# ISO/TR 12885:2018-12 (E)

## Nanotechnologies - Health and safety practices in occupational settings

## Contents

Page


Foreword ..... v

Introduction ..... vi

1 Scope ..... 1

2 Normative references ..... 1

3 Termsanddefinitions ..... 1

4 Symbols and abbreviated terms ..... 1

5 Nanomaterials: Description and manufacturing ..... 3
5.1 Manufactured nanomaterials ..... 3
5.2 Production processes ..... 5
5.2.1 Typical production processes ..... 5
5.2.2 Aerosol generation methods ..... 5
5.2.3 Vapor deposition methods ..... 5
5.2.4 Colloidal/self-assembly methods ..... 5
5.2.5 Electrodeposition ..... 6
5.2.6 Electrospinning ..... 6
5.2.7 Attrition methods ..... 6

6 Hazard characterization ..... 6
6.1 Health effects ..... 6
6.1.1 General ..... 6
6.1.2 Basic principles and uncertainties ..... 7
6.1.3 Potential relevance of health effects information about incidental or naturally-occurring NOAAs ..... 8
6.1.4 Relationship between toxicity and surface area, surface chemistry, and particle number ..... 8
6.1.5 Inflammatory response to NOAAs ..... 9
6.1.6 Observations from epidemiological studies involving fine and nanoscale particles ..... 9
6.2 Physical hazards ..... 10
6.2.1 Fire (exothermic events) ..... 10
6.2.2 Safety consideration in manufacturing NOAAs ..... 10

7 Exposure assessment to nanomaterials ..... 10
7.1 General ..... 10
7.2 Scientific framework for assessing exposure to nanomaterials ..... 12
7.2.1 Routes of exposure ..... 12
7.2.2 Metric for assessing exposure to airborne nanomaterials ..... 14
7.3 Review of methods for characterizing exposure to manufactured NOAAs ..... 17
7.3.1 General ..... 17
7.3.2 Sampling strategy issues ..... 20
7.4 Dustiness assessment ..... 24
7.4.1 General ..... 24
7.4.2 Measurement methods ..... 24
7.5 Dermal exposure assessment ..... 25
7.5.1 Sampling ..... 25
7.5.2 Sample characterization ..... 26
7.6 Dose (internal exposure) assessment ..... 26
7.7 Discussion ..... 26

7.8 Summary ..... 27

8 Risk assessment in occupational settings ..... 27
8.1 Introduction and scope ..... 27
8.2 Risk assessment for NOAAs ..... 28
8.2.1 General ..... 28

8.2.2 Quantitative and qualitative risk assessment ..... 28
8.2.3 Hazard identification ..... 29
8.2.4 Exposure-response assessment ..... 29
8.2.5 Exposure assessment ..... 31
8.2.6 Risk characterization ..... 32
8.3 Conclusions ..... 32

9 Risk mitigation approaches ..... 32
9.1 Introduction ..... 32
9.2 Implication of risk assessment in regard to control methodologies ..... 33
9.2.1 Background ..... 33
9.2.2 Strategies for control ..... 34
9.3 Examination of control methodologies ..... 35
9.3.1 Exposure prevention ..... 35
9.3.2 Control strategies ..... 36
9.3.3 Reducing risk through effective design ..... 36
9.3.4 Substitution of raw materials, products, processes and equipment ..... 37
9.3.5 Engineering control techniques ..... 37
9.3.6 Administrative means for the control of workplace exposures ..... 44
9.3.7 Evaluating the work environment ..... 49
9.3.8 Personal protective equipment (PPE) ..... 50
9.4 Health surveillance ..... 55
9.5 Product stewardship ..... 56

Annex A (informative) Primary chemical composition of nanomaterials ..... 58

Annex B (informative)Nanomaterial-specificanimalandcellculturetoxicitystudies ..... 66

Annex C (informative) Characteristics of selected instruments and techniques for monitoring nano-aerosol exposure ..... 78

Annex D (informative) Characteristics of biosafety cabinets ..... 87

Annex E (informative) Assigned protection factors for respirators ..... 89

Annex F (informative) Advantages and disadvantages of different types of air-purifying particulate respirators ..... 90

Bibliography ..... 93