Subregional Workshop on strengthening mine tailings safety for Central Asian countries

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TMF methodology: Tailings Hazard Index and TMF Checklist, application experience

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UNECE “Safety Guidelines ...” as the basis for the TMF Checklist

- 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 (UNECE) secretariat.
- The Guidelines were endorsed by the Conference of the Parties to the Industrial Accidents Convention (2008) and by the Meeting of the Parties to the Water Convention (2009).
- The document was updated in 2014.
TMF Methodology has been developed by the team of Ukrainian experts with the support of international experts within the project of German Environmental Agency (UBA) “Improving the safety of industrial tailings management facilities based on the example of Ukrainian facilities” (2013-2015).

Method of Evaluation “Tailings Hazard/risk Index” (THI) is intended for prompt preliminary evaluation of tailings hazard for the large amount of TMFs on the national/regional level.

TMF Checklist is developed for evaluation the TMF safety level using the test question method.
Tailings Hazard Index (THI)

$$\text{THI}_{\text{Extended}} = \text{THI}_{\text{Cap}} + \text{THI}_{\text{Tox}} + \text{THI}_{\text{Manag}} + \text{THI}_{\text{Site}} + \text{THI}_{\text{Dam}}$$

- **THI\text{Cap}** is the hazard caused by the amount of tailings materials (TMF capacity)
- **THI\text{Tox}** is the hazard caused by toxicity of substances contained in tailings
- **THI\text{Manag}** is the hazard caused by improper management of facilities
- **THI\text{Site}** is the hazard induced by siting the TMF in the area with specific geological and hydrological conditions
- **THI\text{Dam}** is the dam failure hazard (weaknesses in structural and component integrity and functionality)
TMF Checklist structure

- **Questionnaire**: the identification of incompliances
- **Evaluation Matrix**: the evaluation of the TMF safety level
- **Measure Catalogue**: recommendations to address the incompliances by short-, medium- or long-term measures
Detailed structure of the TMF Checklist

TMF Checklist

- TMF life cycle
  - Pre-construction and Construction
  - Operation and management
  - Emergency planning
  - Closure and Rehabilitation

Basic Check (Group A)
- Basic Visual Inspection (Subgroup A1)
- Basic Document Check (Subgroup A2)
  - 16 questions
  - 11 questions
  - 3 questions
  - 5 questions

Detailed Check (Group B)
- Detailed Visual Inspection (Subgroup B1)
- Detailed Document Check (Subgroup B2)
  - 33 questions
  - 4 questions
  - 107 questions
  - 89 questions
  - 45 questions
  - 26 questions

Check of Inactive Sites (Group C)
- Visual Inspection of Inactive Sites (Subgroup C1)
- Document Check of Inactive Sites (Subgroup C2)
  - 33 questions
  - 4 questions
  - Assessment of and priority tasks for inactive sites (18 questions)
  - Management of inactive sites (6 questions)

Evaluation Matrix
- Group A
- Group B
- Group C

Overall Evaluation
- Categorial Evaluation
- Measure Catalogue
# General view of the Checklist questionnaire

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>Recommendation (Factors and parameters to be taken into consideration to answer the questions)</th>
<th>Answer</th>
<th>Data source (requisites of documents or photos as evidences)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Does the design documentation correspond to actual locations of TMF elements?</td>
<td>Matching of charts and maps to the displayed TMF elements on-site.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cross-checking of data
Evaluation Matrix

Quantification of answers

• The positive answer “Yes” is interpreted as the maximum level of TMF safety per the evaluated factor.
• The negative answer “No” is considered as the minimum level of TMF safety per the evaluated factor or does not have any information to answer the question.
• The ambiguous answers “Mostly yes” and “Mostly no” allow the Checklist user to be flexible in evaluations taking into account availability and credibility of data sources.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Yes</th>
<th>Mostly Yes</th>
<th>Mostly No</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value (answer numerical equivalent)</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Types of TMF safety level evaluation

The overall safety level

- Priorities of further detailed check (for preliminary check)
- TMF conditions and recommended measure priorities to eliminate incompliances to safety requirements

Categorial evaluation

- TMF safety in different aspects and operation specifics
Parameters of the TMF safety level

• “MSR” rank ("Meeting Safety Requirements") within the TMF Checklist is the index quantifying how the parameters of the inspected TMF meet the minimum set of requirements of environmental and industrial safety.

• “Credibility” rank within the TMF Checklist is the index quantifying the sufficiency and consistency of data used for calculating the “MSR” rank.
An example of TMF overall evaluation

The results of evaluation by Group A

<table>
<thead>
<tr>
<th>The number of applicable questions</th>
<th>Yes</th>
<th>Mostly yes</th>
<th>Mostly no</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>38</td>
<td>10</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

The values of “MSR” and “Credibility” ranks

\[
MSR = 100\% \cdot \frac{1}{3 \cdot 60} (36 \cdot 3 + 10 \cdot 2 + 8 \cdot 1 + 6 \cdot 0) = 100\% \cdot \frac{136}{180} \\
\approx 76\%
\]

\[
Credibility = 100\% \cdot \frac{1}{(60 - 18)} = 100\% \cdot \frac{42}{132} \approx 70\%.
\]

Low safety level

High safety level
## Classification of TMF by the evaluation results

<table>
<thead>
<tr>
<th>TMF safety level</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptable</td>
<td>100% of minimum set of safety requirements are met (MSR = 100%)</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>Less than 100% of minimum set of safety requirements are met (MSR &lt; 100%)</td>
</tr>
</tbody>
</table>
Category importance

- **Critical (Highly important) safety categories** are the categories of TMF safety that cover, primarily, the technical aspects of TMF operation and are vitally important for maintaining tailings facilities in safe condition.

- **General safety categories** cover the issues related mostly to documentation, personnel, and paperwork.
An example of categorial evaluation. Spider diagram
Measure Catalogue

- Detected problem at the TMF
- Intended (prescribed) measures
- Measure priority

<table>
<thead>
<tr>
<th>#</th>
<th>Problem to be solved</th>
<th>Measures prescribed</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design documentation is incomplete</td>
<td>1A. Update design documentation made by a licensed company</td>
<td>Short-term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1B. Update design documentation involving licensed and skilled staff</td>
<td>Short-term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1C. Perform expert analysis of design documents for authorities</td>
<td>Short-term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1D. Prepare or complete design documentation according to regulatory requirements</td>
<td>Short-term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1E. Prepare a detailed map of the TMF site and the surrounding area</td>
<td>Short-term</td>
</tr>
</tbody>
</table>

UNECE “Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities”
Key measures to improve TMF safety

- Strengthening of dams and other critical components.
- Improving the methods for neutralization of toxic substances, drainage facilities, monitoring procedures, Emergency plan as well.
- Updating design documentation.
- Conduct expert assessments, including within the EIA.
- Personnel training, improving of reporting.
- Development of plans for closure and rehabilitation, the use of man-made mineral resources.
Lower scores for the visual check compared to the document check (50-85% and 85-95%, respectively). These checks do not completely coincide in the categories of questions; they were obtained in a fundamentally different way and cannot be directly averaged.

**Recommendation.** These evaluations should be considered only individually with the priority of visual inspection.

Visual check is to save the dam;
Document check is to save reputation.
TMF Checklist application experience in 2018-2019

• The causes of differences in the results of visual and document checks.

Objective: Actual changes at TMFs are ahead of changes in documentation, many processes are not very noticeable at first, they appear weakly and not recognized in time.

Subjective: stricter criteria for visual check, the desire of TMF operators to show a more favorable picture in reporting.

• Recommendations.
  1. Enhance the role of visual check and instrumental observations in the conclusions of the evaluations.
  2. Train the TMF personnel and inspectors on how to recognize external signs of dam failure and timely diagnosis.
It makes sense to use a quantitative scale to evaluate the TMF safety level. The versions of the TMF methodology used in Kazakhstan and Armenia do not have such a scale, the result is estimated as 100% (compliance) and <100% (non-compliance). This does not allow formally distinguishing between the very different results of a detailed check, for example, evaluated with a safety level of 30% and 80%.

**Recommendation.** Consider using the Leopold matrix (1971), used in particular by the US. EPA, to assess the environmental impact of projects.
TMF Checklist application experience in 2018-2019

• The need to improve the application sequence of the Checklist, in particular, Measure catalogue. The current version of the methodology does not describe the procedure for repeated checks with the control over the safety actions taken.

• **Recommendation.** Formulate and describe the priority principle how to re-check TMFs depending on the evaluated safety level and the effectiveness of measures taken after previous inspections.
Thank you for attention!