the French Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) collaborated on a methodological guide for the *Identification and Management of Contaminated Sites*.¹²

141. The International Association for Impact Assessment brings together researchers, practitioners, and users of various types of impact assessments worldwide (www.iaia.org).

142. The International Organization for Standardization (ISO) standards in the ISO 9000 series (relating to quality management systems) and the ISO 14000 series (addressing various aspects of environmental management) both contain specific standards relevant to TMFs management.¹³

⁷ See www.icmm.com/publications/.

⁸ Paris, 2003. Available from www.oecd.org/chemicalsafety/riskmanagement/2789820.pdf.

⁹ See www.unep.org/resourceefficiency/Business/CleanerSaferProduction/SaferProduction/APELL/tabid/78881/Default.aspx.

¹⁰ Available from www.unep.fr/shared/publications/pdf/WEBx0055xPA-APELLminingEN.pdf.

¹¹ APELL/UNEP, 2nd ed., Paris, 1996. and See www.unep.fr/shared/publications/pdf/WEBx0062xPA-HazardId.pdf.

¹² Paris, ADEME Editions, 2005.

¹³ Available from the Organization's website, www.iso.org.

143. The Global Reporting Initiative (www.globalreporting.org) develops and disseminates globally applicable *Sustainability Reporting Guidelines* for voluntary use by organizations reporting on economic, environmental, and social performance.

144. For training, a number of publications have been produced by UNEP and other partners. Some of these can be found on the UNEP website.¹⁴ UNEP has also produced trainers' manuals on environmental impact assessment and environmental management systems. The International Cyanide Management Institute trains prospective auditors in various aspects of cyanide management including at TMFs.¹⁵

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¹⁴ See www.unep.org/resourceefficiency/.

¹⁵ See www.cyanidecode.org/about-icmi.

Safety guidelines and good practices for tailings management facilities

Two United Nations Economic Commission for Europe (ECE) treaties — the Convention on the Transboundary Effects of Industrial Accidents and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes — together provide a legal framework for addressing the risk of transboundary water pollution arising from industrial accidents.

ECE member States have used this comprehensive legal framework for addressing industrial accidents to examine and develop guidance on particularly hazardous activities. The failure of tailings management facilities, in particular, can lead to the unintended large-scale transboundary movement of hazardous materials, which can cause environmental degradation of transboundary watercourses and international lakes and threaten the health and livelihoods of people using these waters.

These safety guidelines and good practices for tailings management facilities promote good practices that will help avoid accidents at such facilities and minimize the effects of any accidents that should still occur. By using these guidelines, Governments and industry are fostering the protection of the environment and human welfare in our region.