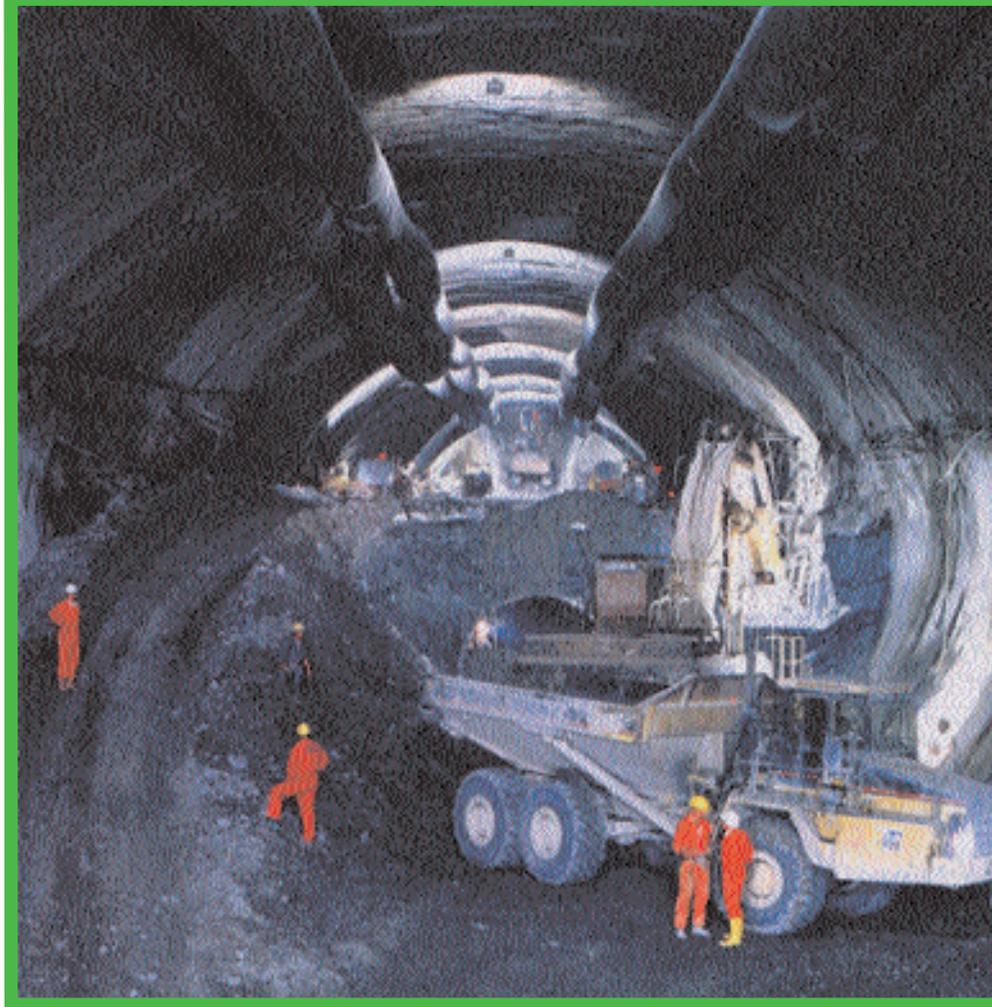


Safe Working In Tunnelling

This document is written
for tunnel workers
and first line supervision



Dear Tunneller,

Underground construction work can be dangerous and the best way to prevent accidents is to recognise the risks in time and then to act in the appropriate way.

Insignificant happenings can often cause severe accidents which could be avoided by observing some important rules. The following sketches serve as a guide for safe and accident-free underground construction work. Taking examples from routine tasks a dangerous situation is compared with the equivalent safe operation.

Acting in the right way reduces the risk for accidents. We hope you will enjoy reading this booklet and that you may never be involved in an accident at work.

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Design Concept & Layout: Graphicteam Köln Bonn
Illustrations: Eitel Schwarzer

Safe Working In Tunnelling

**This document is written
for tunnel workers
and first line supervision**

Prepared by the ITA Working Group
"Health and Safety"
and financed by TBG and ITA

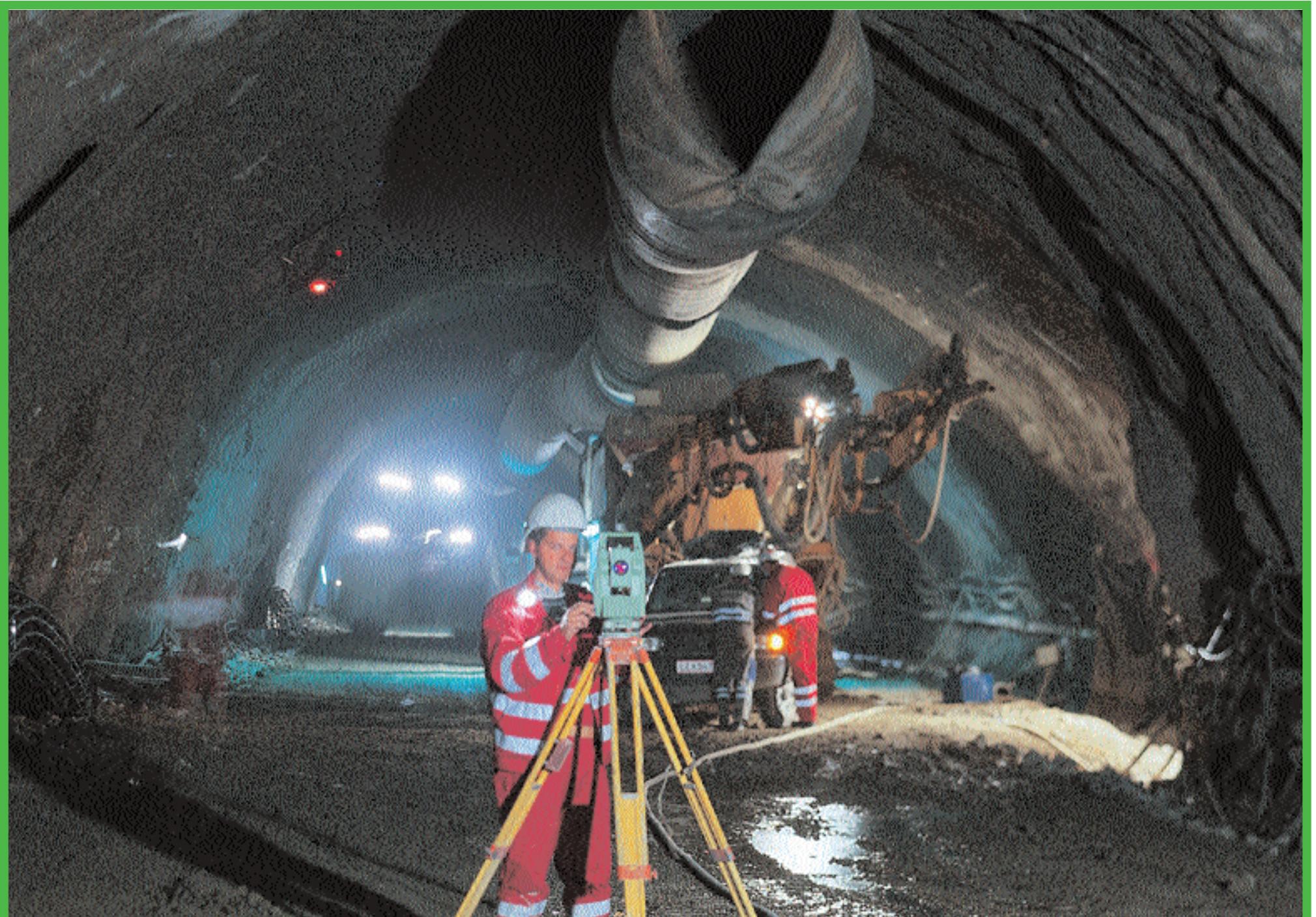


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1

The Tunneller's Equipment



1.1

Personal Safety Outfit



6

7

- hard hat
- safety shoes (boots)
- gloves
- protective clothing
- other personnel protective equipment (depending on working process)

1.2

Personal Safety Outfit



- 1 • eye protection
- 2 • hard hat
- 3 • respiratory protection
- 4 • gloves
- 5 • ear muffs
- 6 • ear plugs
- 7 • safety boots

1.3

Personal Safety Outfit



- 1 • waterproof clothing
- 2 • self rescuer
- 3 • reflecting warning vest
- 4 • hard hat for shotcreting
- 5 • hand lamp
- 6 • cap lamp

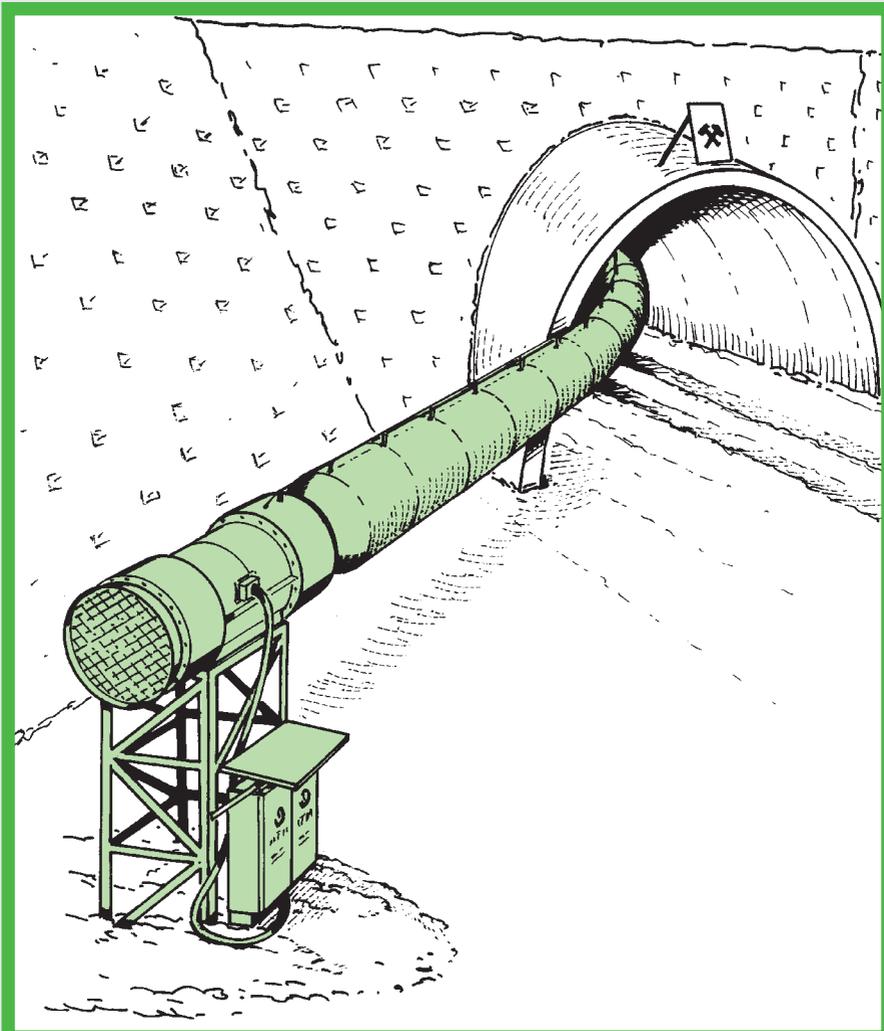
2

Tunnel Installations



2.1

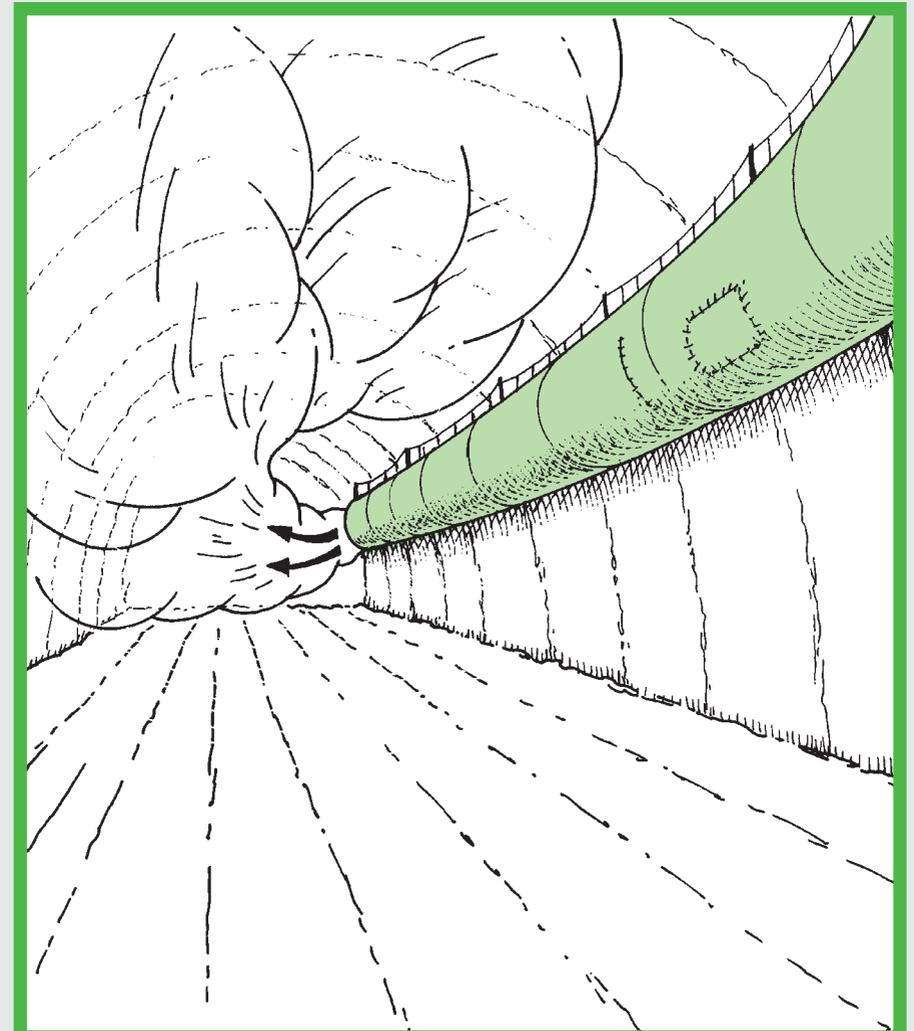
Ventilation



14

Ventilation

- sufficient ventilation
- test and measure at regular intervals
- avoid re-circulation from the portal



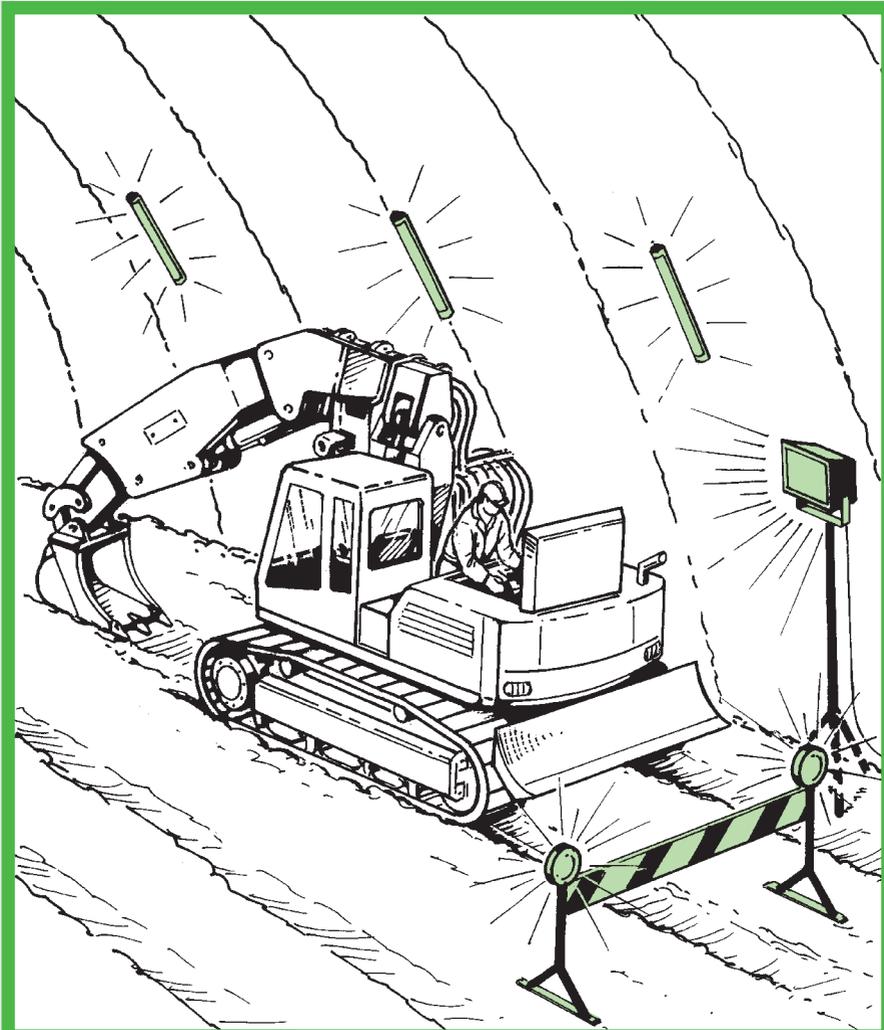
15

Fresh air ducts

- extend close to the working face
- avoid kinks
- repair any damage immediately

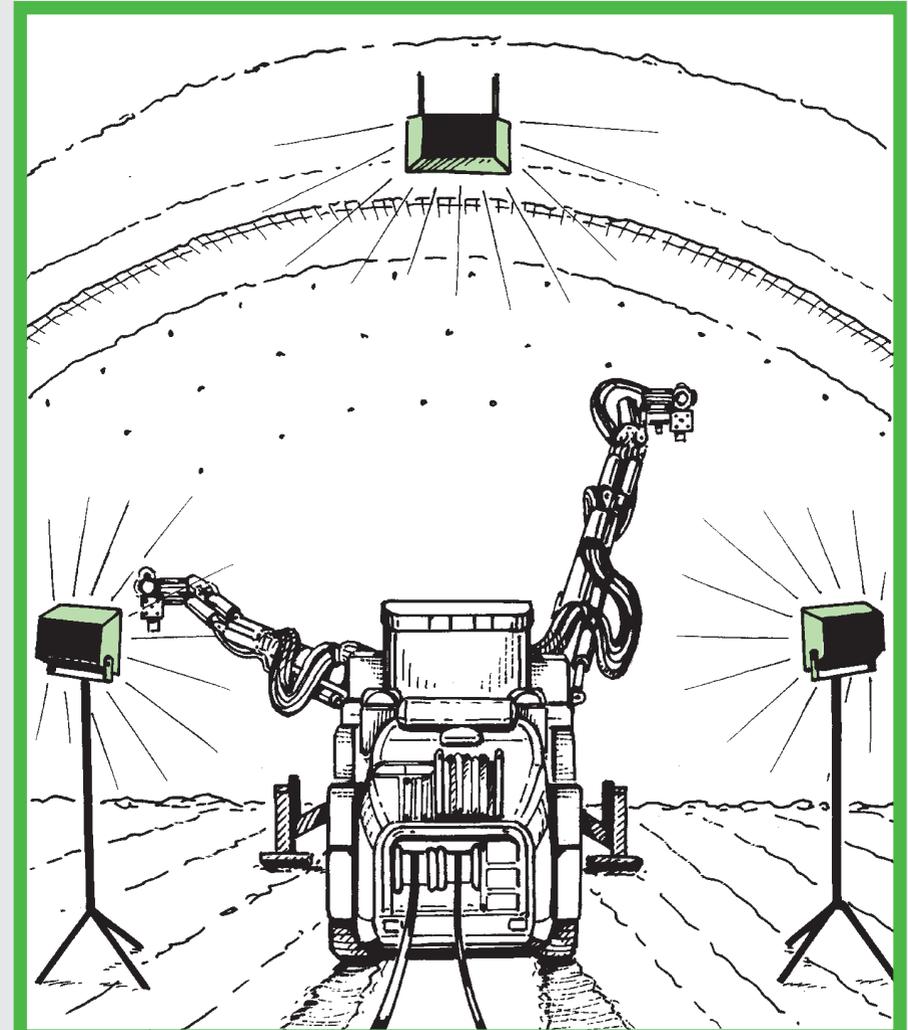
2.2

Lighting



16

- light all places of work and access ways
- install special lighting at dangerous places
- use flashing warning lights adjacent to dangerous locations

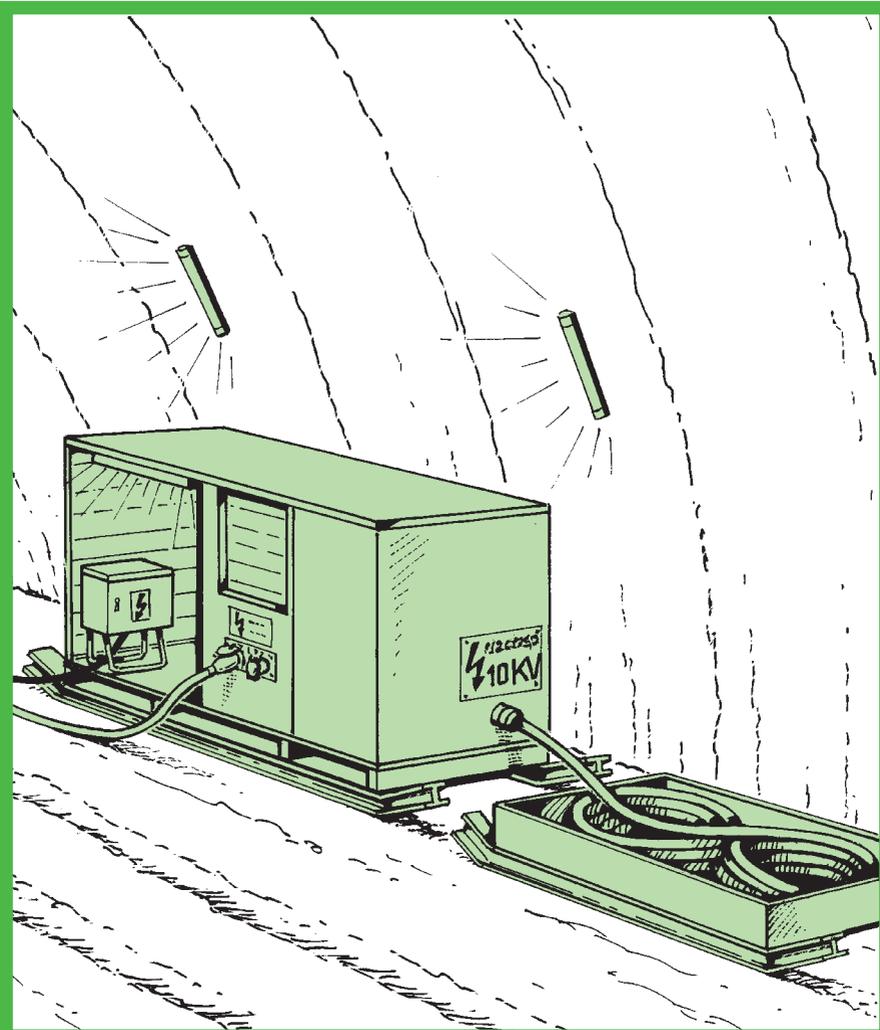


17

- all light fittings should be protected against ingress of water
- check, maintain and clean lighting installations regularly
- safety lighting system (emergency lighting)

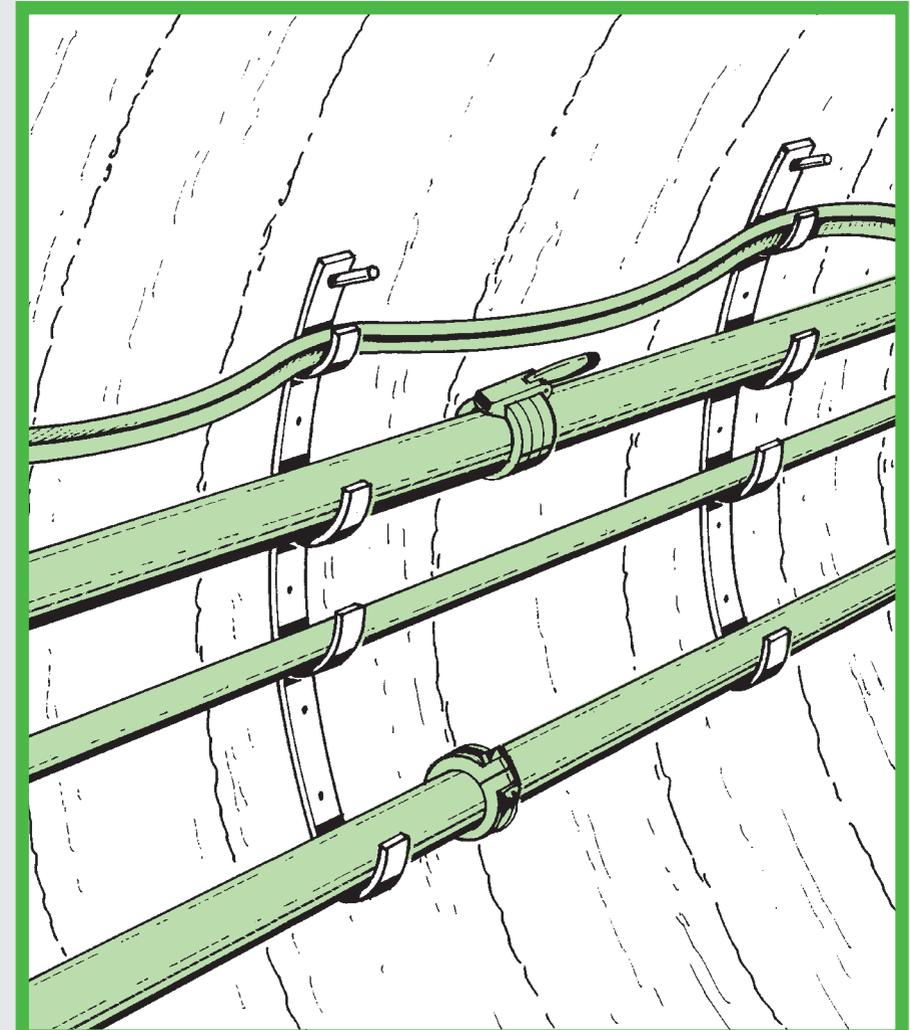
2.3

Electrical Installations and Supply Lines



18

- all electrical installations to be set, modified and repaired by qualified electricians; (work on high voltage network [transmission or power lines] only permitted with a special authorisation)
- adhere to national requirements
- use earth fault circuit breaker ≤ 30 mA

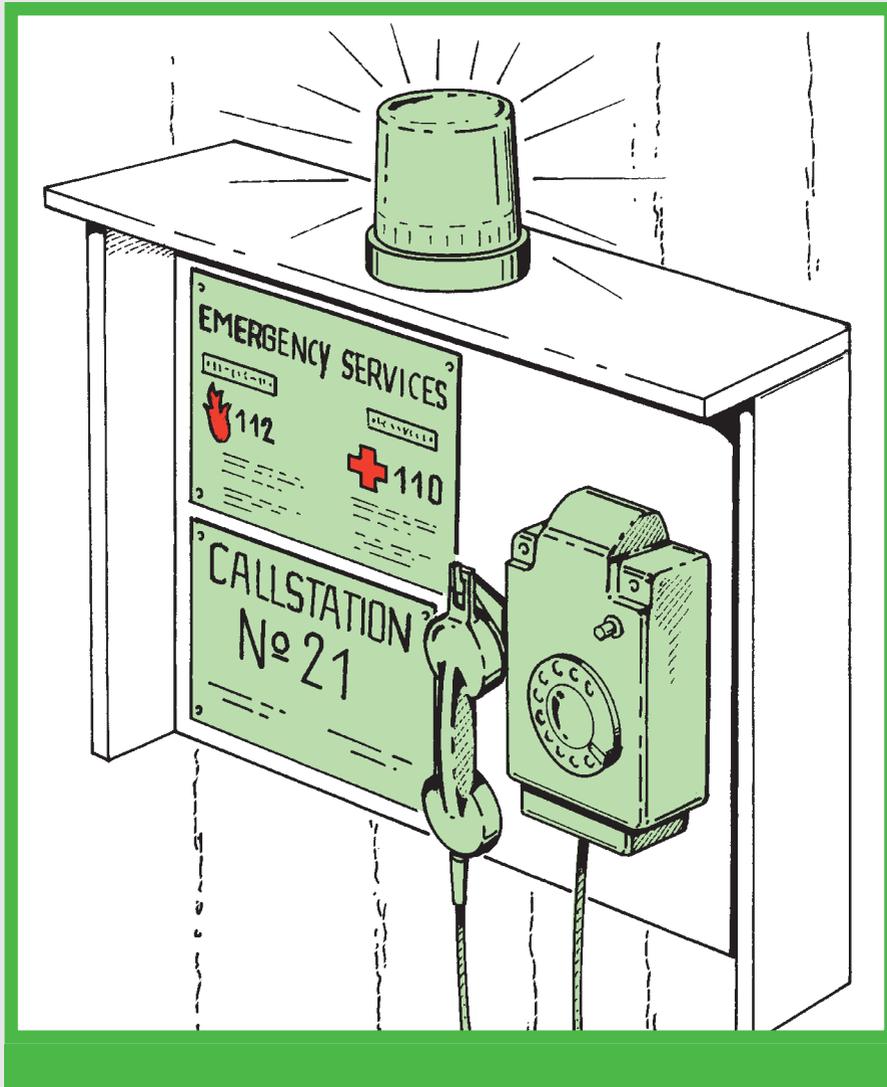


19

- support cables and pipelines securely on brackets against risks of impact, bending, abrasion, tension
- use appropriate fittings and coupling system

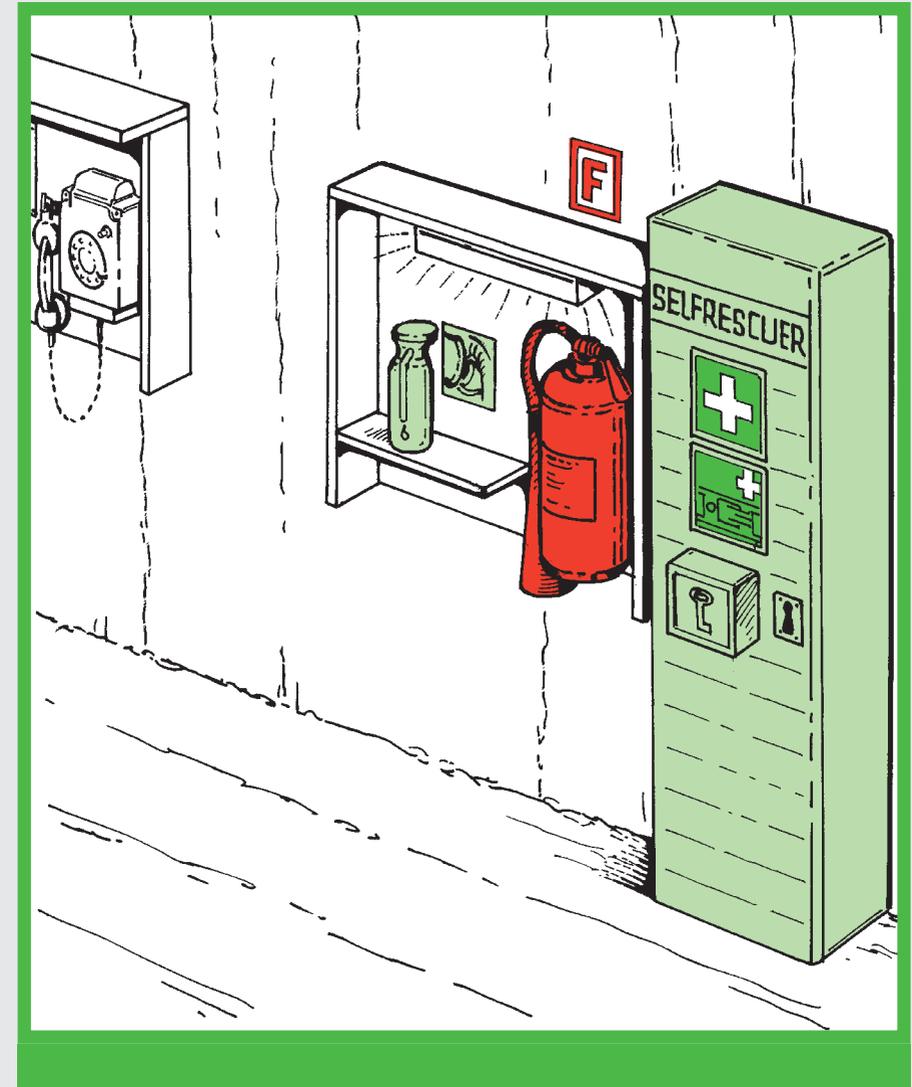
2.4

Emergency Equipment



20

- give regular instructions on emergency drills and rescue procedures
- carry out emergency drills with the participation of the fire-brigade
- provide effective emergency communications (check regularly)



21

- set up first aid and rescue installations
- set up appropriate fire extinguishers (observe fire classification)
- provide self-rescuers in sufficient number and size

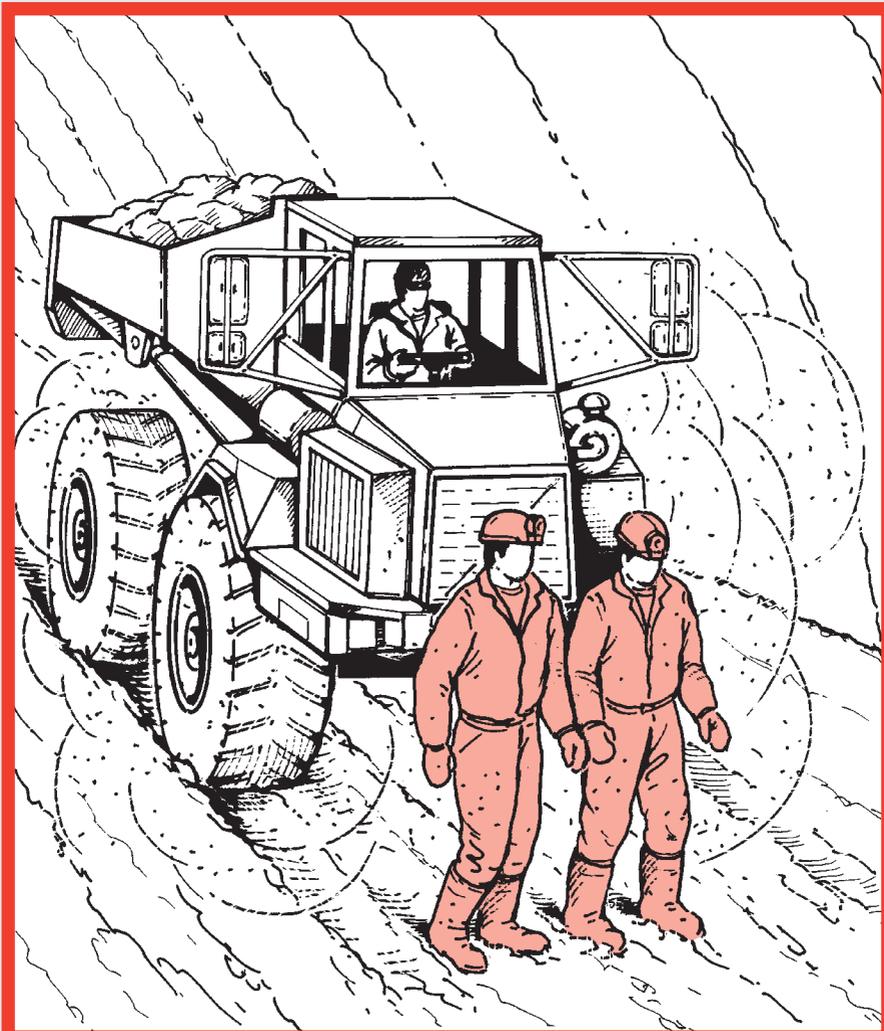
3

Walkways to Working Places



3.1

Walkways with Non-rail Operation



24

Danger

- being struck



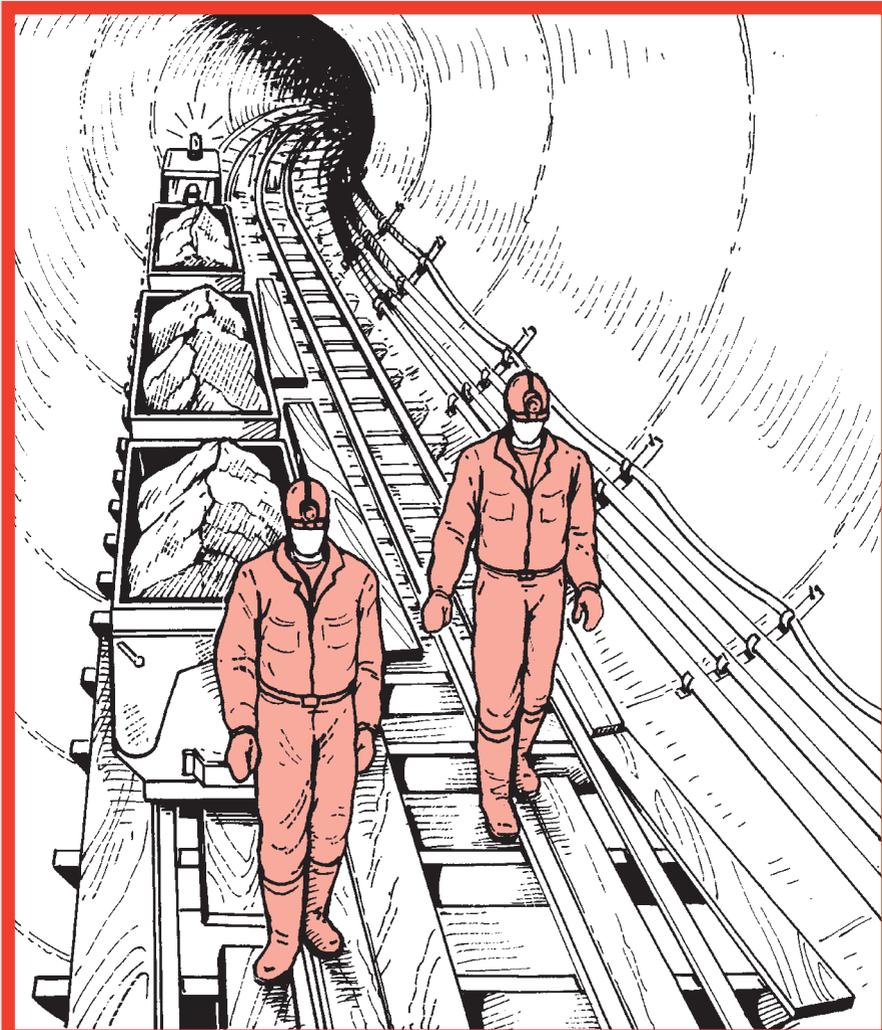
25

Protection

- separate paths for vehicles and pedestrians
- install guard rails alongside the pedestrian path
- maintain the vehicle path surface and wet it to reduce dust

3.2

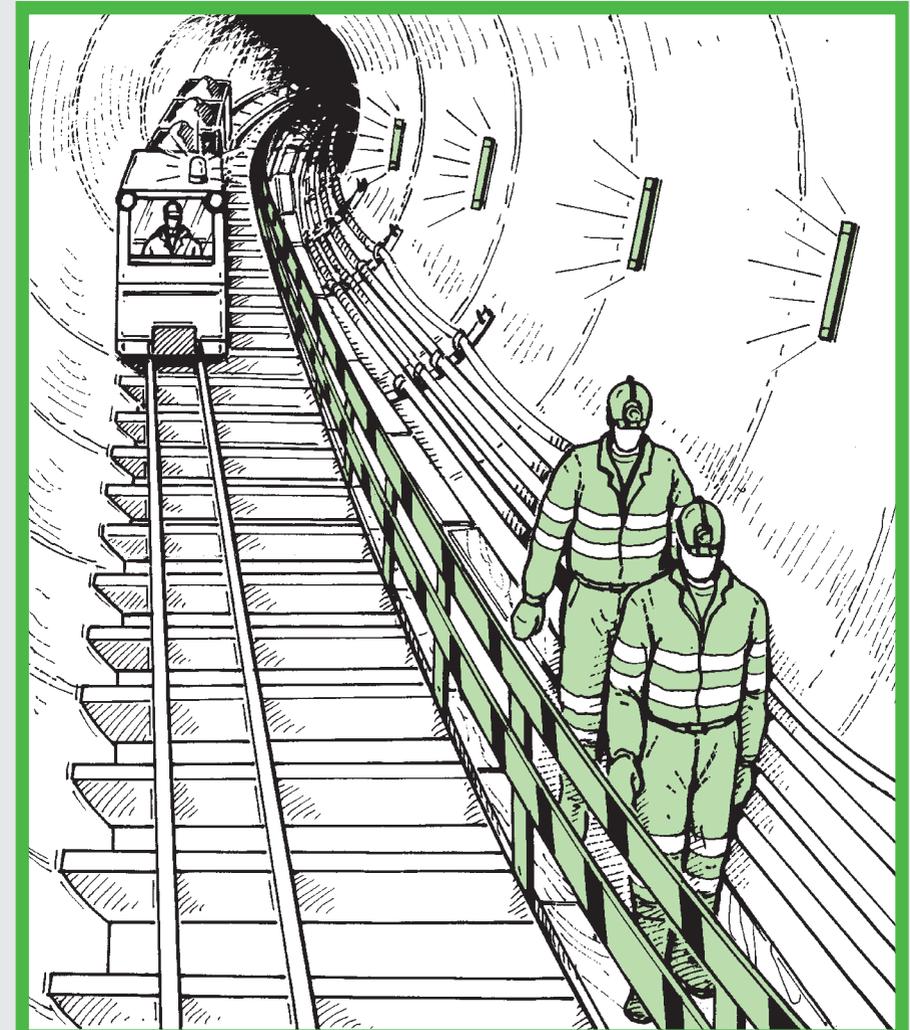
Walkways with Track Operation



26

Danger

- being struck
- slipping and tripping hazards



27

Protection

- separate path for vehicles and pedestrians
- put locos at the ends
- provide a video monitoring system to observe ahead of train when pushing
- in longer tunnels use rail personnel carriers

3.3

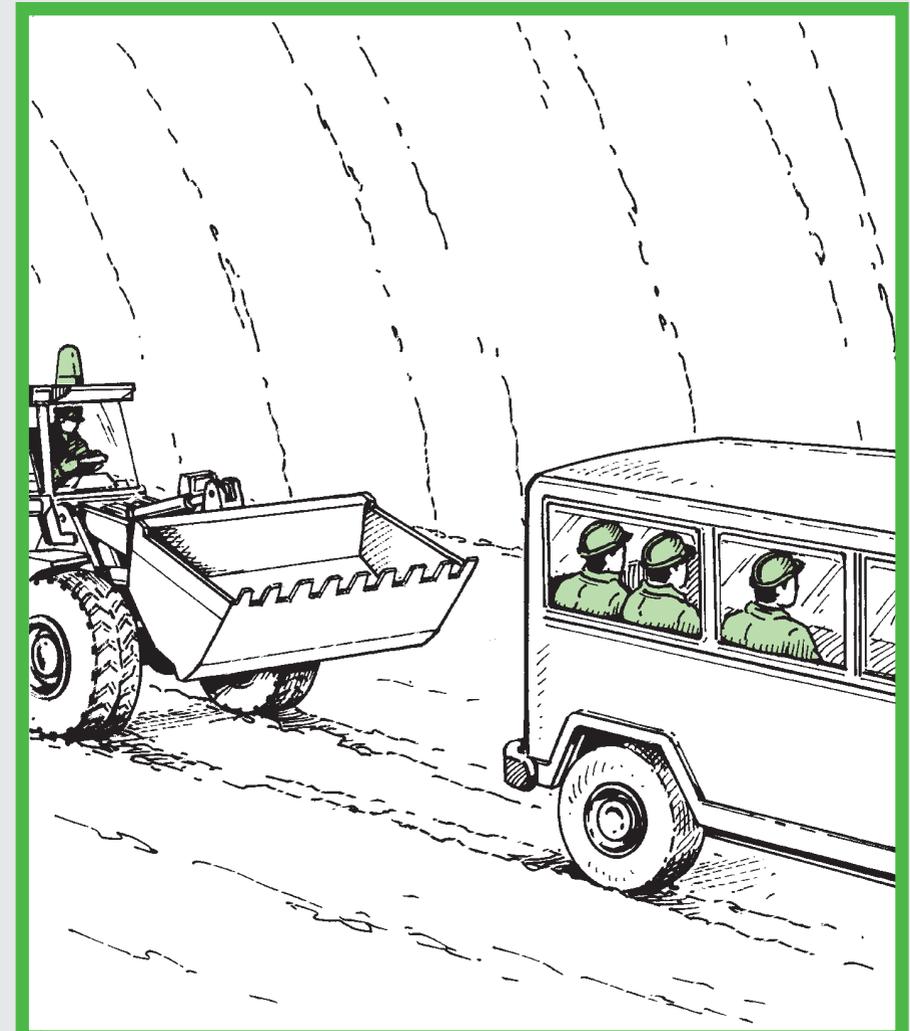
Passenger Transport



28

Danger

- falling
- being struck



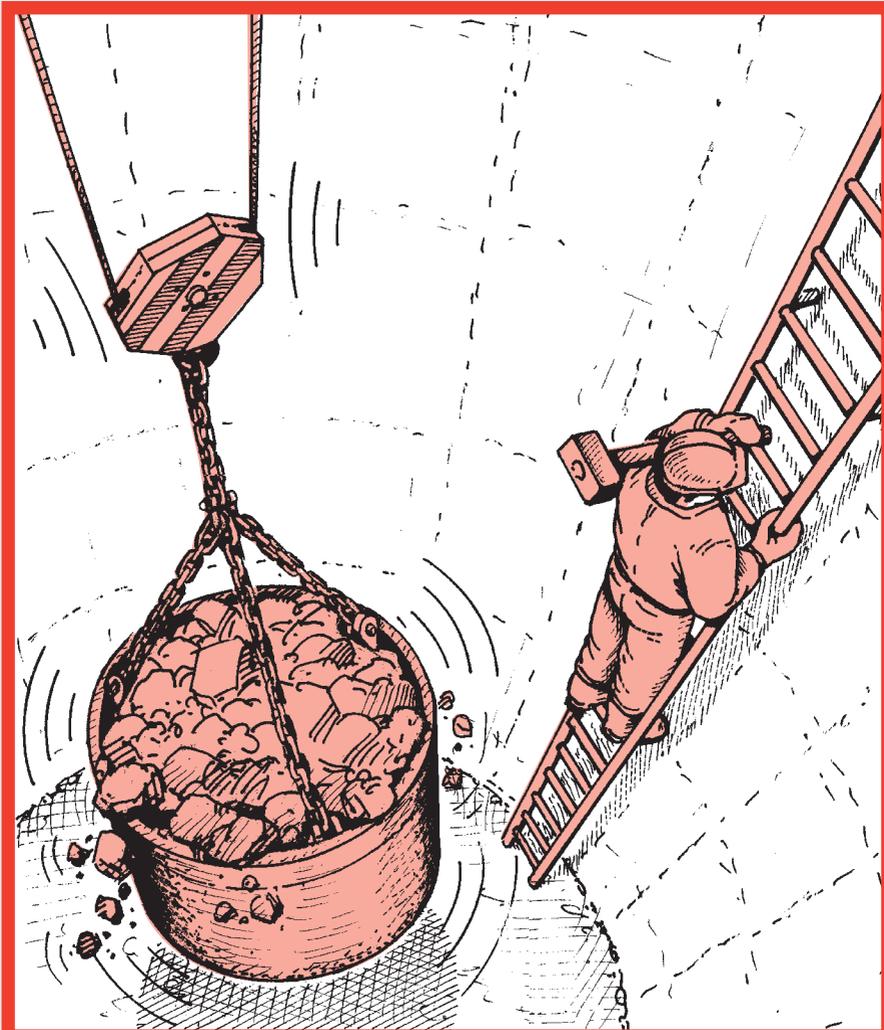
Protection

- do not ride on equipment
- provide and use suitable vehicles for passenger transport

29

3.4

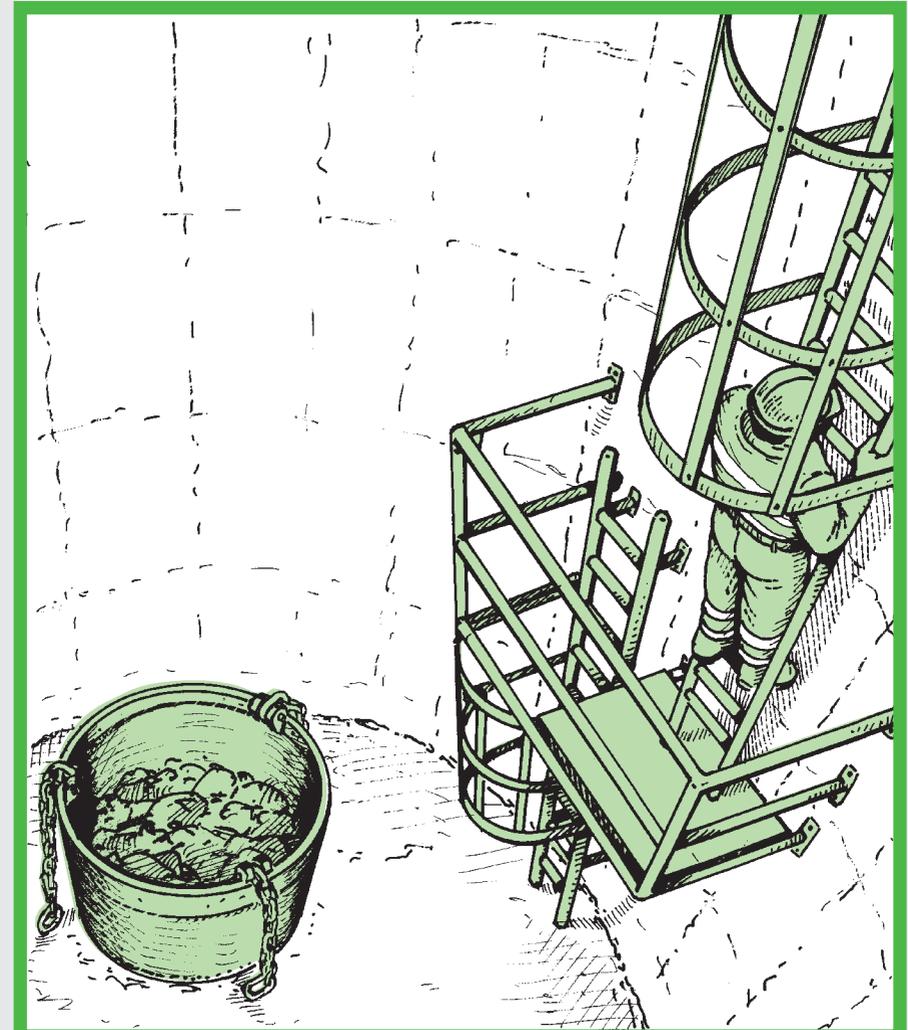
Transport in Shafts



30

Danger

- falling from the ladder
- being crushed by the skip
- fall of excavated material



31

Protection

- install safety hoops and intermediate landings
- do not overload skip
- use either stair tower (diagonal ladderways) or personnel lift
- do not carry heavy items

3.5

Access and Work Places on Ladders



32

Danger

- falling



Protection

- remove damaged ladders from site
- put both feet on the rung and do not reach over too far while working
- do only simple and close work on ladders

33

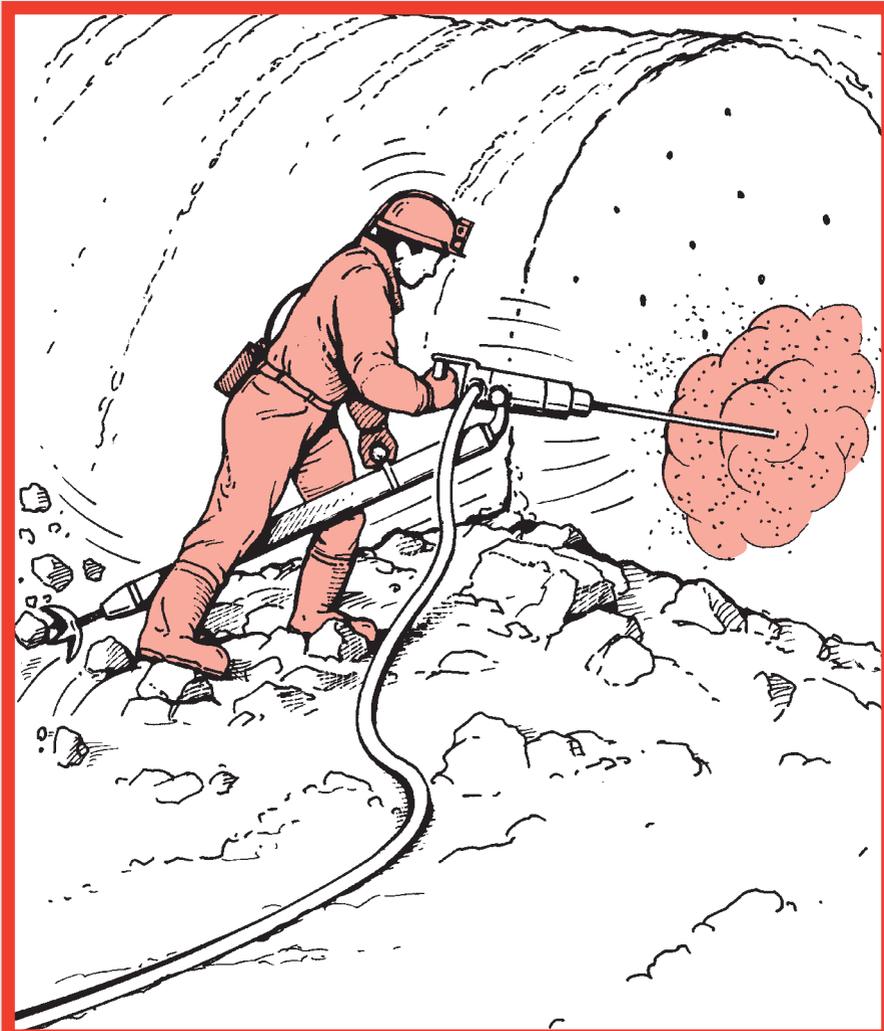
4

Excavation



4.1

Manual Drilling



36

Danger

- slipping and falling
- dust, noise



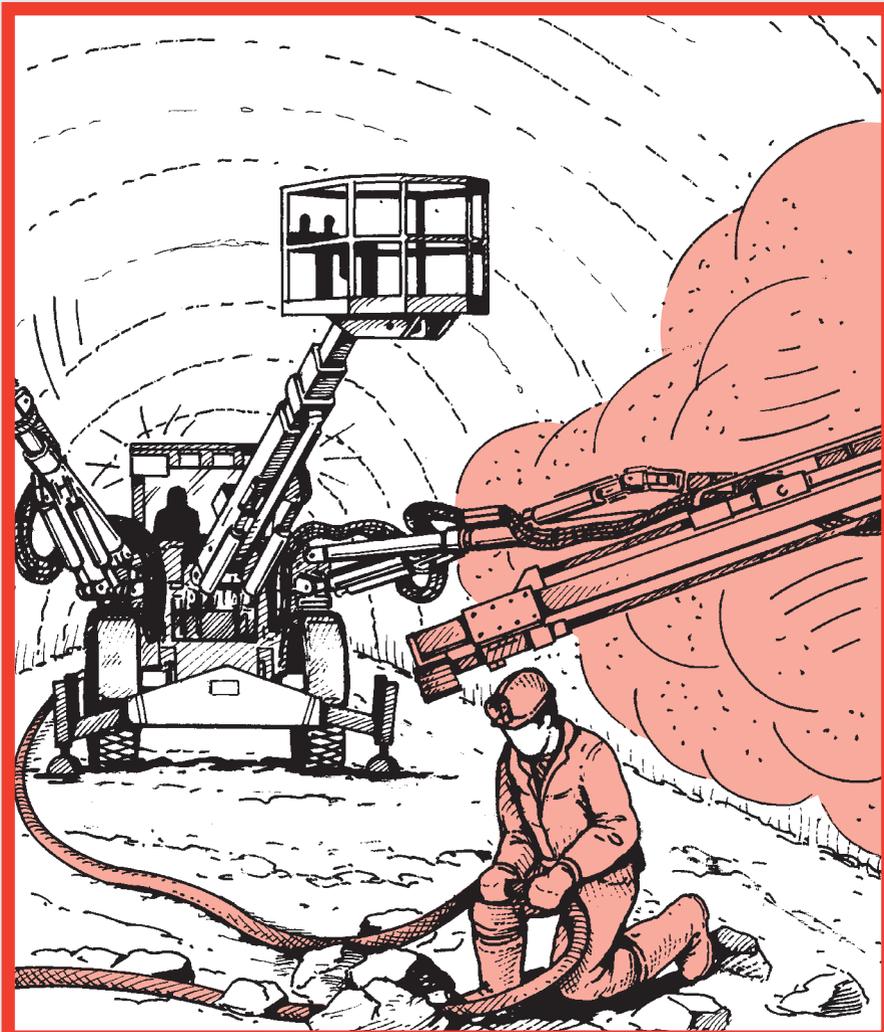
37

Protection

- adopt safe working position – worker as well as drilling tool
- wet drilling
- wear hearing and eye protection

4.2

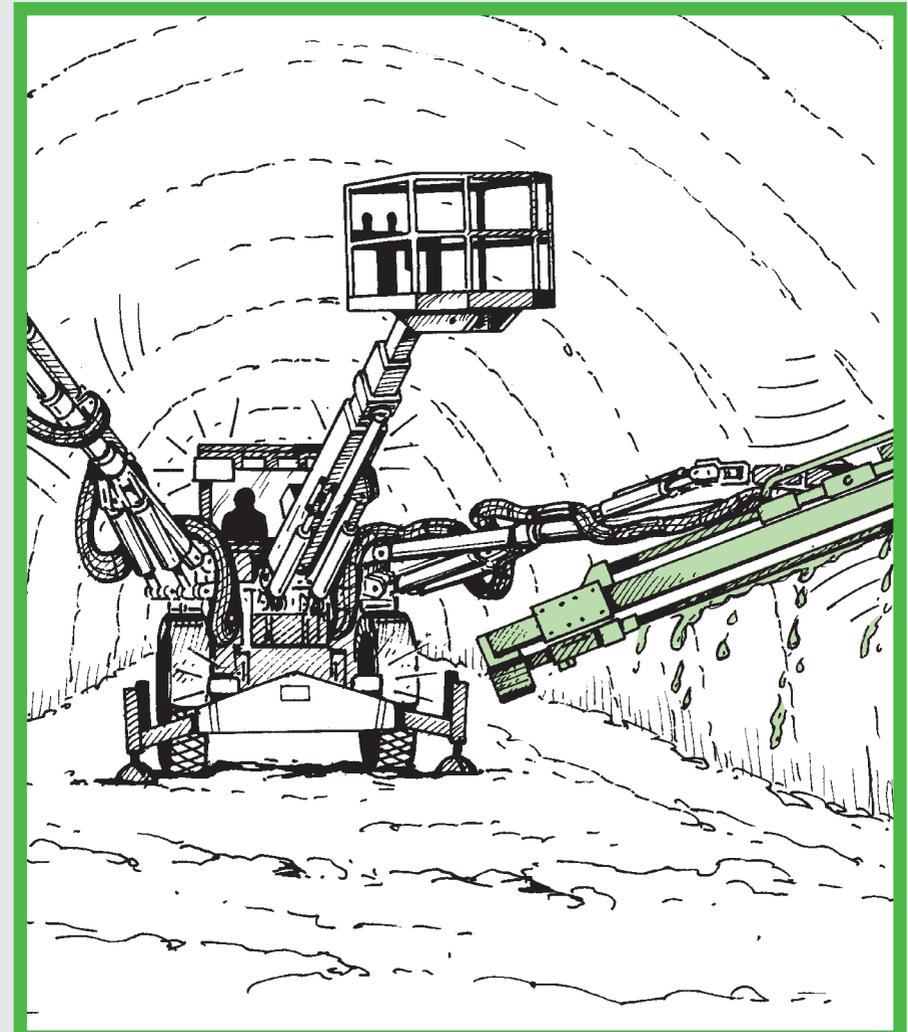
Jumbos



38

Danger

- being knocked over, being crushed, being struck
- rock fall
- dust, noise



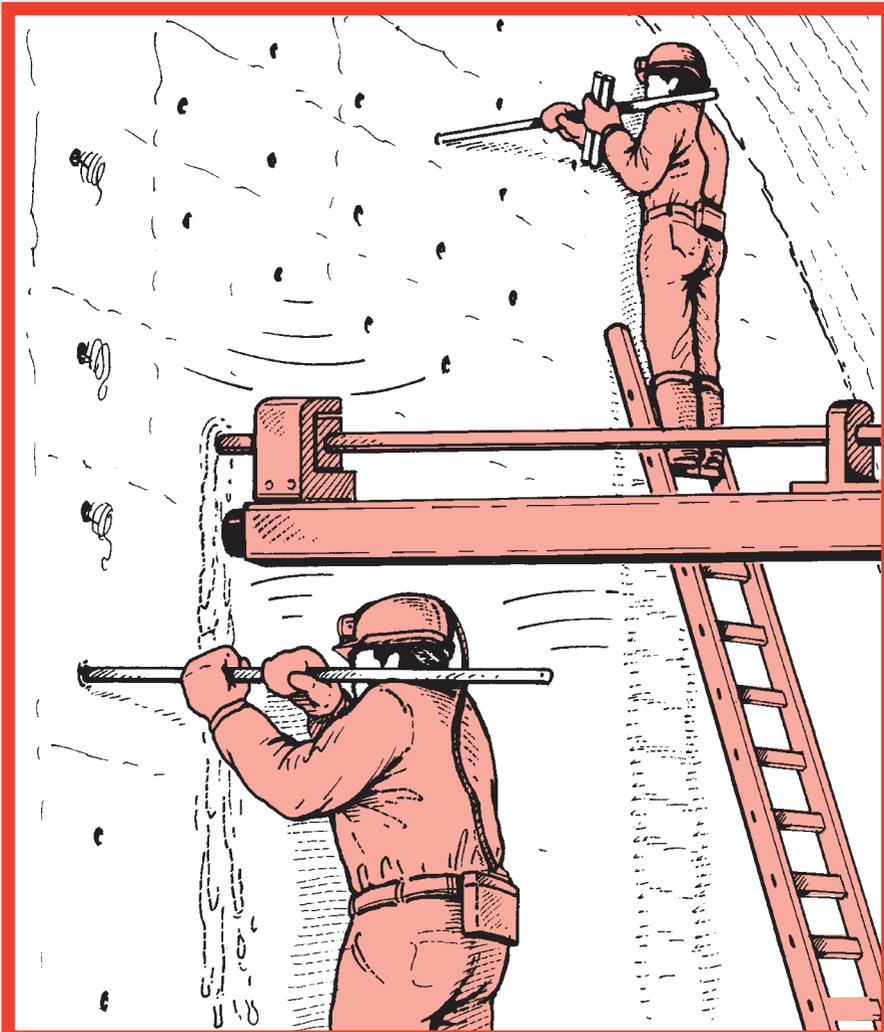
39

Protection

- keep away from danger area
- wet drilling
- wear hearing protection

4.3

Charging the Blast Holes



40

Danger

- accidental detonation by drilling into explosives
- being knocked over or crushed by drilling boom
- falling



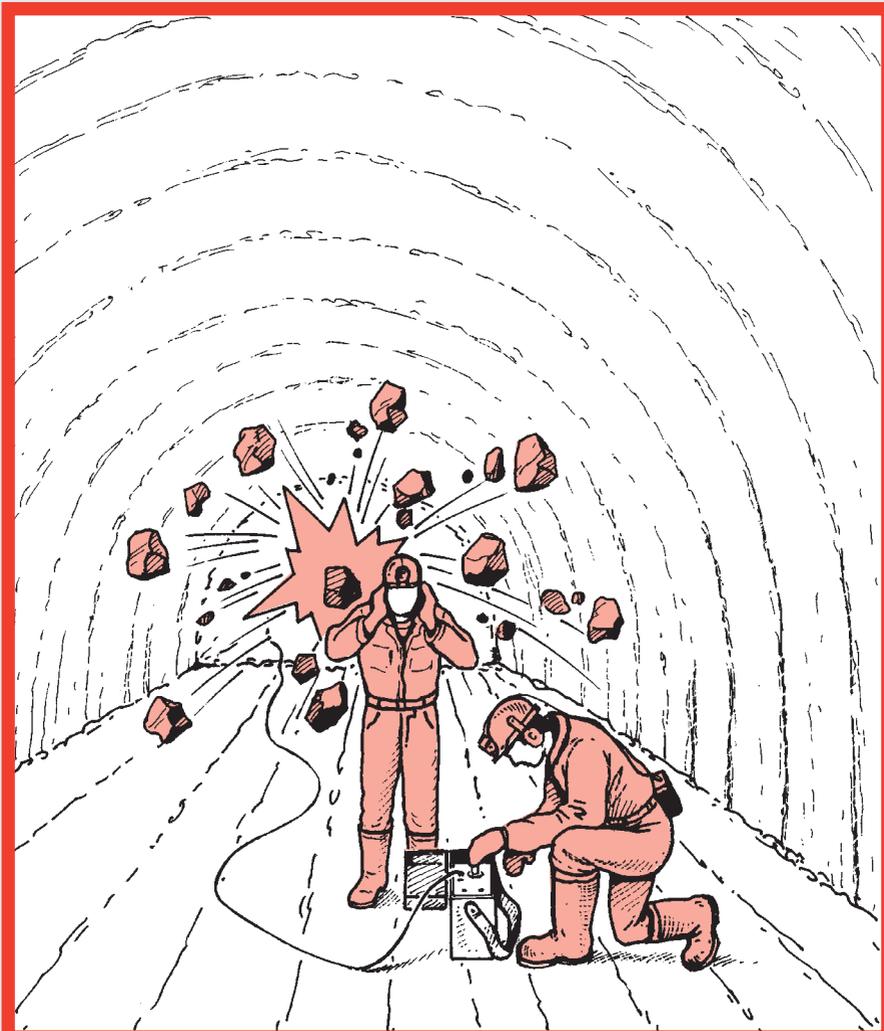
41

Protection

- only charge after the whole face has been completely drilled
- work can only be carried out under the supervision of an authorised and qualified blasting specialist
- use working platforms

4.4

Blasting



42

Danger

- fly rock
- toxic fumes resulting from blasting



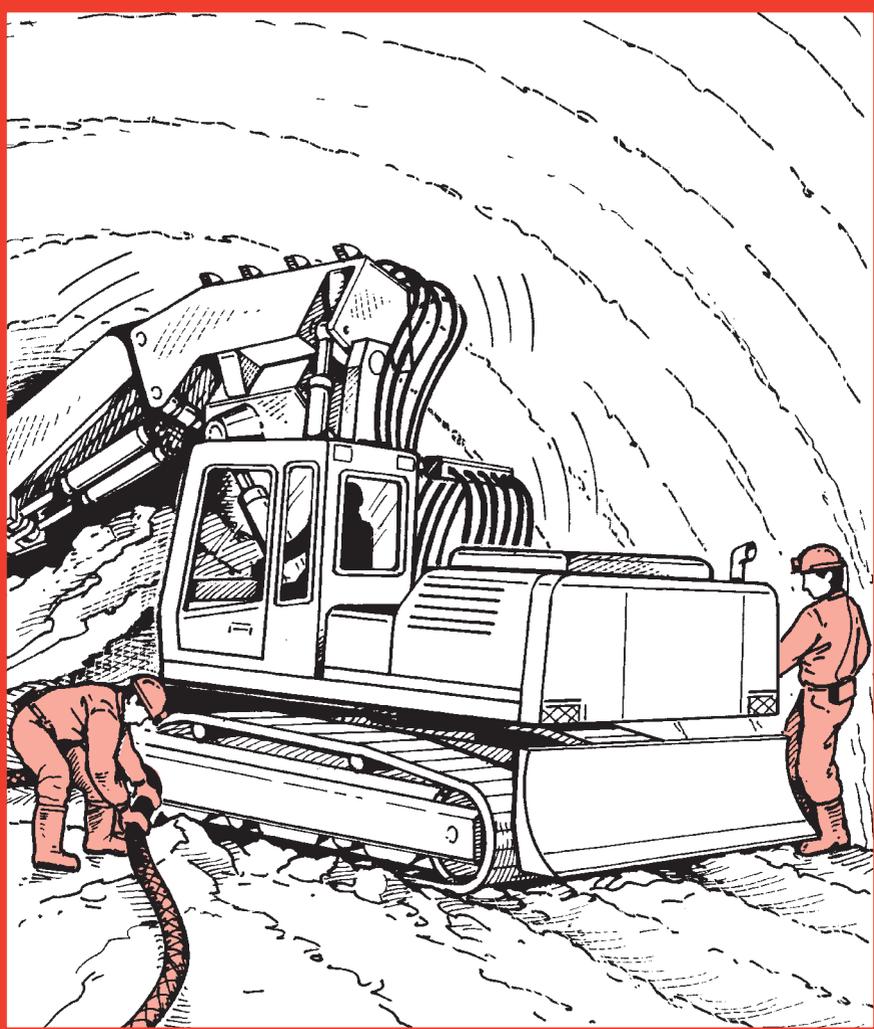
43

Protection

- keep away from the area to be blasted
- switch off the ventilation completely before blasting
- switch on the ventilation at full capacity after blasting
- the team has to stay in a protective shelter (safety container or blasting shelter) after blasting
- in small tunnels the protective shelter can be installed in a niche

4.5

Excavation with Excavator



44

Danger

- being crushed
- being run over



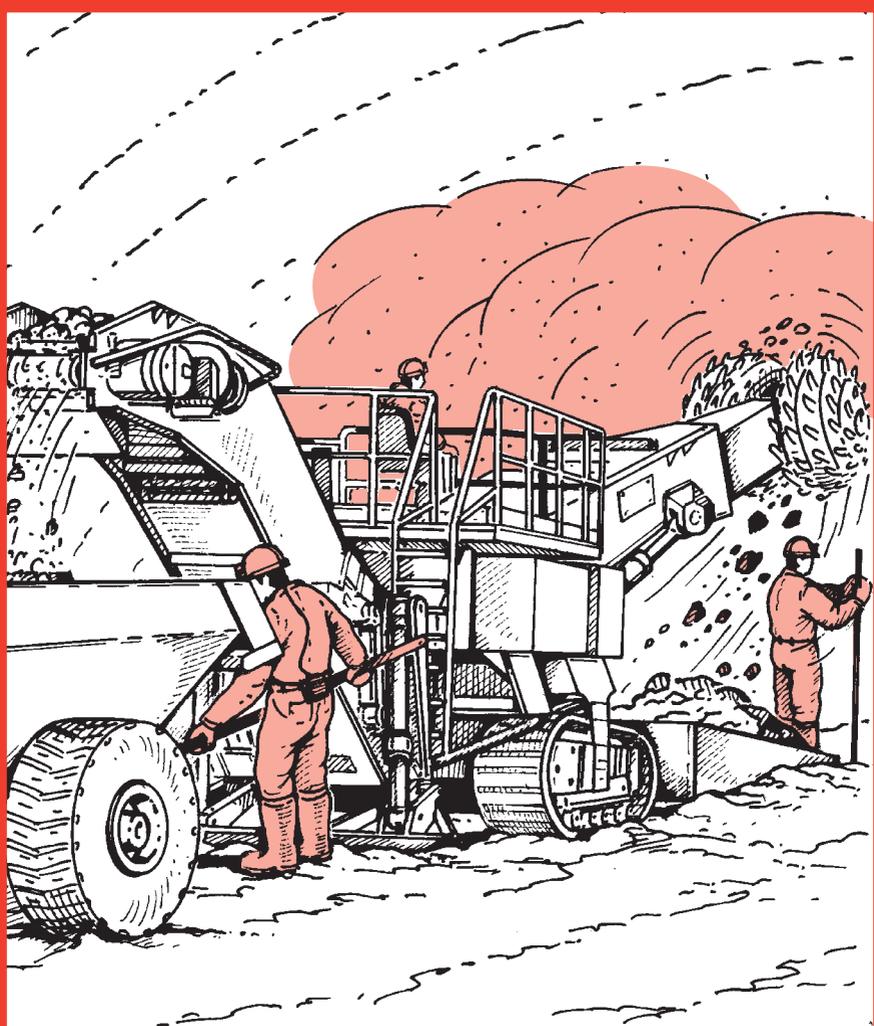
45

Protection

- do not enter danger zone
- light the working area adequately
- use acoustic signal when driving backwards

4.6

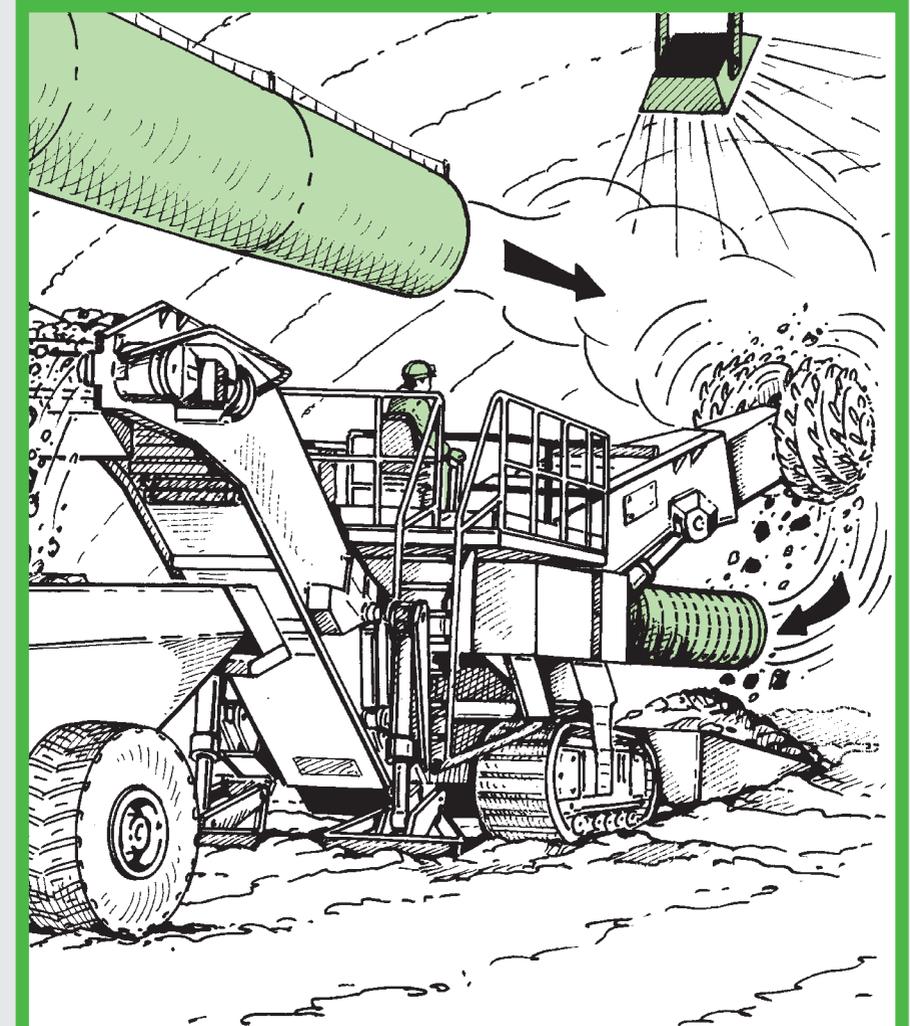
Excavation with Roadheader



46

Danger

- dust containing quartz (silicosis)
- being crushed
- being run over
- flying debris



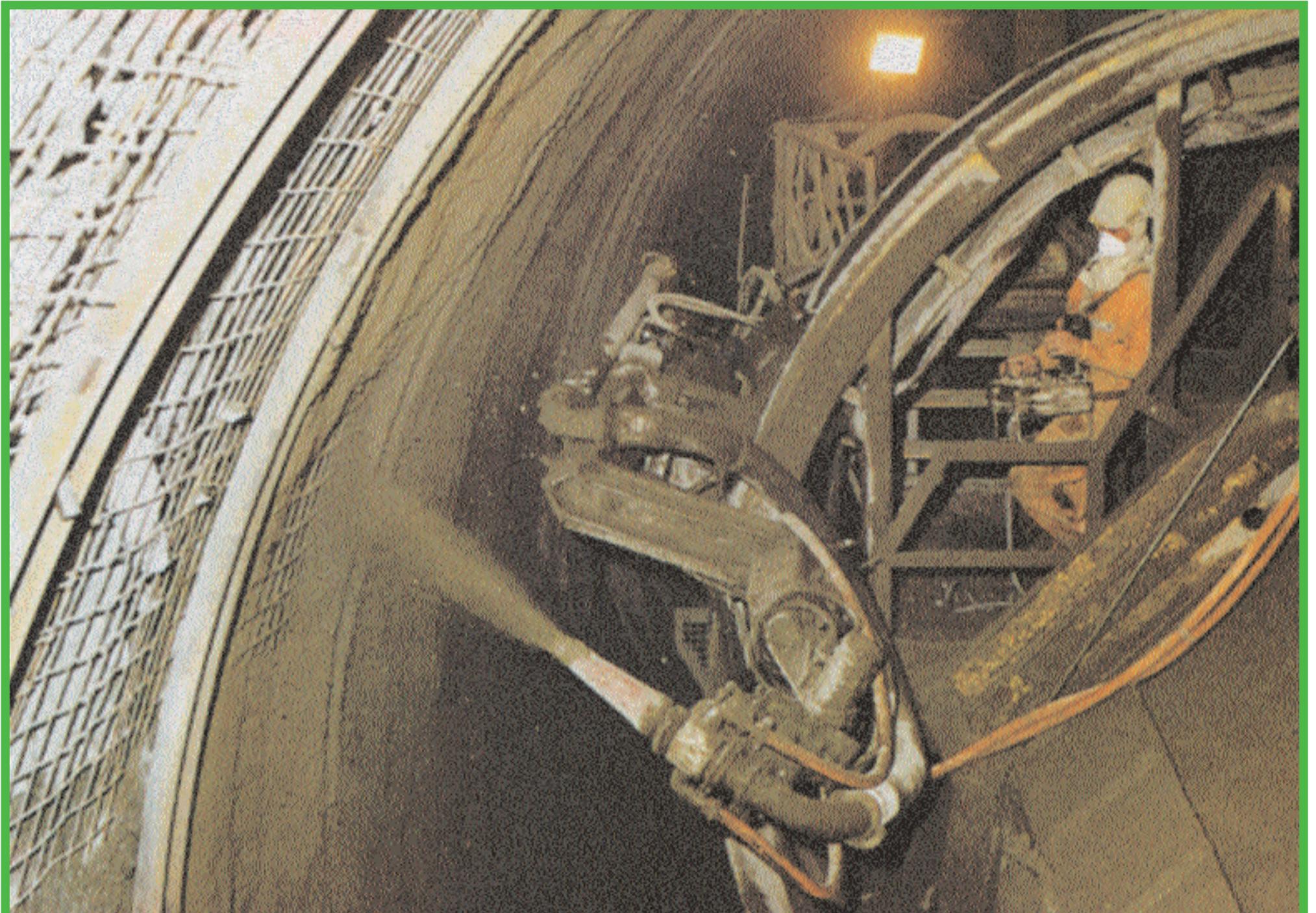
Protection

- install effective dust control system
- install waterspray system at cutting head
- do not enter machine danger zone
- light the working area adequately

47

5

Primary Support



5.1

Scaling



50

Danger

- rock fall
- collapse resulting from the instability of the exposed rock faces



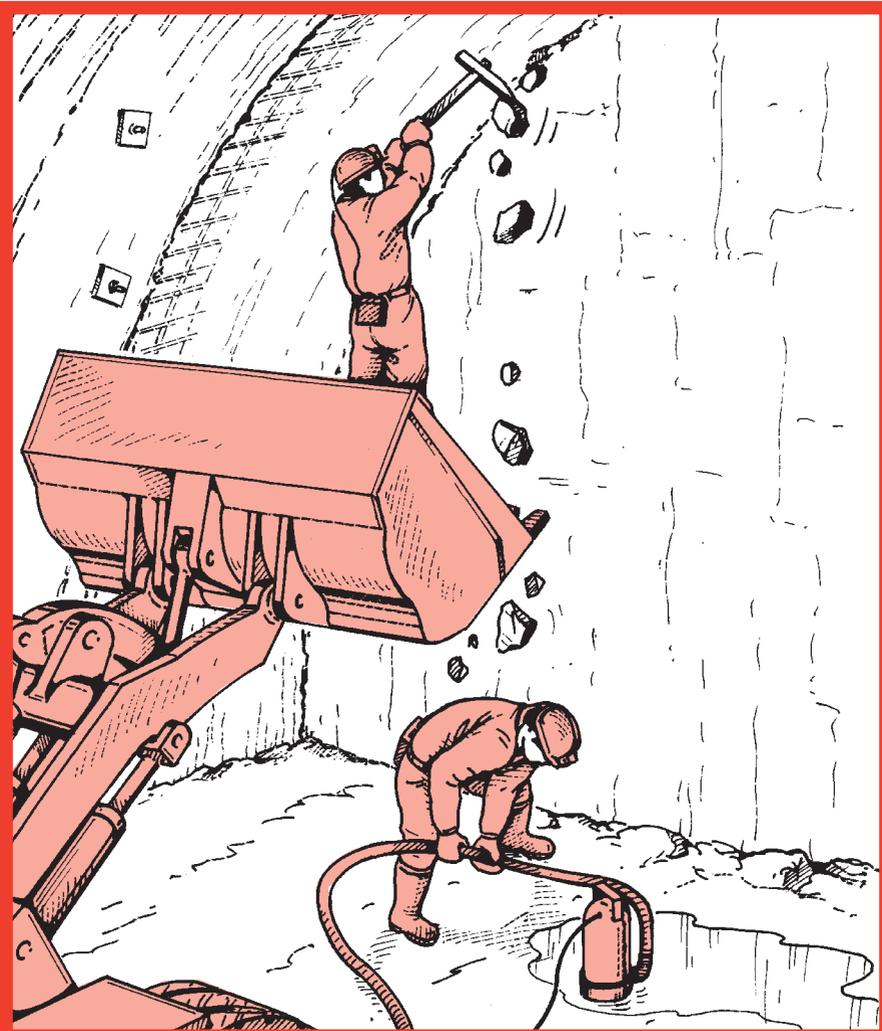
51

Protection

- use a machine for rock scaling
- do not enter the danger zone before scaling completed
- light the working area adequately

5.2

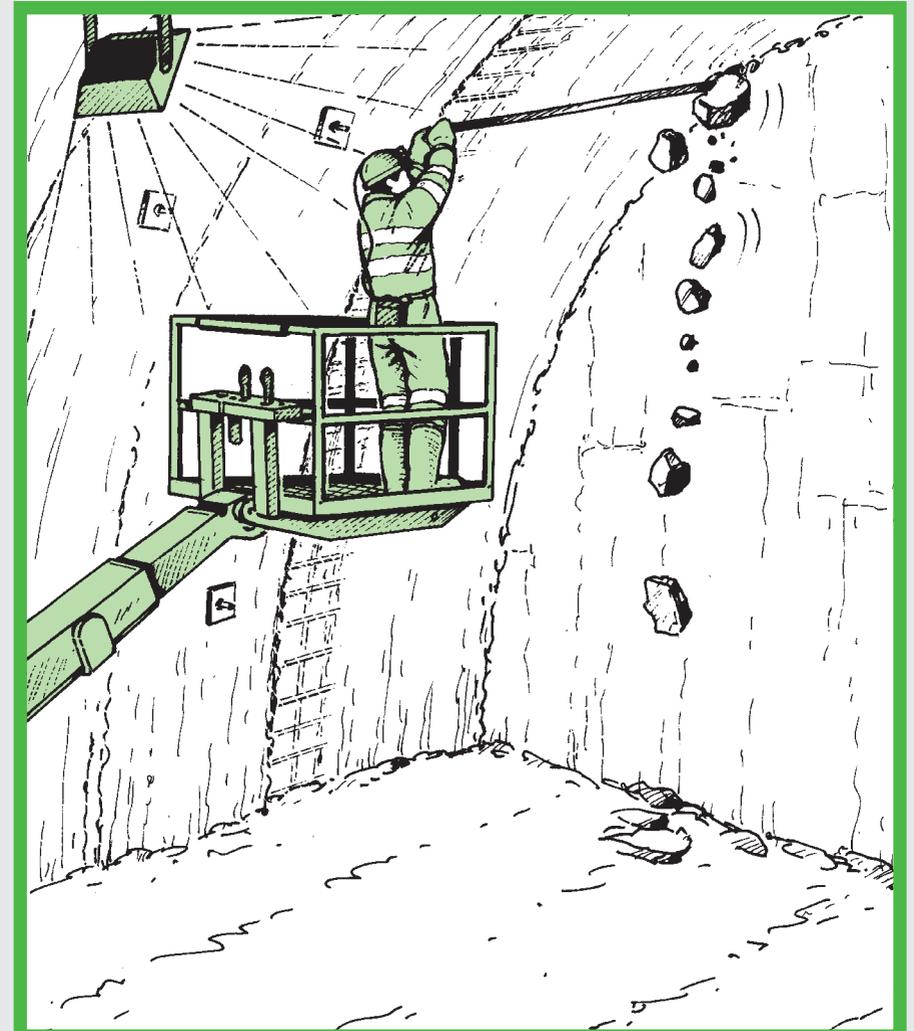
Manual Scaling



52

Danger

- rock fall
- falling from heights
- being crushed



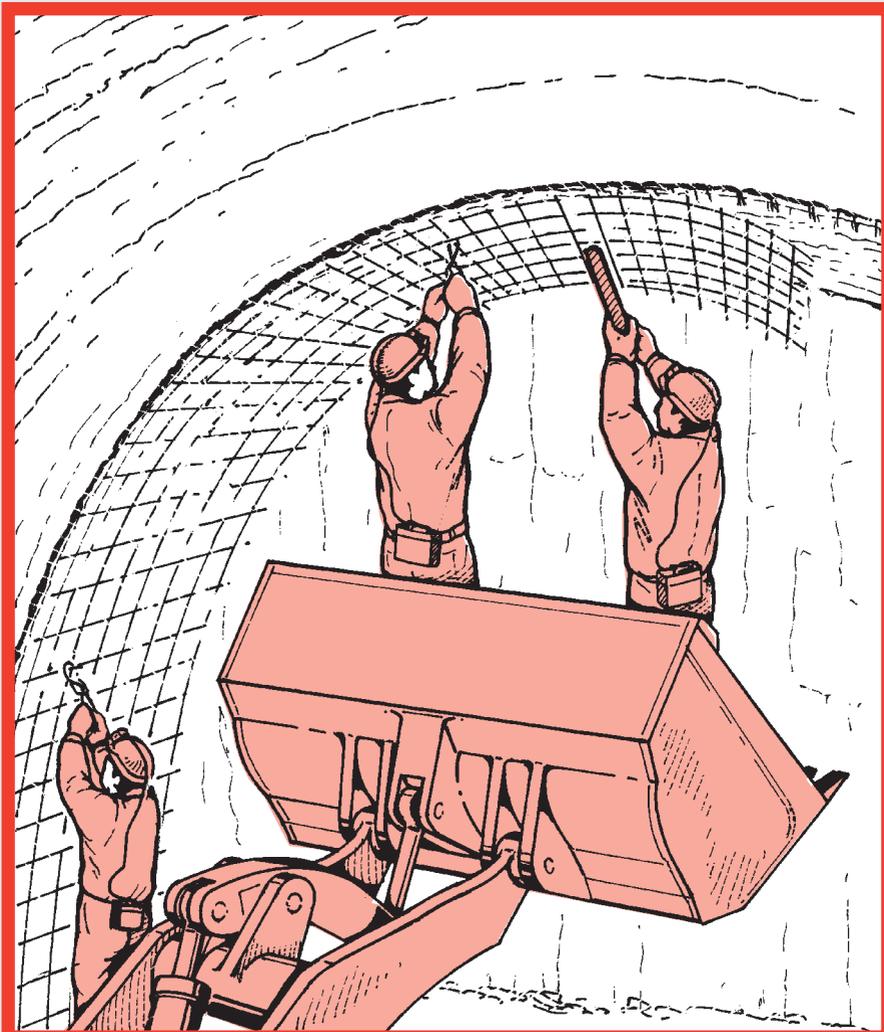
53

Protection

- only work from a safe area
- use working platforms
- light the area adequately

5.3

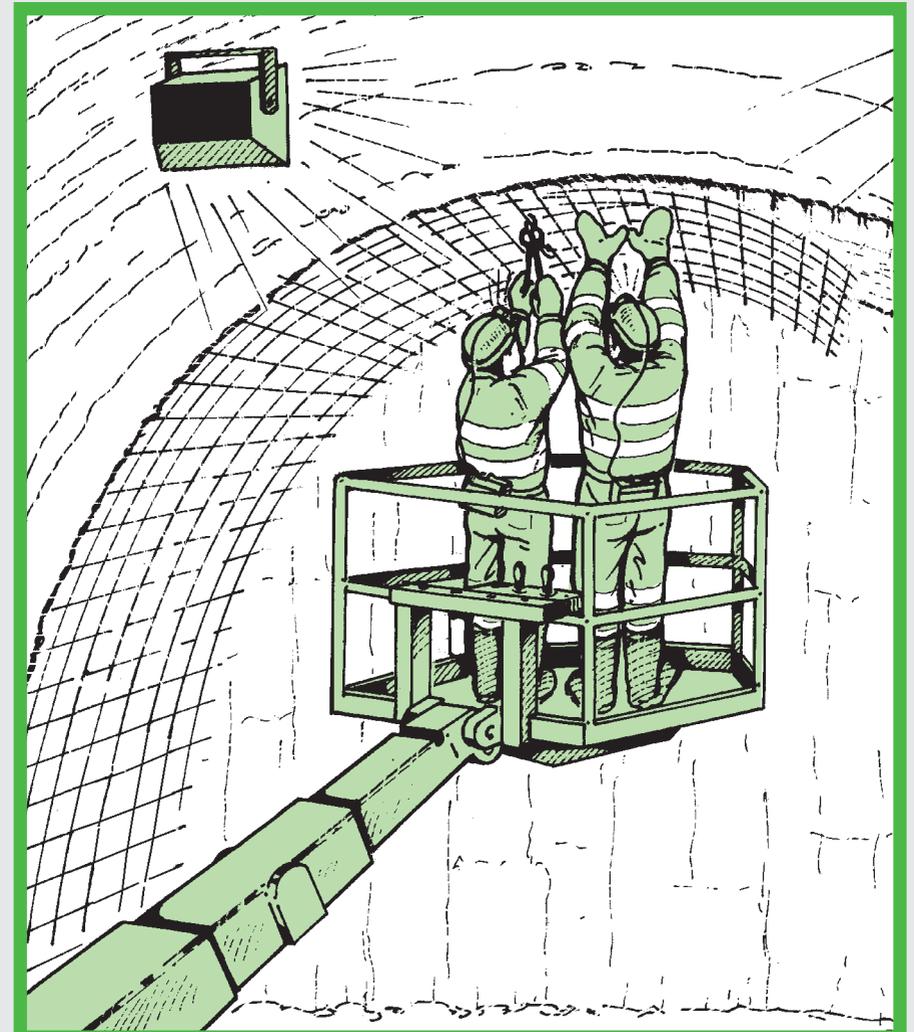
Installing Wire Mesh



54

Danger

- falling
- being crushed



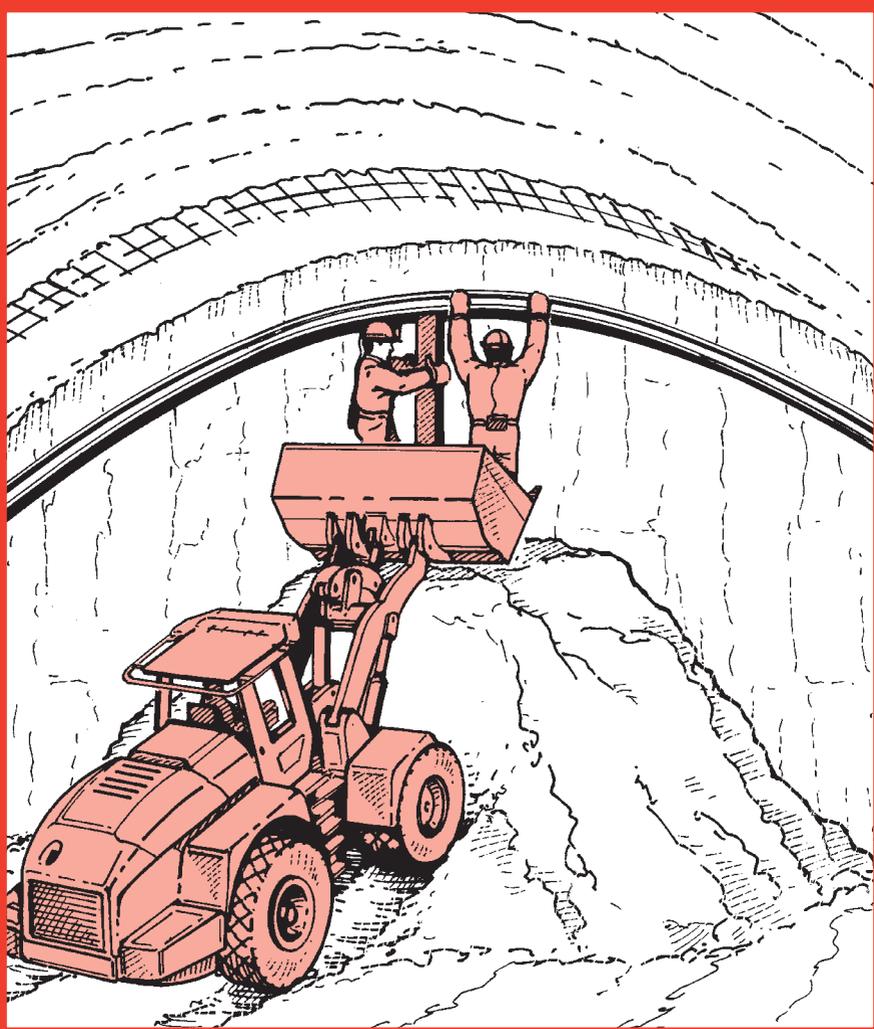
Protection

- use working baskets
- Keep clear of machine working zone
- light the area adequately

55

5.4

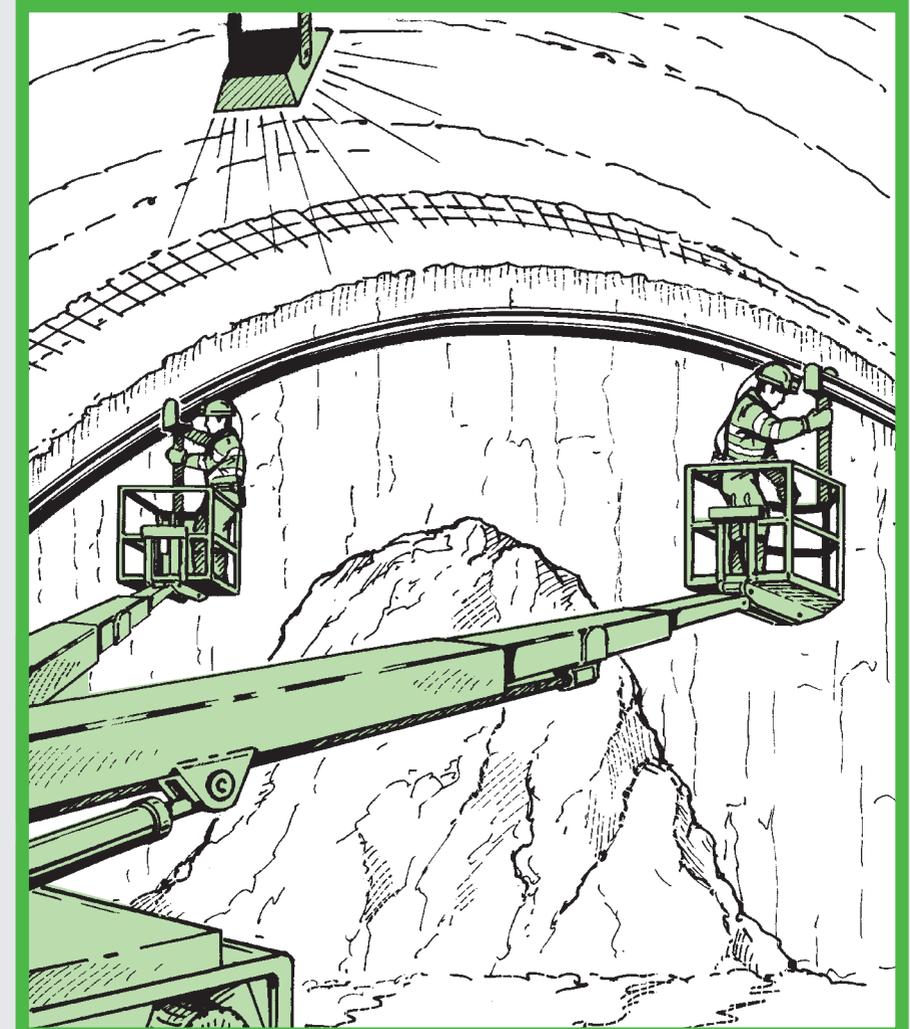
Installing Arches



56

Danger

- falling from heights
- being crushed
- lack of adequate lighting



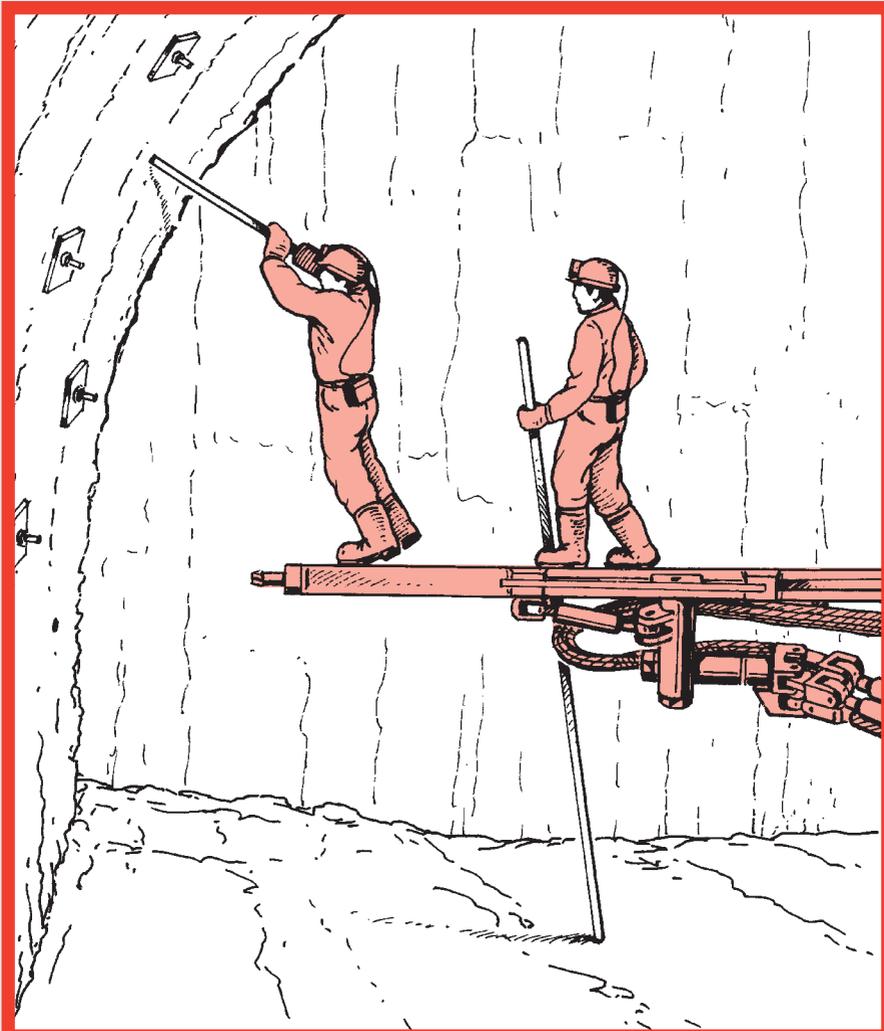
57

Protection

- use working baskets (twin-lift booms with 2 platforms)
- use machine according to its intended use
- do not enter the danger zone

5.5

Setting Rock Bolts



58

Danger

- falling from heights
- noise



59

Protection

- use working baskets of jumbo
- wear eye and hearing protection

5.6

Shotcreting



60

Danger

- falling from heights
- rebound
- dust
- chemical additives



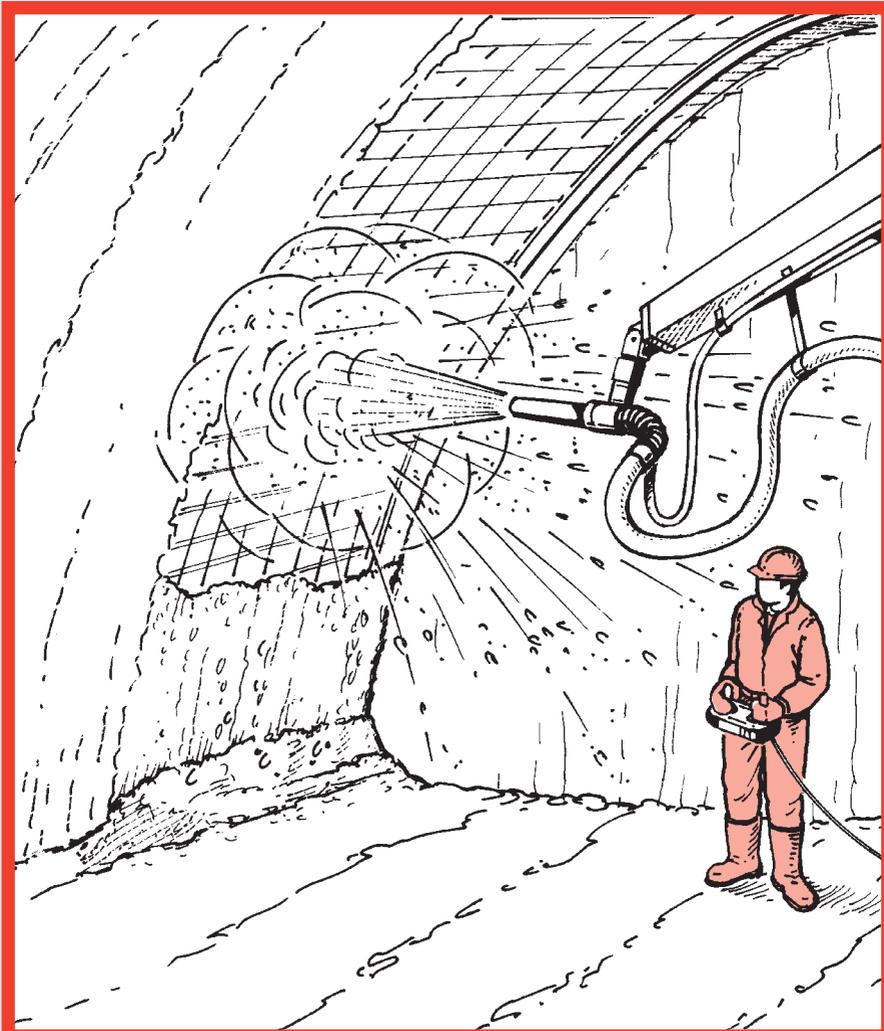
61

Protection

- use working baskets
- use protective clothing
- use shotcrete robot where possible
- wear protective hard hat for shotcreting
- wear respiratory protection

5.7

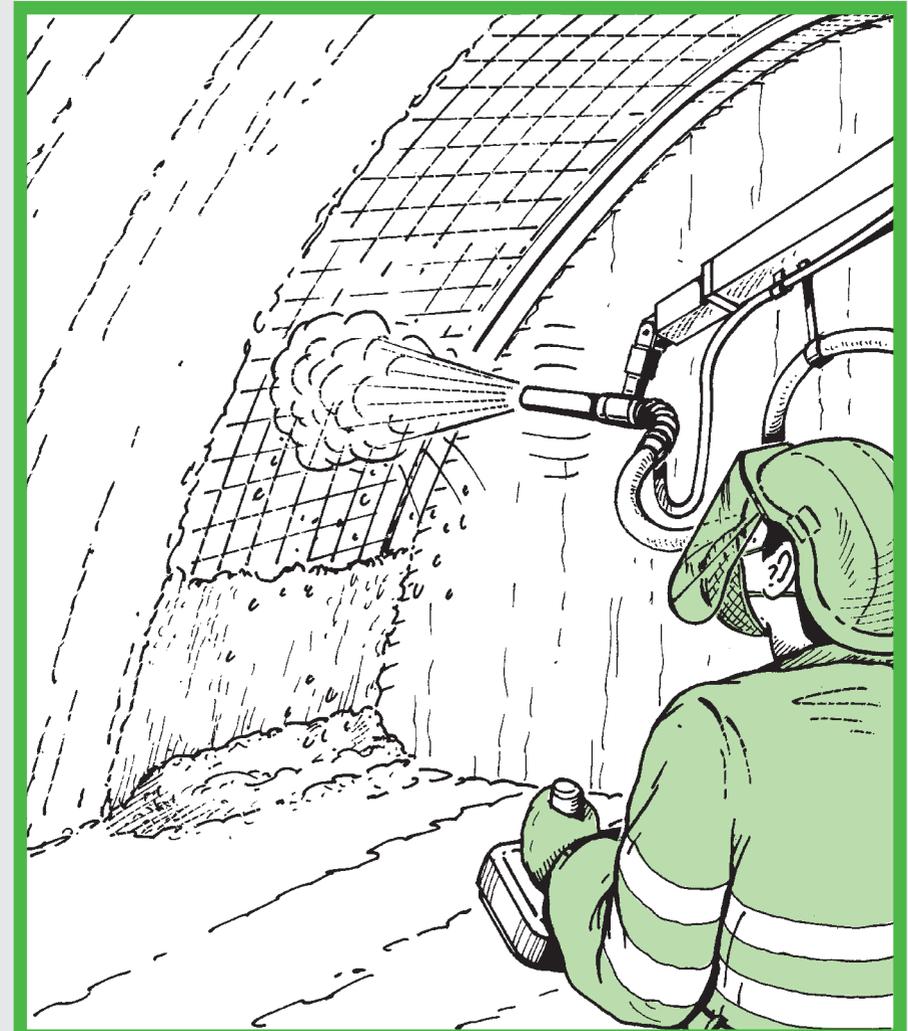
Spraying Manipulator



62

Danger

- being crushed
- rebound
- dust
- burst of concrete hose



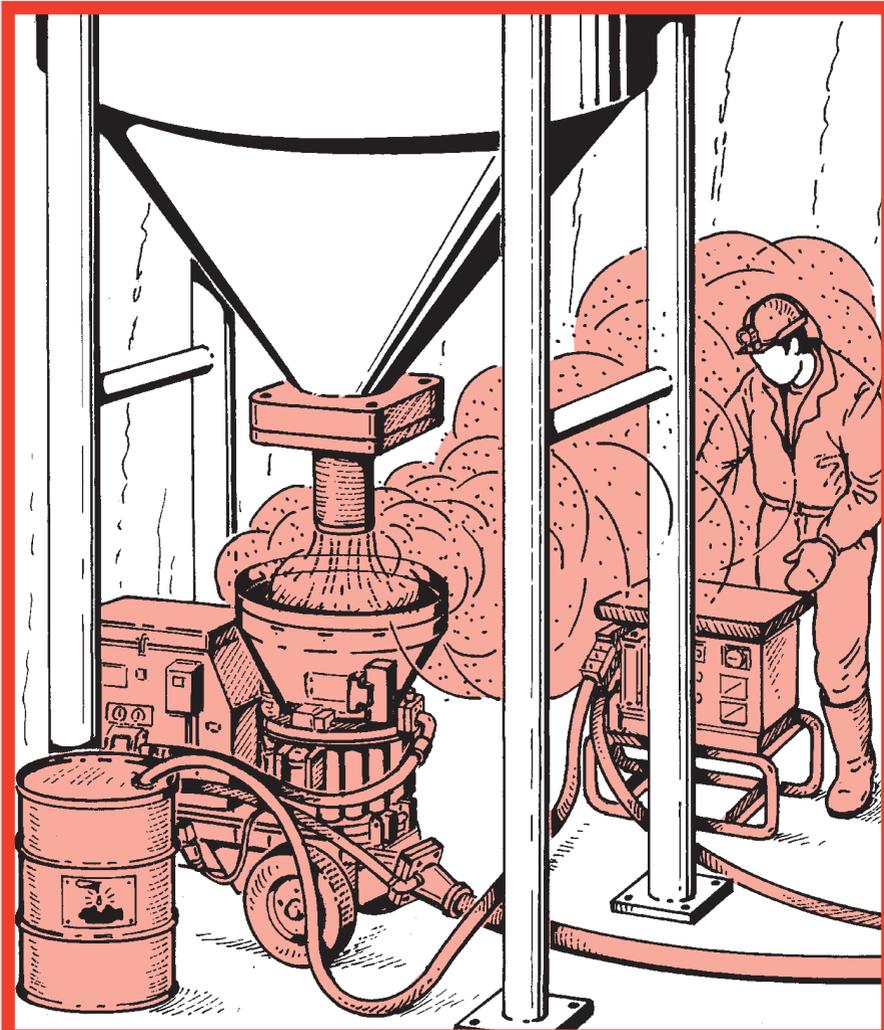
63

Protection

- do not enter the danger zone
- distance between nozzle and wall $\leq 1,5$ m
- wear shotcrete protective helmet
- wear respiratory protection
- wet mix concrete with alkali free additive to reduce dust and atmospheric pollution

5.8

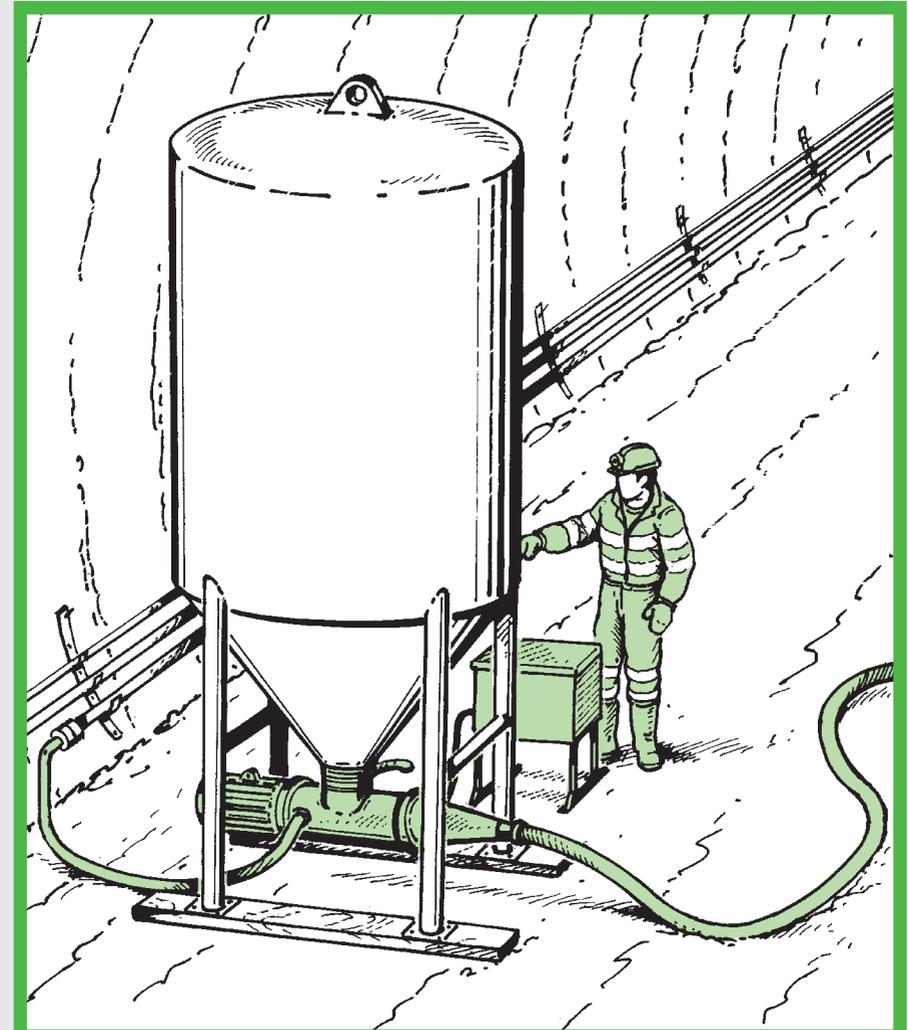
Shotcreting (dry process)



64

Danger

- dust containing quartz (silicosis)
- skin and eye irritation resulting from accelerator containing alkali



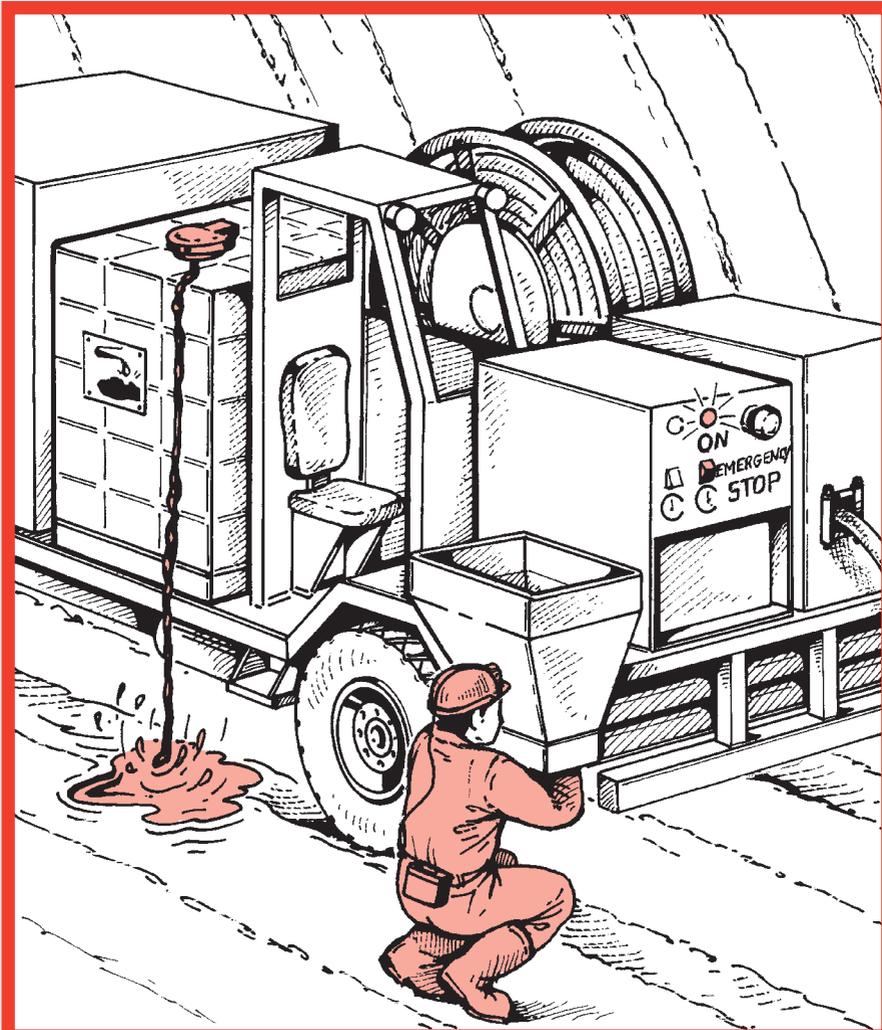
65

Protection

- use closed shotcreting machine
- use dry mix sprayed concrete with cement (without accelerator)
- alternative: use moist aggregates (with alkali-free accelerator)
- use a nozzle with pre-dampening system

5.9

Maintenance of Shotcrete Plant / Equipment



66

Danger

- crushed limbs as a result of the machine being unintentionally switched on
- skin and eye irritation resulting from the spillage of accelerator containing alkali



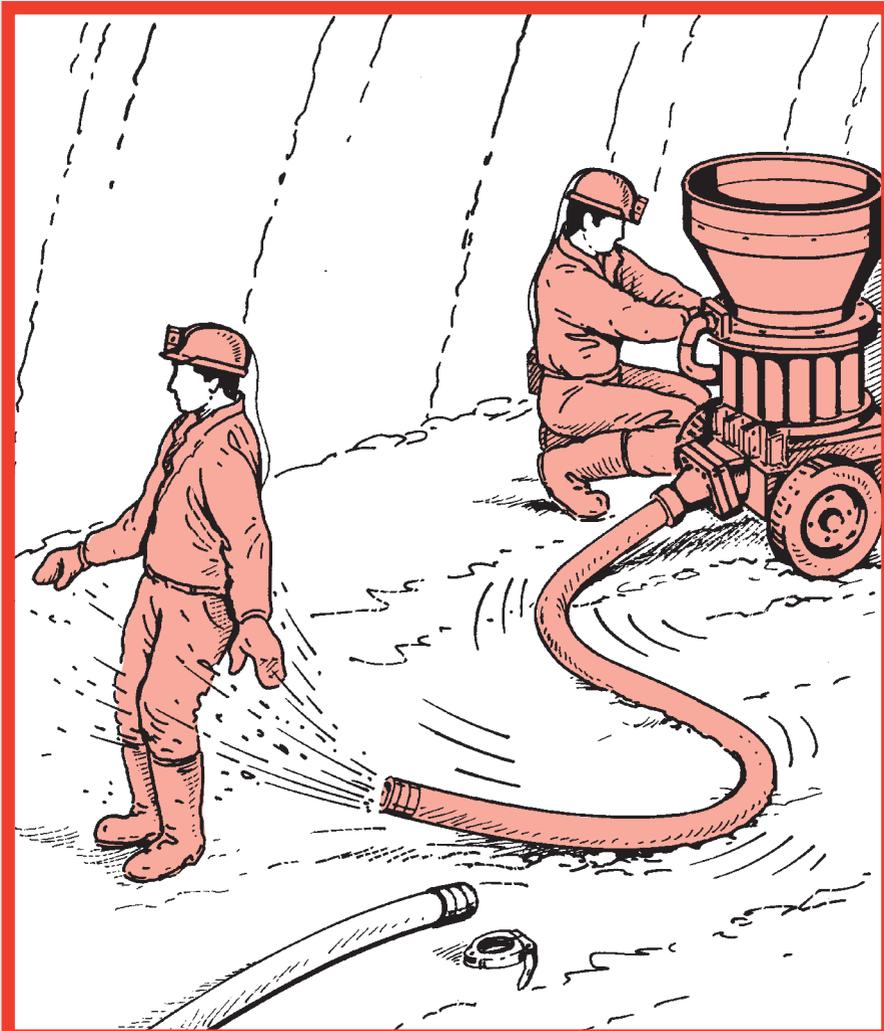
67

Protection

- clean the equipment with high pressure water jet
- machine must be switched off when cleaning inside it
- use alkali-free accelerator

5.10

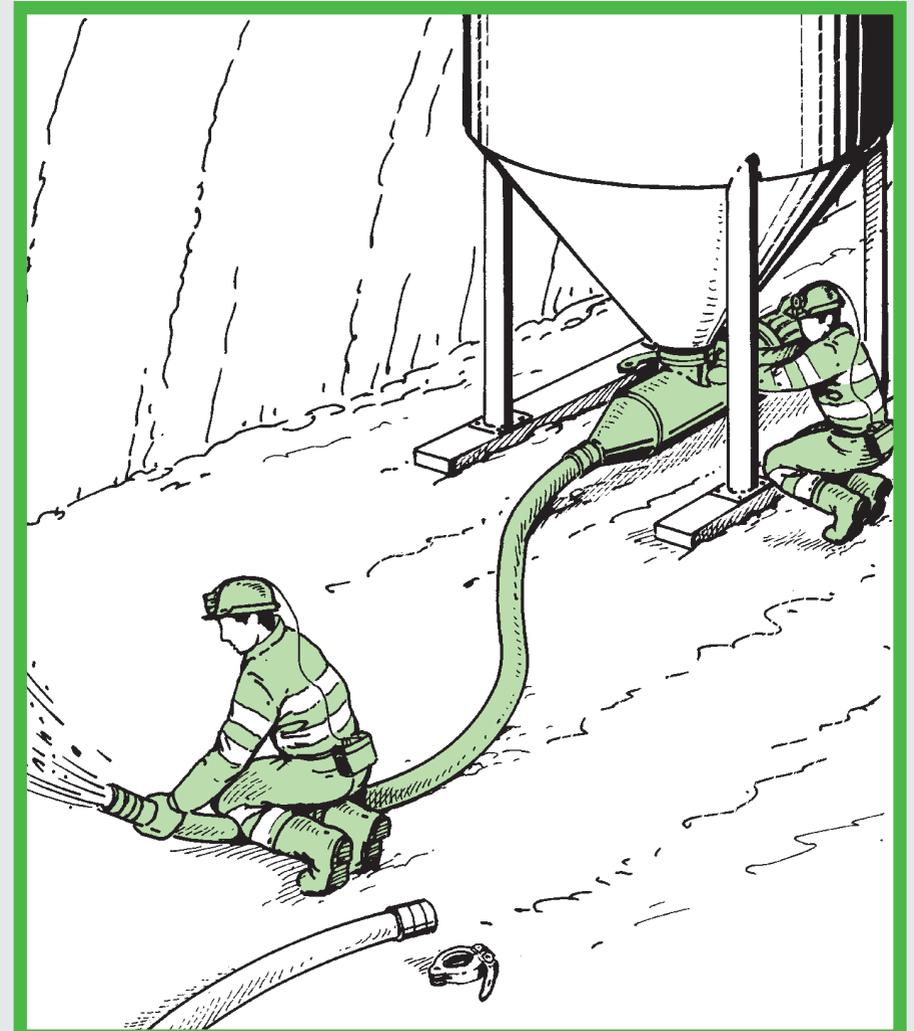
Removing Obstructions



68

Danger

- injury resulting from the hose whipping about
- danger when opening the clogged up supply hose



69

Protection

- take hold of the end of the hose
- do not enter the danger zone where concrete is being ejected
- the operator must monitor the danger zone

6

Transport



6.1

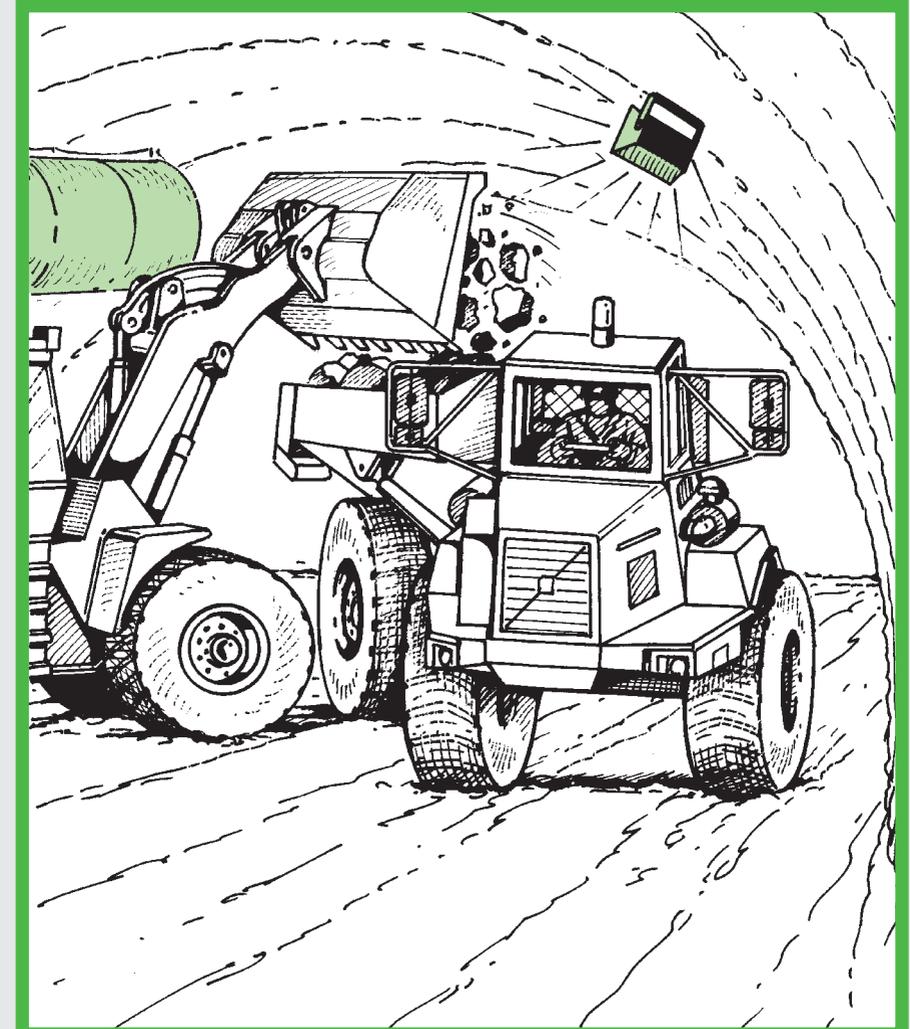
Loading the Excavated Material



72

Danger

- being struck
- being crushed
- falling material
- dust, noise
- tripping, falling



73

Protection

- do not enter the loading area (danger zone)
- keep the running surface in good condition
- do not overload dumper
- light the loading zone adequately

6.2

Travelling Past Working Areas



74

Danger

- being run over
- falling material



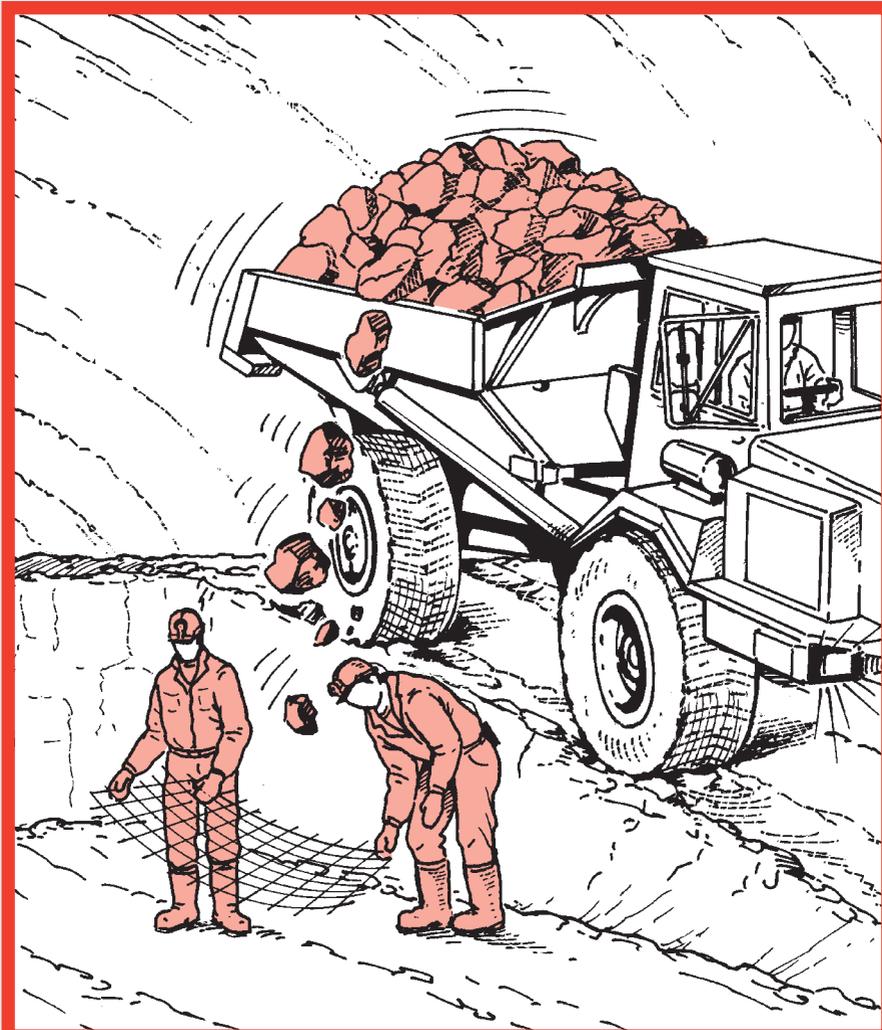
75

Protection

- use flashing warning lights at secured working areas
- keep a safe distance, drive slowly
- do not overload dumper
- light all working places adequately

6.3

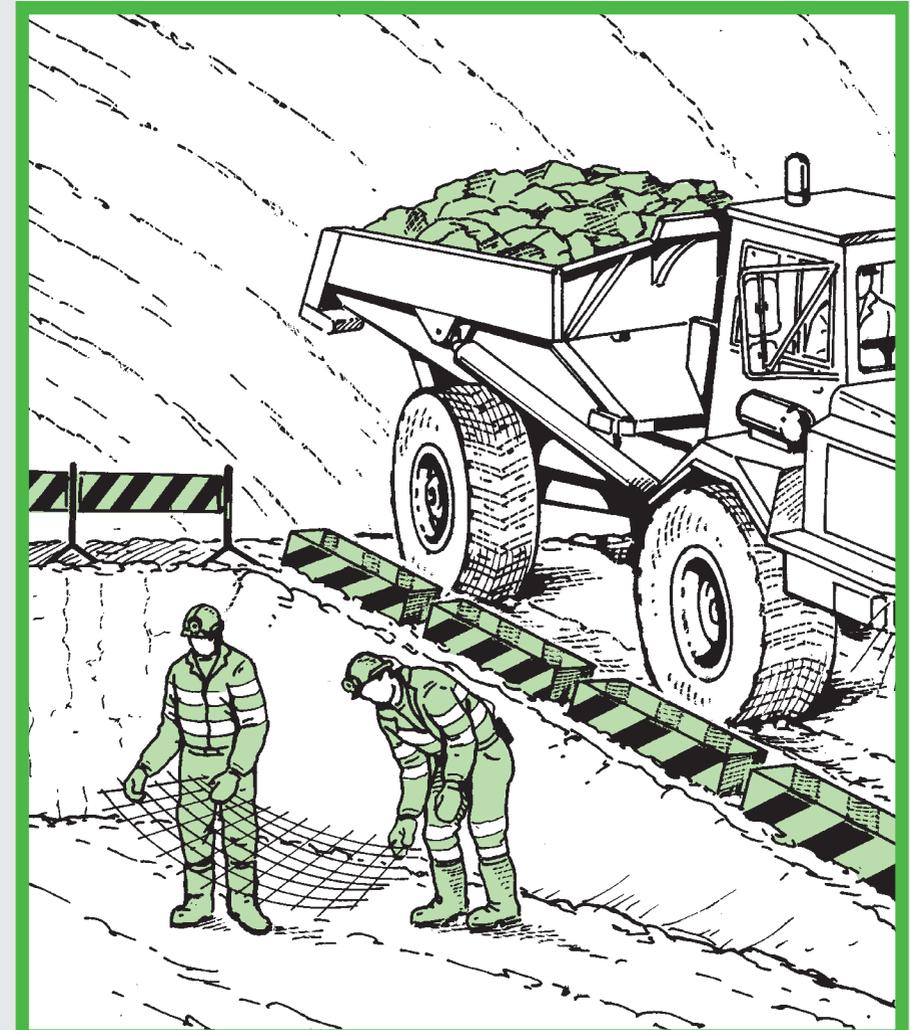
Driving Past the Edge of an Excavation



76

Danger

- the vehicle could tip over
- falling material



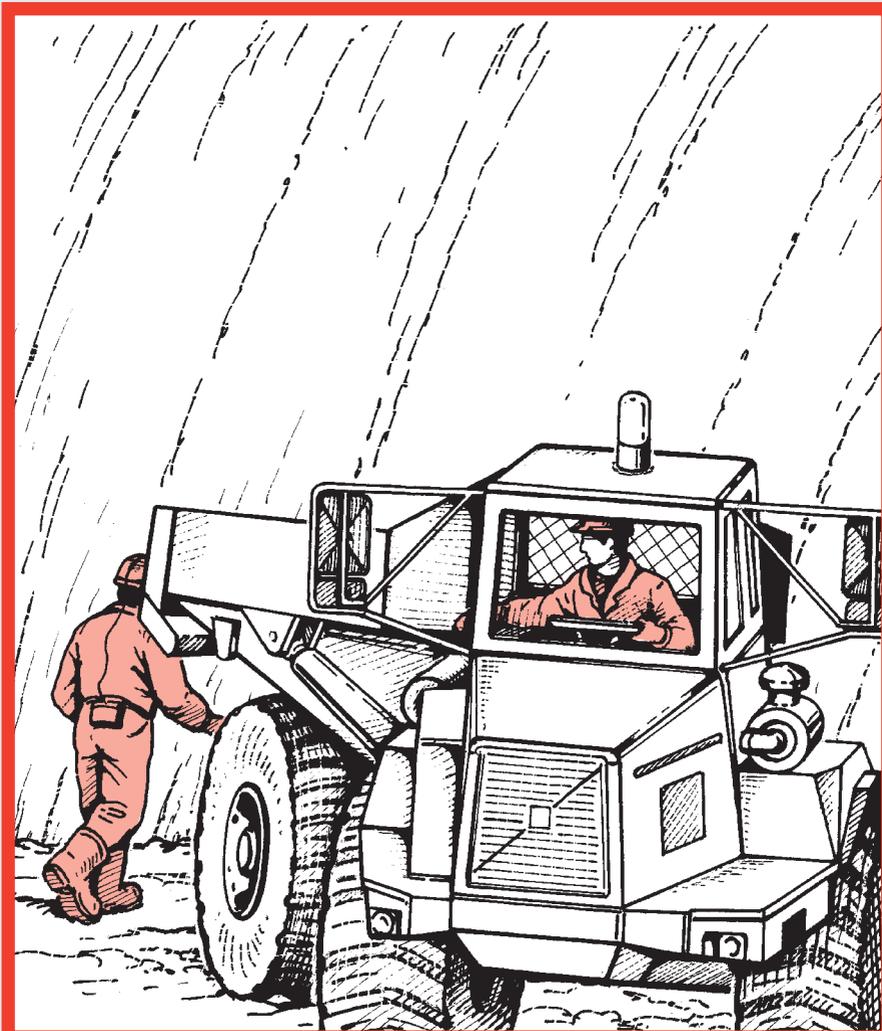
77

Protection

- maintain a safety distance from edge
- place guard barriers at the edge of ramp incline
- drive slowly on ramp incline
- do not overload dumper

6.4

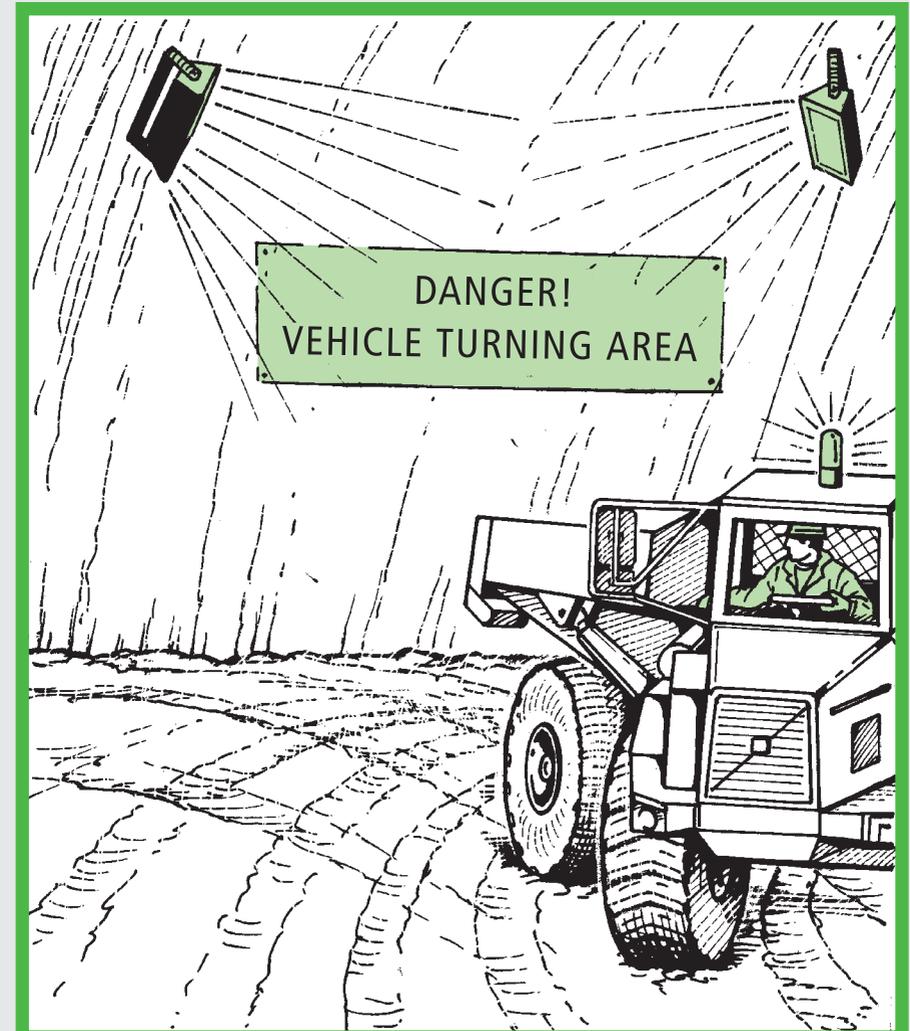
Turning in Tunnels



78

Danger

- being run over
- being crushed



79

Protection

- do not enter the danger zone
- visual monitoring of the rear
- mark turning area, provide adequate surface and light it adequately

6.5

Reversing in Tunnels



80

Danger

- being struck or run over



81

Protection

- separate paths for vehicles and pedestrians
- visual monitoring of the rear of vehicle
- regularly clean vehicle mirrors and lights and replace defective ones
- light the area adequately
- wear reflective clothing

6.6

Narrow Areas where Rail Vehicles are used



82

Danger

- being crushed
- being struck
- tripping up



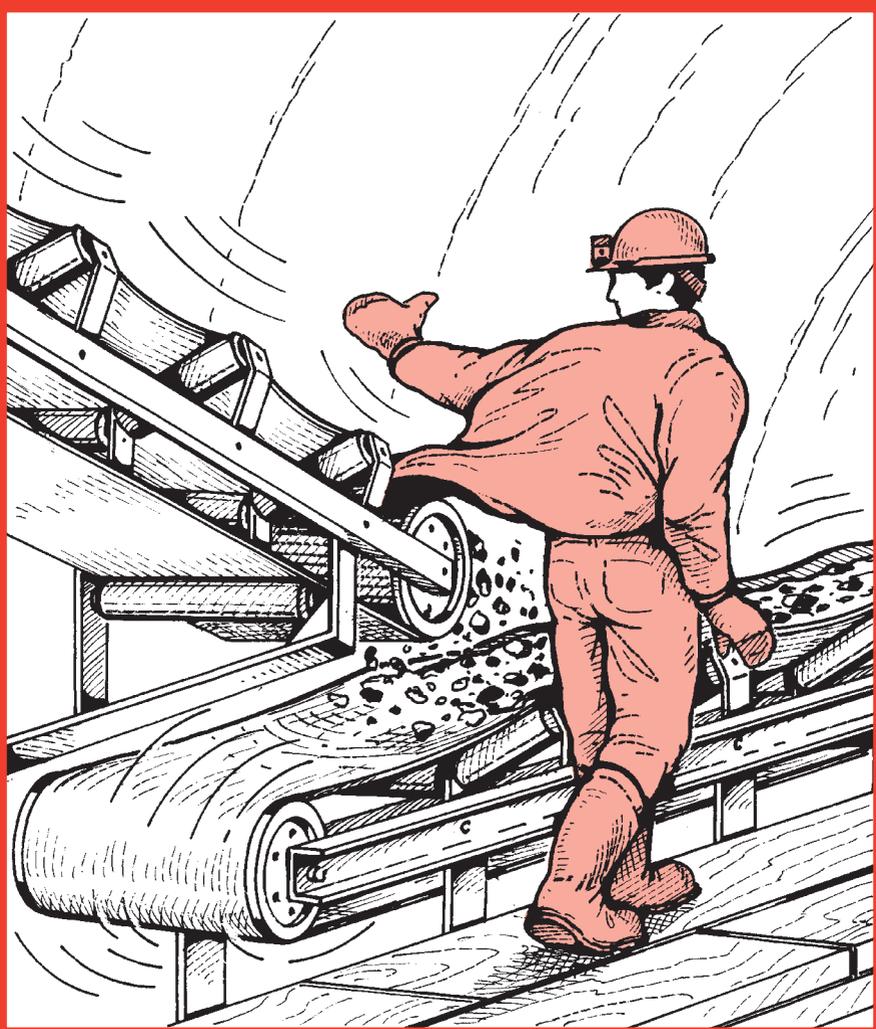
83

Protection

- keep clear of track and mine cars when under operation
- separate railway area and pedestrian path
- keep pedestrian path clear of material and obstructions

6.7

Belt Transport



84

Danger

- being trapped or grasped by running conveyor



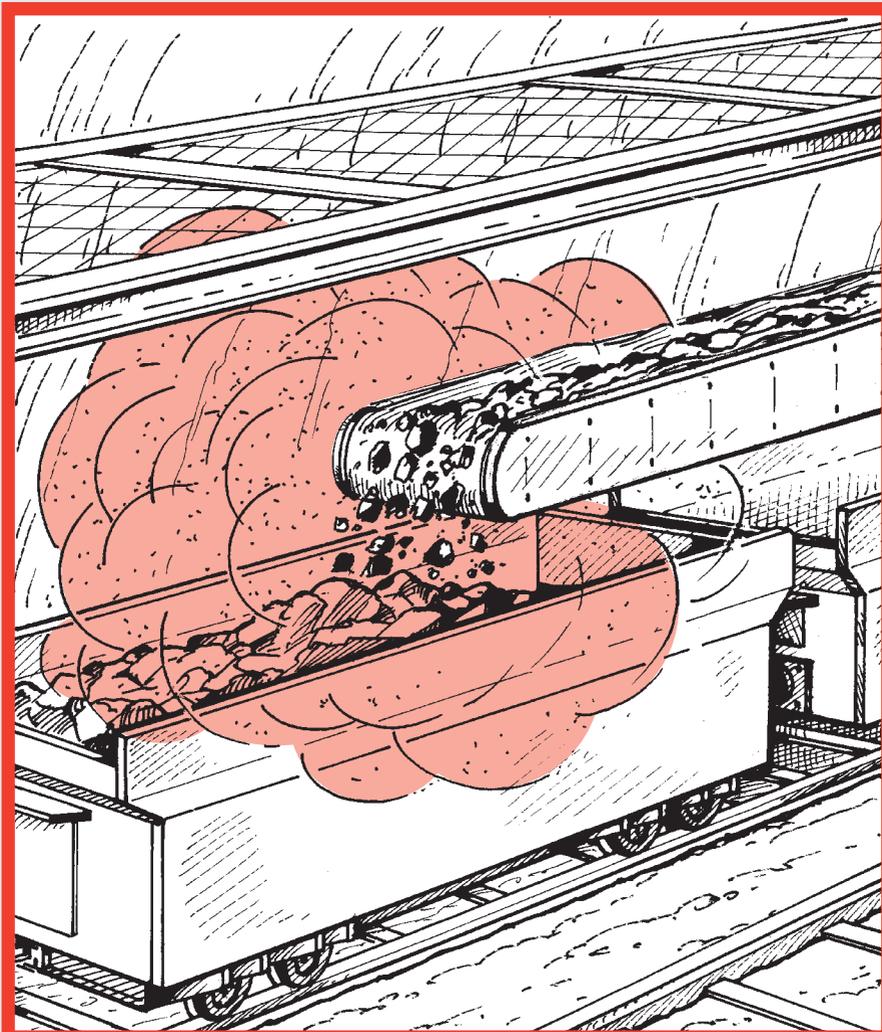
85

Protection

- conveying belt and walkways should be delimited / separated
- place emergency-OFF switches at regular space intervals

6.8

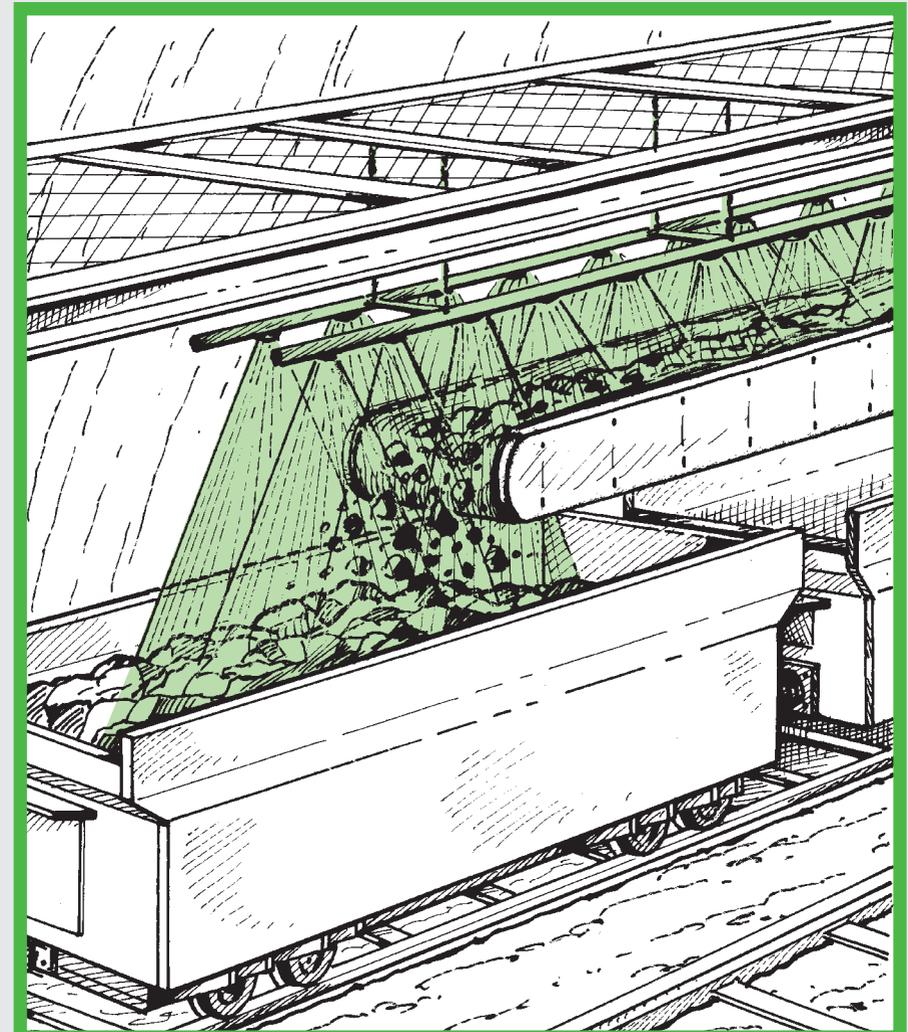
Belt Transport (belt transfer points)



86

Danger

- harmful dust



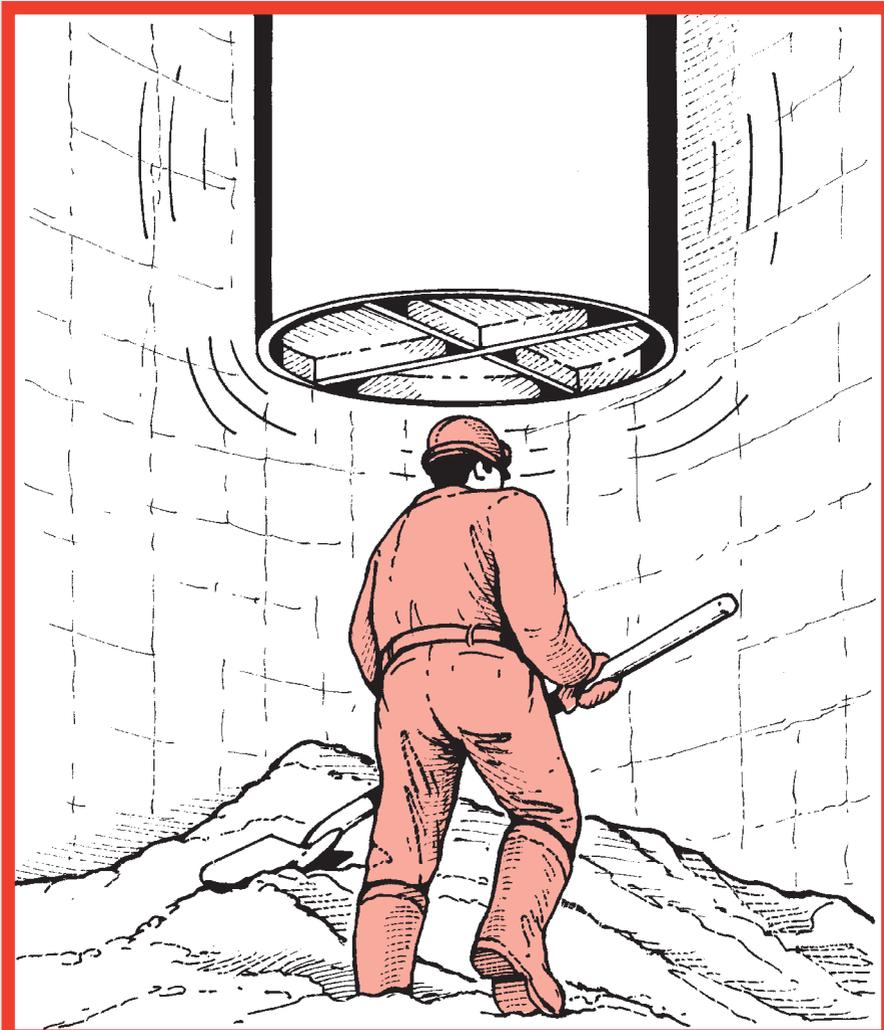
87

Protection

- handing over or loading zone should be equipped with a sprinkler waterspray system
- Alternative: housing system with dust exhaustion control system

6.9

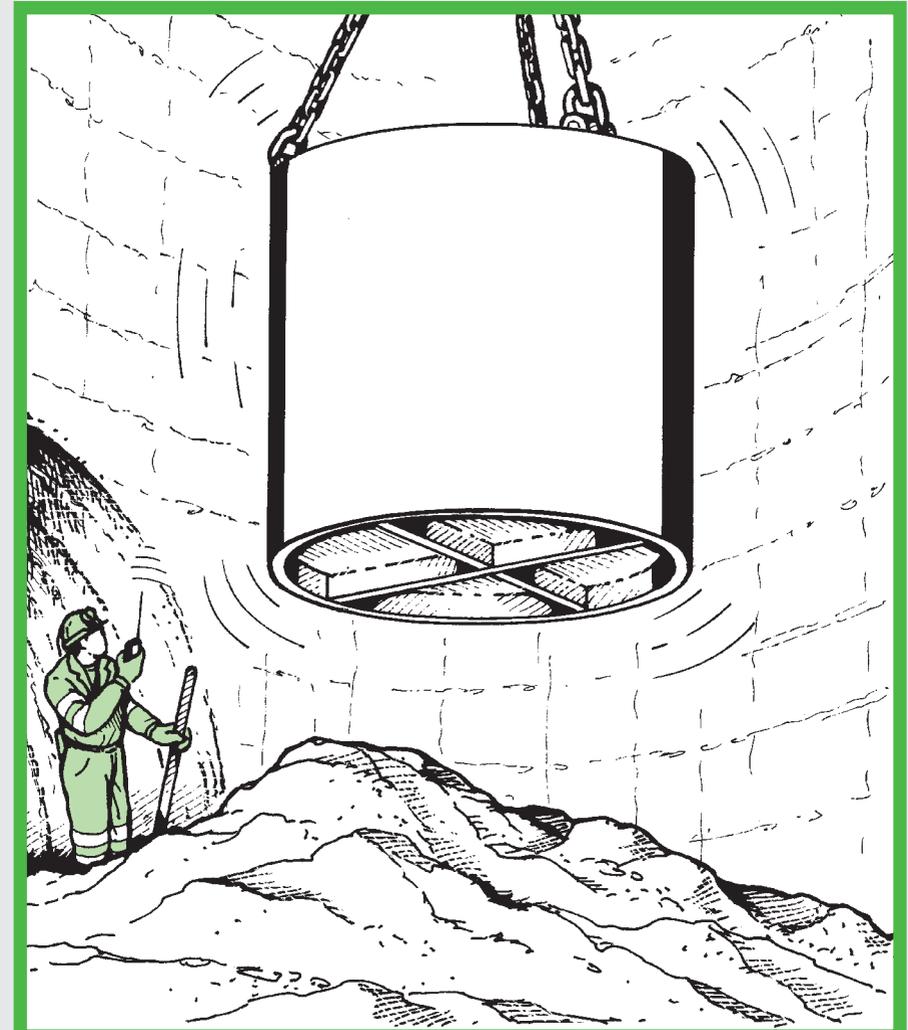
Shaft Transport (removal of excavated material)



88

Danger

- being crushed
- falling material



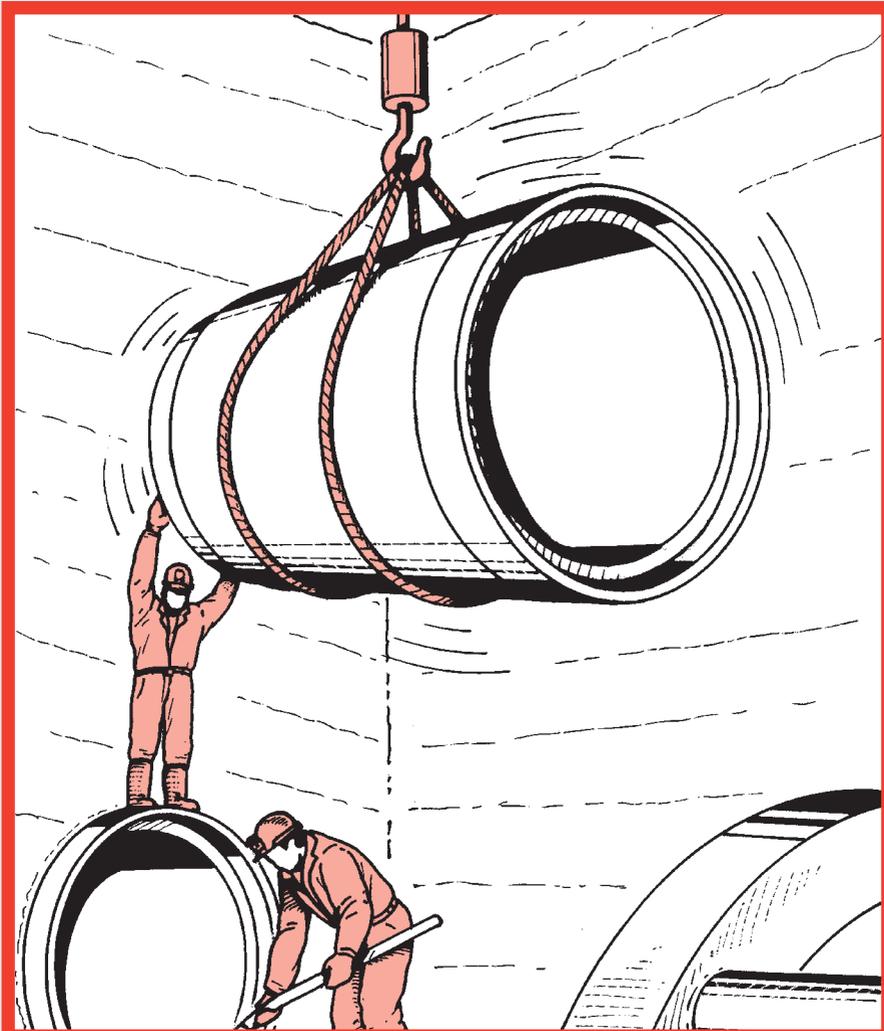
89

Protection

- do not enter the danger zone under skip
- supervise movements of skip
- instruct hoisting equipment operator by radio or telephone

6.10

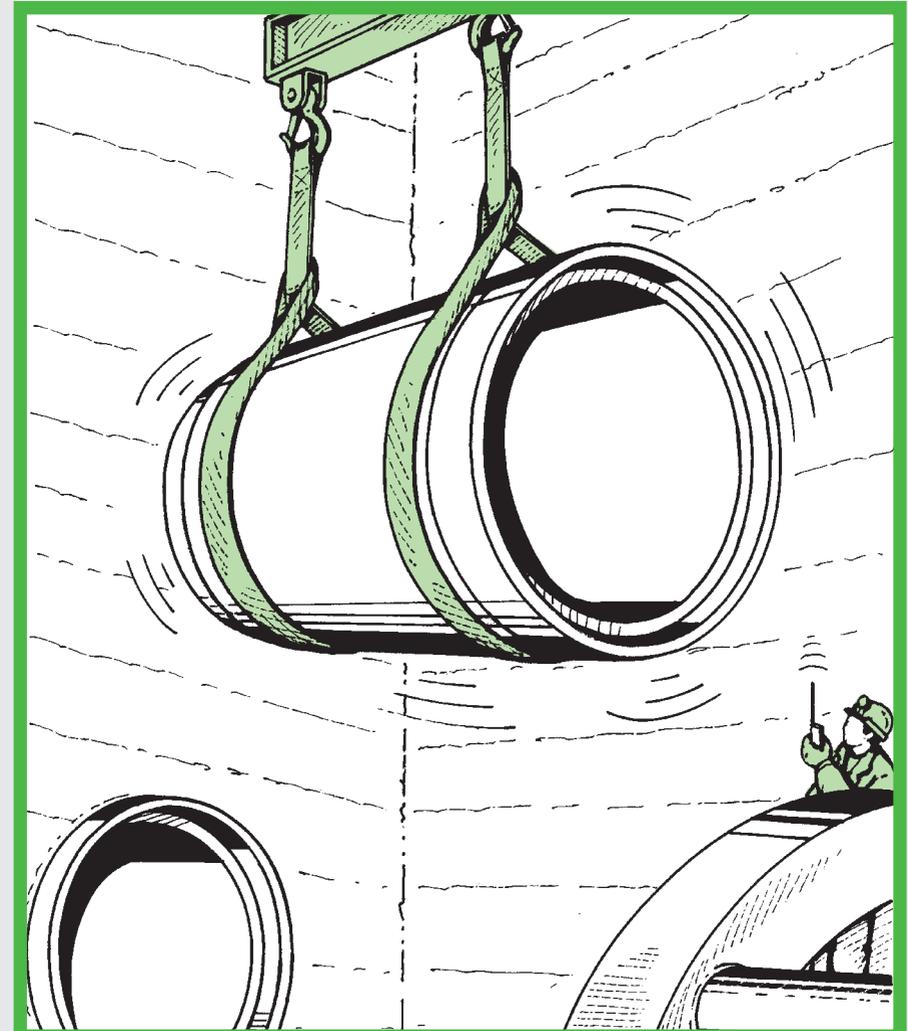
Shaft Transport (loads)



90

Danger

- being injured by falling or swinging load



91

Protection

- do not stand under load
- sling properly loads
- instruct hosting equipment operator by radio or telephone

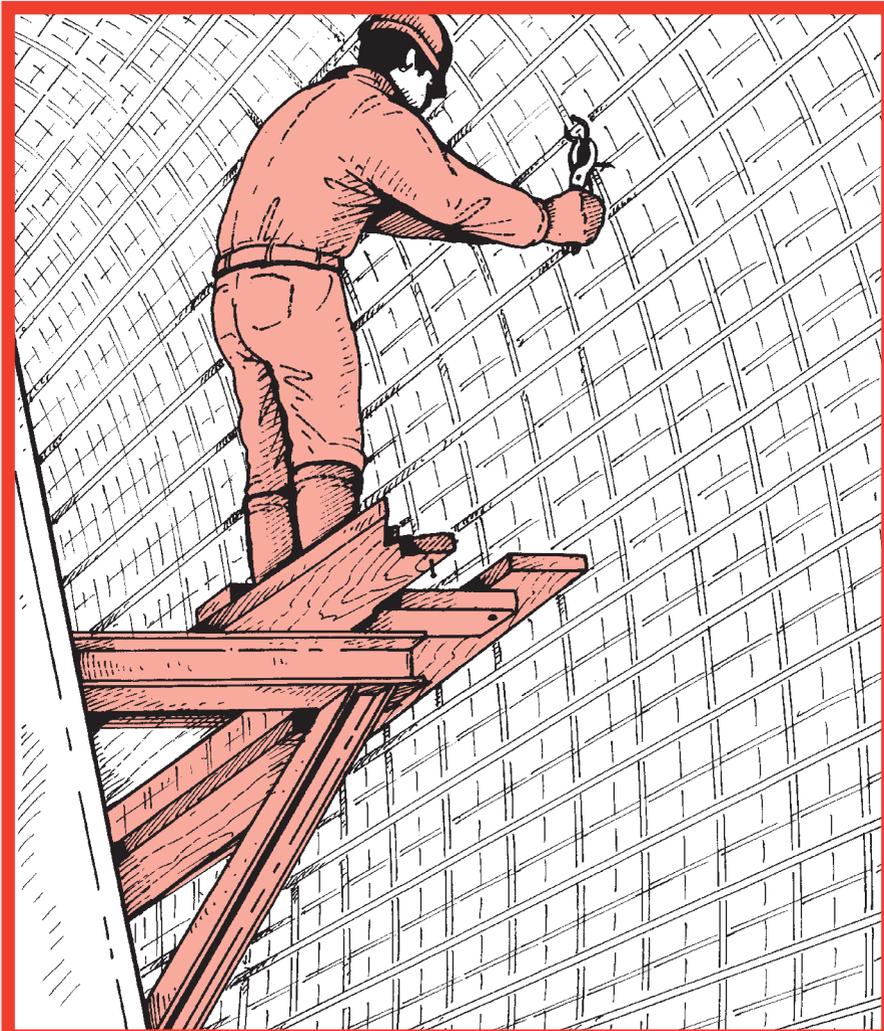
7

Final Lining



7.1

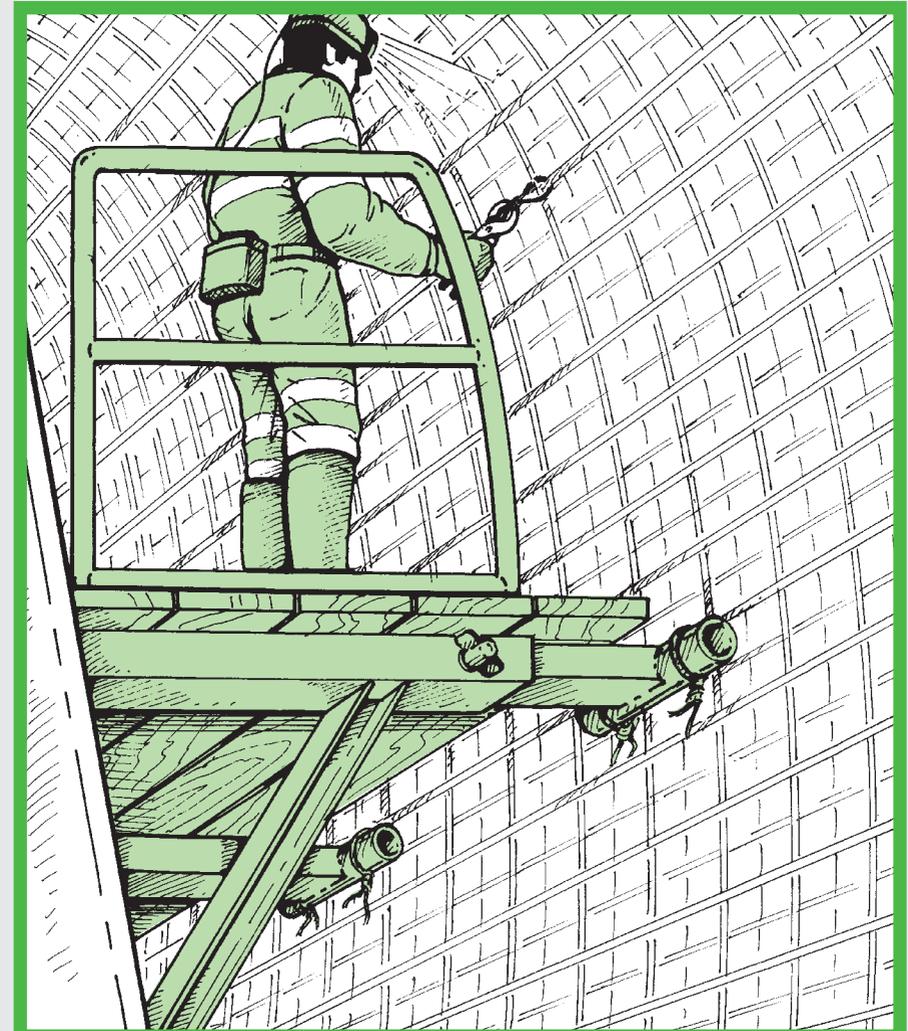
Installing Reinforcement



94

Danger

- falling



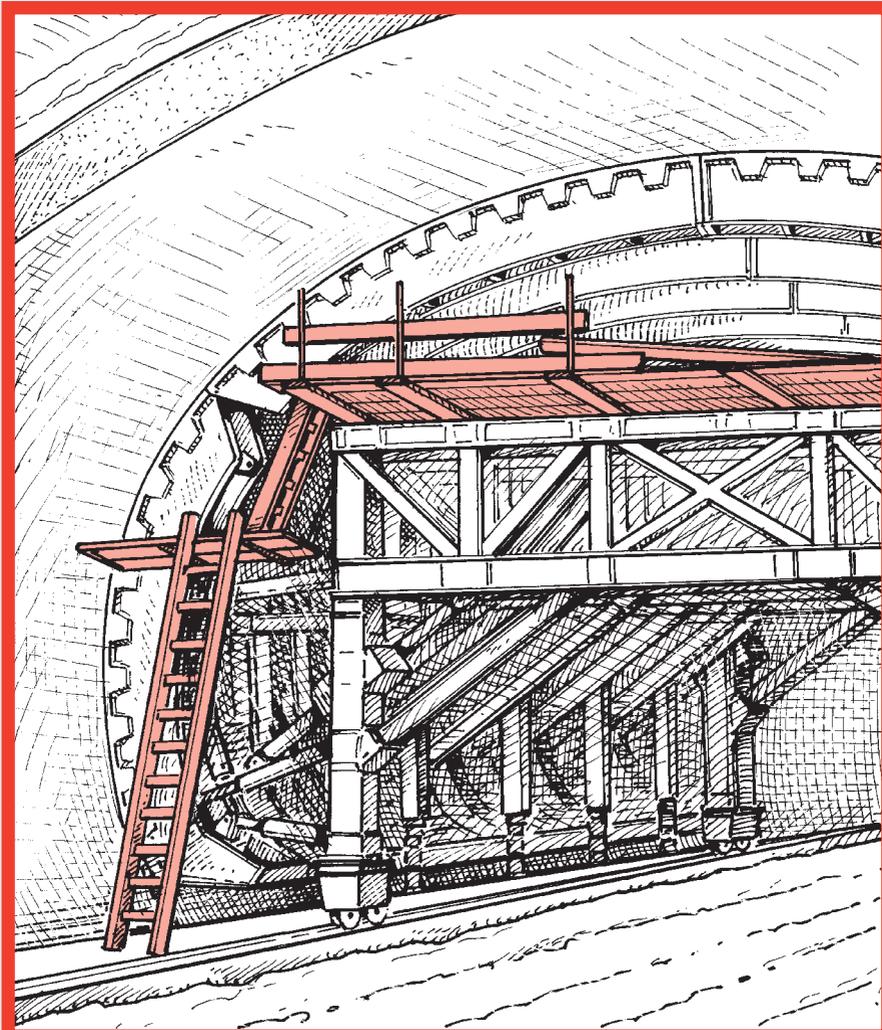
95

Protection

- install side-guards
- use a telescopic working platform
- make sure that planking has correctly been put in place

7.2

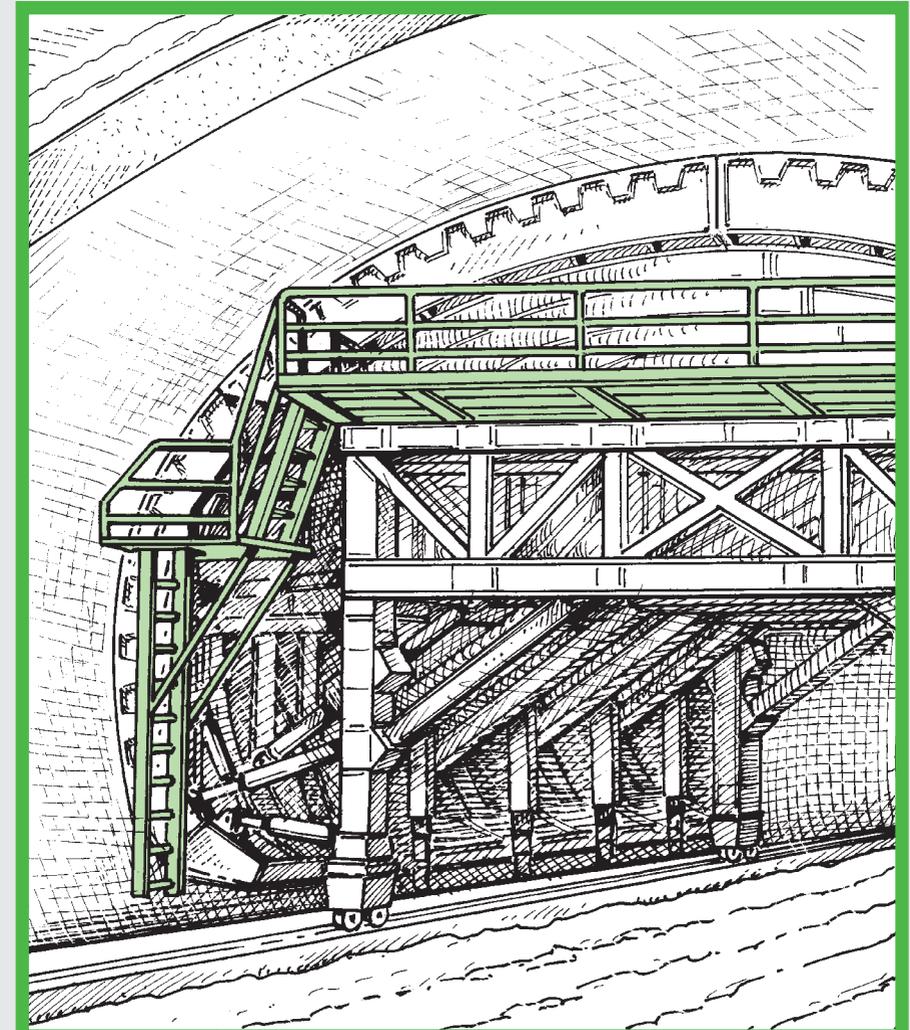
Travelling Formwork



96

Danger

- falling



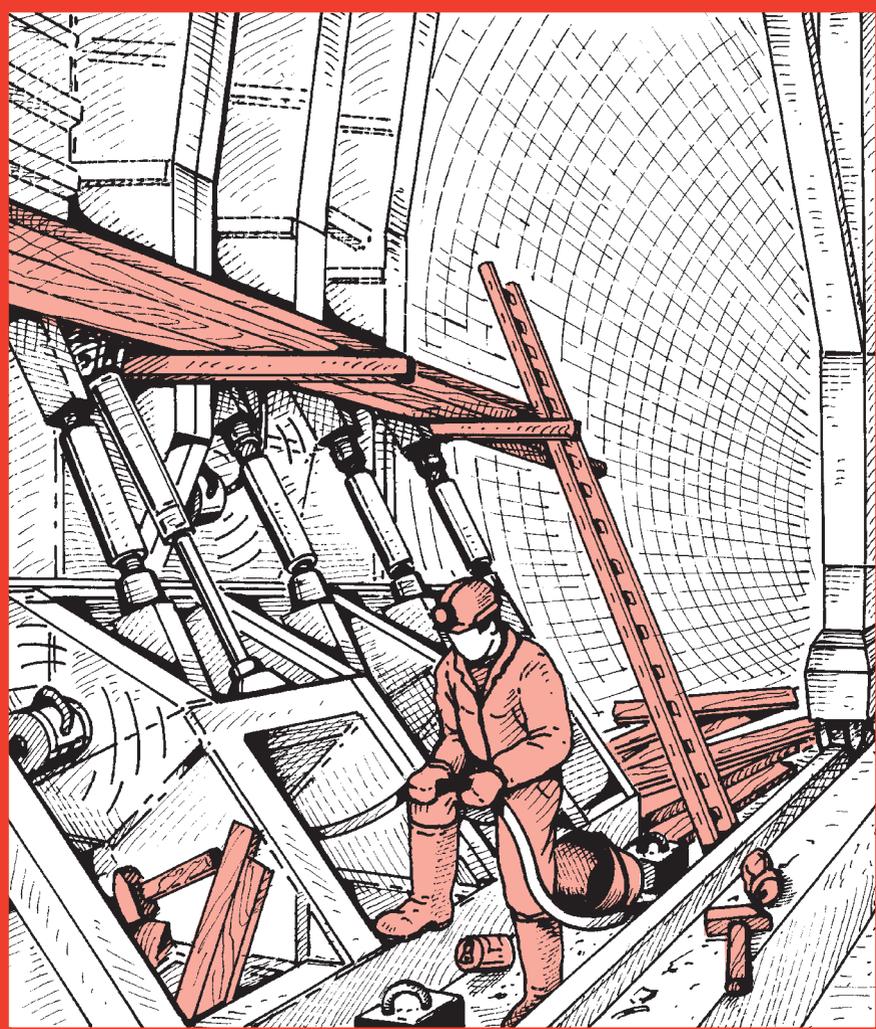
97

Protection

- access ways should be properly constructed and guarded

7.3

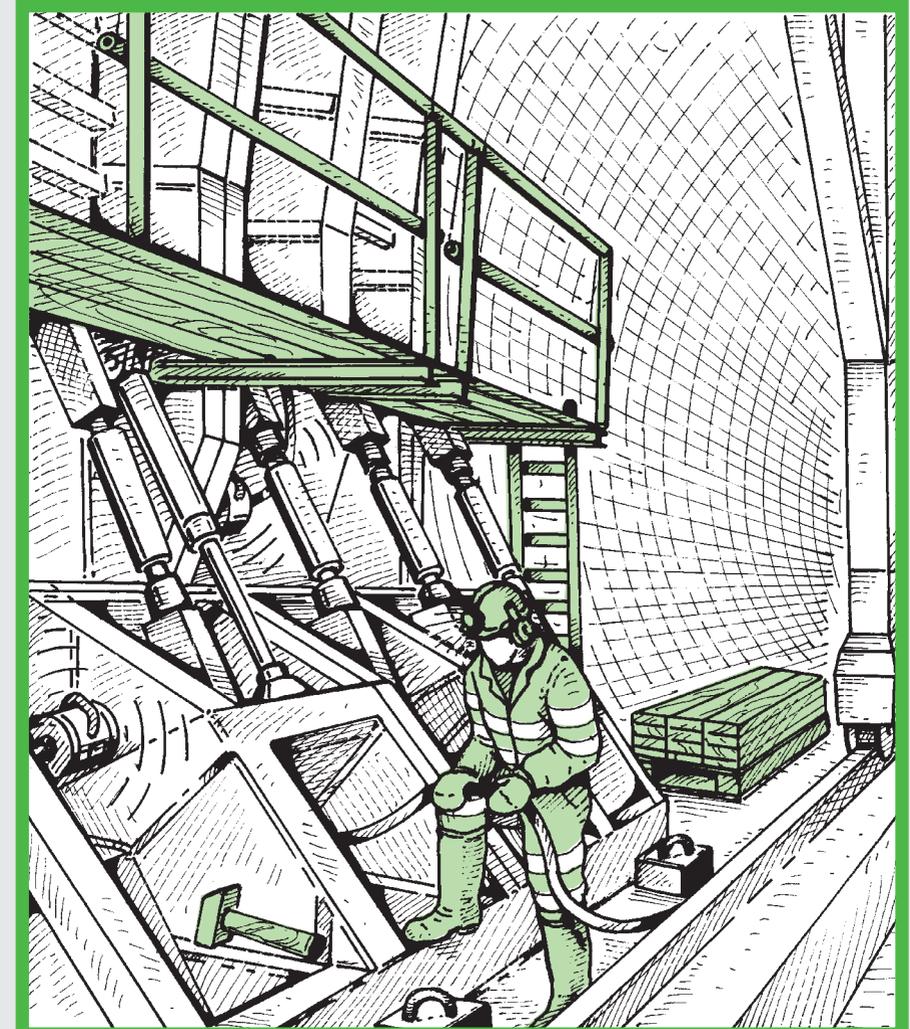
Working in the Tunnel Formwork



98

Danger

- tipping over and falling
- noise resulting from the external vibrator
- unsafe access and working places



99

Protection

- keep the access ways clear of all loose material
- maintain working place in good order
- wear hearing protection when pouring concrete



8.1

Maintenance of a Full Face Tunneling Machine



102

Danger

- falling
- drowning in bentonite
- collapse of excavated face



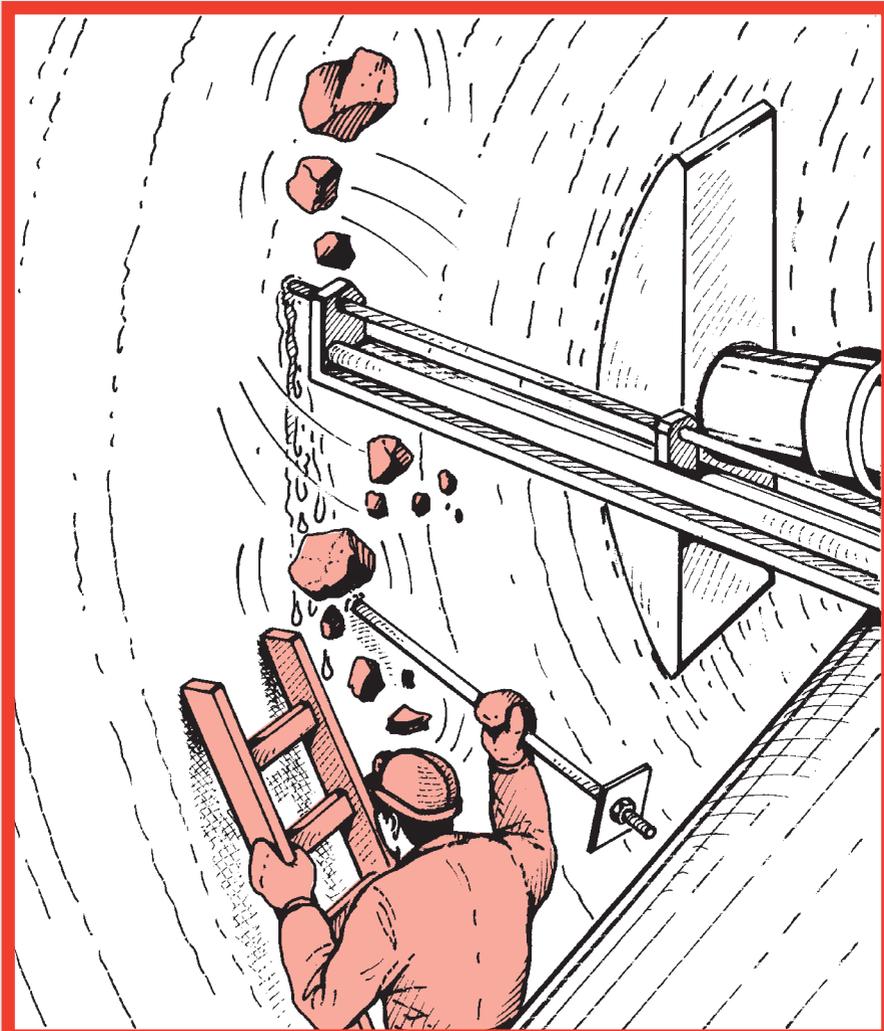
103

Protection

- use the platform provided by manufacturer
- driving up of sheeting plates at workface should be made hydraulically where required
- working face should be set under compressed air

8.2

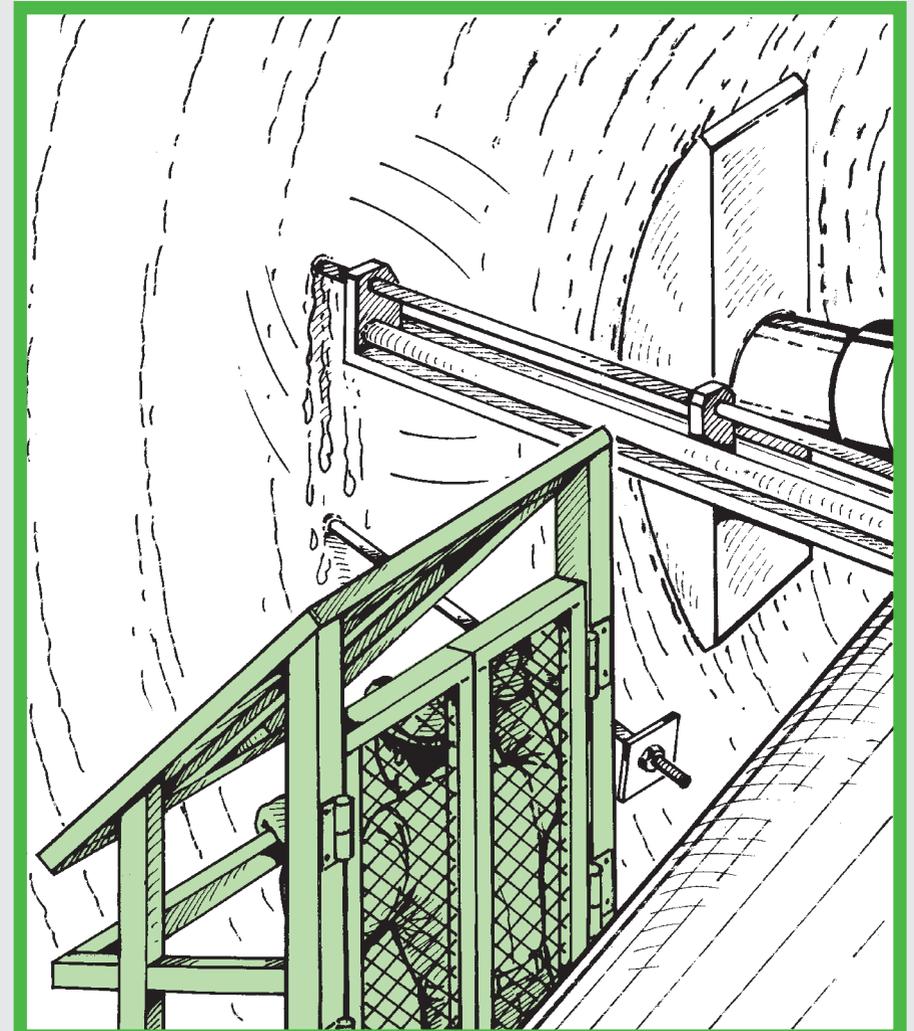
Installing Anchors in TBM Tunnels



104

Danger

- cave-in and rock fall
- falling



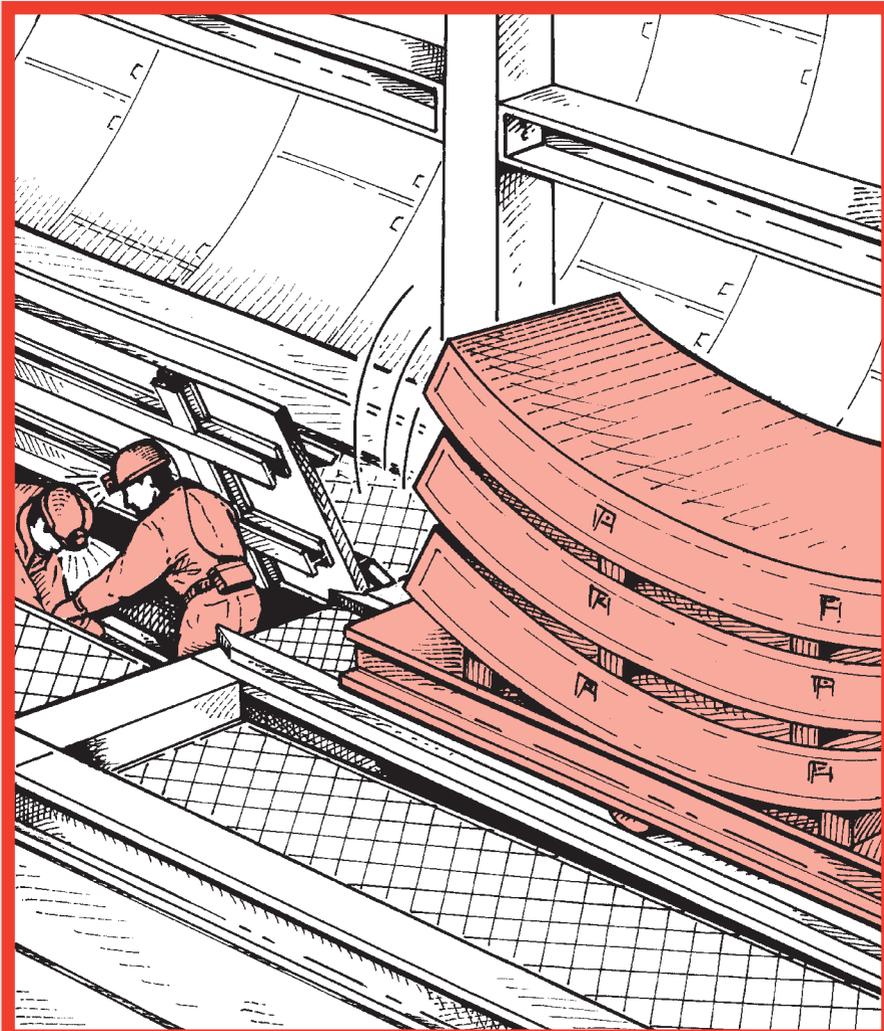
105

Protection

- provide safe, defined working place
- do not enter danger zone operator

8.3

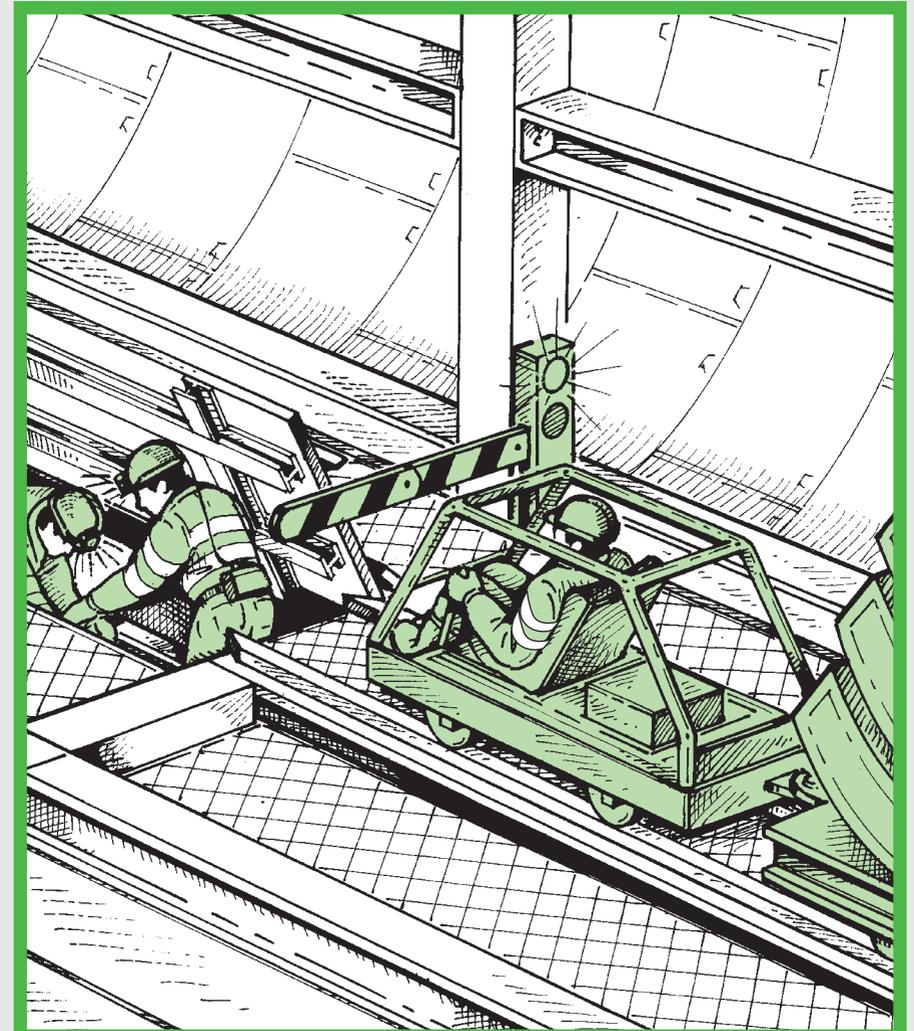
Driving / Heading in Tracked Tunnels



106

Danger

- being crushed
- being struck



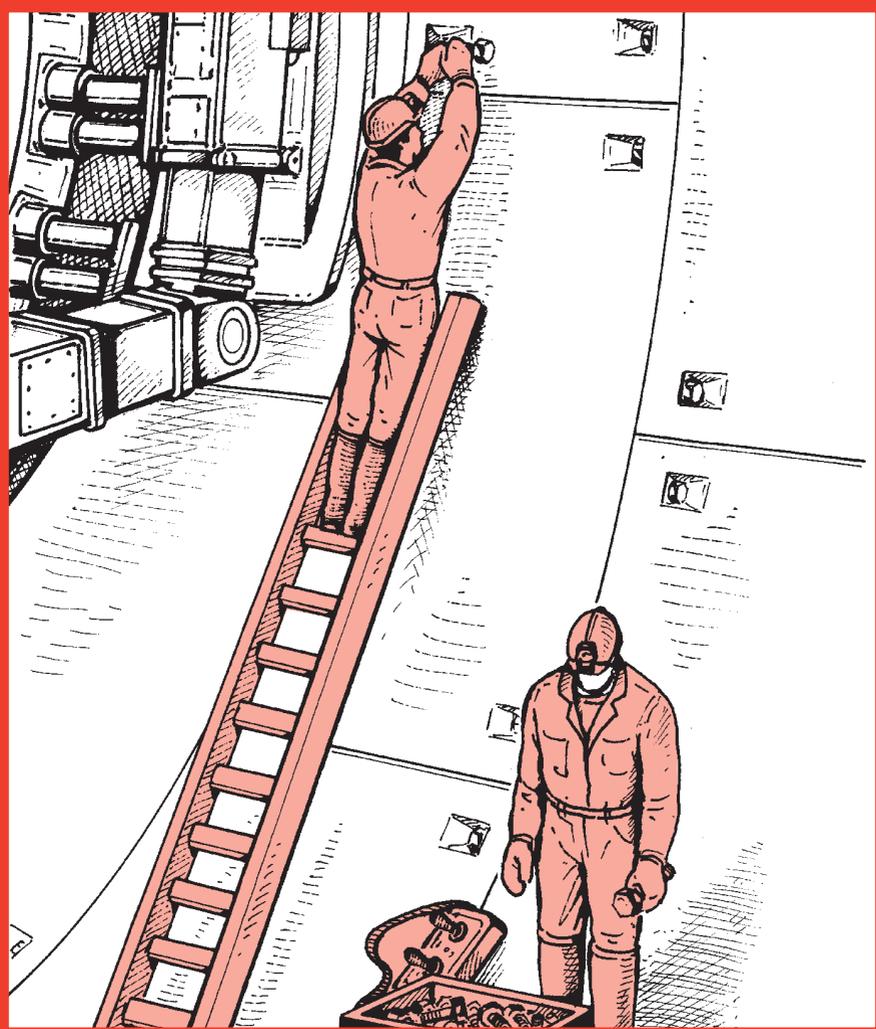
107

Protection

- track operation should be stopped when works are carried out
- use gates or signalling system (stoplights)
- driver cabs at both ends of train

8.4

Installing Segments (big tunnel)



108

Danger

- falling
- being crushed



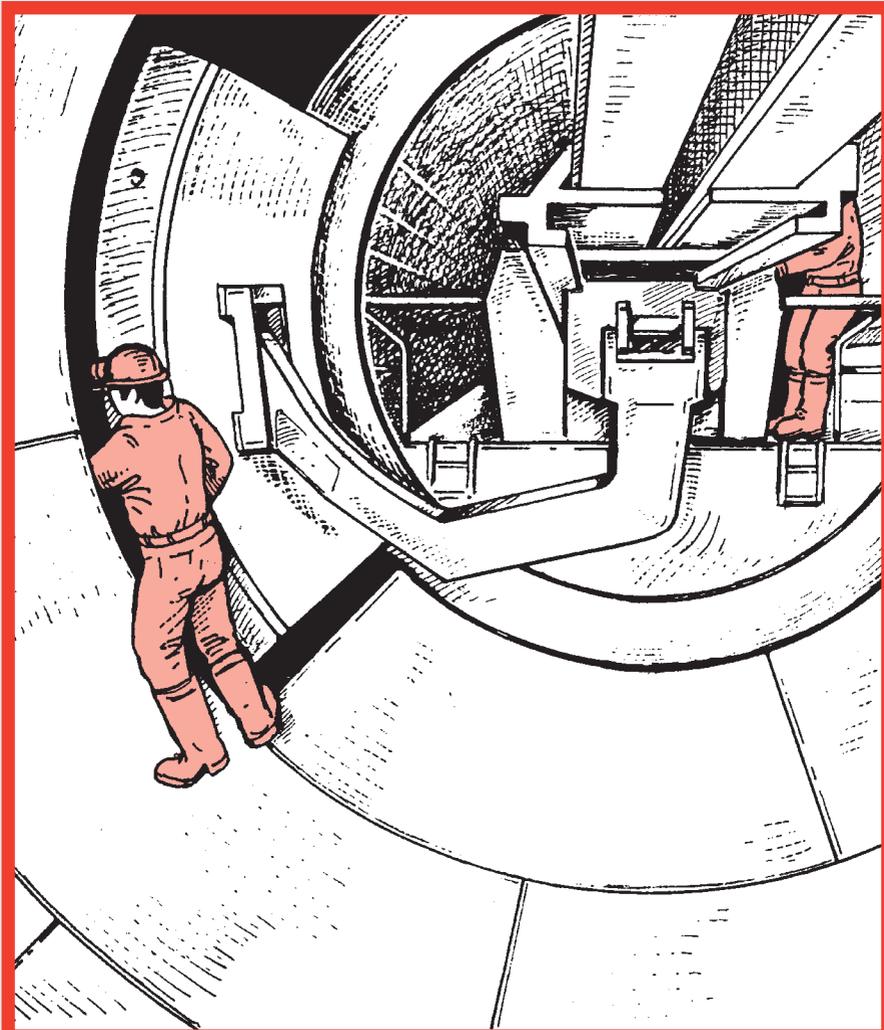
109

Protection

- provide safe, defined working place, use platform
- do not enter danger zone when segments are being put in place
- maintain eye / visual contact with segment erector operator

8.5

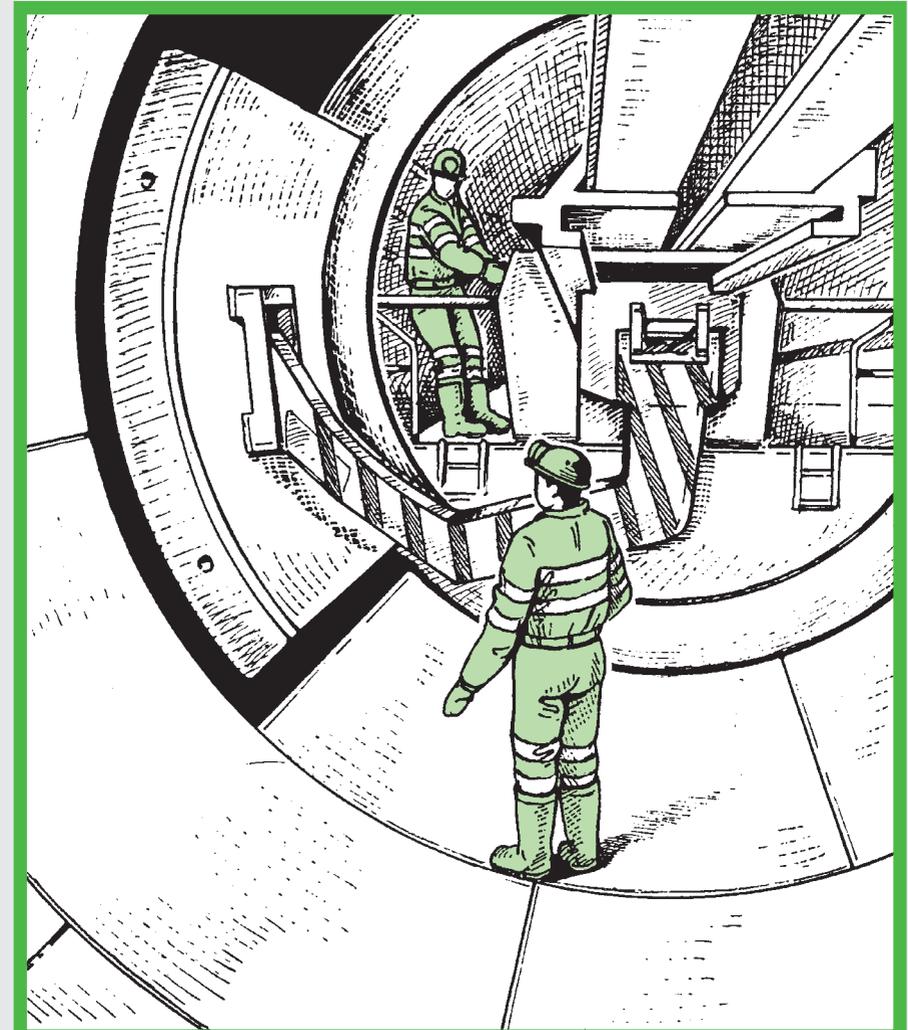
Installing Segments (small tunnel)



110

Danger

- being crushed
- being knocked down



111

Protection

- do not enter danger zone when segments are being put in place
- maintain eye / visual contact with segment erector operator

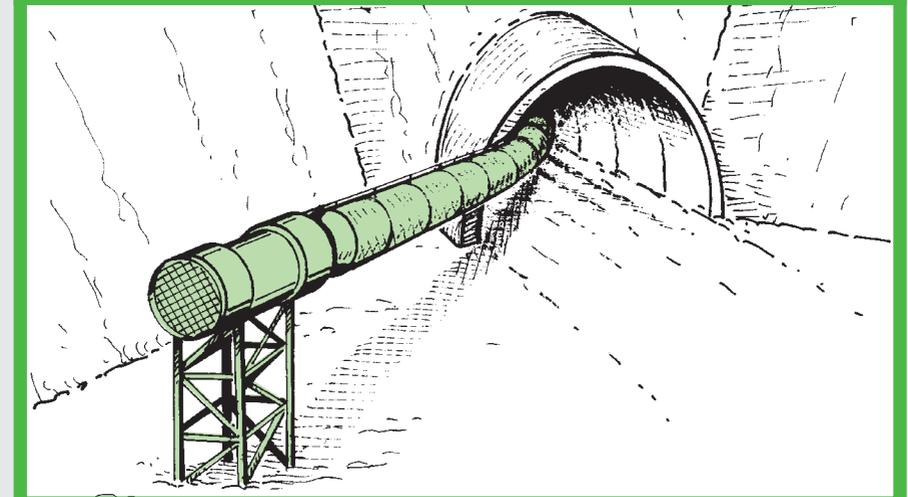
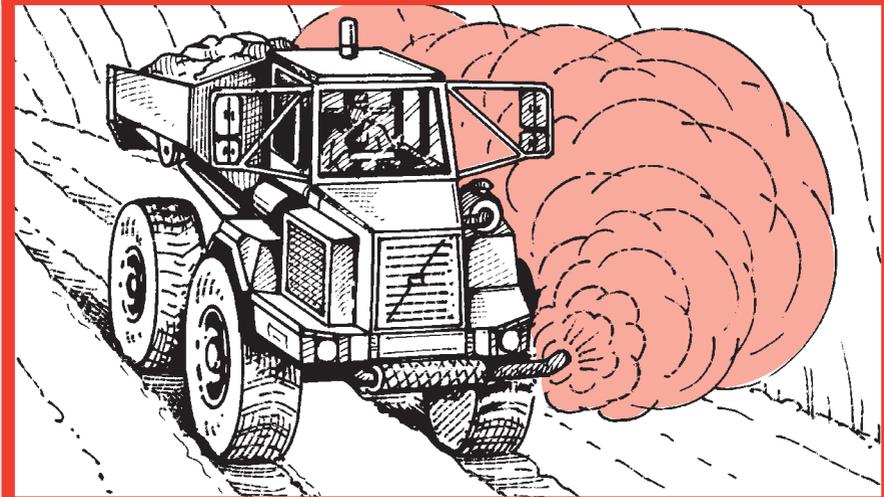
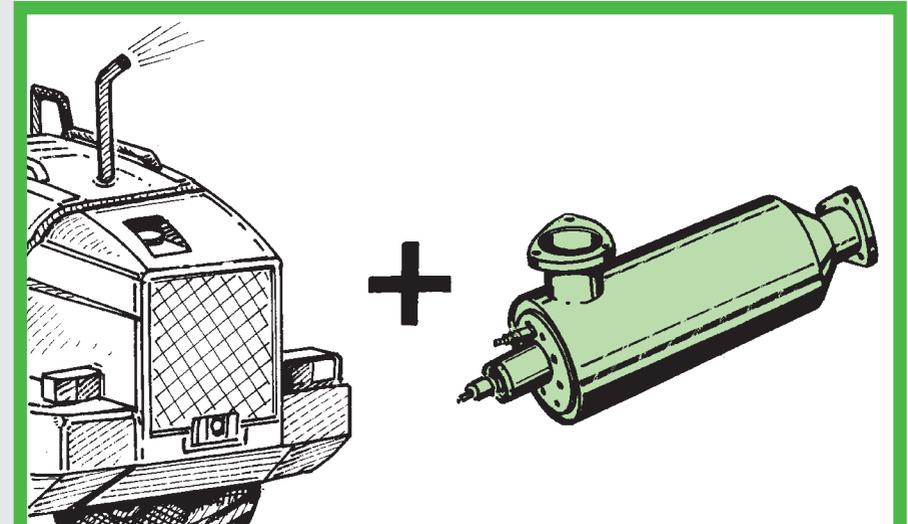
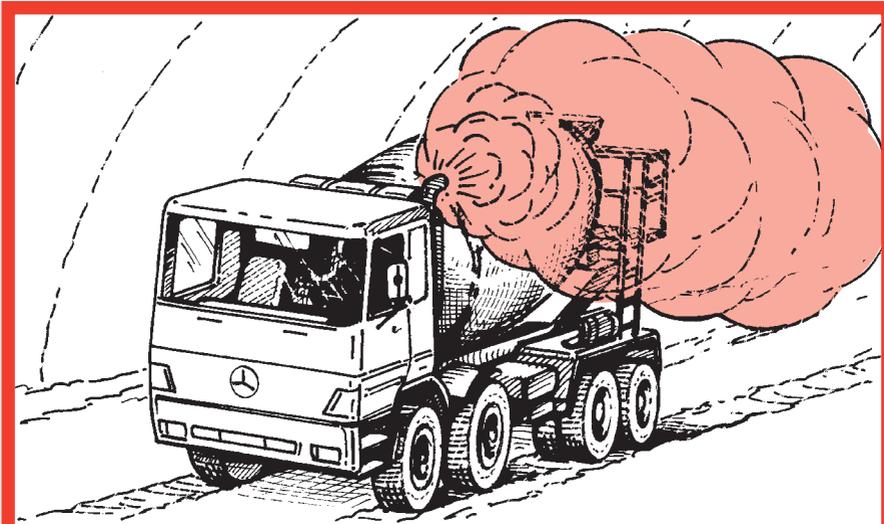
9

Toxic Substances in the Breathing Air



9.1

Diesel Motor Emissions



114

Danger

- diesel engine exhaust gas

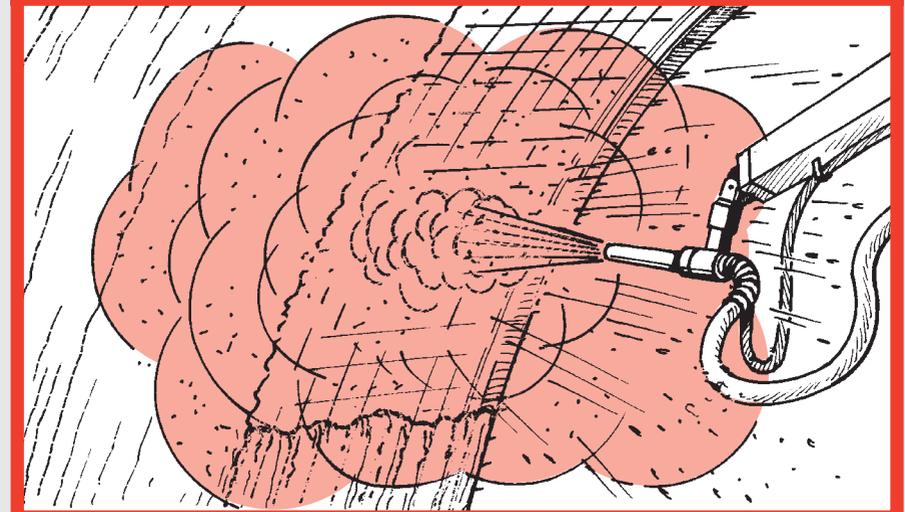
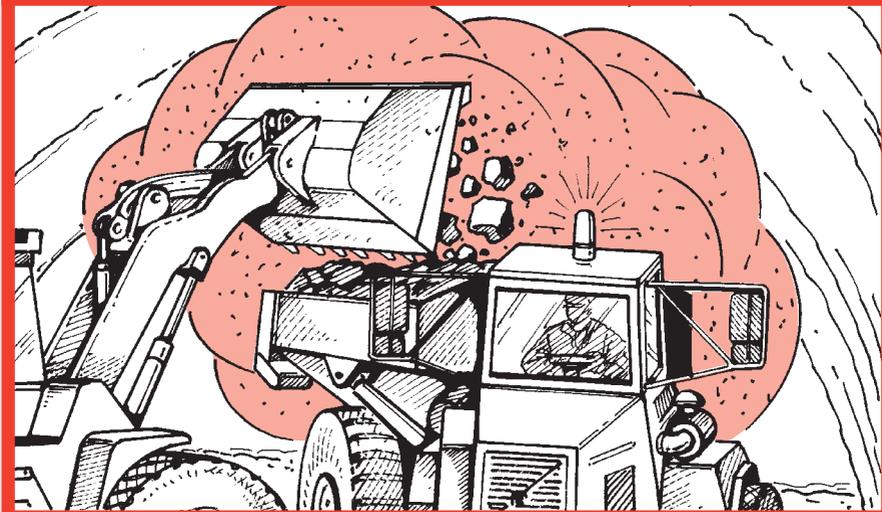
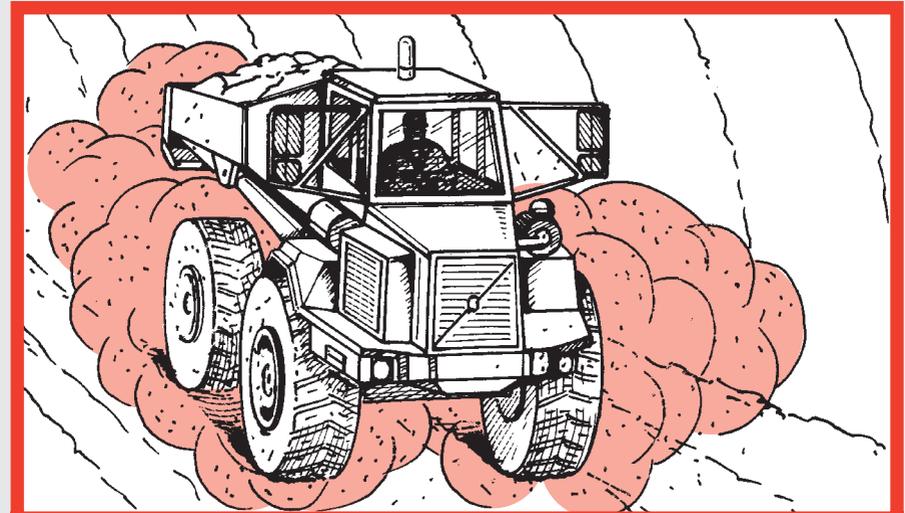
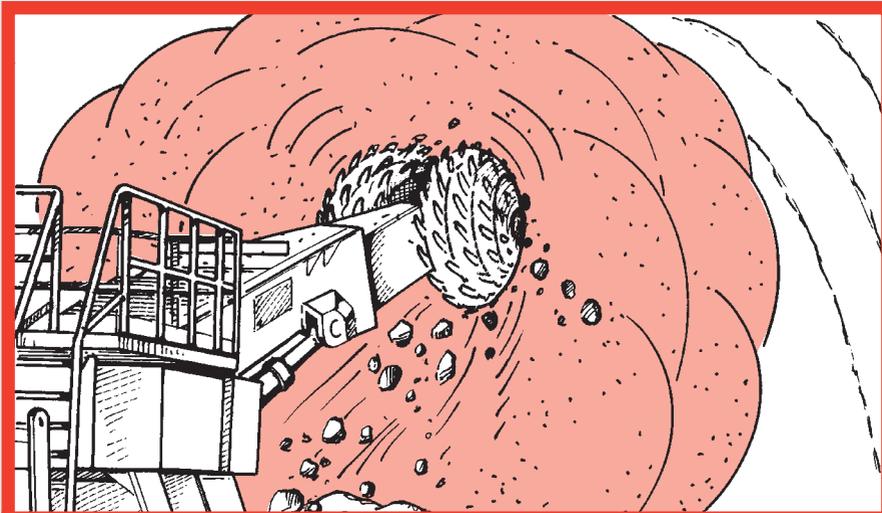
115

Protection

- equip machinery with particle filters
- use low emission diesel engine
- do not let the engine running unnecessarily
- provide sufficient ventilation

9.2

Dust Emission



116

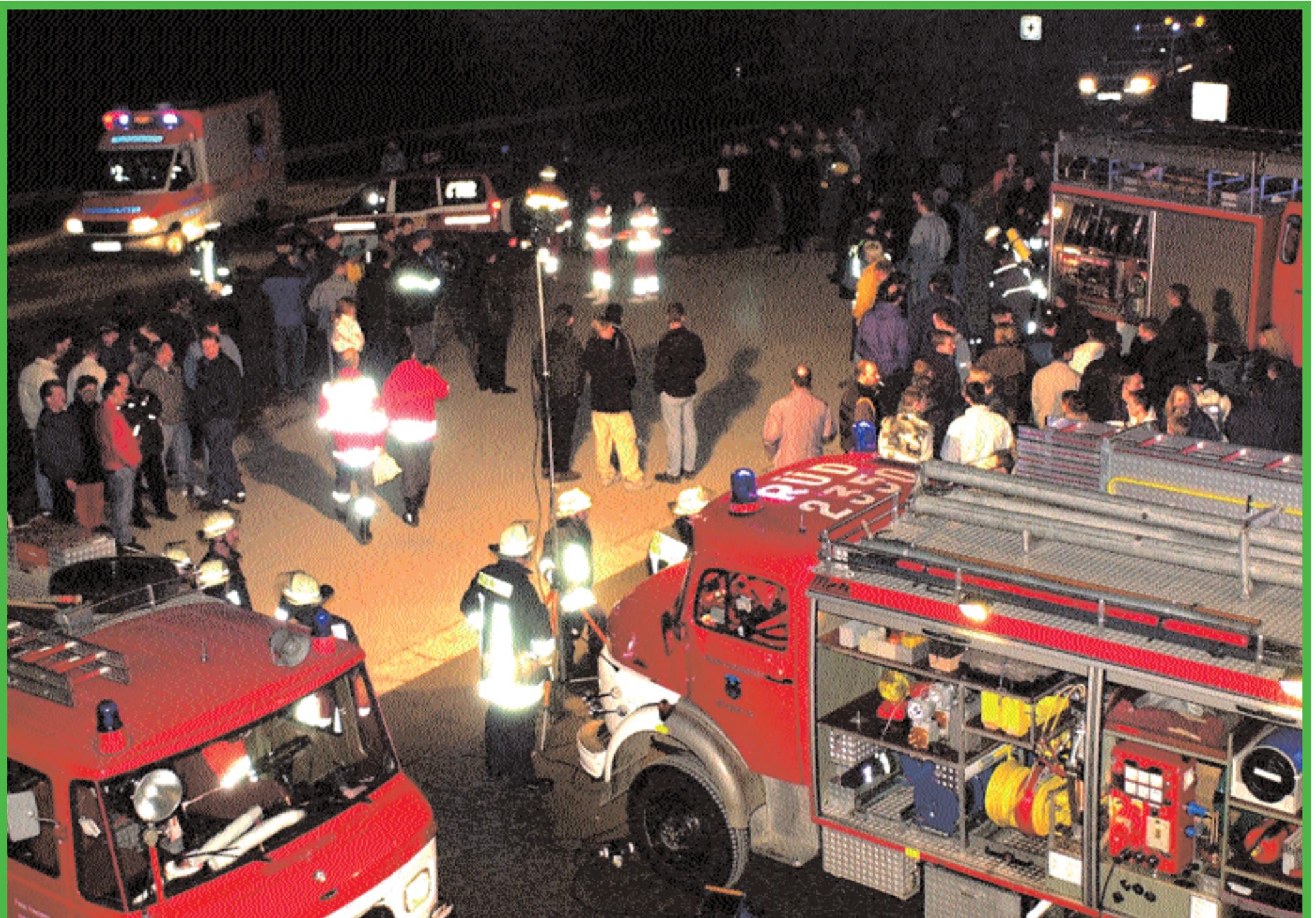
Danger

- harmful dust (silicosis, black lungs, other lung damage)

117

Danger

- provide sufficient extraction ventilation
- exhaust dusts
- wet dusty areas
- use appropriate respiratory protection



10.1

Rescue Chain



120

On-the-spot-measures
(on principle: do not move injured person
unless in further danger)

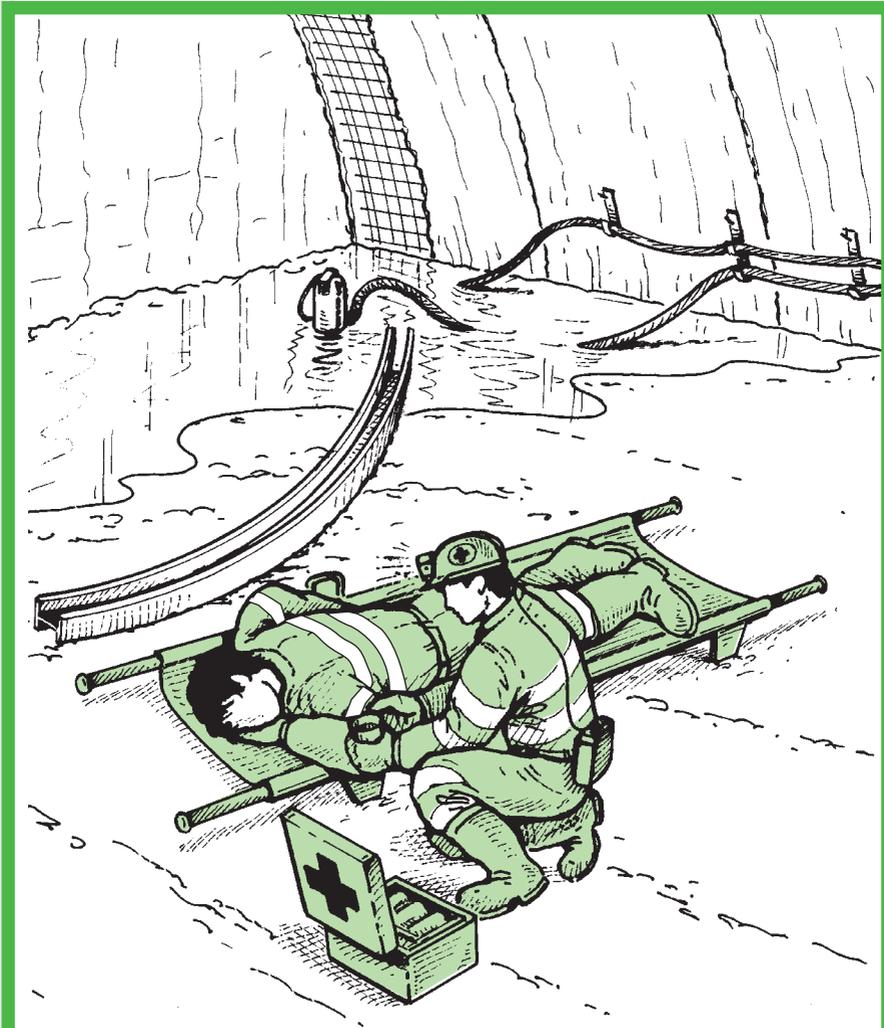


121

Emergency call

10.2

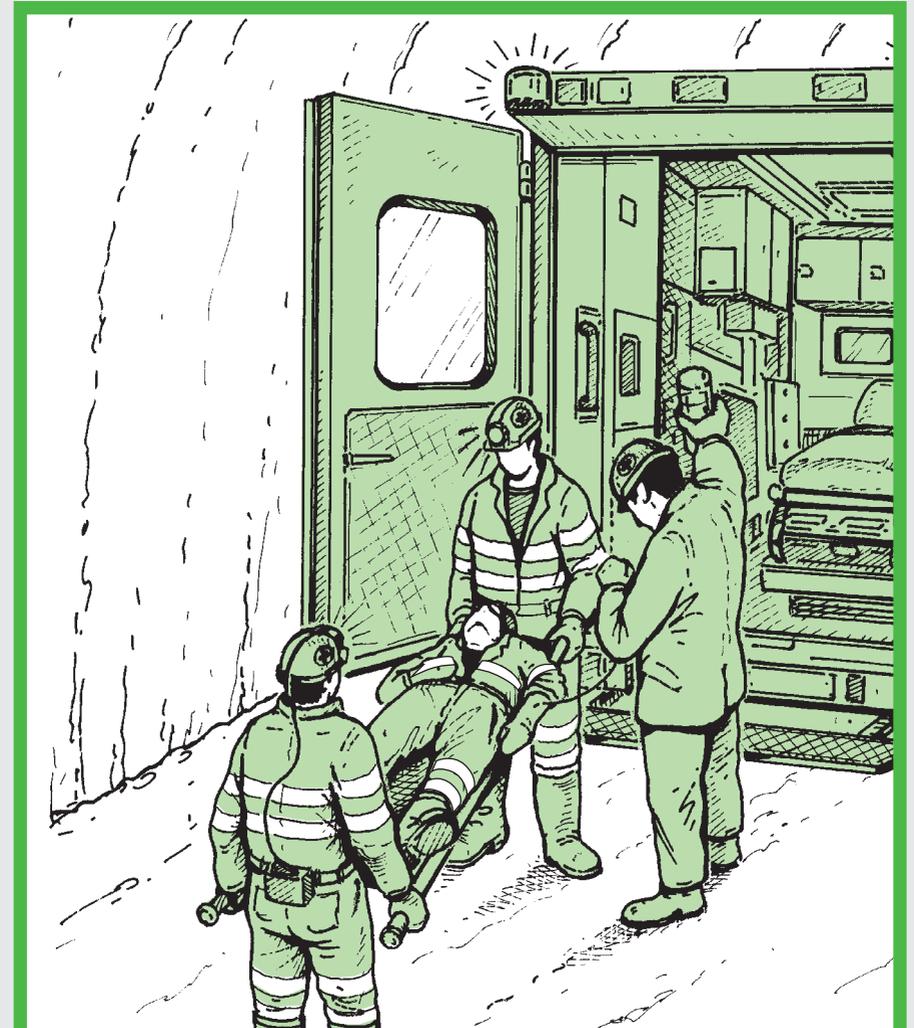
Rescue Chain



122

First Aid

(if casualty unconscious turn head to side to prevent suffocation)



123

Transport to medical centre

Picture Proof

Front page

ARGE Engelberg-Basistunnel
Züblin, Bilfinger+Berger, Hochtief, Baresel,
Wayss & Freytag, Wolff & Müller

Last page

ARGE Pumpspeicherwerk Goldisthal
Walter Bau vereinigt mit DYWIDAG, Züblin, STRABAG

Page 4: Geodata

Page 12: Walter Bau AG

Page 22: Philipp Holzmann AG

Page 34: ARGE Rennsteig Tunnel

Page 48: Vereina Tunnel

Page 70: ARGE Rennsteig Tunnel

Page 92: Walter Bau AG

Page 100: ARGE 4te Röhre Elbtunnel

Herrenknecht AG

Page 112: ARGE Rennsteig Tunnel

Page 118: ICE Tunnel Idstein

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