ISO 24212:2024-09 (E)

Remediation techniques applied at contaminated sites

Contents

Page

Foreword viii

Introduction ix

1 Scope 1

2 Normative references 1

3 Termsanddefinitions 1

4 Abbreviated terms 3

5 Overview 5
5.1 Structure of this document 5
5.2 Generic concepts associated with remediation 6

6 Good practice for carrying out a strategies appraisal prior to implementing remediation strategy 8
6.1 General 8
6.2 Identifying feasible remediation strategies 9
6.3 Detailed evaluation of strategies appraisal 9
6.4 Selecting the final remediation strategy 11

7 Generic recommendations for the selection of remediation techniques 11
7.1 General 11
7.2 Considering the site's context 12
7.3 Remediation set up on-site 13
7.4 Techniques prerequistes 13
7.5 Techniques collateral effects 14
7.6 Laboratory testing and pilot tests 14

8 Generic recommendations for managing hazards and risks during remediation 14
8.1 General 14
8.2 Risk management process 15
8.2.1 General 15
8.2.2 Hazards and controls associated with contaminated soil and groundwater 15
8.2.3 Asbestos 16
8.2.4 Dust 16
8.2.5 Offensive or noxious odours 16
8.2.6 Contaminated waste 16
8.2.7 Remediation equipment 16
8.2.8 Unexpected finds 17
8.2.9 Long-term monitoring 17
8.2.10 Outdoor work 17
8.2.11 Remote or isolated working 17
8.2.12 Underground services and pipelines 17
8.2.13 Ground stability 18
8.2.14 Excavations 18
8.2.15 Unexploded ordnance (UXO) 18
8.2.16 Confined space 18
8.2.17 Hazardous chemicals and dangerous goods 18
8.2.18 Hazardous manual tasks 19

8.2.19 Slips, trips and falls 19
8.2.20 Plant and equipment 19
8.2.21 Noise 19

9 Remediation techniques description 20
9.1 In situ chemical oxidation (ISCO) 20
9.1.1 Technique principle 20
9.1.2 Scope and applicability of the technique (operating window) 20
9.1.3 Technology description 20

9.1.4 Design considerations and dimensioning 20
9.1.5 Key monitoring parameters 21
9.1.6 Advantages and limitations 21
9.1.7 Specific EHS aspects 21
9.1.8 Other techniques or containment approaches that can be combined with the technique .. 22
9.2 In situ chemical reduction (ISCR) 22
9.2.1 Technique principle 22
9.2.2 Scope and applicability of the technique 22
9.2.3 Technology description 22
9.2.4 Design considerations and dimensioning 22
9.2.5 Key monitoring parameters 22
9.2.6 Advantages and limitations 23
9.2.7 Specific EHS aspects 23
9.2.8 Other techniques that can be combined with the technique 23
9.3 Enhanced in situ bioremediation (EISB) 23
9.3.1 Technique principle 23
9.3.2 Scope and applicability of the technique (operating window) 23
9.3.3 Description of technology 24
9.3.4 Design considerations and dimensioning 24
9.3.5 Key monitoring parameters 24
9.3.6 Advantages and limitations 24
9.3.7 Specific EHS aspects 25
9.3.8 Other techniques or containment approaches that can be combined with the technique .. 25
9.4 Monitored natural attenuation (MNA) 25
9.4.1 Technique principle 25
9.4.2 Scope and applicability of the technique (operating window) 25
9.4.3 Description of technology 25
9.4.4 Design considerations and dimensioning 25
9.4.5 Key monitoring parameters 25
9.4.6 Advantages and limitations 26
9.4.7 Specific EHS aspects 26
9.4.8 Other techniques or containment approaches that can be combined with the technique .. 26
9.5 Incineration 26
9.5.1 Technique principle 26
9.5.2 Scope and applicability of the technique 26
9.5.3 Technology description 26
9.5.4 Design considerations and dimensioning 27
9.5.5 Key monitoring parameters 27
9.5.6 Advantages and limitations 27
9.5.7 Specific EHS aspects 28
9.5.8 Other techniques or containment approaches that can be combined with the technique .. 28
9.6 In situ thermal remediation (ISTR) 28
9.6.1 Technique principle 28
9.6.2 Scope and applicability of the technique (operating window) 28
9.6.3 Description of technology 28
9.6.4 Design consideration and dimensioning 29
9.6.5 Key monitoring parameters 29
9.6.6 Advantages and limits 29
9.6.7 Specific EHS aspects 30
9.6.8 Other techniques or containment approaches that can be combined with the technique .. 30
9.7 On-site thermal desorption 30
9.7.1 Technique principle 30

9.7.2 Scope and applicability of the technique (operating window) 30
9.7.3 Technology description 30
9.7.4 Design considerations and dimensioning 30
9.7.5 Key monitoring parameters 31
9.7.6 Advantages and limits 31
9.7.7 Specific EHS aspects 31
9.7.8 Other techniques or containment approaches that can be combined with the technique ..31
9.8 Soil vapour extraction (SVE) 31
9.8.1 Technique principle 31
9.8.2 Scope and applicability of the technique (operating window) 32
9.8.3 Technology description 32
9.8.4 Design and dimensioning considerations 32
9.8.5 Key monitoring parameters 32
9.8.6 Advantages and limits 33
9.8.7 Specific EHS aspects 33
9.8.8 Other techniques or containment approaches that can be combined with the technique ..33
9.9 Air-sparging 33
9.9.1 Technique principle 33
9.9.2 Scope and applicability of the technique (operating window) 33
9.9.3 Technology description 34
9.9.4 Design considerations and dimensioning 34
9.9.5 Key monitoring parameters 34
9.9.6 Advantages and limits 34
9.9.7 Specific EHS aspects 34
9.9.8 Other techniques or containment approaches that can be combined with the technique ..34
9.10 Multi-phase extraction (MPE) 35
9.10.1 Technique principle 35
9.10.2 Scope and applicability of the technique (operating window) 35
9.10.3 Technology description 35
9.10.4 Design considerations and dimensioning 35
9.10.5 Key monitoring parameters 35
9.10.6 Advantages and limitations 36
9.10.7 Specific EHS aspects 36
9.10.8 Other techniques or containment approaches that can be combined with the technique ..36
9.11 Dual pump liquid extraction (DPLE) 36
9.11.1 Technique principle 36
9.11.2 Scope and applicability of the technique (operating window) 36
9.11.3 Technology description 37
9.11.4 Design considerations and dimensioning 37
9.11.5 Key monitoring parameters 37
9.11.6 Advantages and limitations 37
9.11.7 Specific EHS aspects 37
9.11.8 Other techniques or containment approaches that can be combined with the technique ..37
9.12 Hydraulic techniques for groundwater remediation 38
9.12.1 Technique principle 38
9.12.2 Scope and applicability of the technique (operating window) 38
9.12.3 Technology description 38
9.12.4 Design considerations and dimensioning 38
9.12.5 Key monitoring parameters 39
9.12.6 Advantages and limitations 39
9.12.7 Specific EHS aspects 39
9.12.8 Other techniques or containment approaches that can be combined with the technique ..39
9.13 Soil washing 39
9.13.1 Technique principle 39
9.13.2 Scope and applicability of the technique (operating window) 39
9.13.3 Technology description 40
9.13.4 Design and dimensioning considerations 40
9.13.5 Key monitoring parameters 40
9.13.6 Advantages and limitations 40
9.13.7 Specific EHS aspects 40

9.13.8 Other techniques or containment approaches that can be combined with the technique .. 41
9.14 Biopiling 41
9.14.1 Technique principle 41
9.14.2 Scope and applicability of the technique (operating window) 41
9.14.3 Technology description 41
9.14.4 Design considerations and dimensioning 41
9.14.5 Advantages and limitations 42
9.14.6 Key monitoring parameters 42
9.14.7 Specific EHS aspect 42
9.14.8 Other techniques or containment approaches that can be combined with the technique .. 42
9.15 Landfarming 43
9.15.1 Technique principle 43
9.15.2 Scope and applicability of the technique (operating window) 43
9.15.3 Technology description 43
9.15.4 Design considerations and dimensioning 43
9.15.5 Key monitoring parameters 44
9.15.6 Advantages and limitations 44
9.15.7 Specific EHS aspects 44
9.15.8 Other techniques or containment approaches that can be combined with the technique .. 44
9.16 Vertical barrier technologies (VBT) 44
9.16.1 Technique principle 44
9.16.2 Scope and applicability of the technique 45
9.16.3 Technology description 45
9.16.4 Design considerations and dimensioning 45
9.16.5 Key monitoring parameters 45
9.16.6 Advantages and limitations 45
9.16.7 Specific EHS aspects 46
9.16.8 Other techniques or containment approaches that can be combined with the technique .. 46
9.17 Cover systems 46
9.17.1 Technique principle 46
9.17.2 Scope and applicability of the technique 46
9.17.3 Technology description 47
9.17.4 Design considerations and dimensioning 47
9.17.5 Key monitoring parameters 48
9.17.6 Avantages and limitations 48
9.17.7 Specific EHS aspects 48
9.18 Permeable reactive barrier (PRB) systems 49
9.18.1 Technique principle 49
9.18.2 Scope and applicability of the technique (operating window) 49
9.18.3 Technology description 49
9.18.4 Design considerations and dimensioning 49
9.18.5 Key monitoring parameters 49
9.18.6 Advantages and limits 50
9.18.7 Specific EHS aspects 50
9.18.8 Possible combination with other techniques and technique variations 50
9.19 Immobilisation techniques for soil and solid materials 50
9.19.1 Technique principle 50
9.19.2 Scope and applicability of the technique (operating window) 50
9.19.3 Technology description 51
9.19.4 Design and dimensioning considerations 51

9.19.5 Key monitoring parameters 52
9.19.6 Advantages and limitations 52
9.19.7 Specific EHS aspects 53
9.19.8 Other techniques or containment approaches that can be combined with the technique .. 53
9.20 Excavation 53
9.20.1 Technique principle 53
9.20.2 Scope and applicability of the technique (operating window) 53
9.20.3 Description of technology 53
9.20.4 Design considerations and dimensioning 53
9.20.5 Key monitoring parameters 54
9.20.6 Advantages and limitations 54

9.20.7 Specific EHS aspects 54
9.20.8 Other techniques or containment approaches that can be combined with the technique .. 54
9.21 Off-gas treatment technologies and wastewater treatment technologies 54
9.21.1 General 54
9.21.2 Carbon adsorption 55
9.21.3 Off-gas treatment technologies 55
9.21.4 Wastewater treatment technologies 56

Annex A (informative) Remediation techniques, characteristics and conditions of implementation .. 59

Annex B (informative) Remediation techniques suitability for contaminants 63

Annex C (informative) Examples of illustrative diagrams of remediation techniques 71

Bibliography 99