

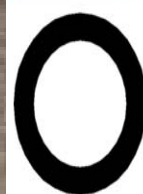
SAFE WORKING IN TUNNELING

For tunnel workers and first line supervision



BG BAU

Berufsgenossenschaft
der Bauwirtschaft



ASSOCIATION
INTERNATIONALE DES TUNNELS
ET DE L'ESPACE SOUTERRAIN

ITA

AITES

INTERNATIONAL TUNNELLING
AND UNDERGROUND SPACE
ASSOCIATION

SAFE WORKING IN TUNNELING

This document is written
for tunnel workers
and first line supervision

Prepared by the ITA Working Group
'Health and Safety'
and financed by BG BAU and ITA



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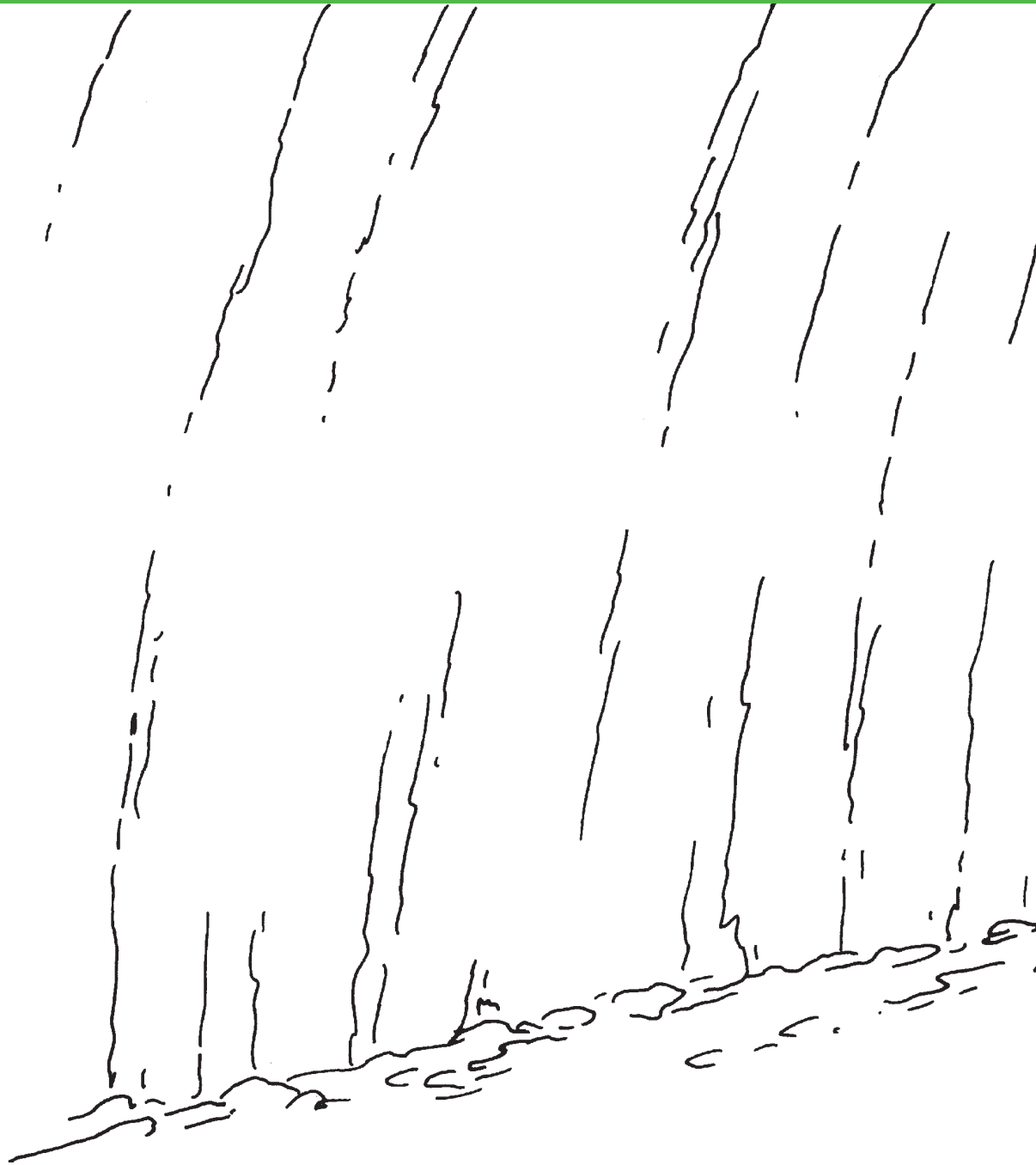


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The Tunneller's Equipment



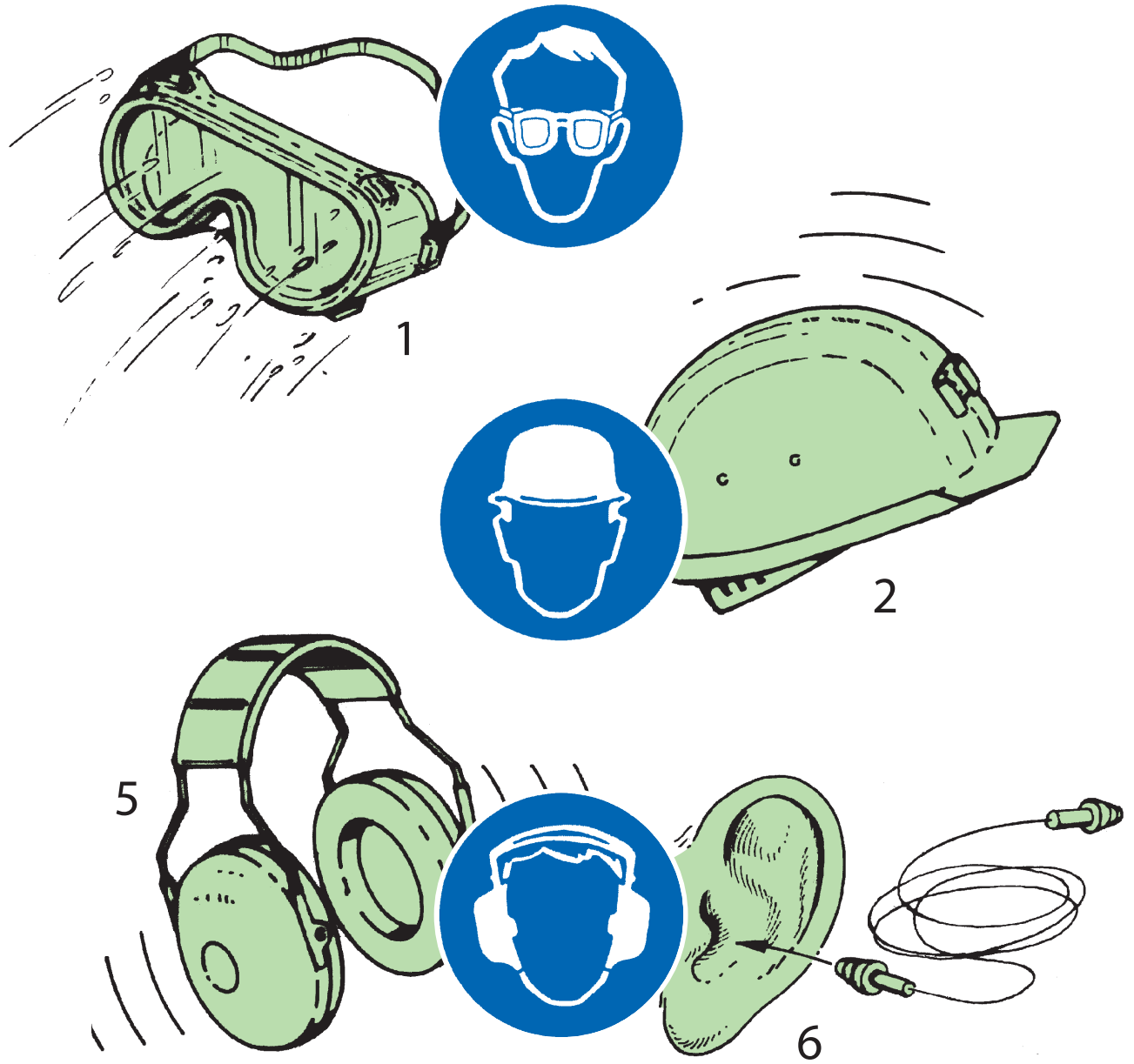


Personal Safety Outfit

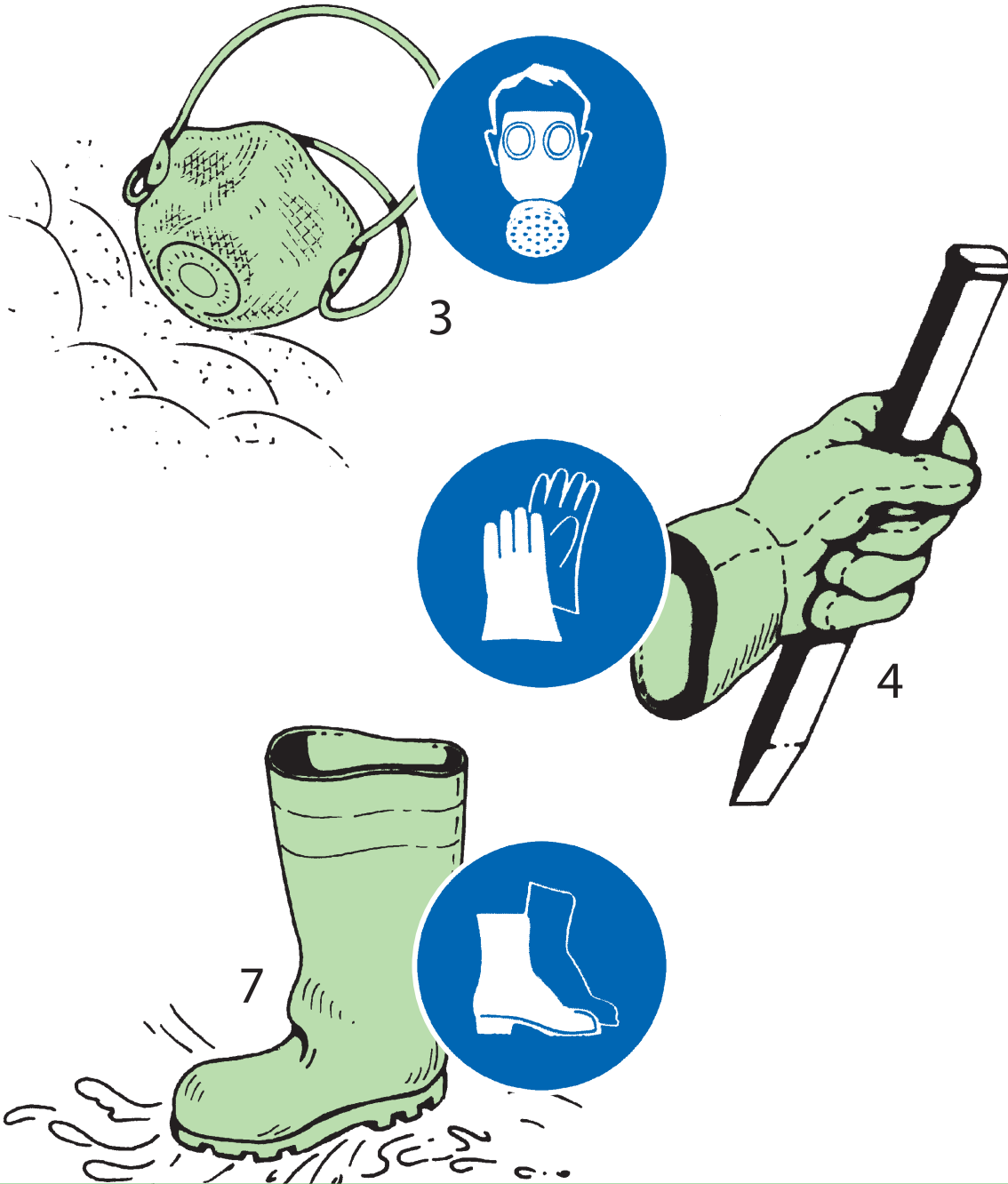


- hard hat
- safety shoes (boots)
- gloves
- protective clothing
- self rescuer
- other personnel protective equipment (depending on working process)

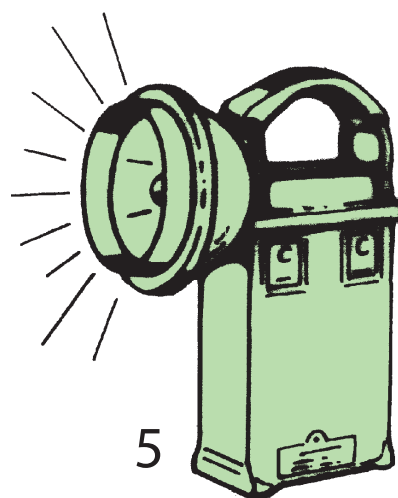
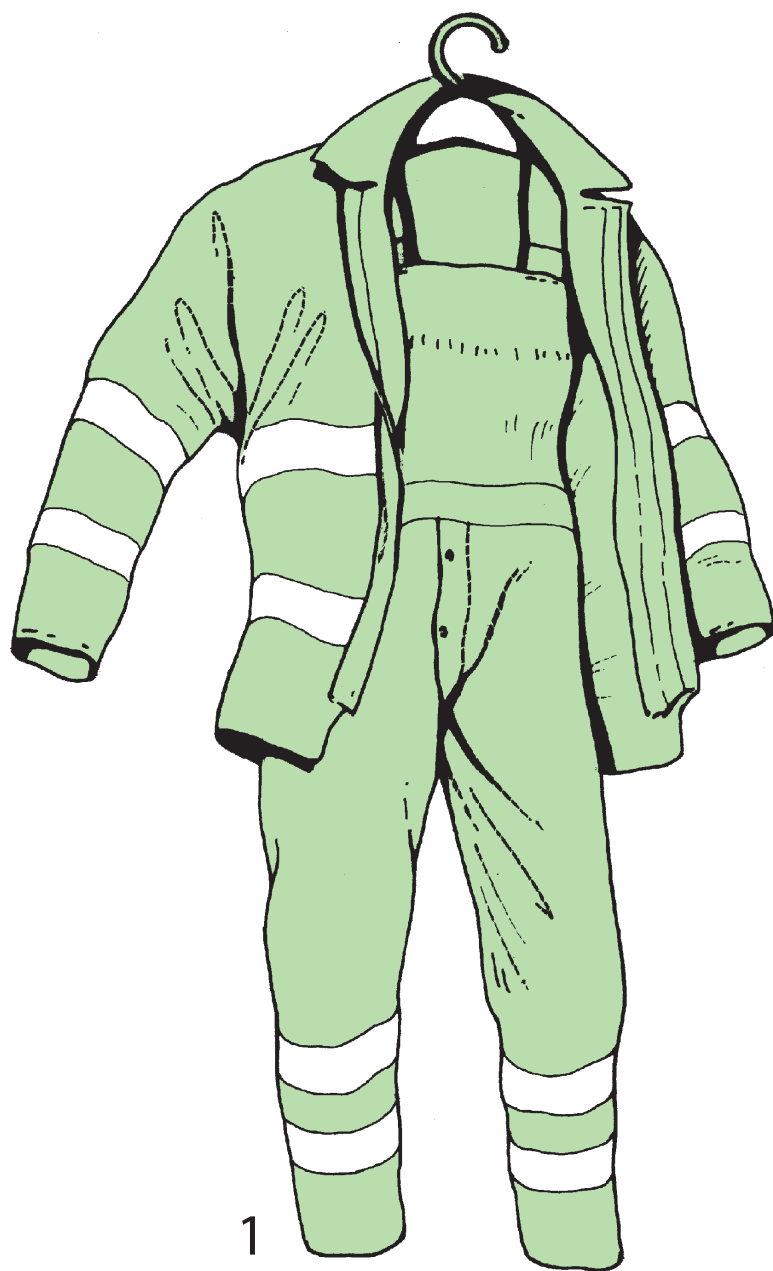
1.2



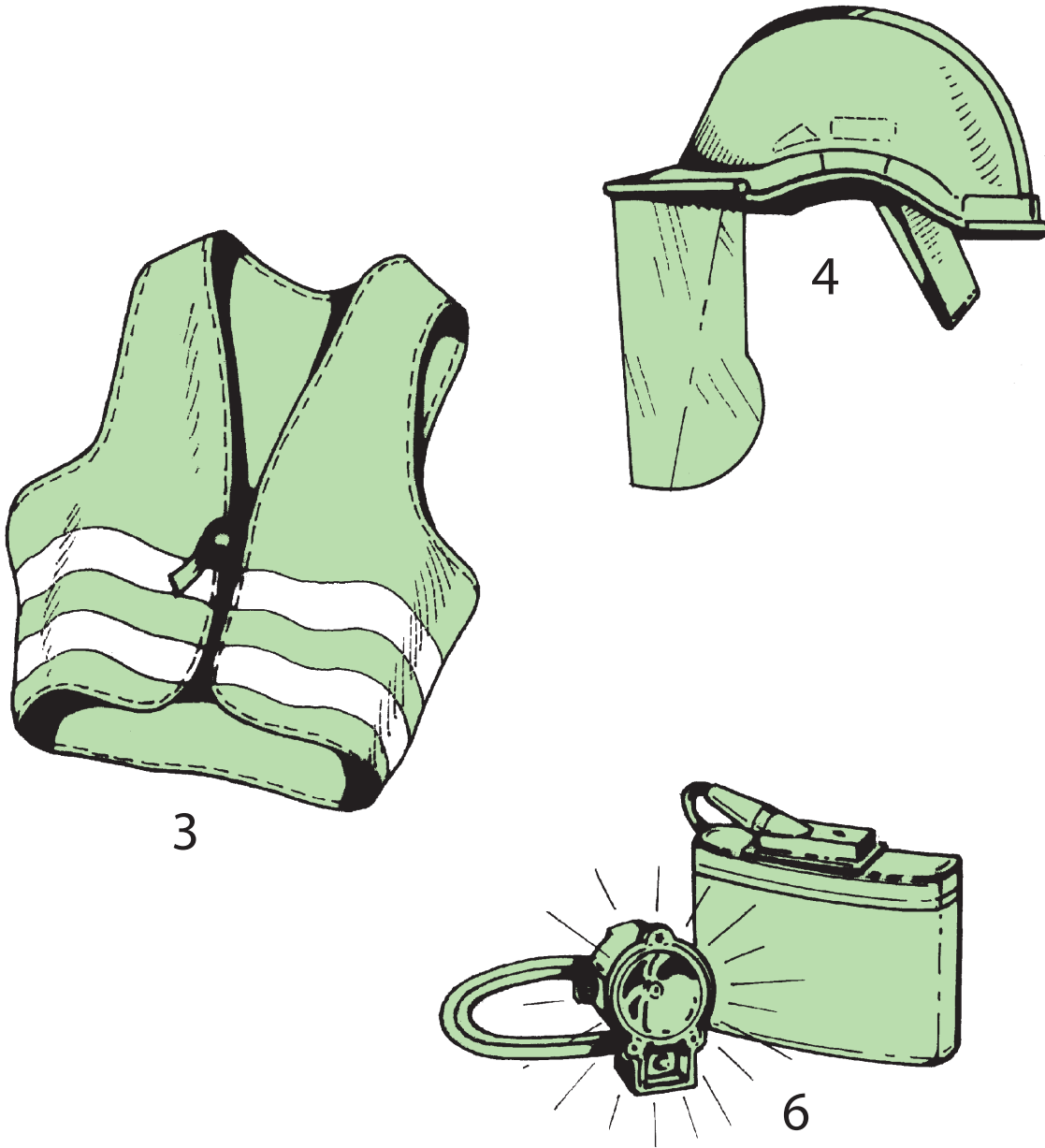
Personal Safety Outfit



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



Personal Safety Outfit

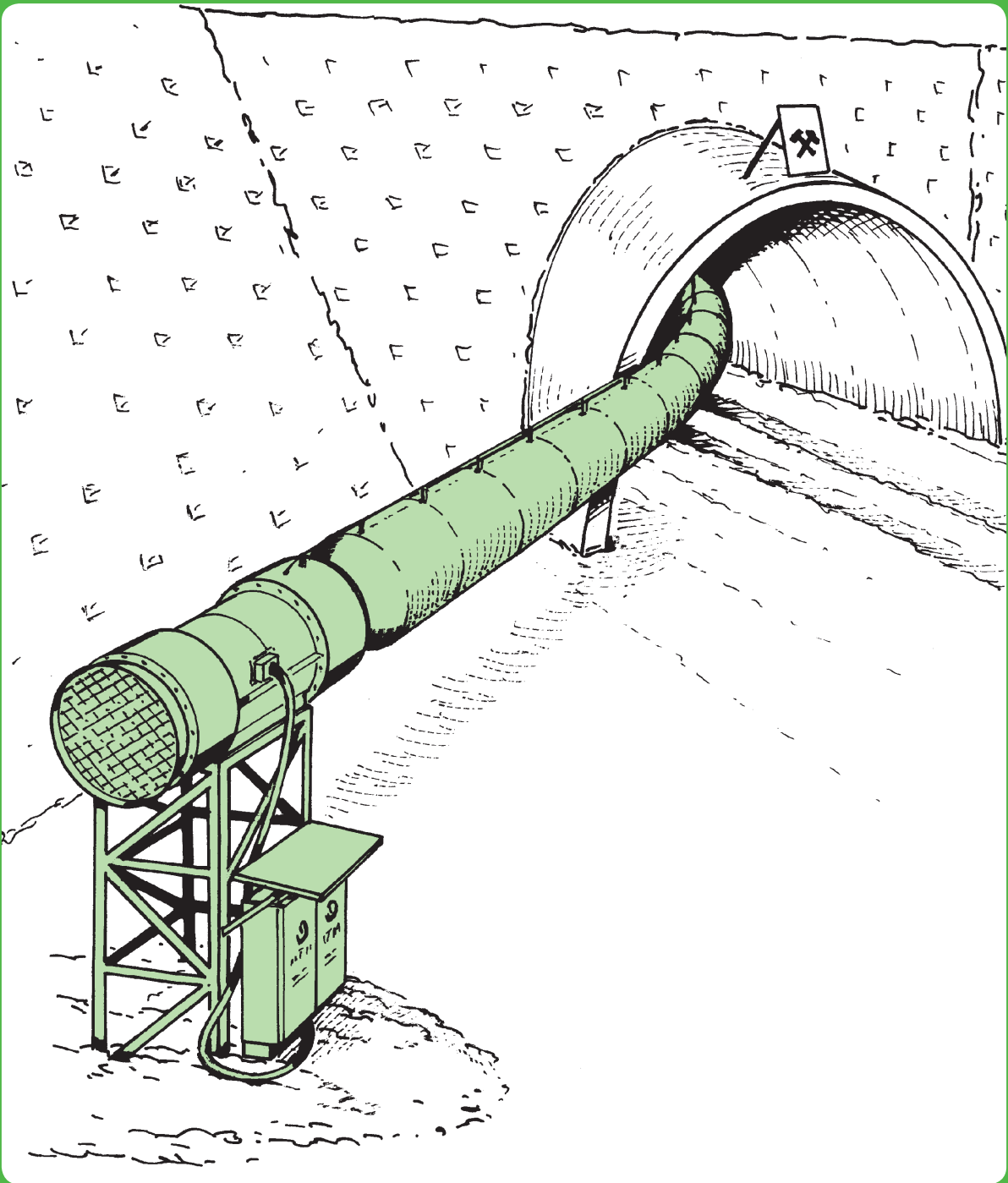


- 1 • high visibility protective clothing
- 2 • self rescuer
- 3 • reflecting warning vest
- 4 • hard hat for shotcreting
- 5 • hand lamp
- 6 • cap lamp



Tunnel Installations



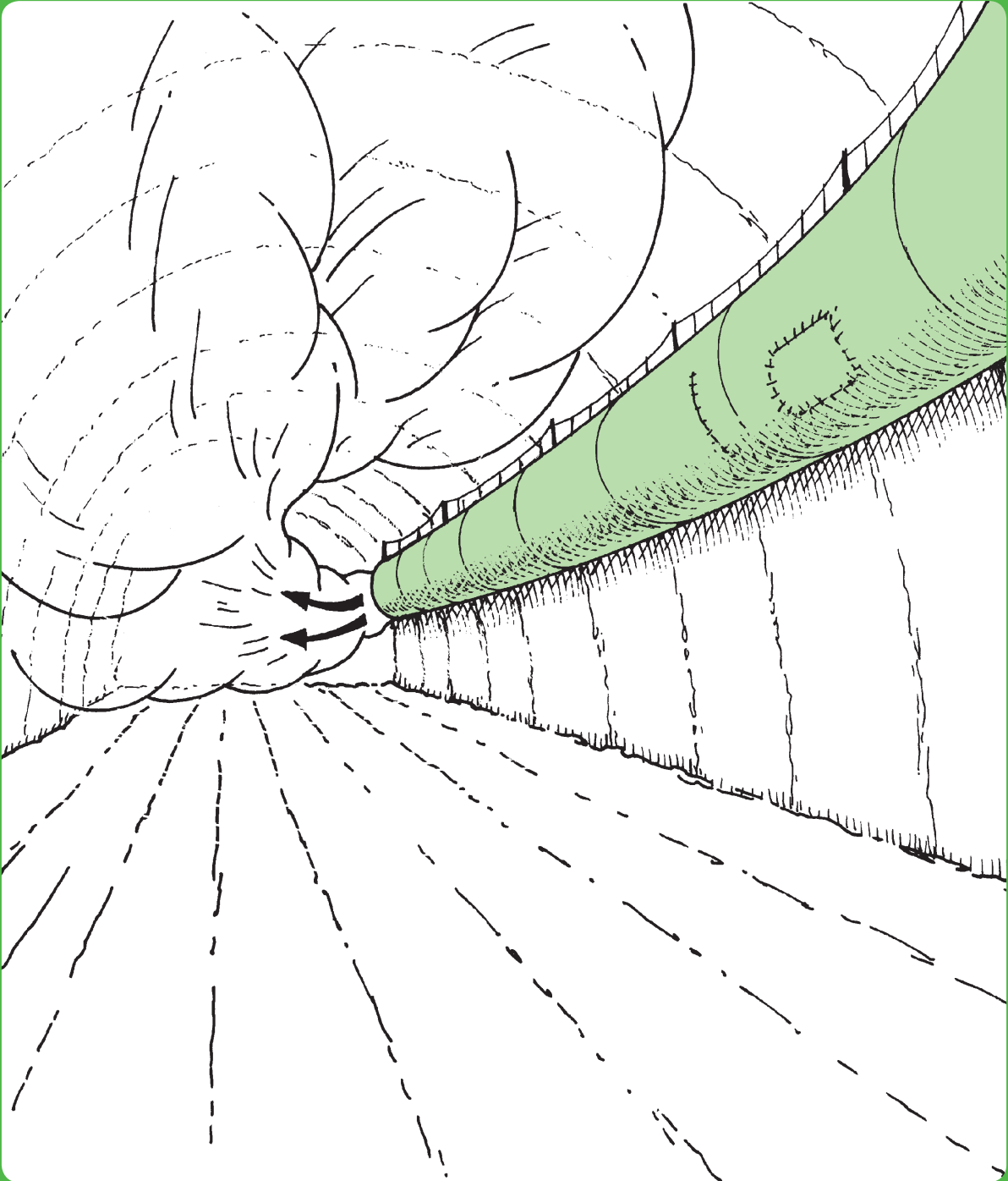


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Ventilation

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

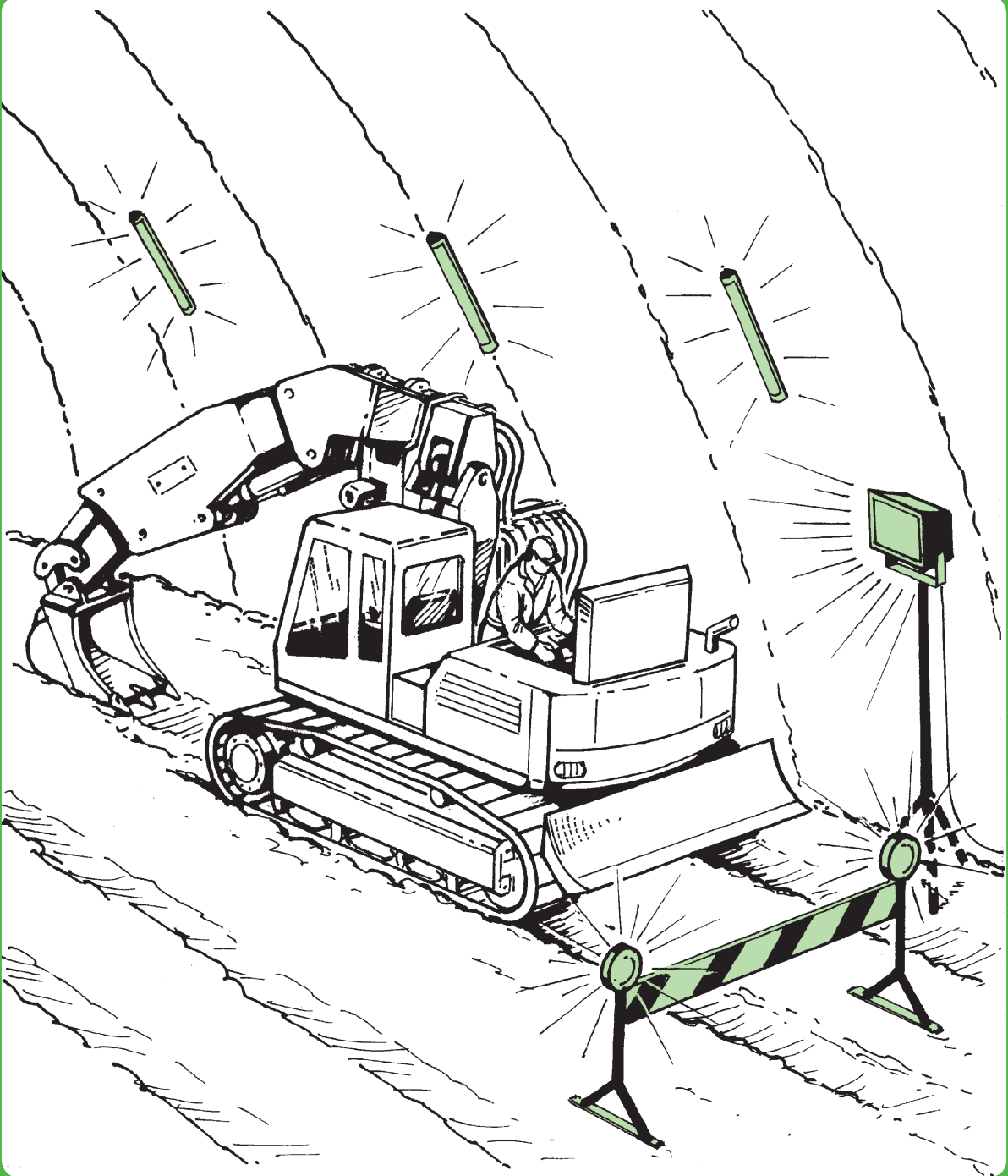
Ventilation



Fresh air ducts

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

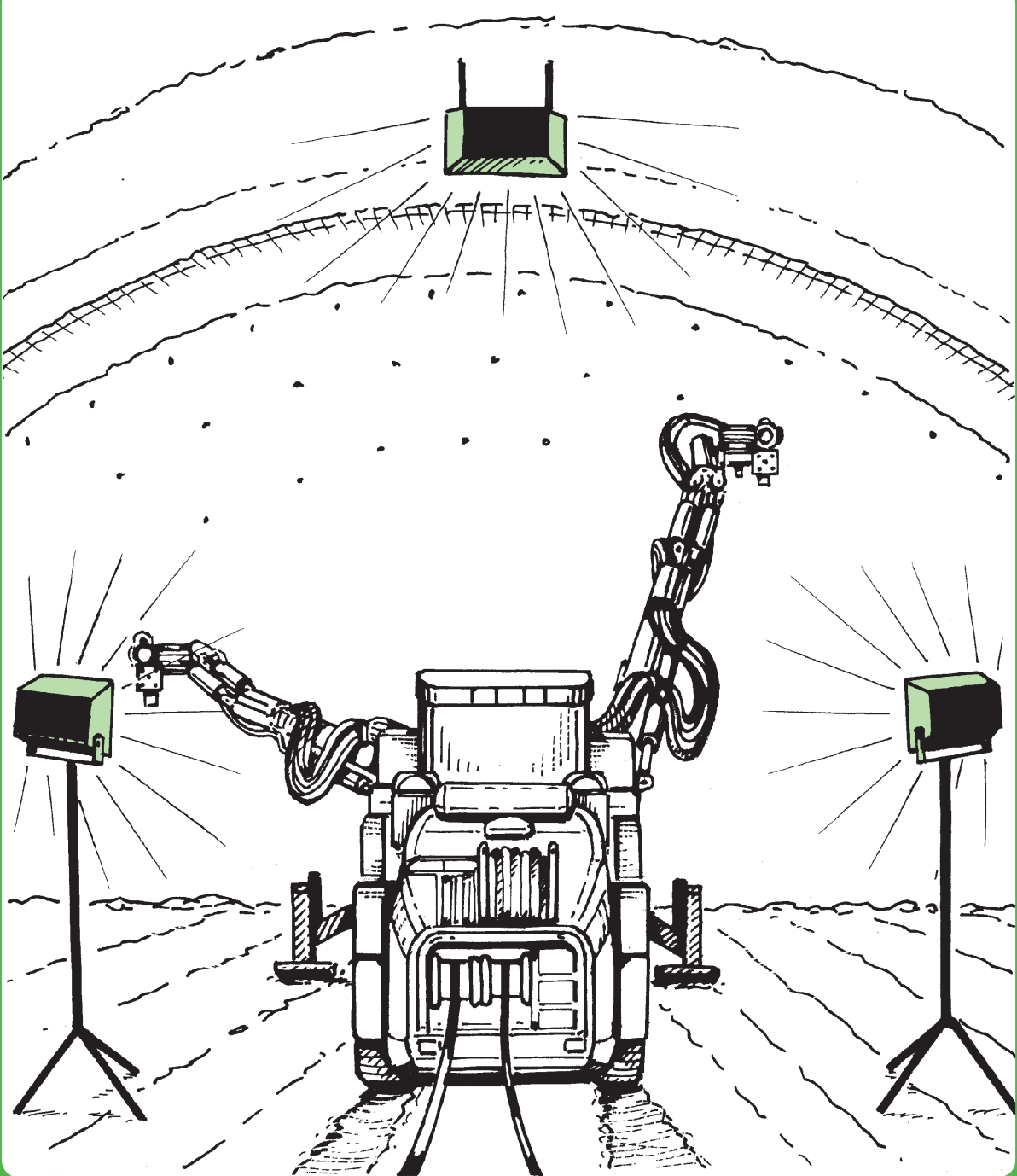
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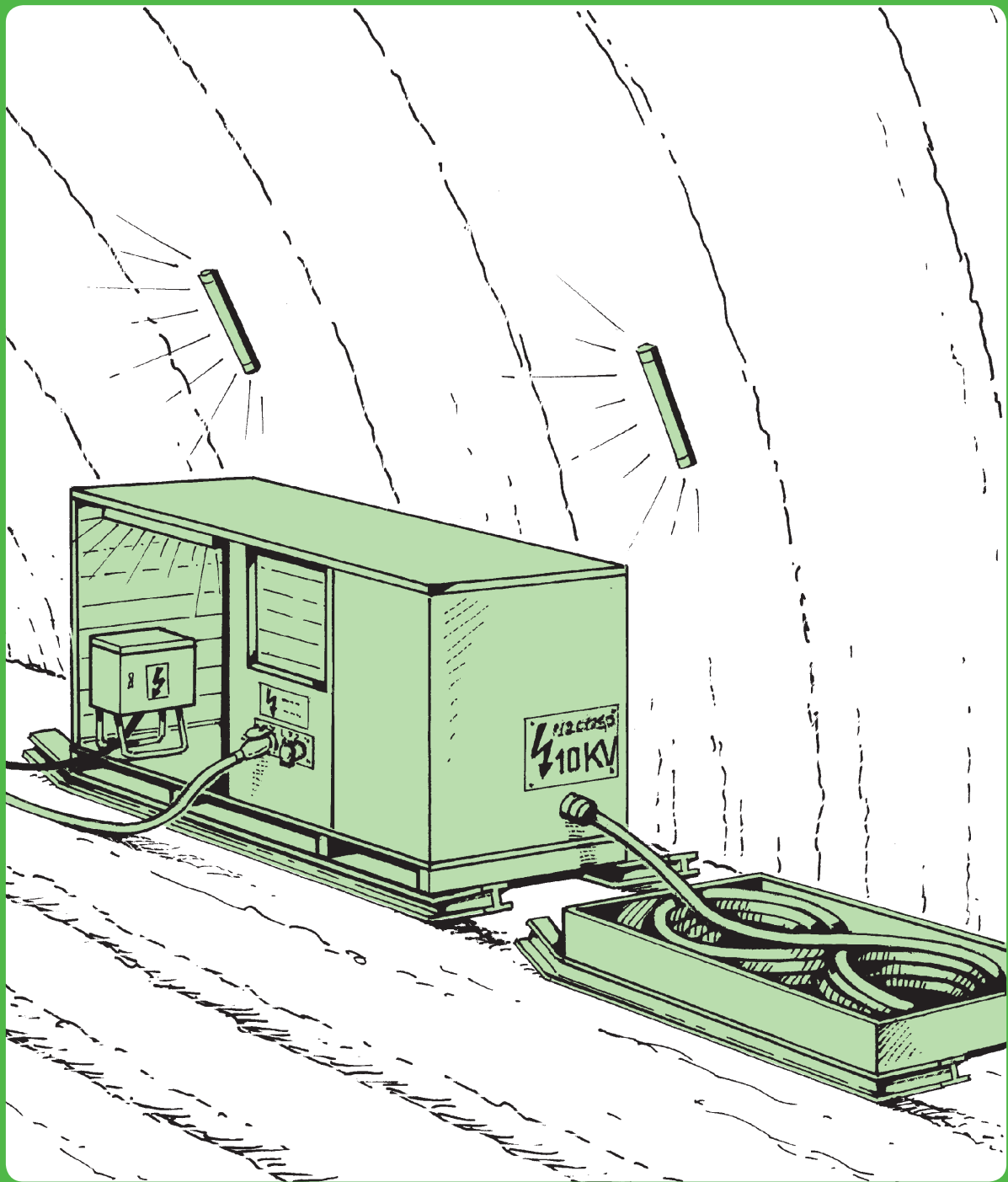
- light all work places and access ways
- install special lighting at dangerous places
- use flashing warning lights adjacent to dangerous locations

Lighting



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

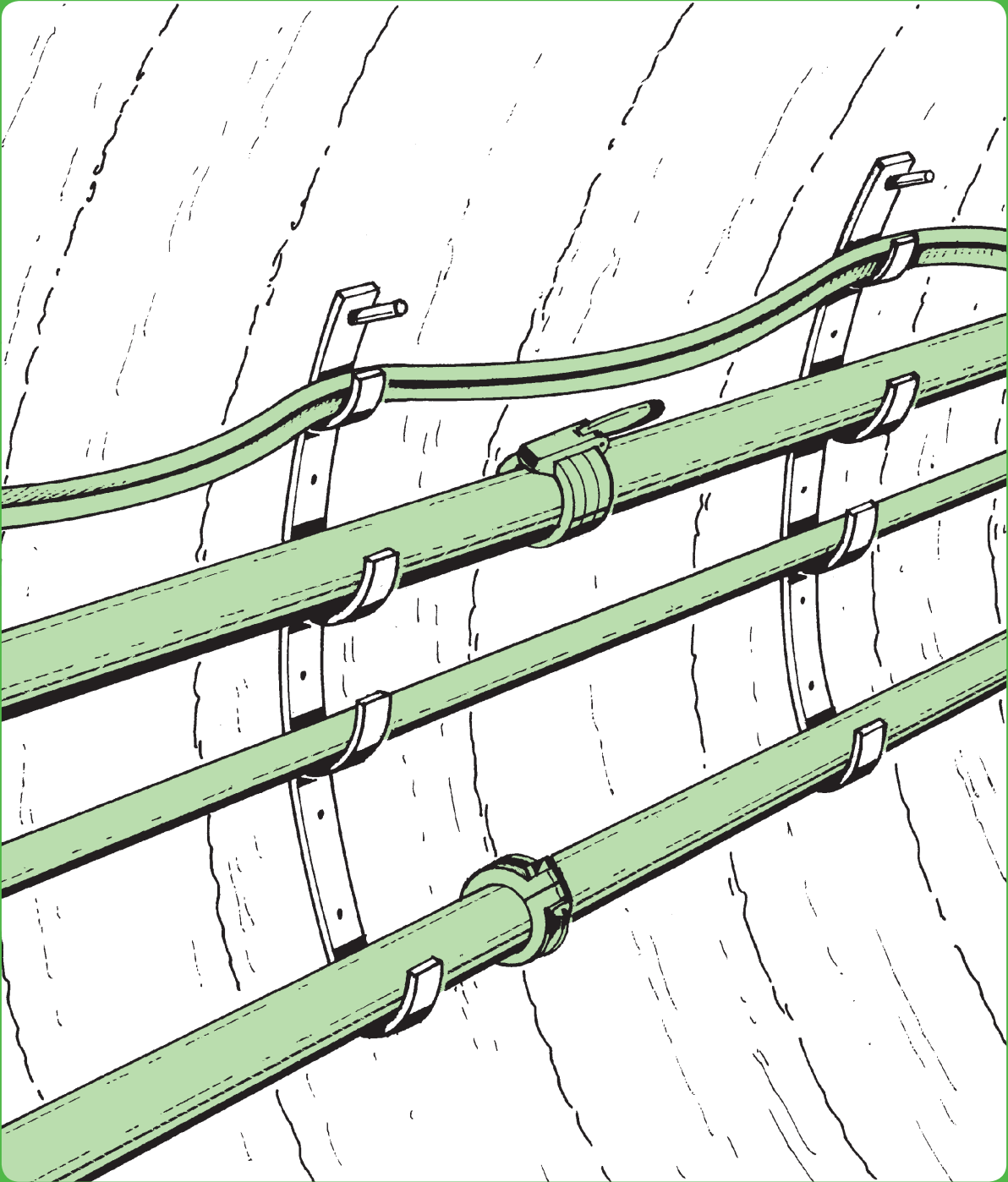
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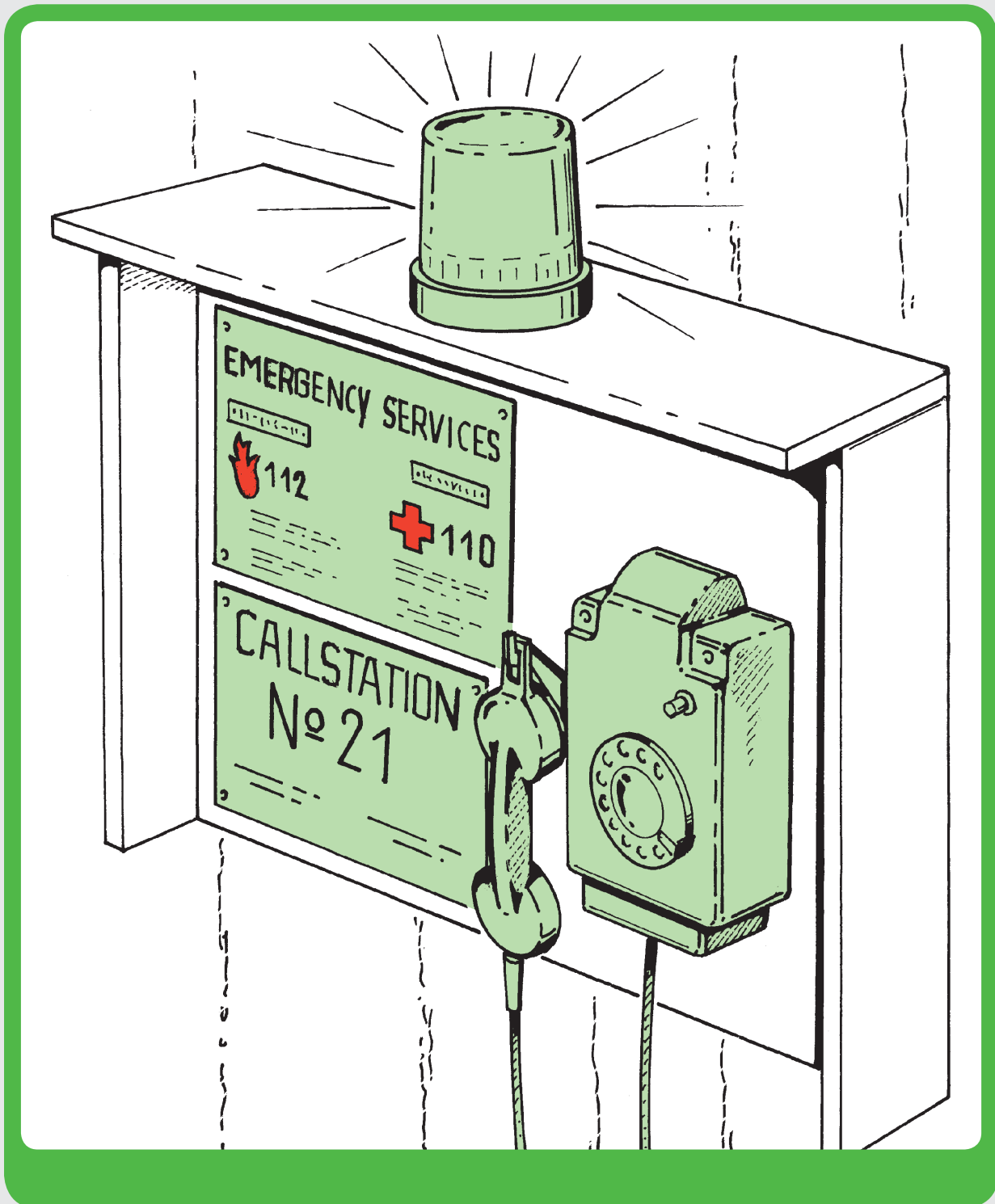
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- all electrical installations to be set, modified and repaired by qualified electricians;
(work on high voltage network [transmission or power lines] only permitted with a special authorisation)
- adhere to national requirements
- use earth fault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

Electrical Installations and Supply Lines

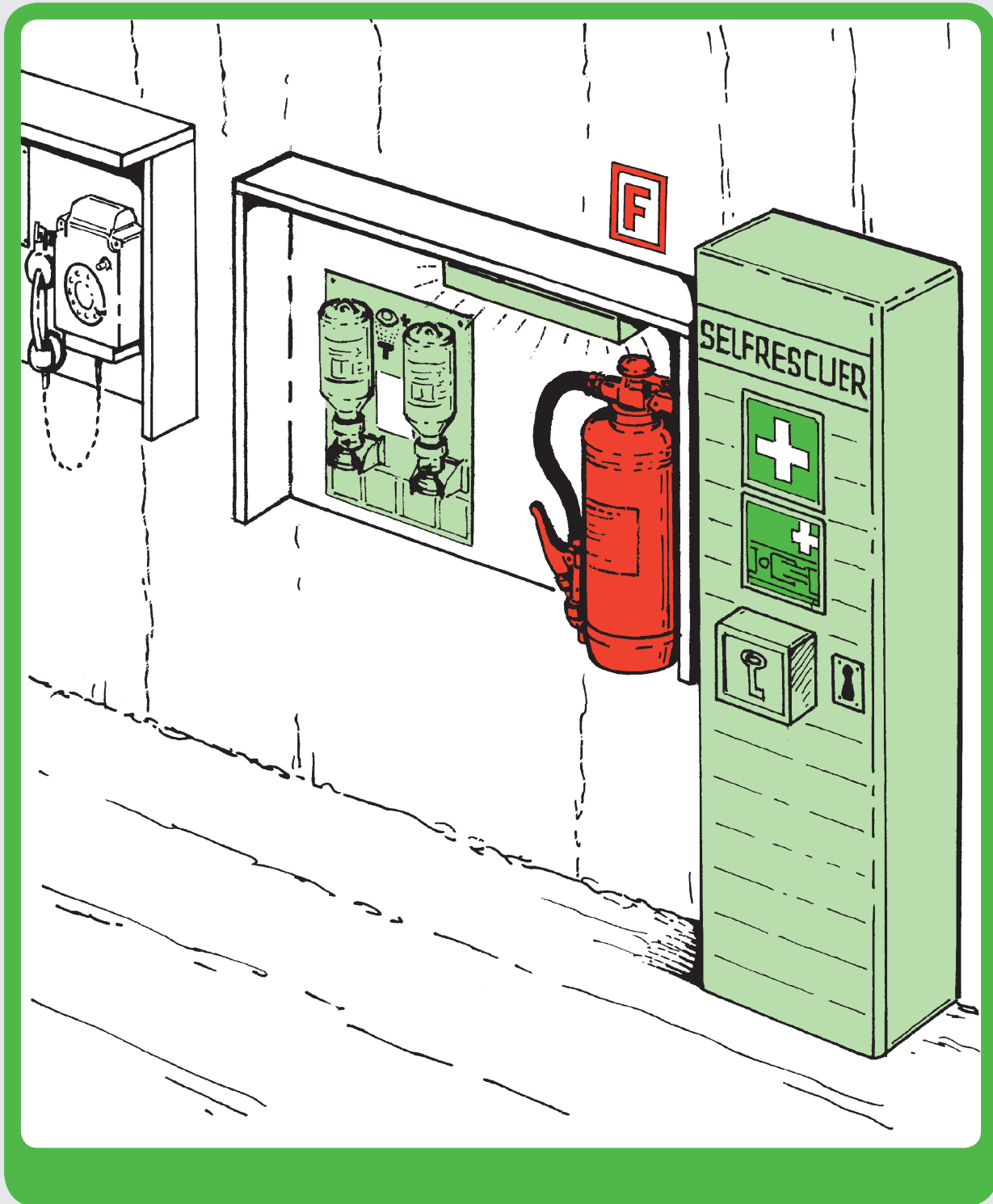


- support cables and pipelines securely on brackets against risks of impact, bending, abrasion, tension
- use appropriate fittings and coupling system



- 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)

Emergency Equipment

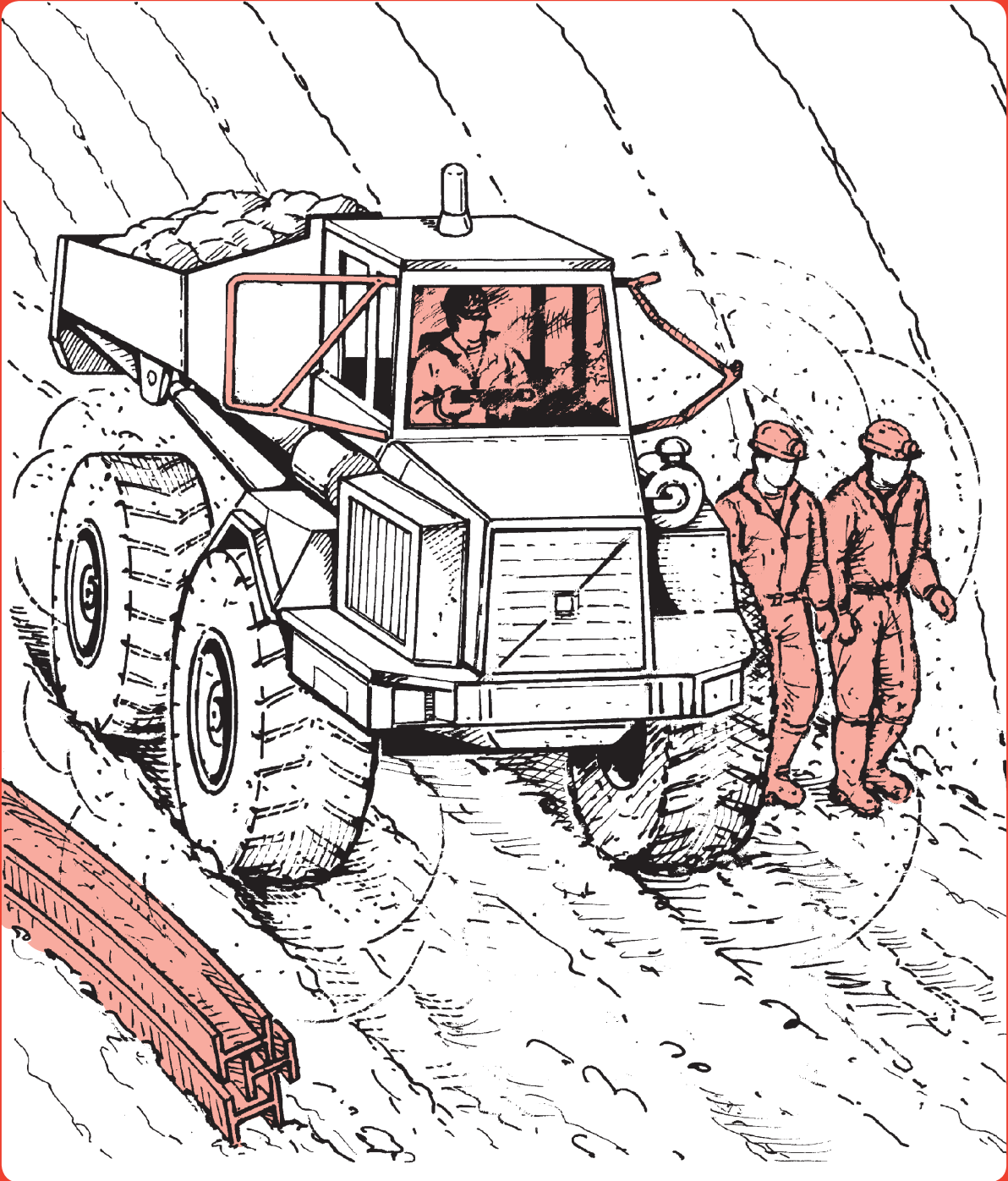


- set up first aid and rescue installations
- set up appropriate fire extinguishers (observe fire classification)
- provide self-rescuers of sufficient number and size



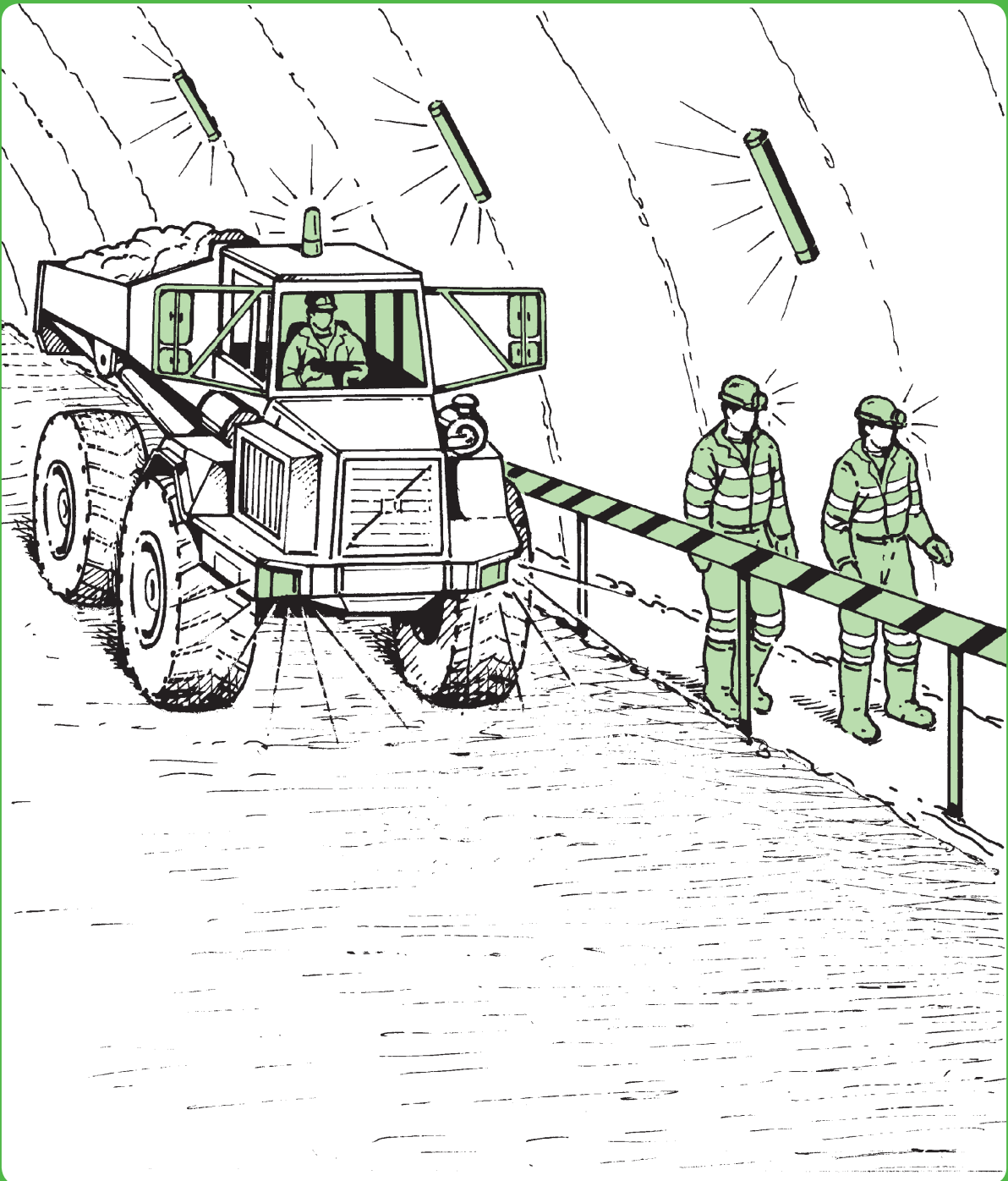
Walkways to Working Places



**Danger**

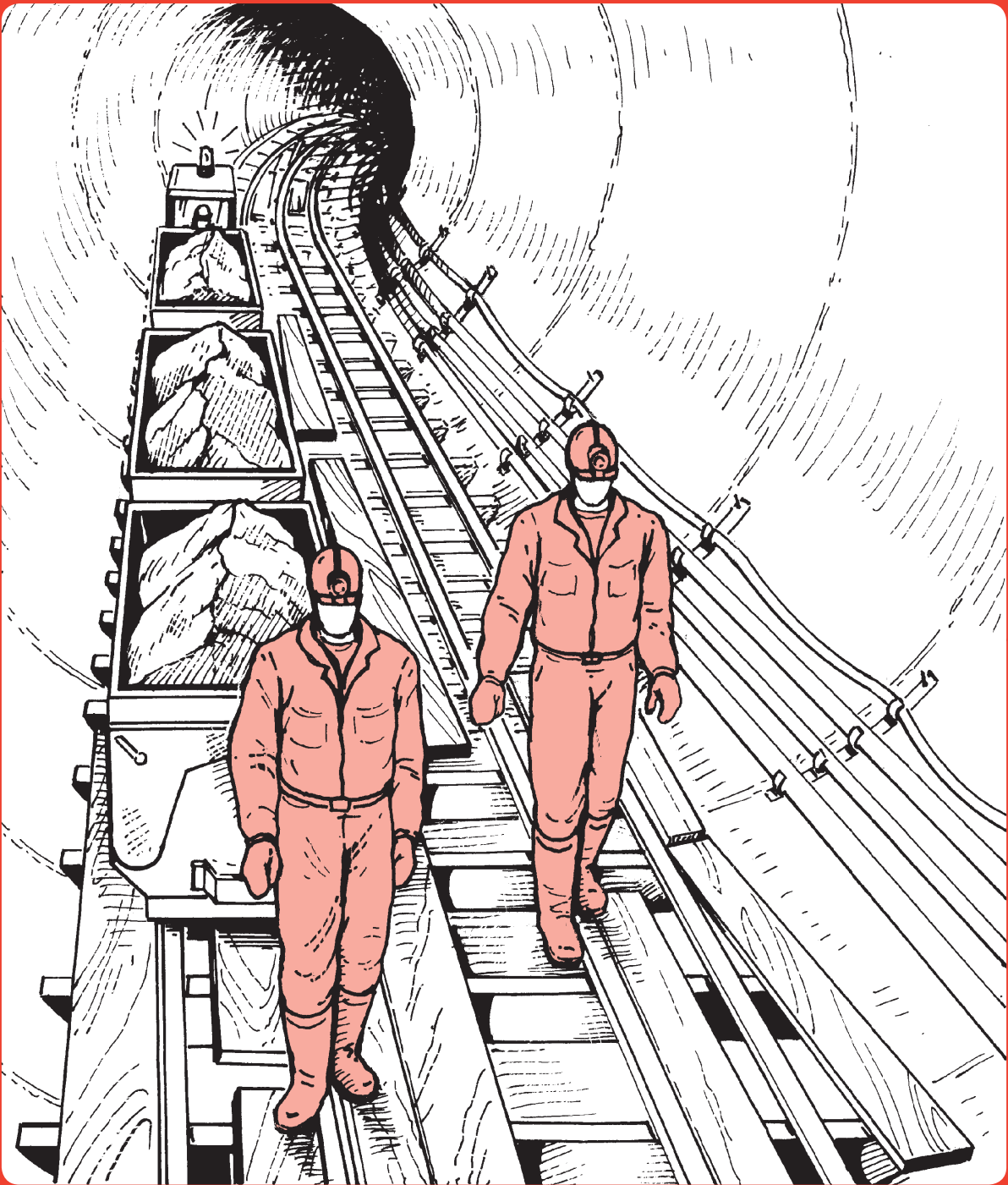
- being struck / run over

Walkways with Rubber-Tyred Vehicles



Protection

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



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Danger

- being struck / run over
- slipping and tripping hazards

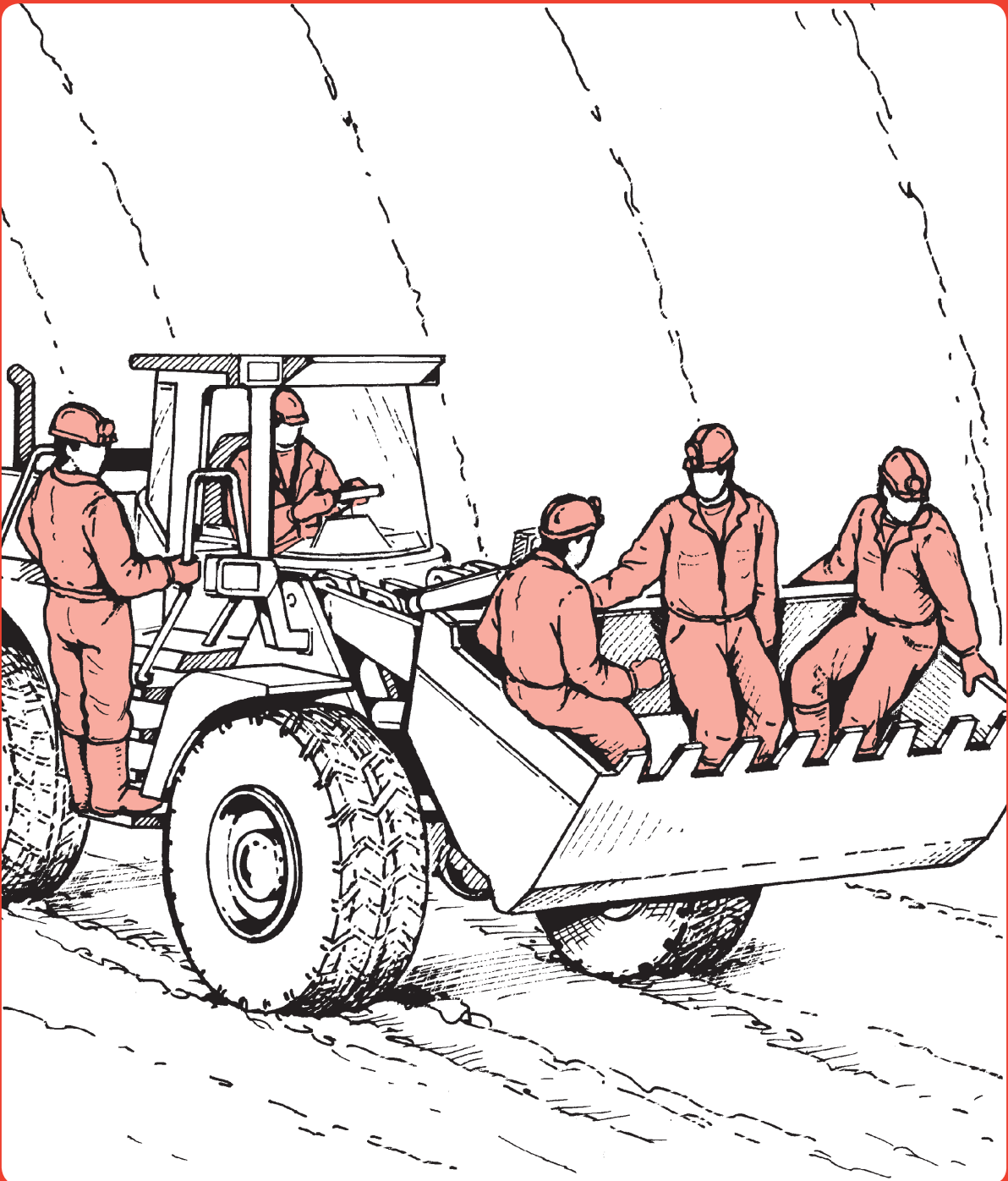
Walkways with Track Operation



Protection

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

3.3

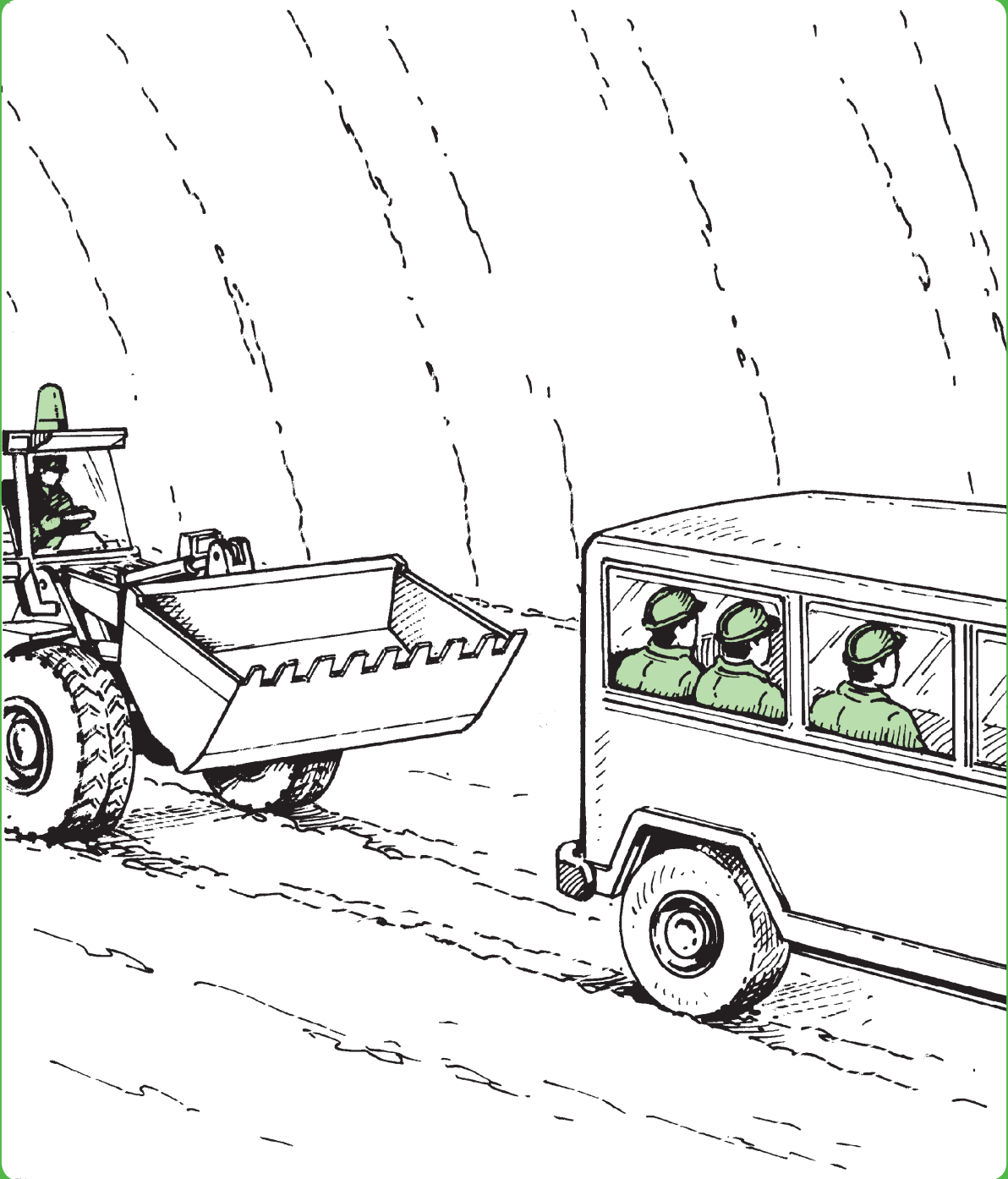


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Danger

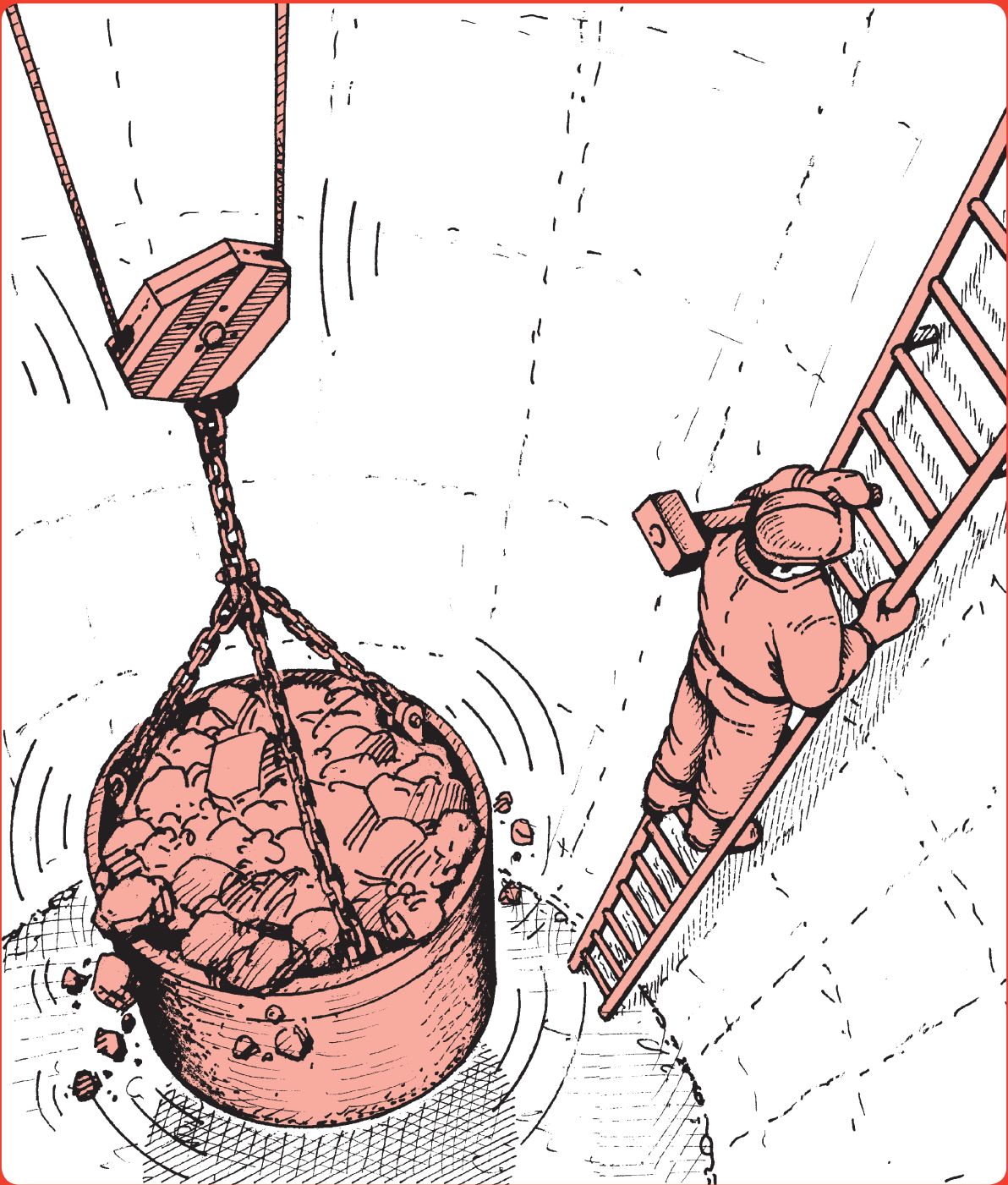
- falling
- being struck / run over

Passenger Transport



Protection

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

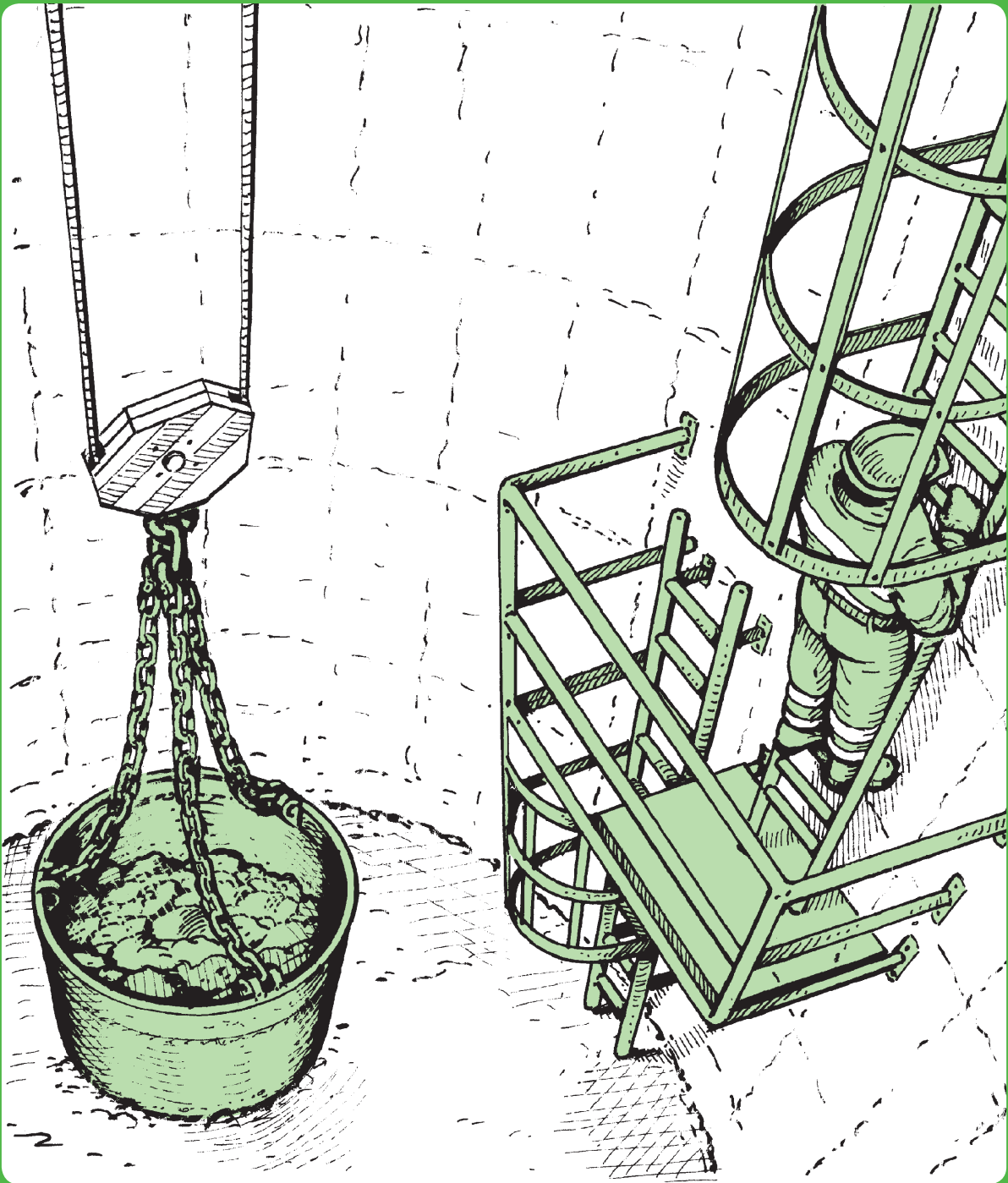


30

Danger

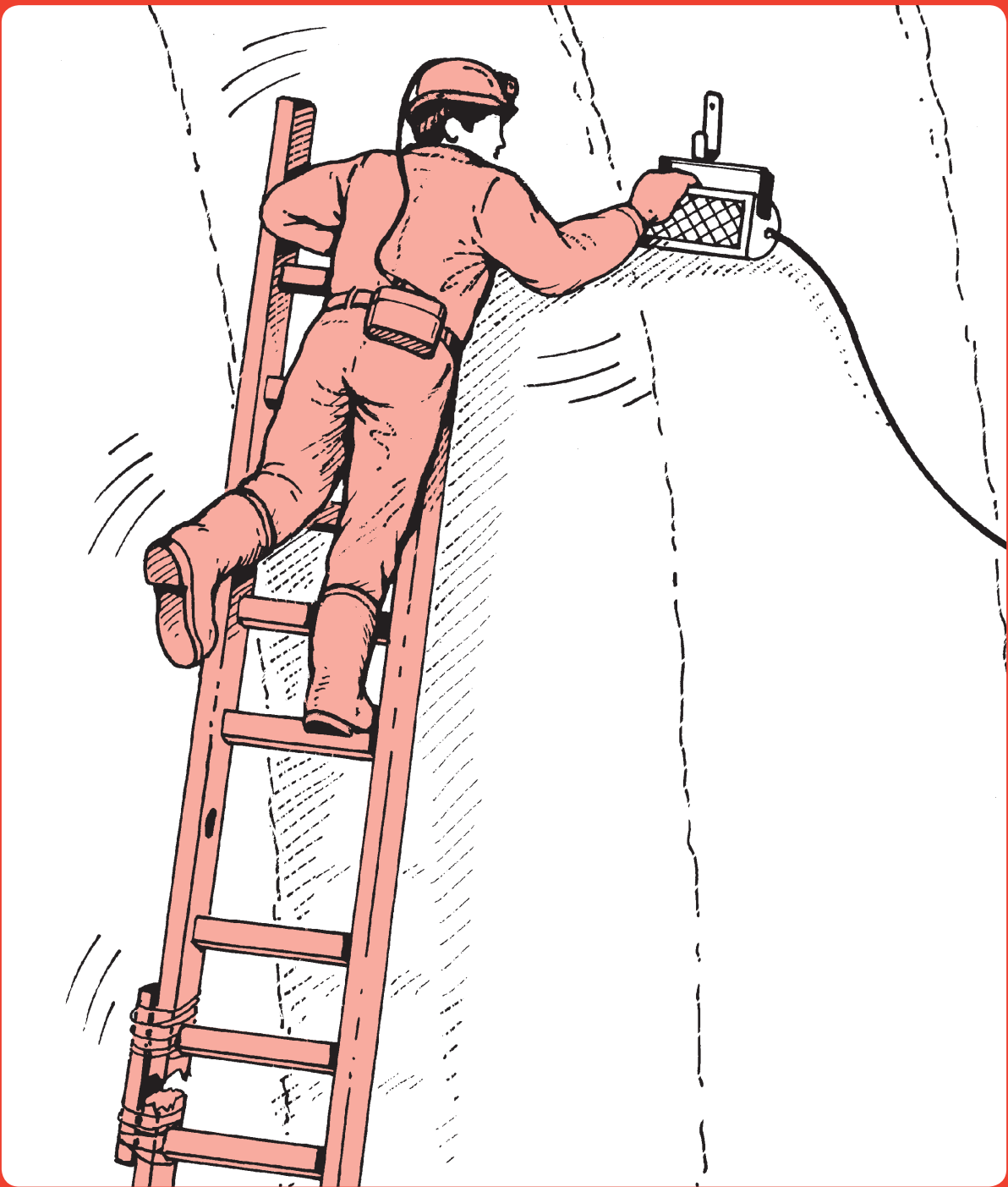
- falling from the ladder
- being crushed by the skip
- fall of excavated material

Transport in Shafts



Protection

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



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Danger

- falling

Access and Work Places on Ladders



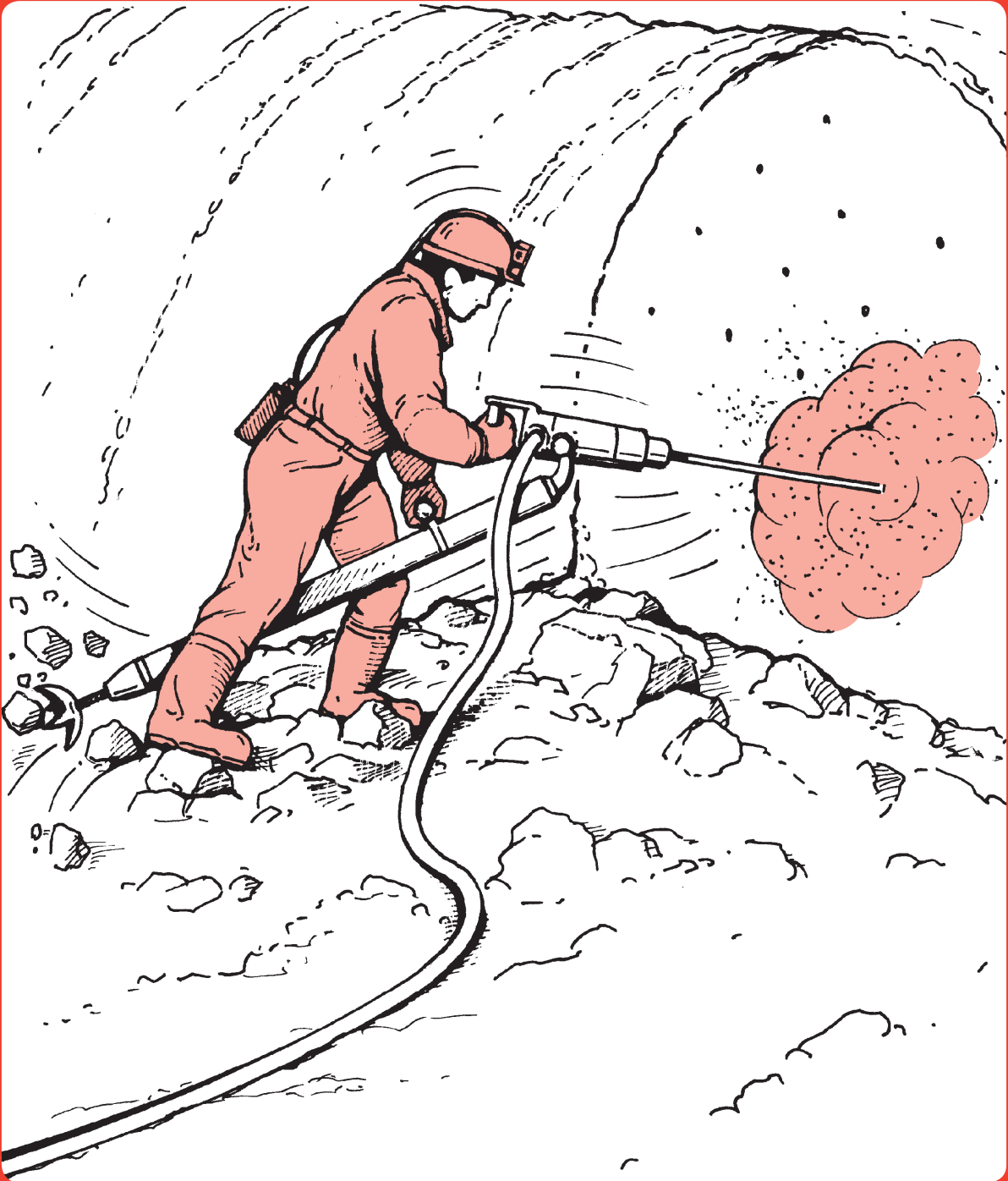
Protection

- 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



Excavation



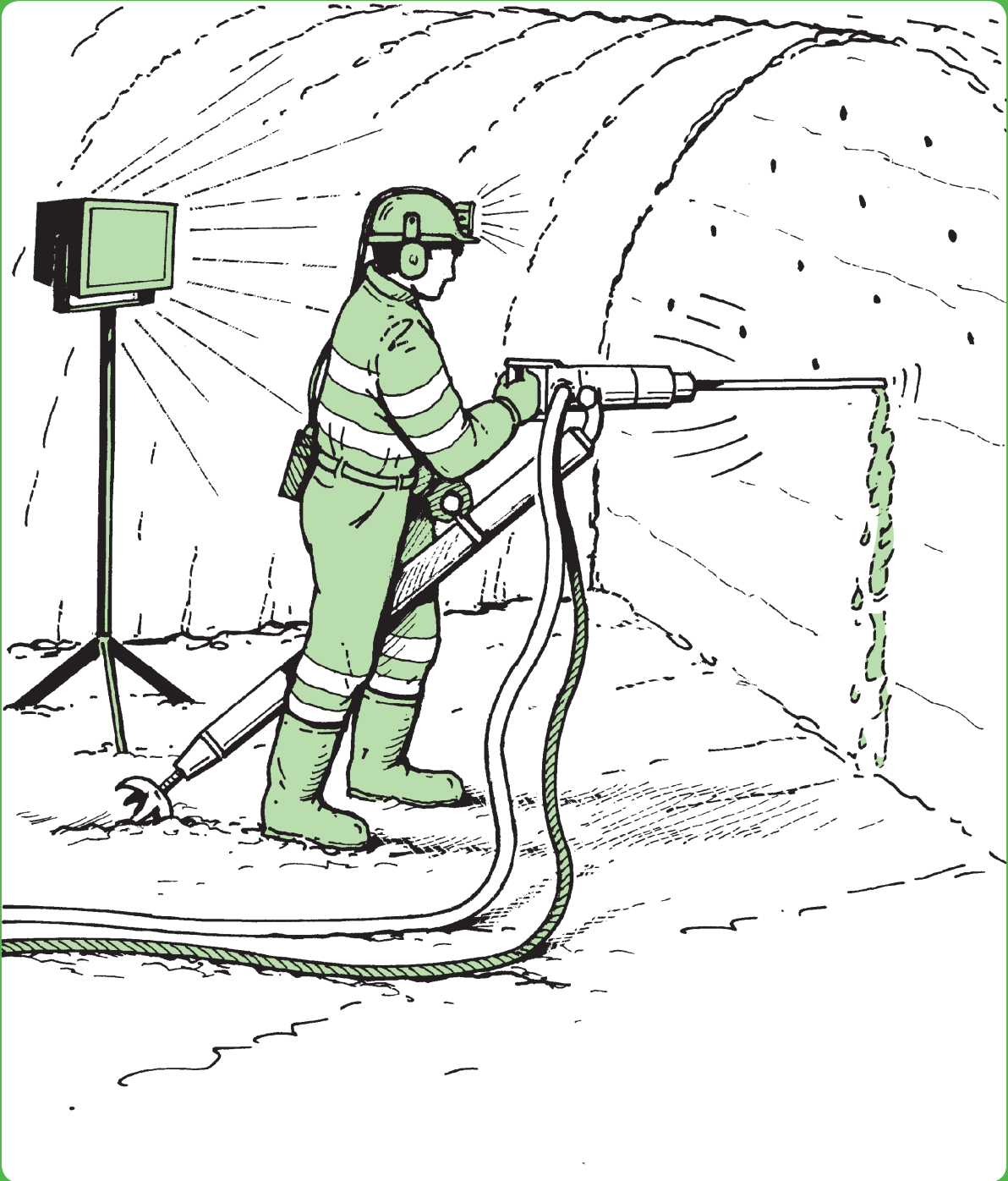


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Danger

- slipping and falling
- dust, noise

Manual Drilling



Protection

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



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Danger

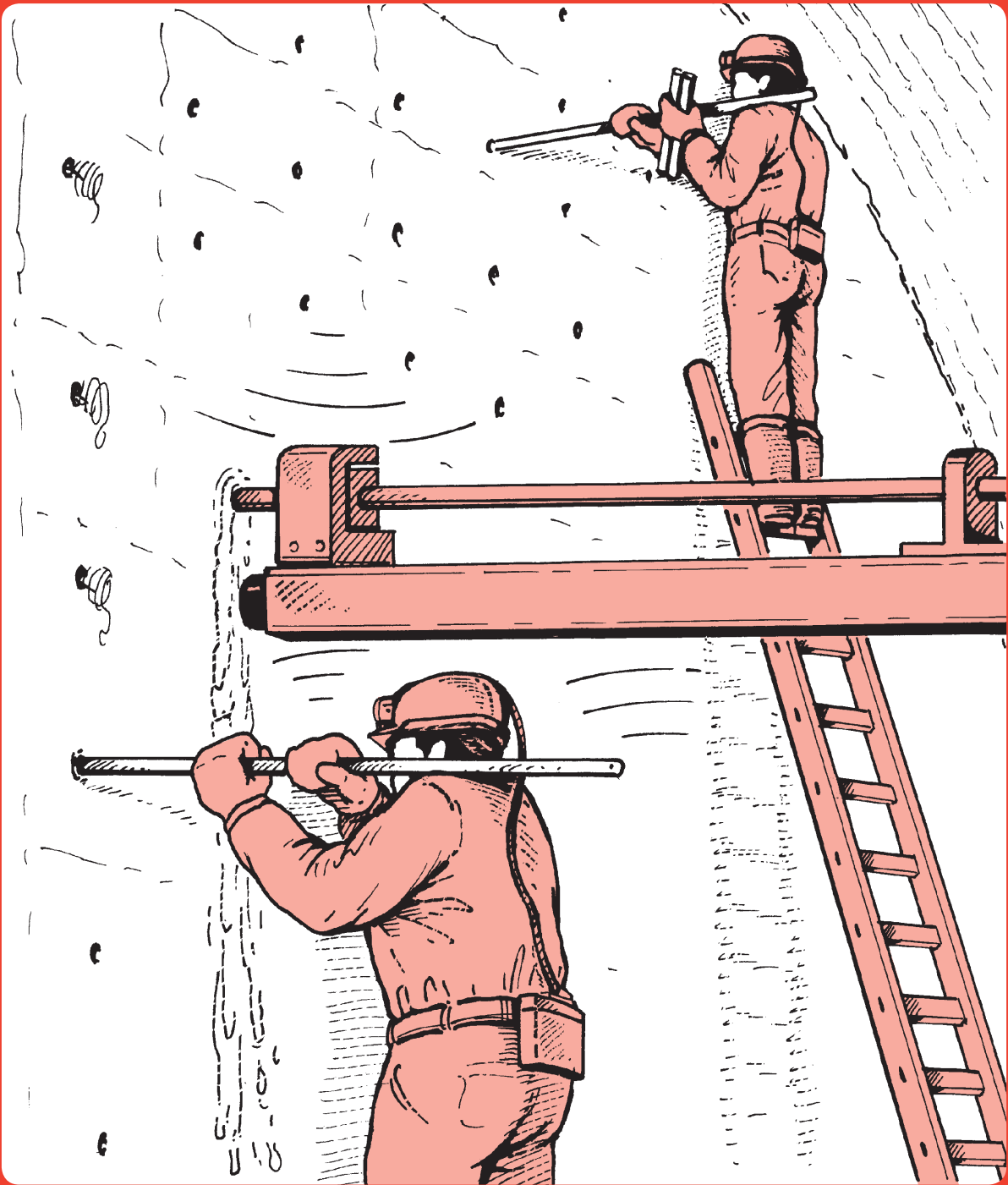
- being knocked over, being crushed, being struck
- rock fall
- dust, noise

Jumbos



Protection

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



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Danger

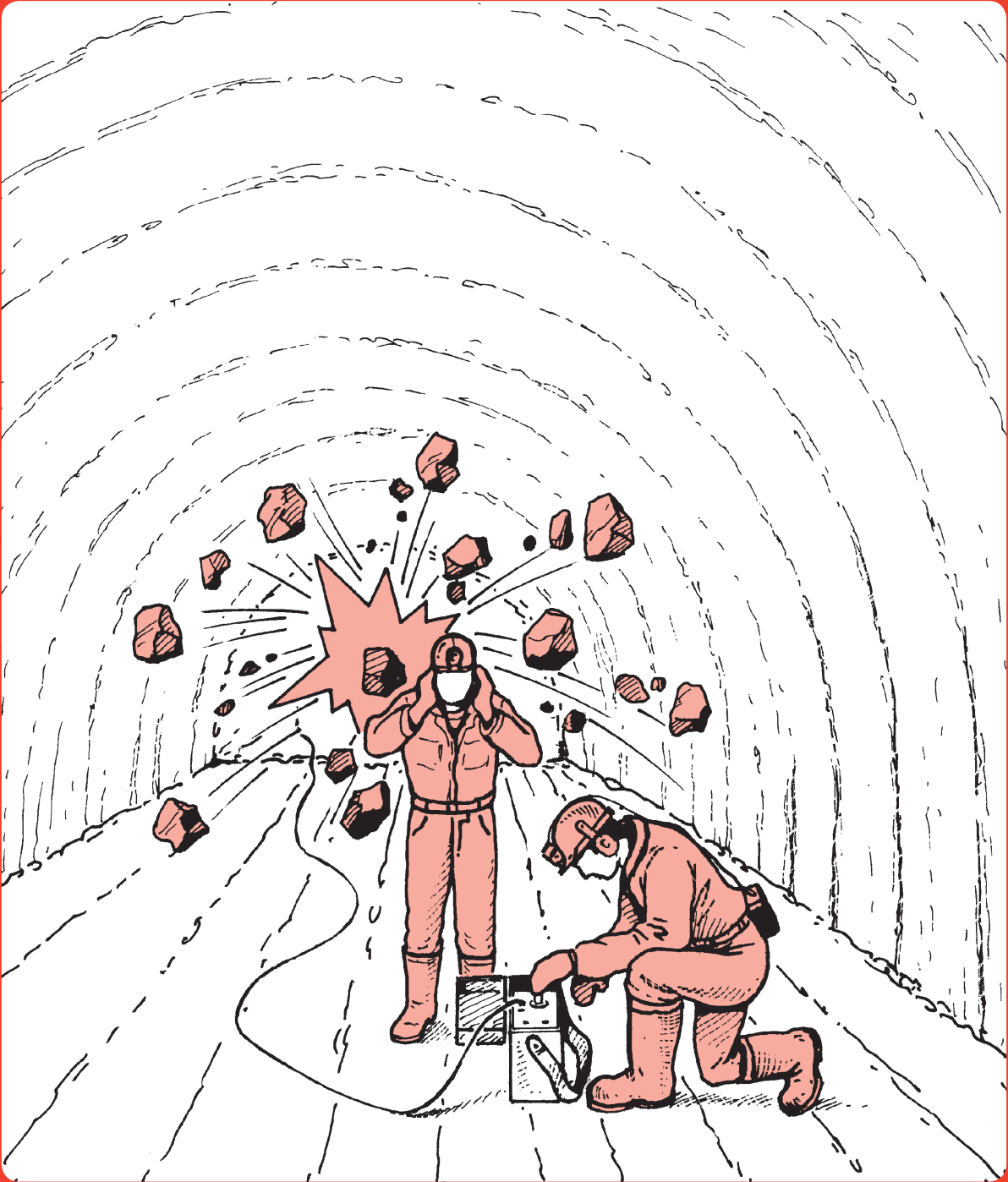
- accidental detonation by drilling into explosives
- being knocked over or crushed by drilling boom
- falling

Charging the Blast Holes



Protection

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

**Danger**

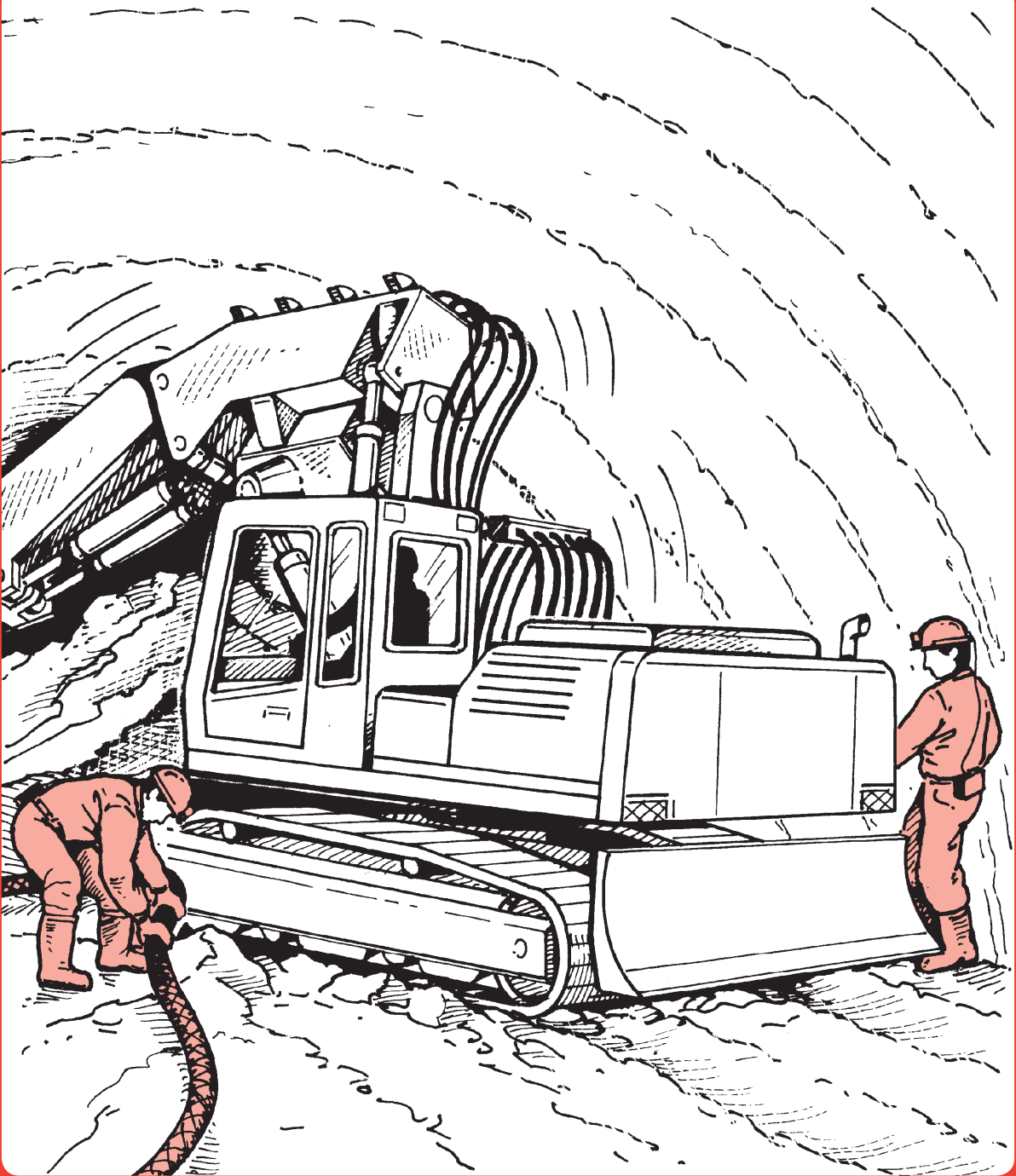
- fly rock
- toxic fumes resulting from blasting

Blasting



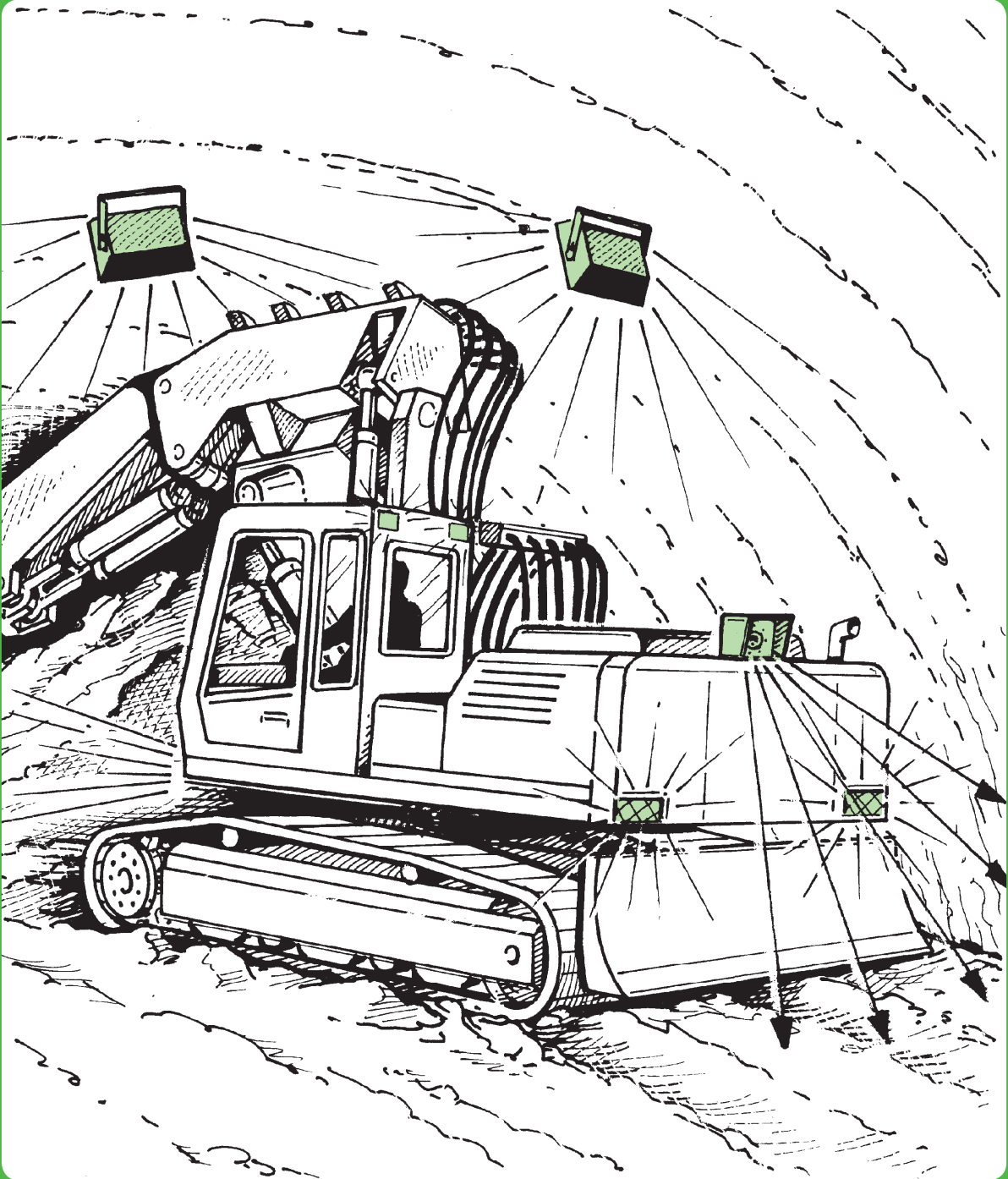
Protection

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

**Danger**

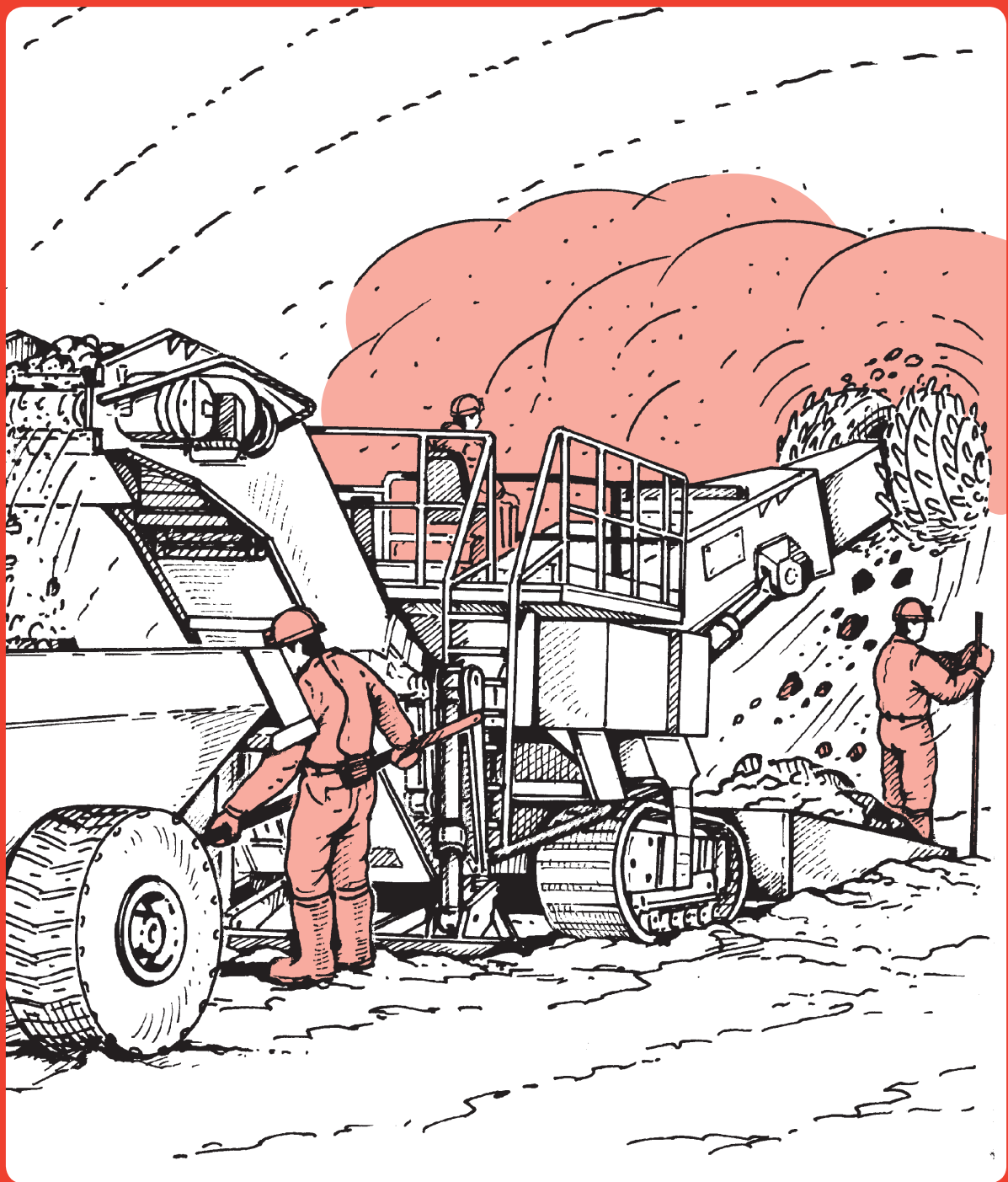
- being crushed
- being run over

Excavation with Excavator



Protection

- do not enter danger zone
- light the working area adequately
- use acoustic signal when driving backwards
- visual monitoring of the rear zone of vehicle

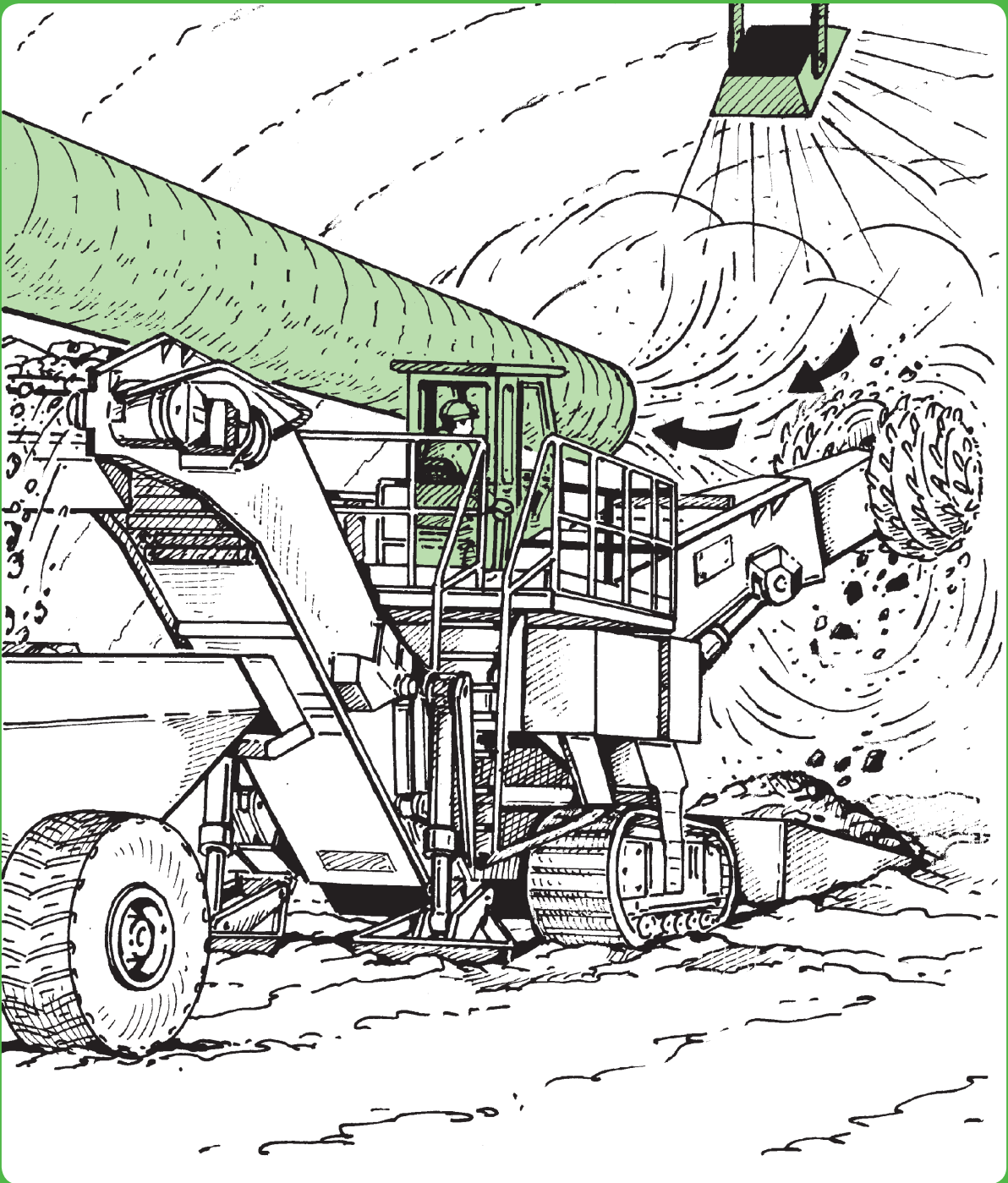


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Danger

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

Excavation with Roadheader



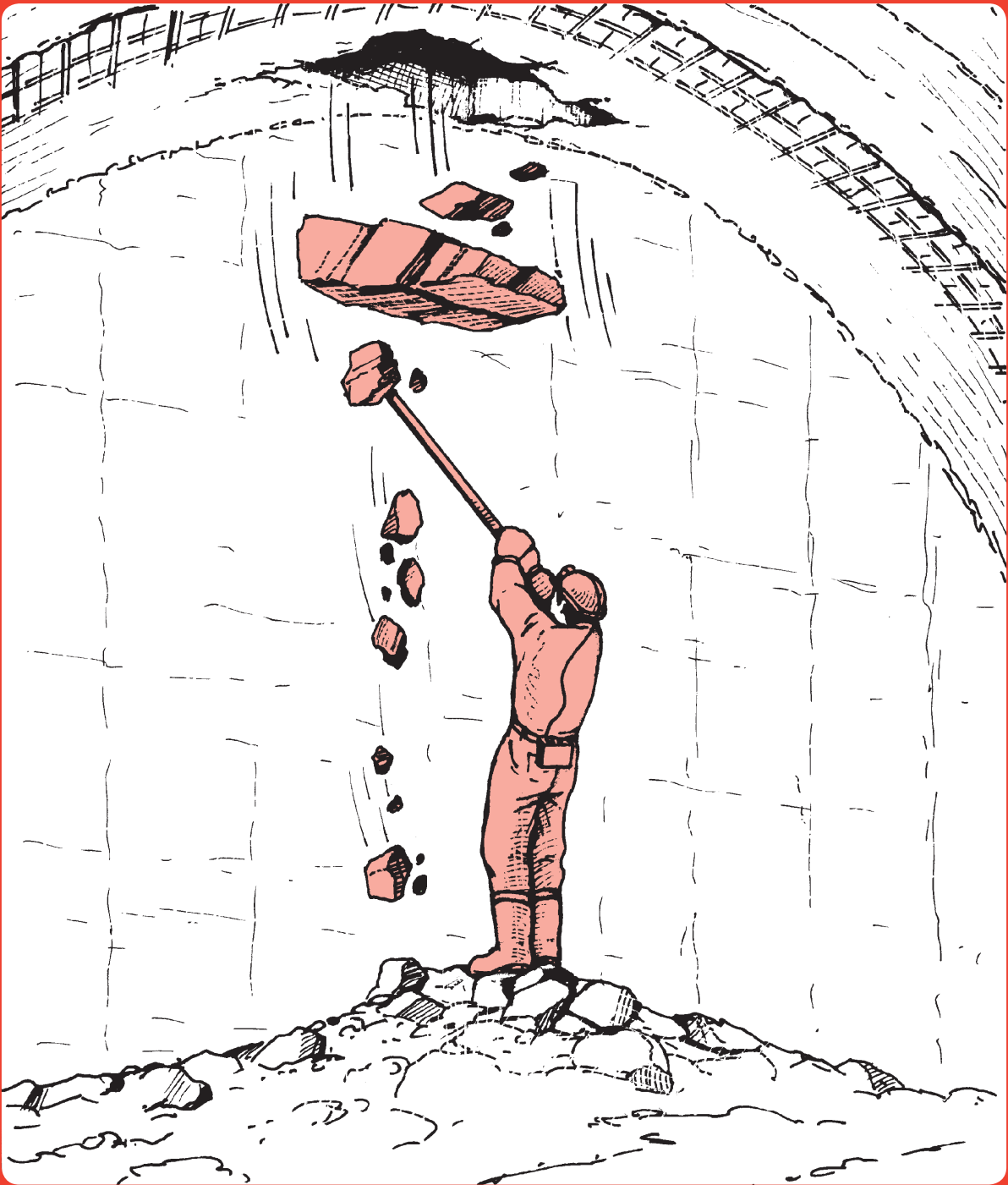
Protection

- install effective dust control system
- use pilot tunnel for dust extraction
- install waterspray system at cutting head
- do not enter danger zone of machine
- light the working area adequately



Primary Support





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Danger

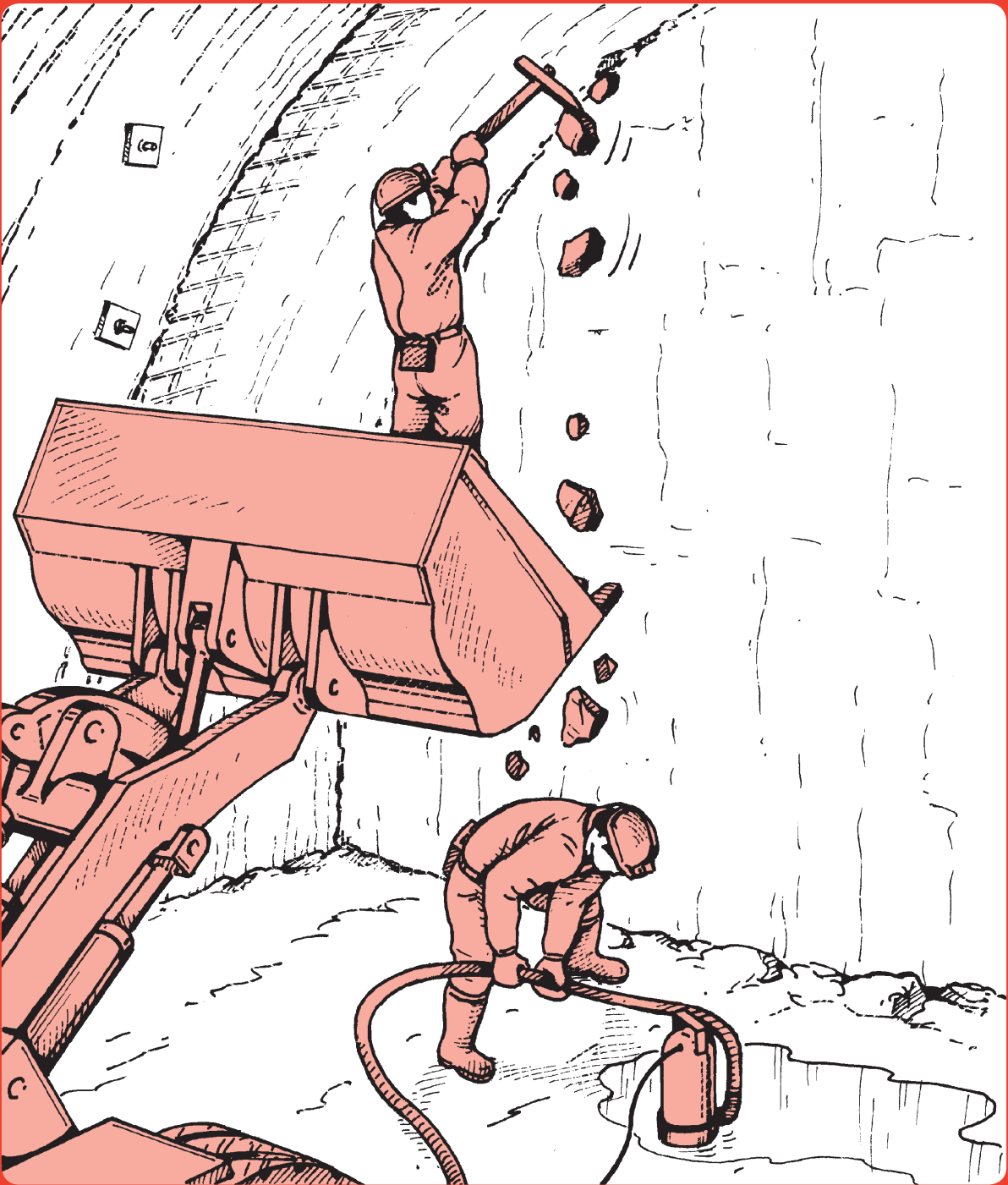
- rock fall
- instability / collapse of working face

Scaling



Protection

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

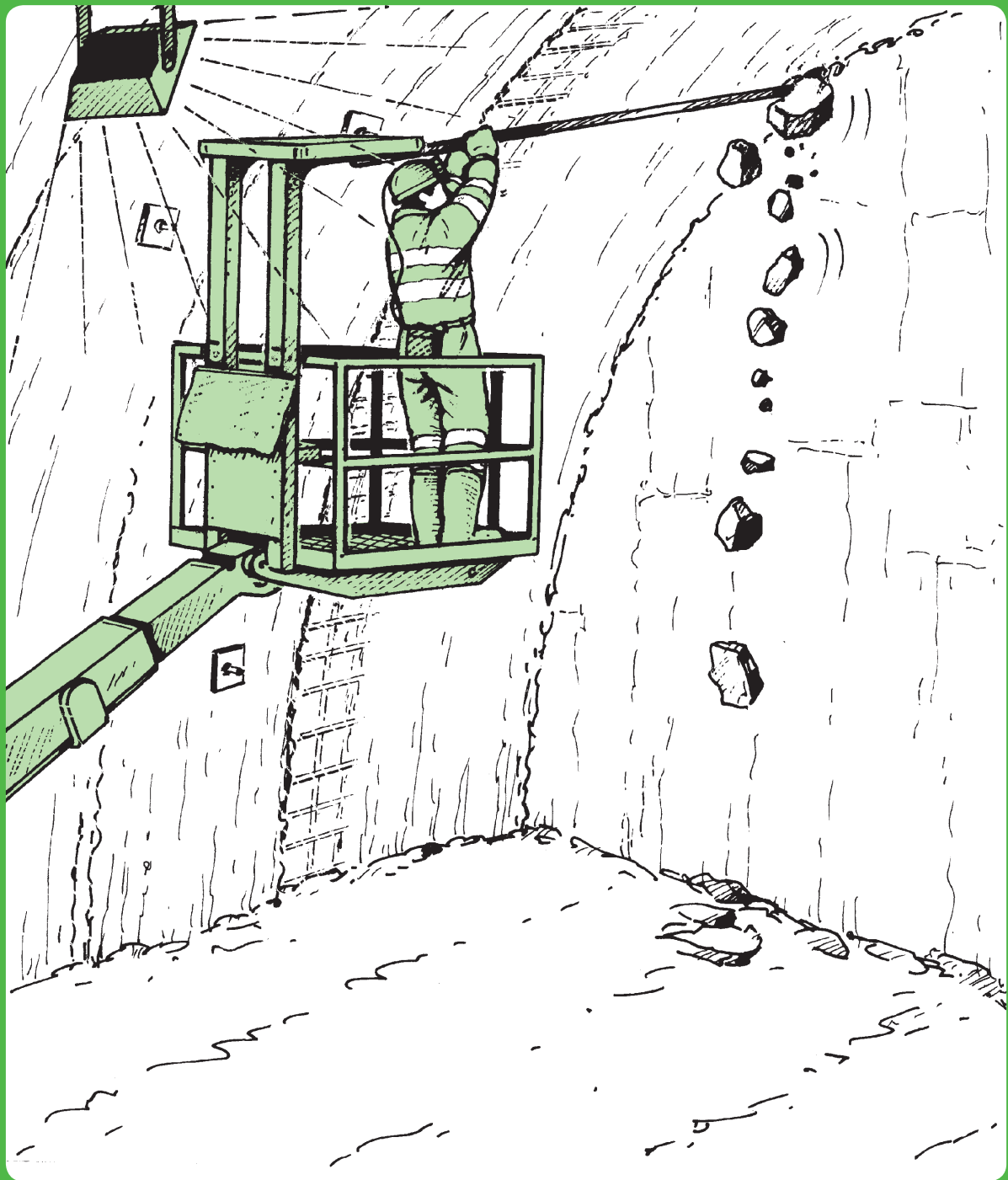


52

Danger

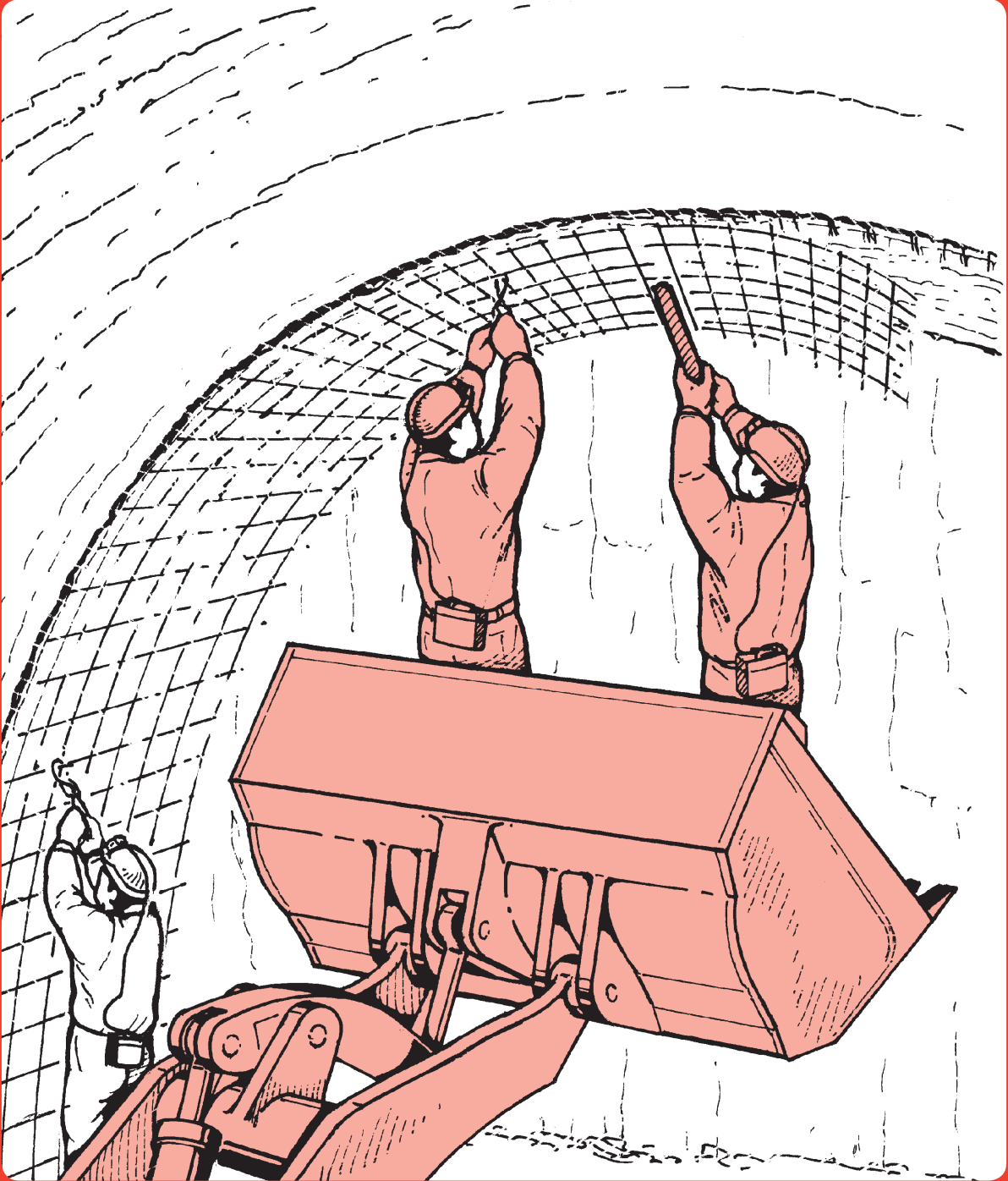
- rock fall
- falling from heights
- being crushed

Manual Scaling



Protection

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

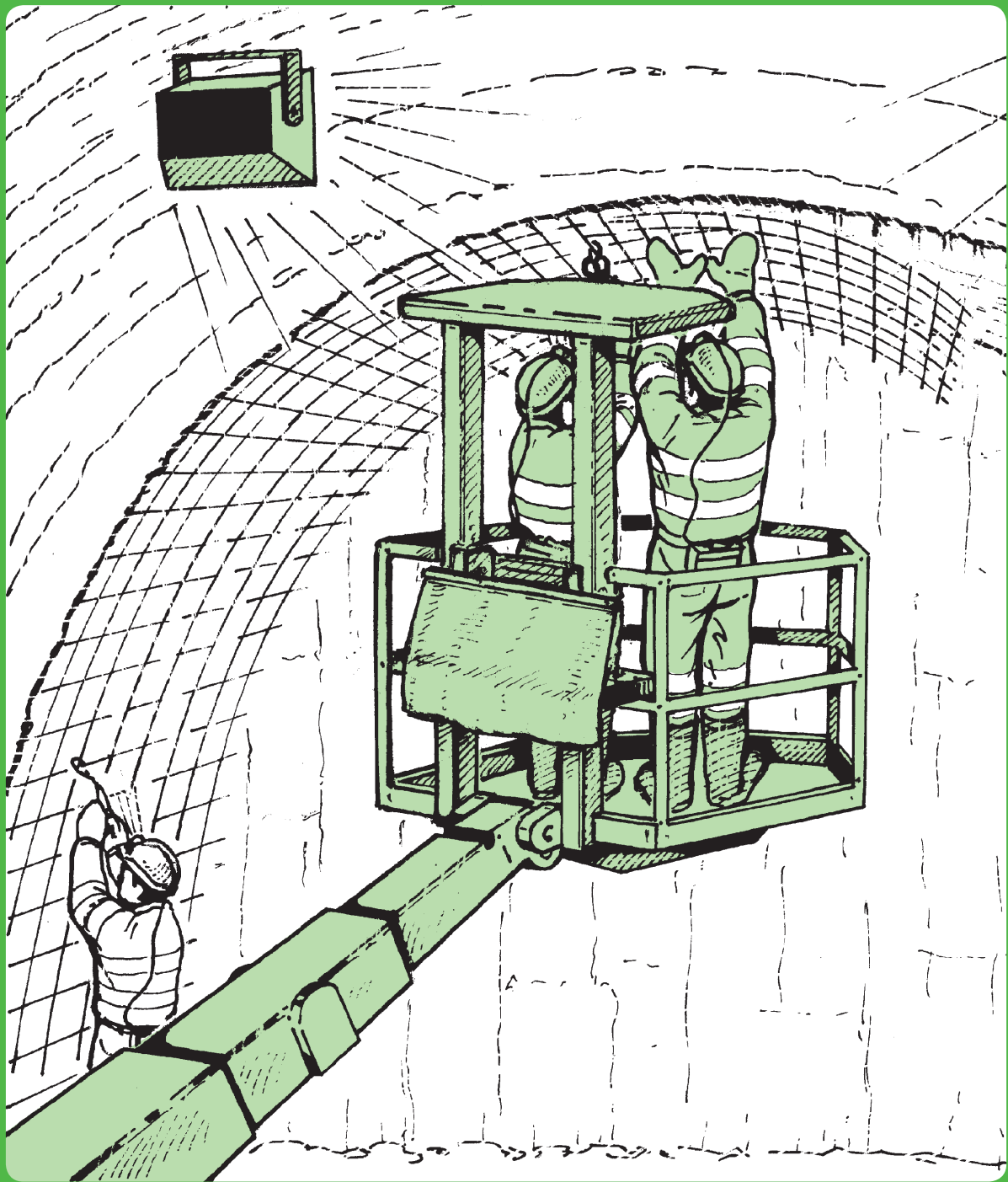


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Danger

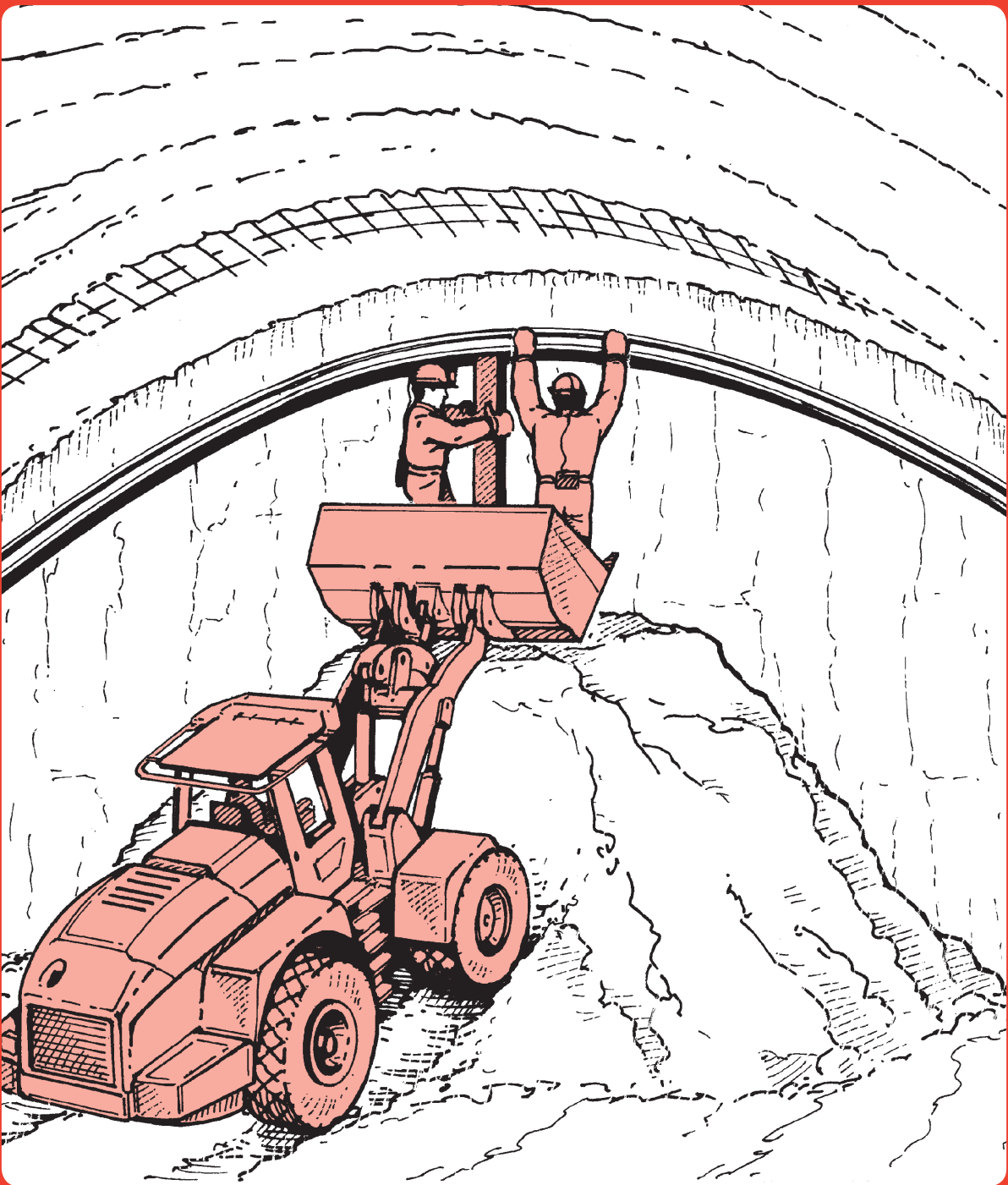
- falling
- being crushed

Installing Wire Mesh



Protection

- use working baskets
- do not enter the danger zone
- light the area adequately

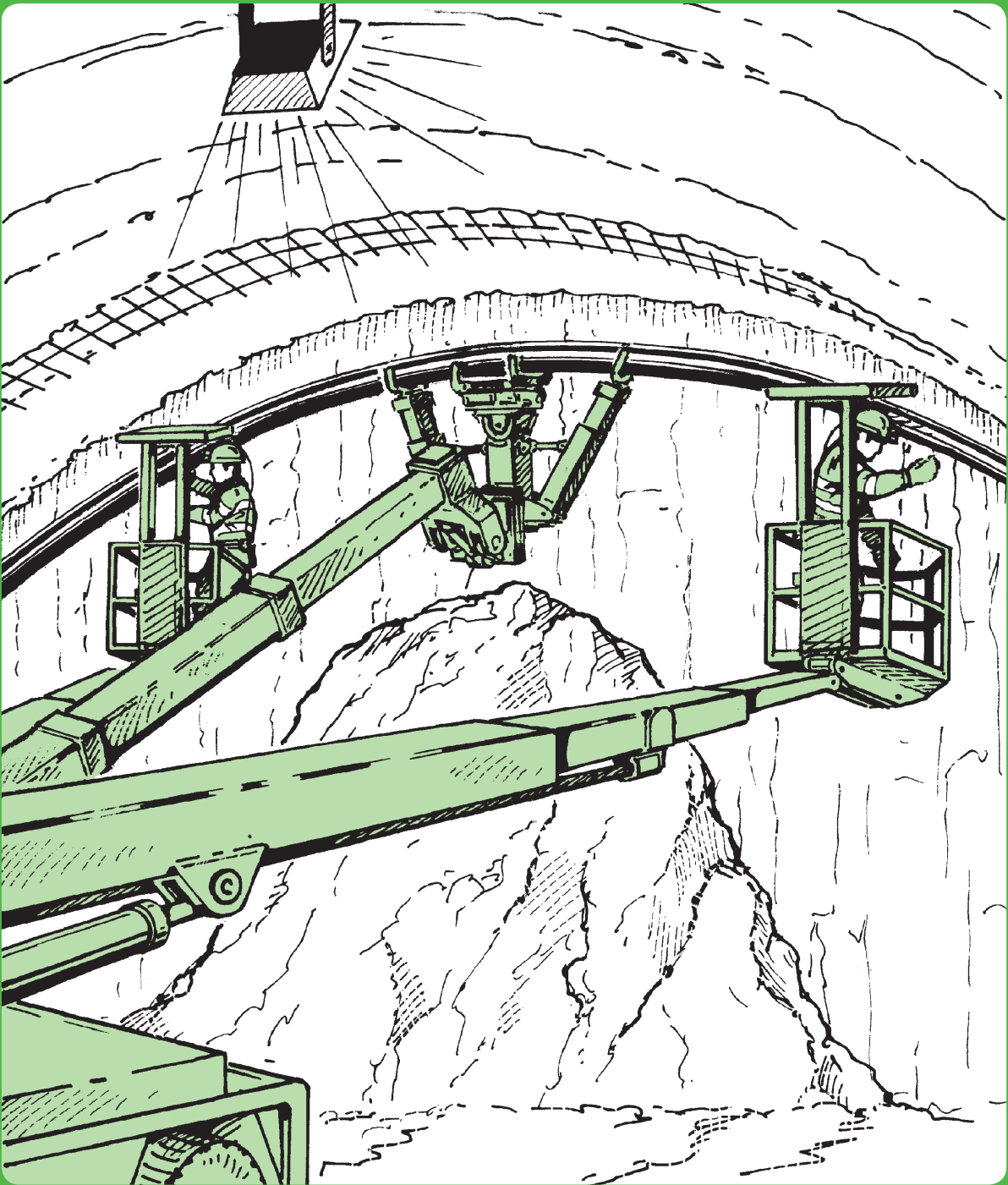


56

Danger

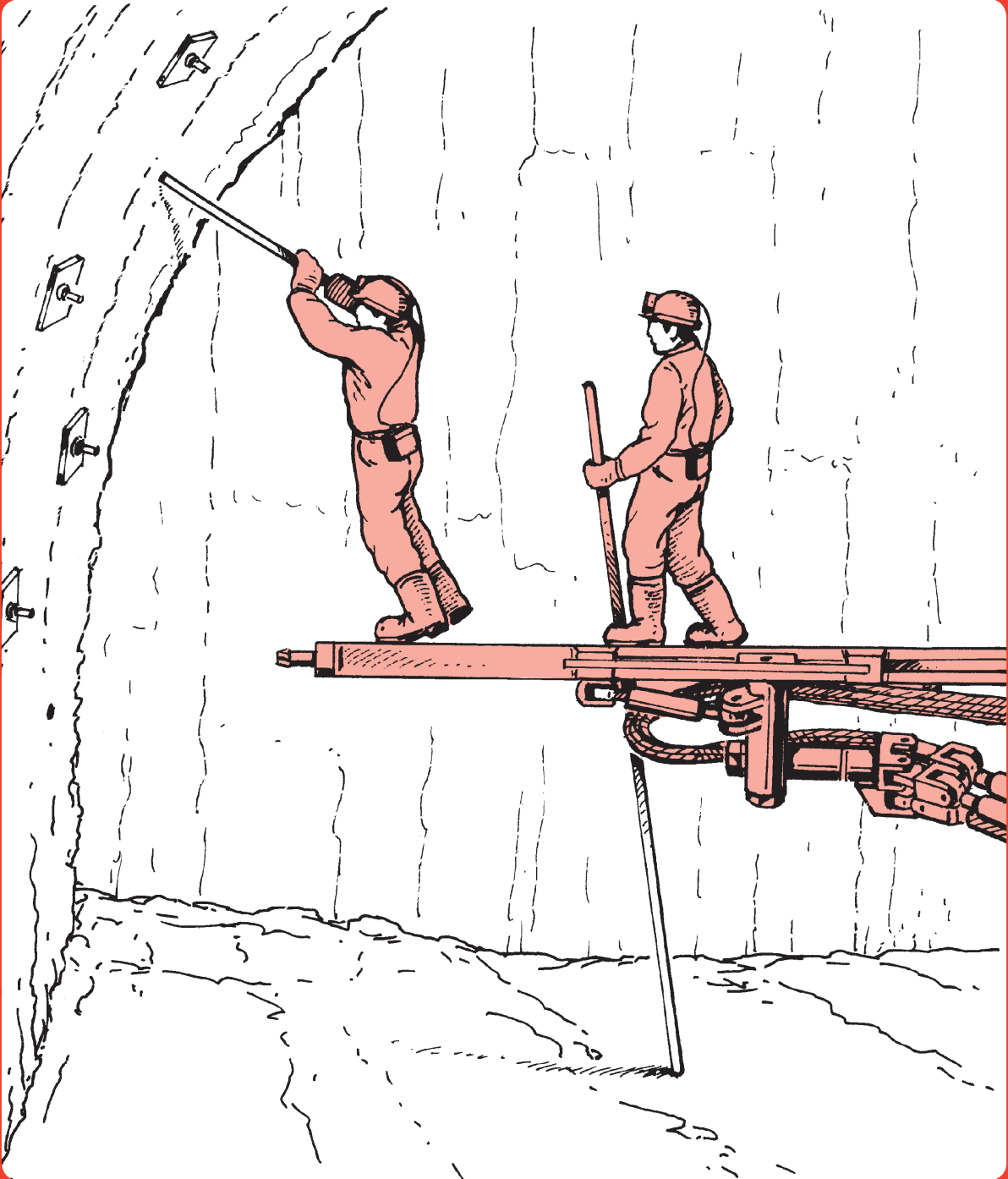
- falling from heights
- being crushed
- lack of adequate lighting

Installing Ribs and Girders



Protection

- use safe equipment
- use machinery according to its intended use
- do not enter the danger zone



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Danger

- falling from heights
- noise

Setting Rock Bolts



Protection

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

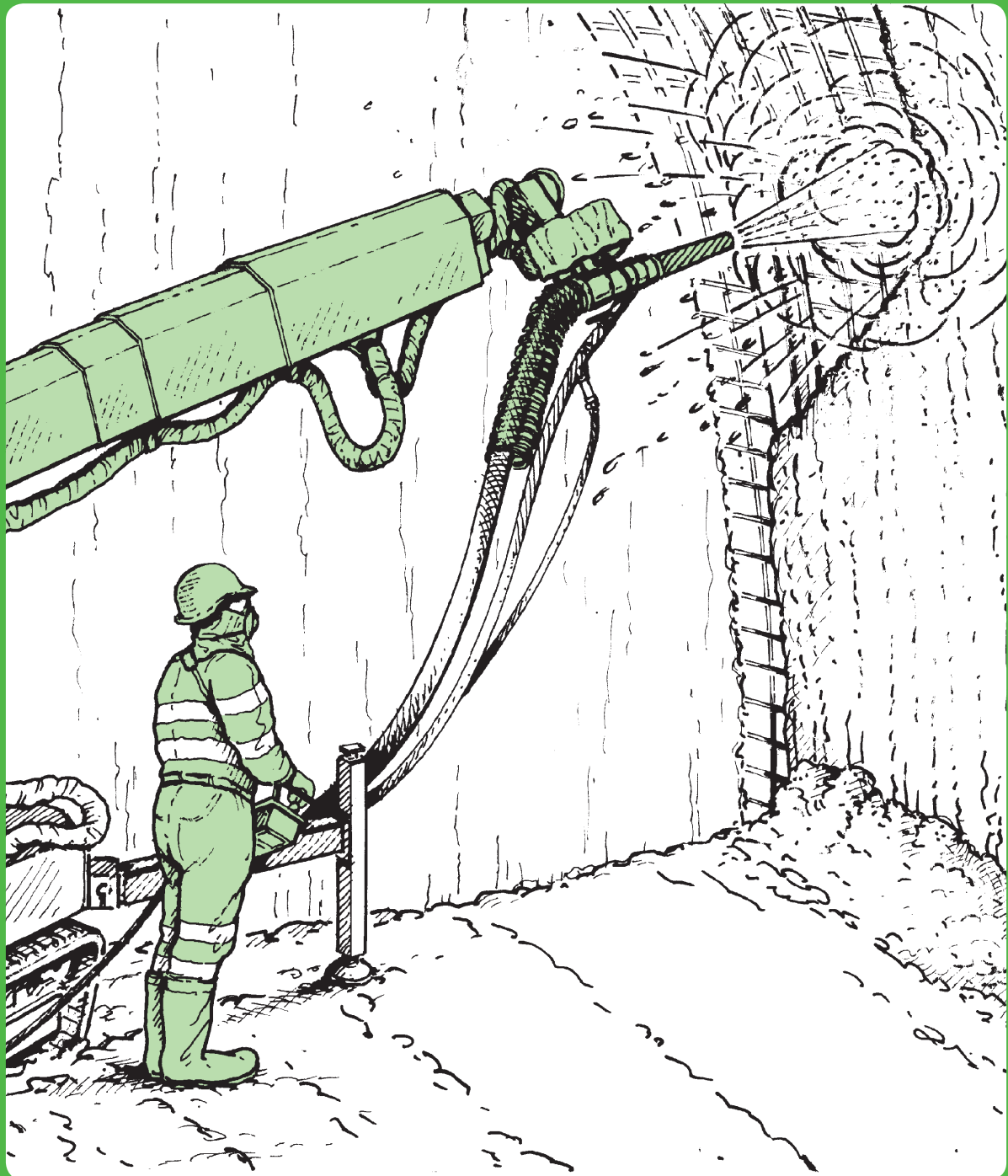


60

Danger

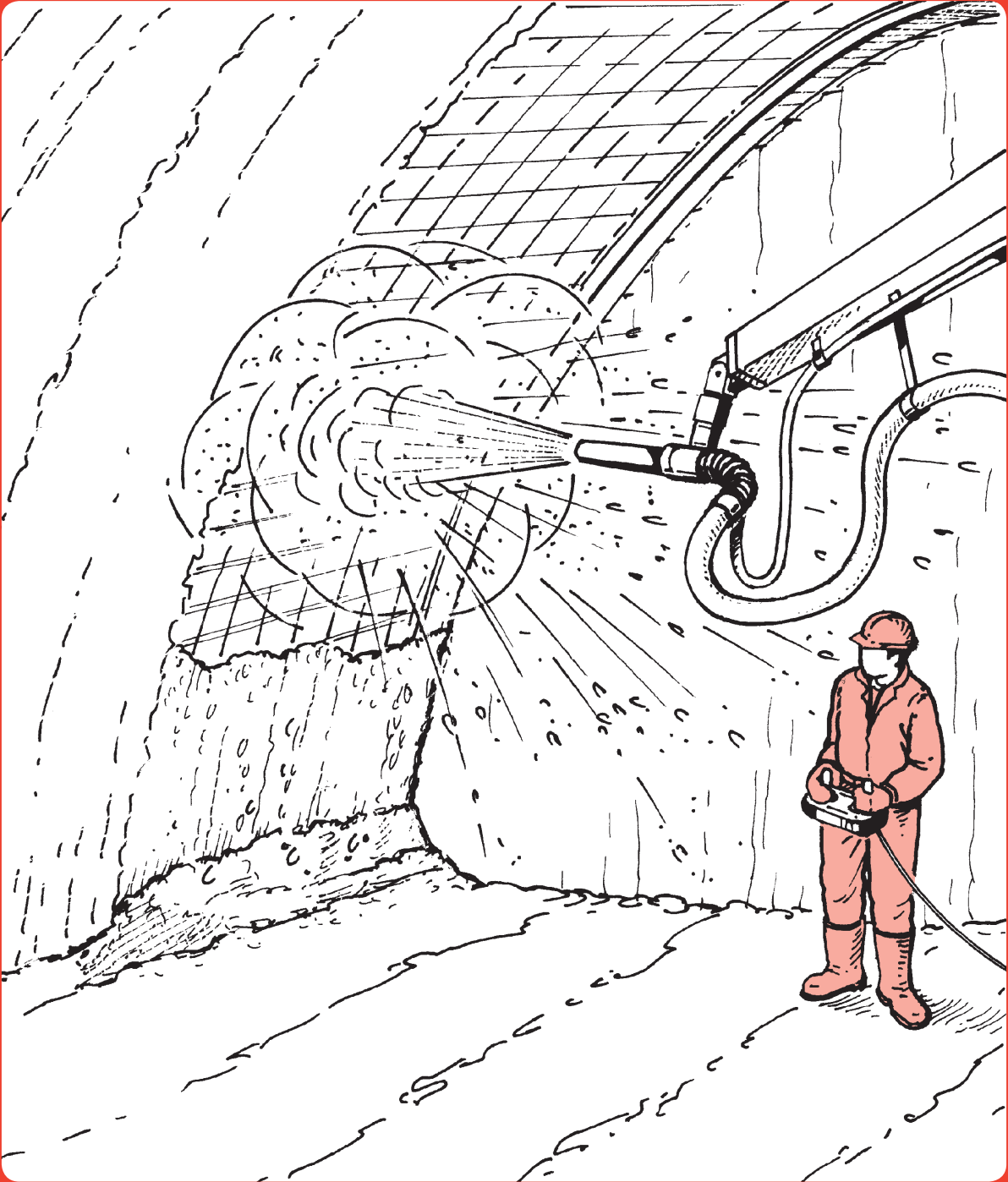
- falling from heights
- rebound
- dust
- chemical additives

Shotcrete Application



Protection

- use shotcrete manipulator
- use protective clothing
- wear eye protection
- wear respiratory protection



Danger

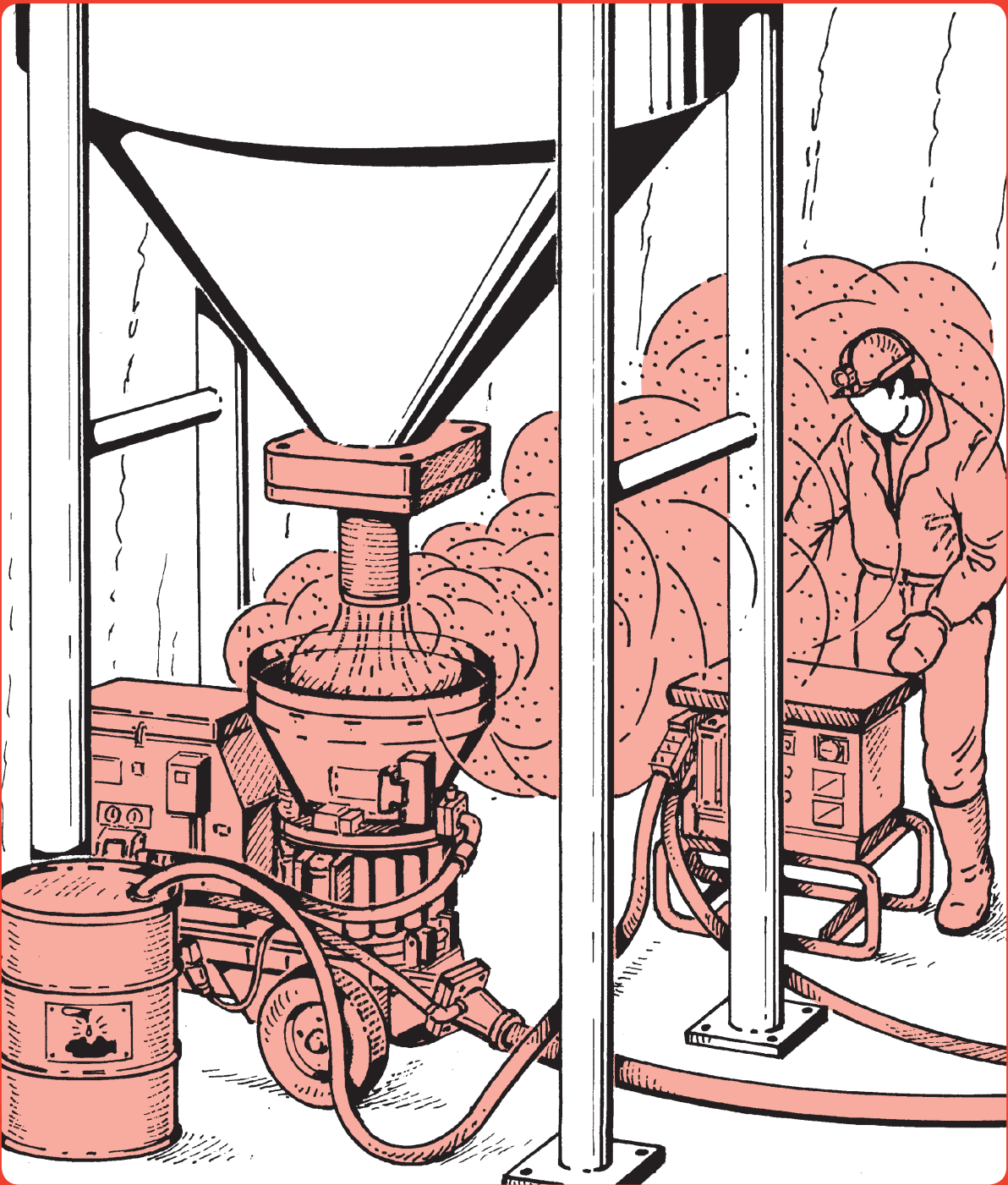
- being crushed
- shotcrete detachment
- rebound
- dust
- burst of shotcrete hose

Shotcrete Manipulator



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 non toxic additive to reduce dust and atmospheric pollution

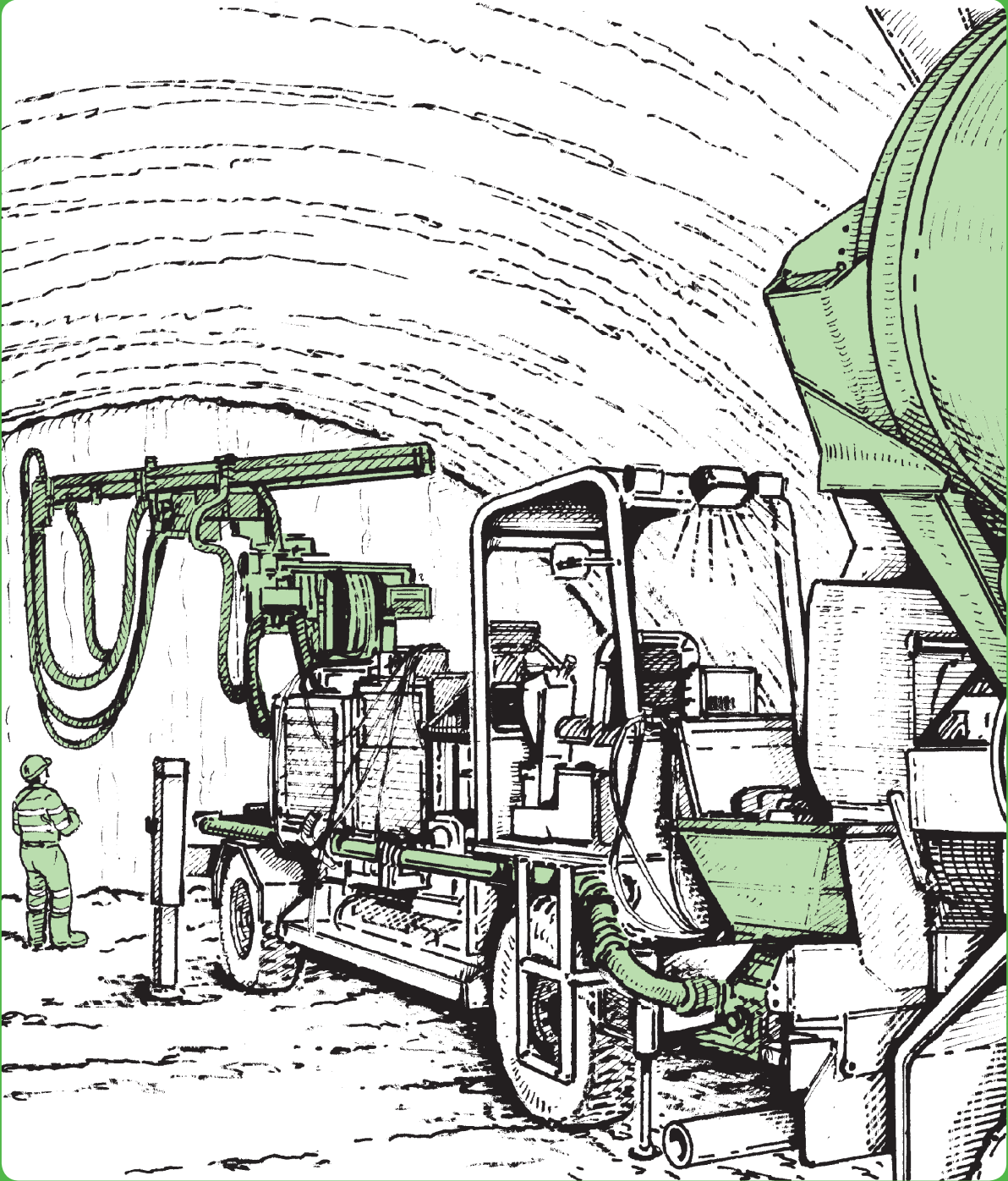


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Danger

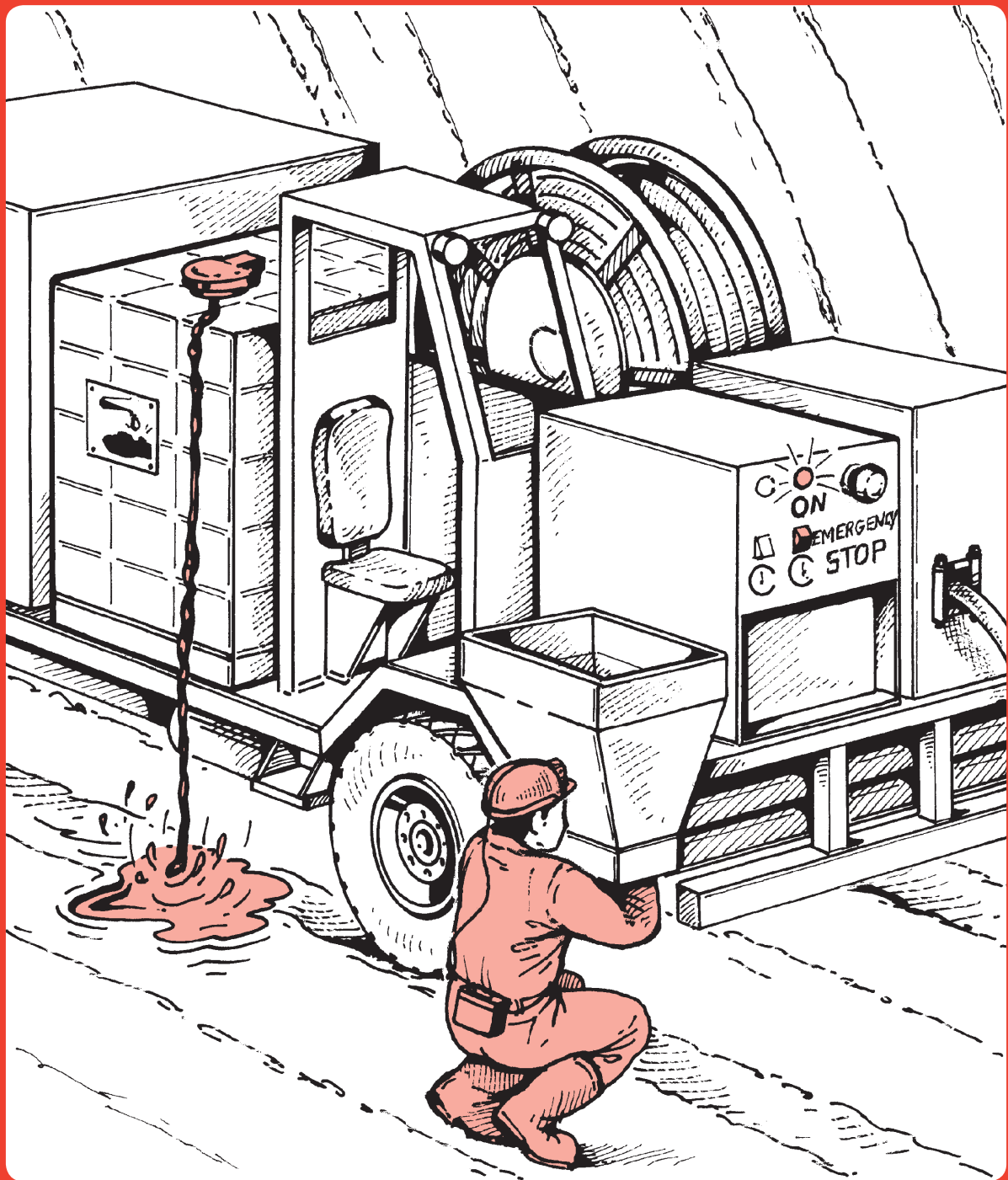
- dust containing quartz (silicosis)
- skin and eye irritation resulting from toxic accelerator

Shotcrete Machinery



Protection

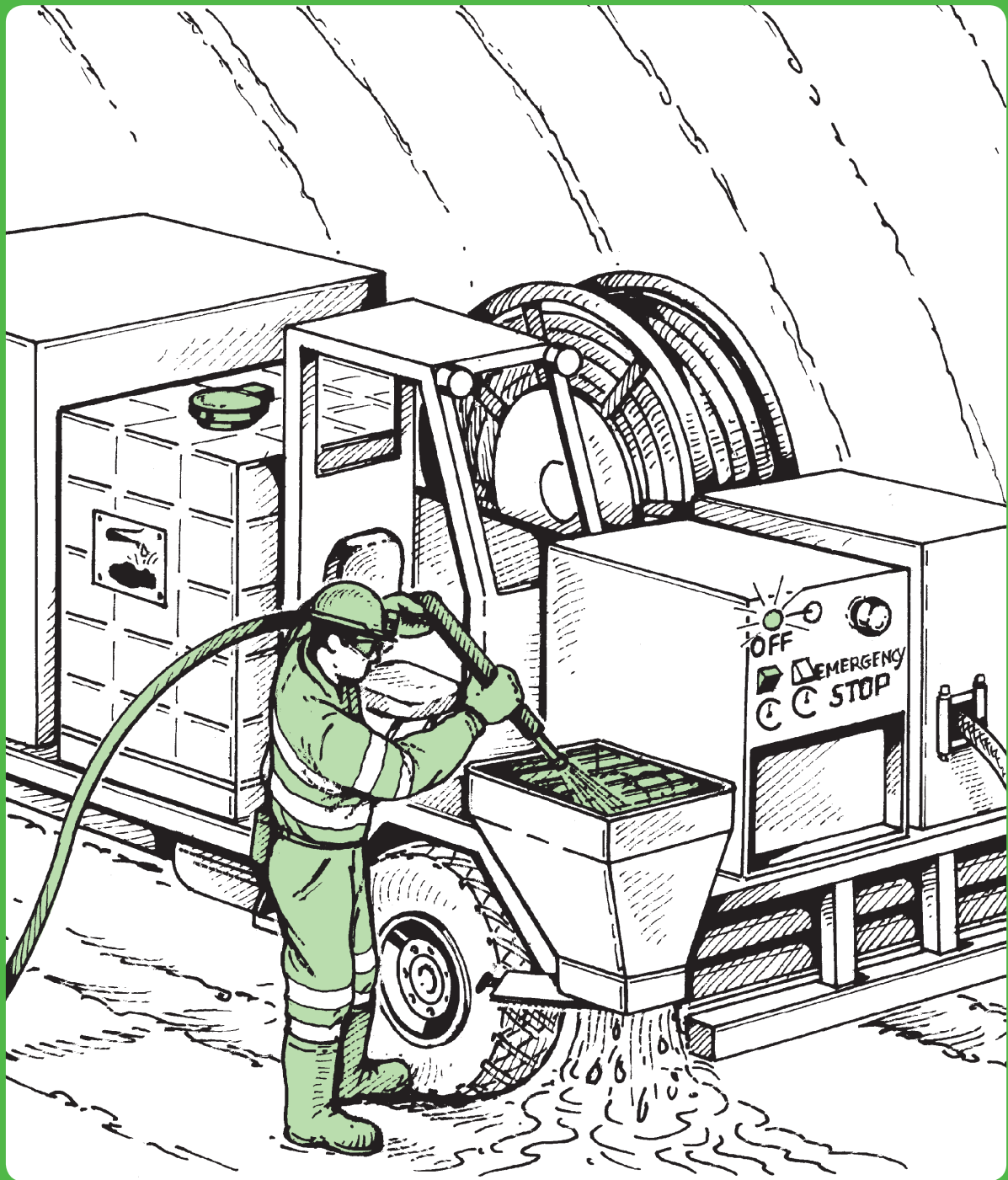
- use wet shotcrete machinery
- use dry mix sprayed concrete with shotcrete cement (without accelerator)
- alternative: use moist aggregates (with non toxic accelerator)
- use a nozzle with pre-dampening system



Danger

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

Maintenance of Shotcrete Plant / Equipment



Protection

- clean the equipment with high pressure water jet
- machine must be switched off when cleaning inside it
- use non-toxic accelerator
- wear eye protection

5.10

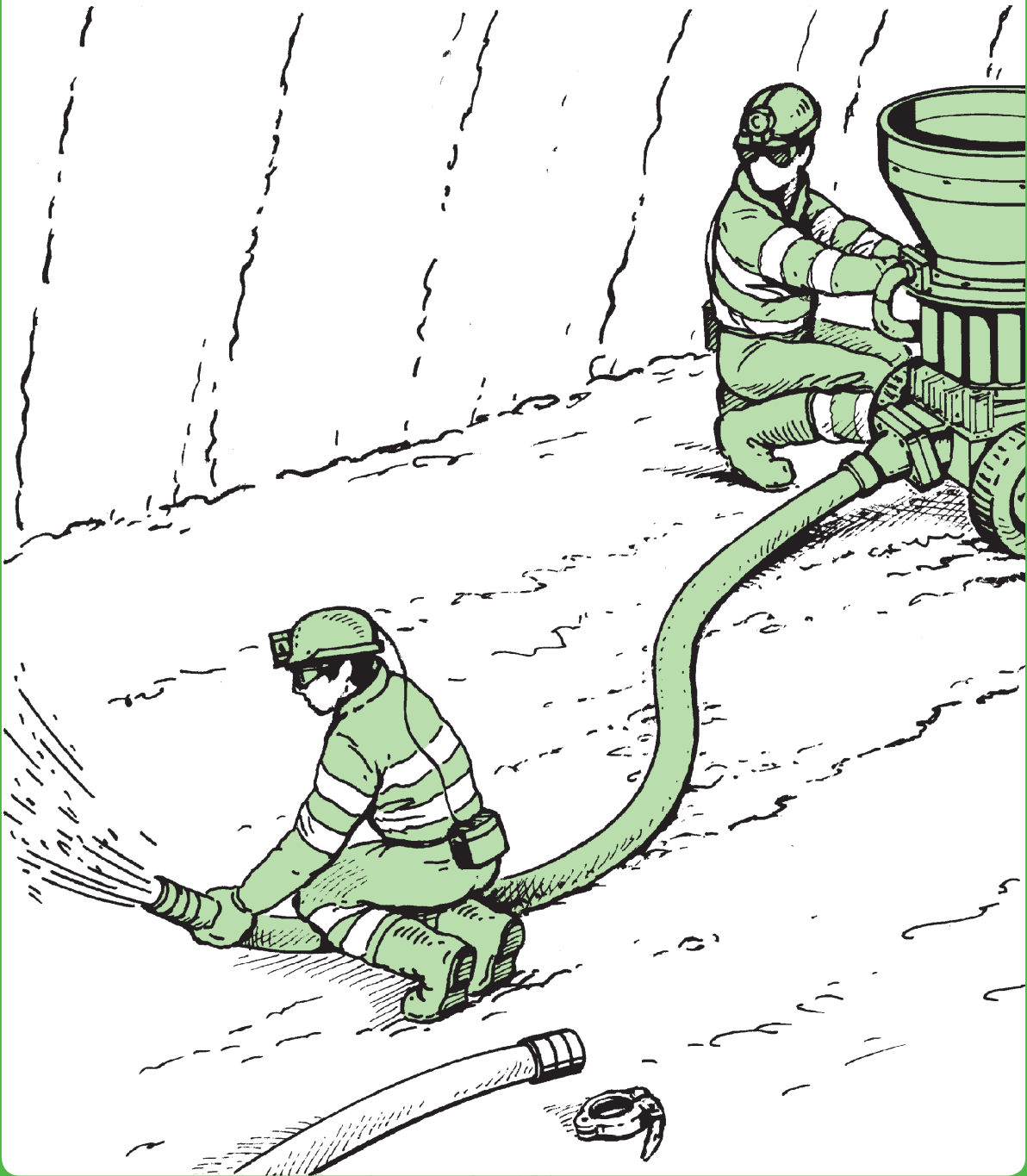


68

Danger

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

Removing Obstructions



Protection

- take hold of the end of the hose
- do not enter the danger zone where shotcrete is being ejected
- the operator shall monitor the danger zone
- wear eye protection



Transport

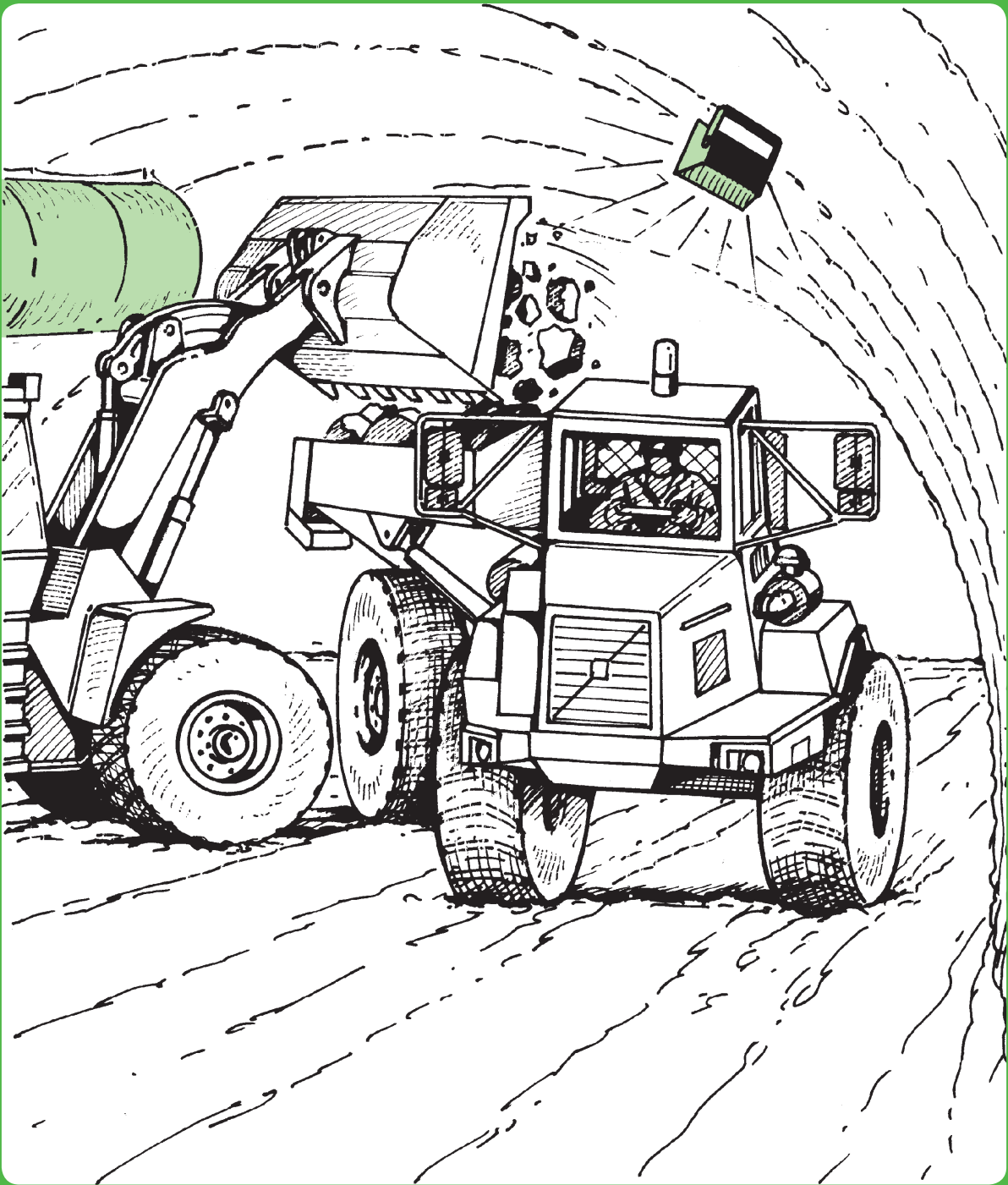




Danger

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

Mucking Out



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

**Danger**

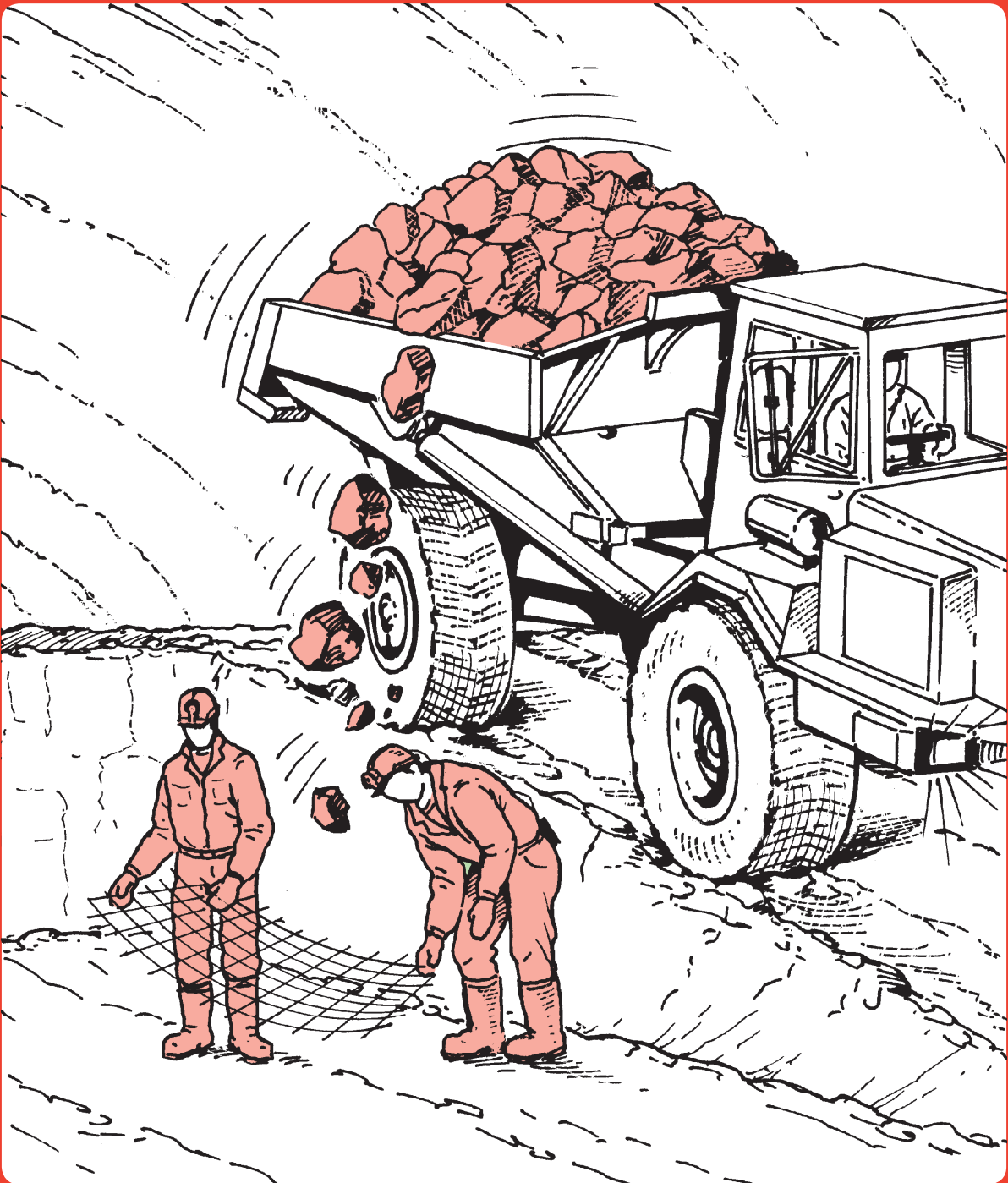
- being run over
- falling material

Travelling Past Working Areas



Protection

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



Danger

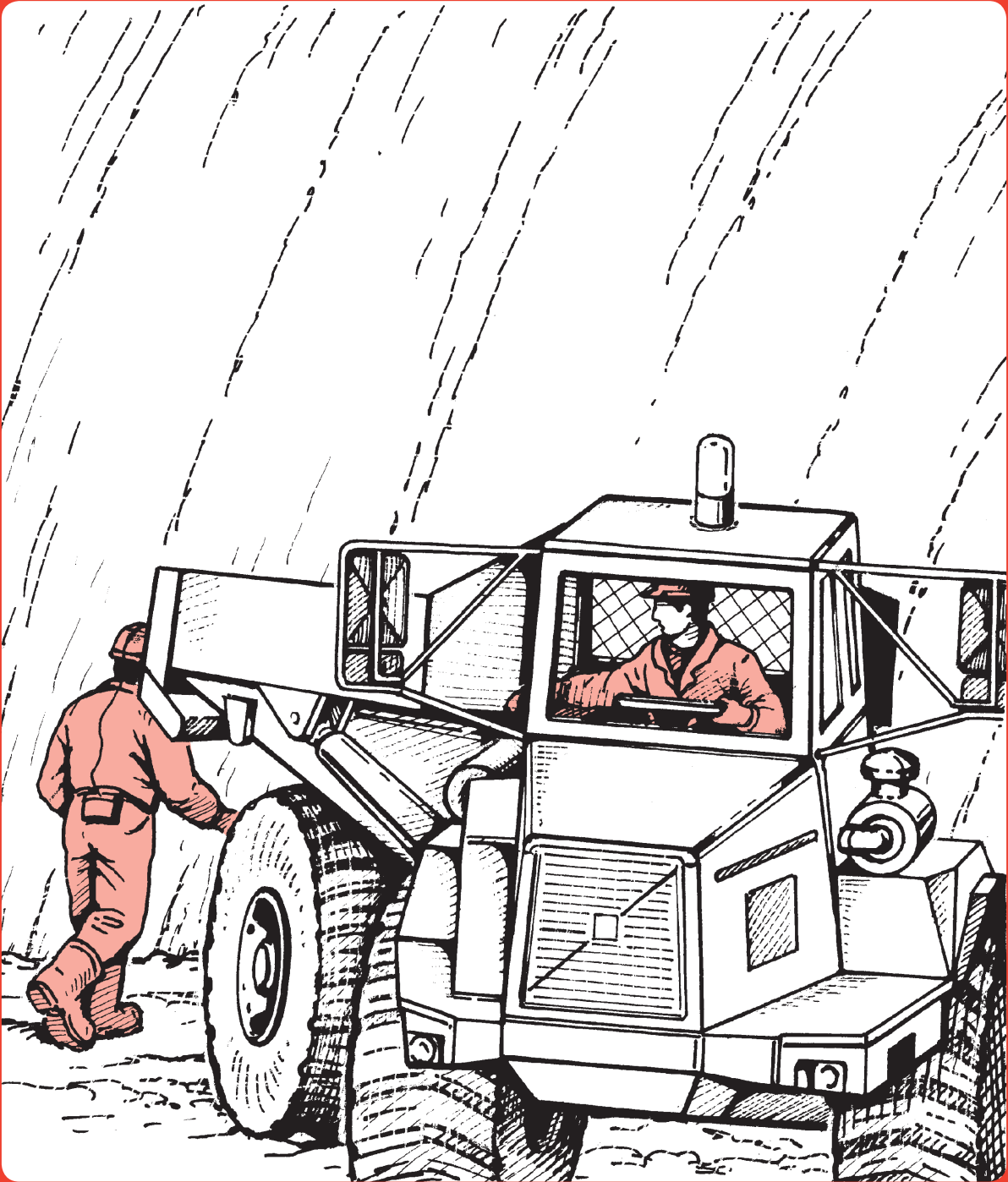
- the vehicle could tip over
- falling material

Driving Past the Edge of an Excavation



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

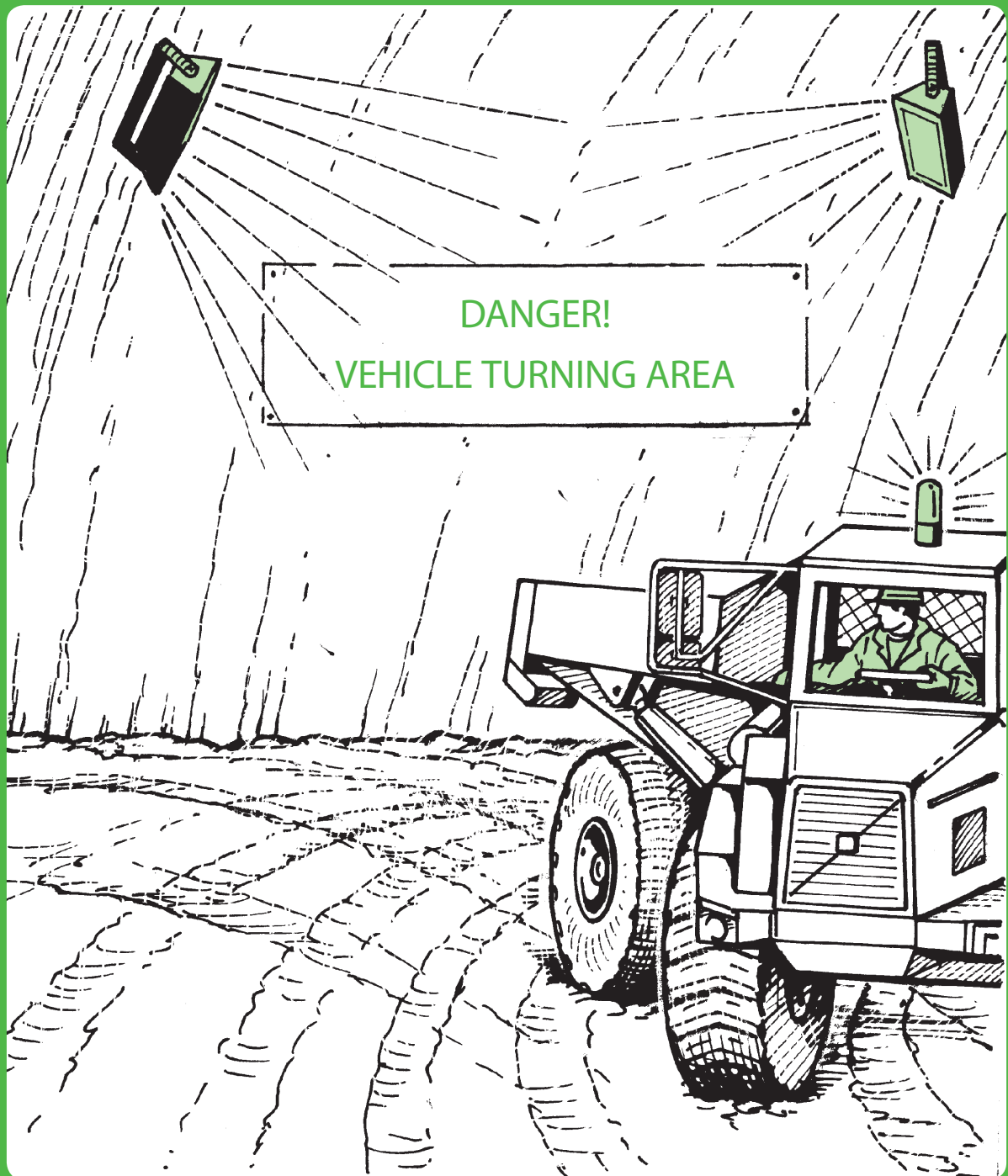


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Danger

- being run over
- being crushed

Turning in Tunnels



Protection

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

**Danger**

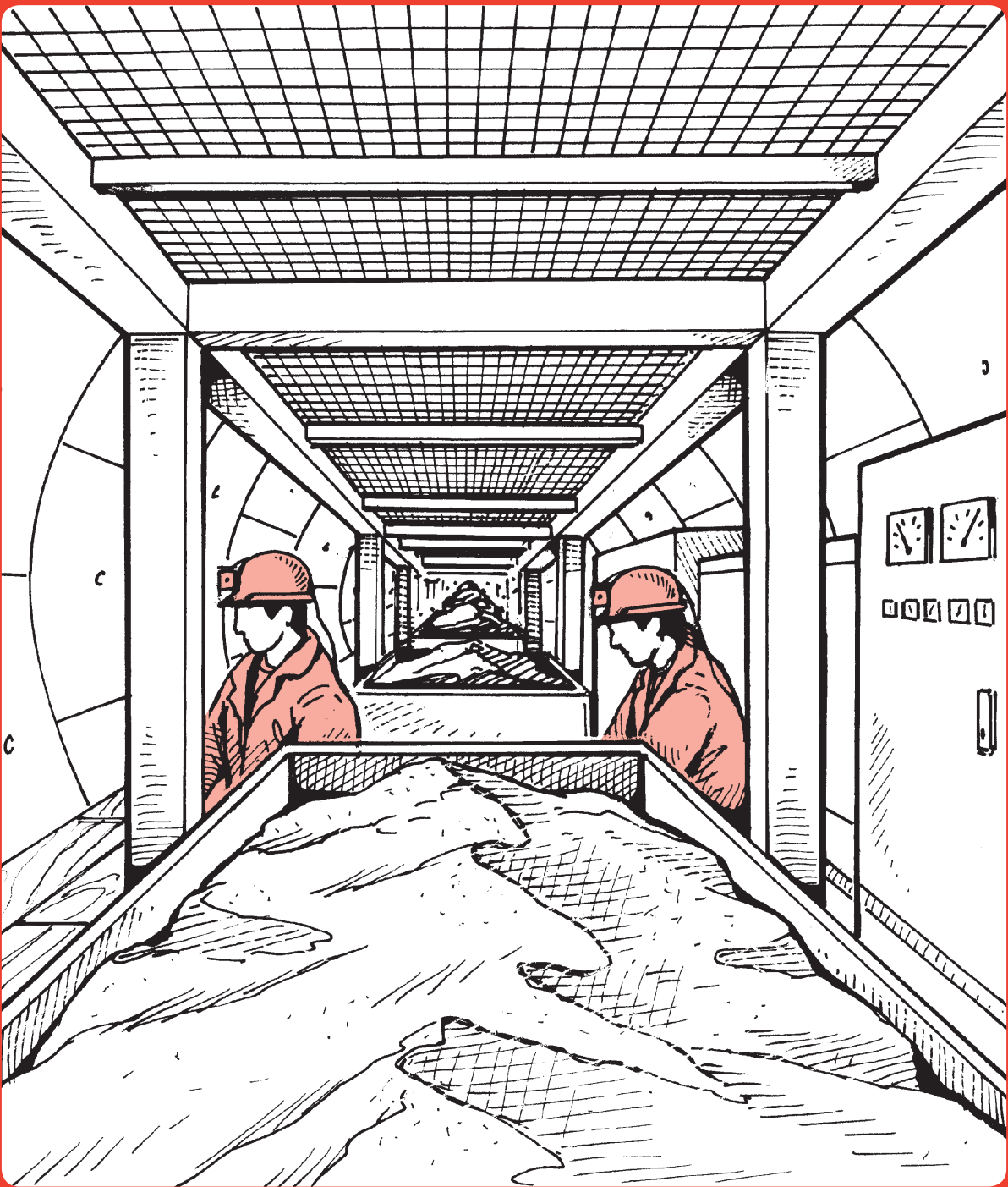
- being struck or run over

Reversing in Tunnels



Protection

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



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Danger

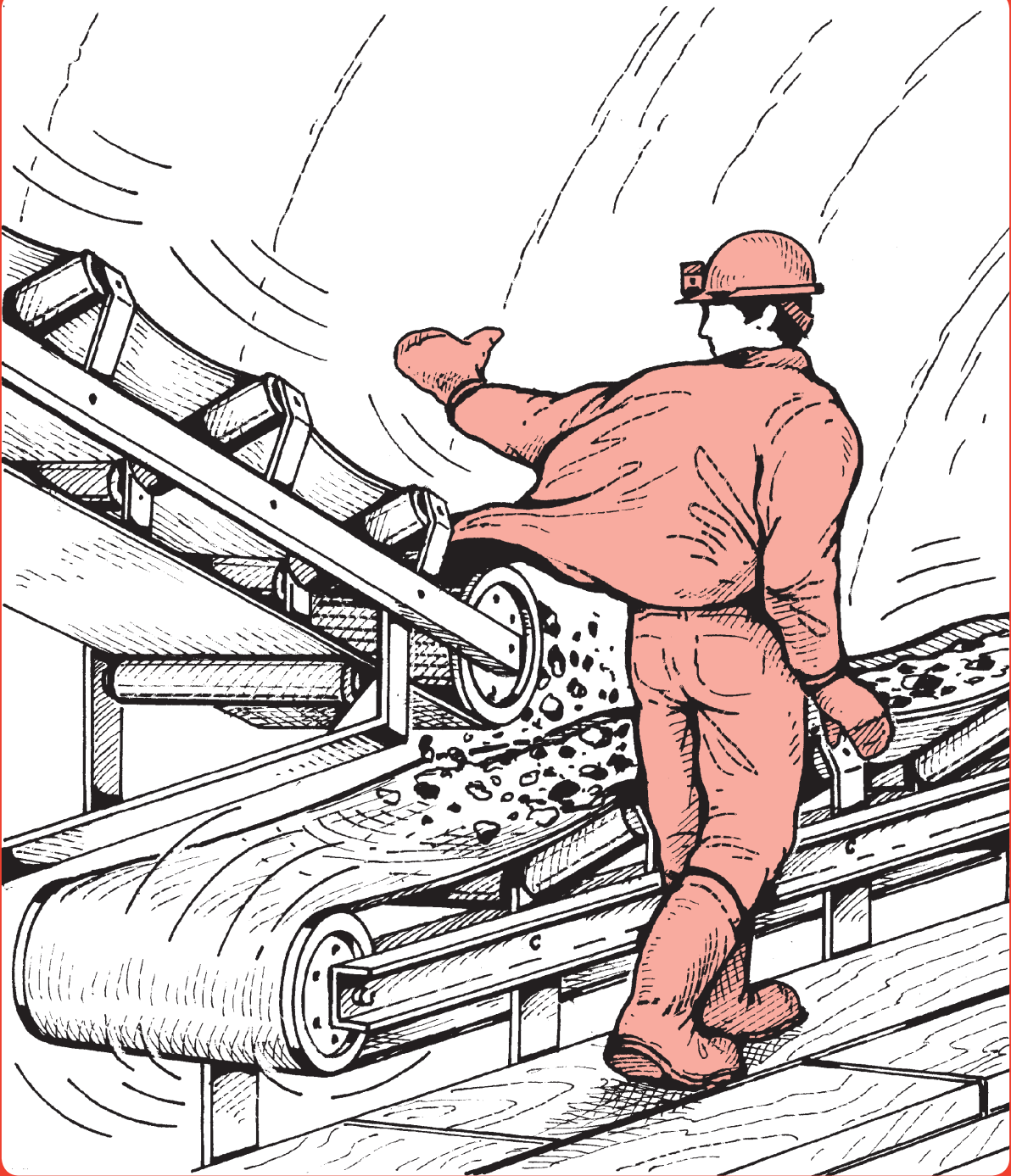
- being crushed
- being struck / run over
- tripping up

Narrow Areas where Rail Vehicles are used



Protection

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

**Danger**

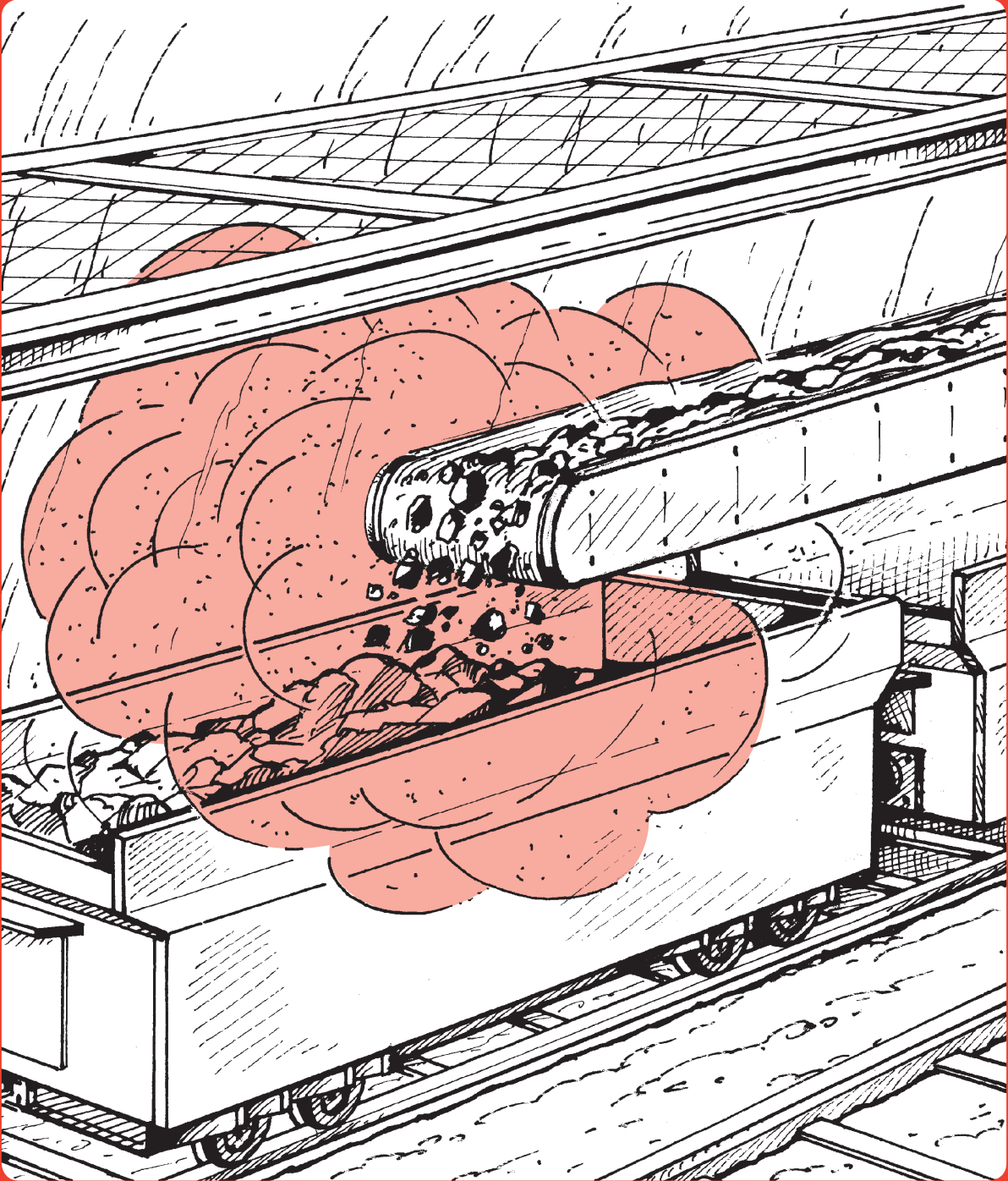
- being trapped or drawn in by running conveyor

Belt Transport



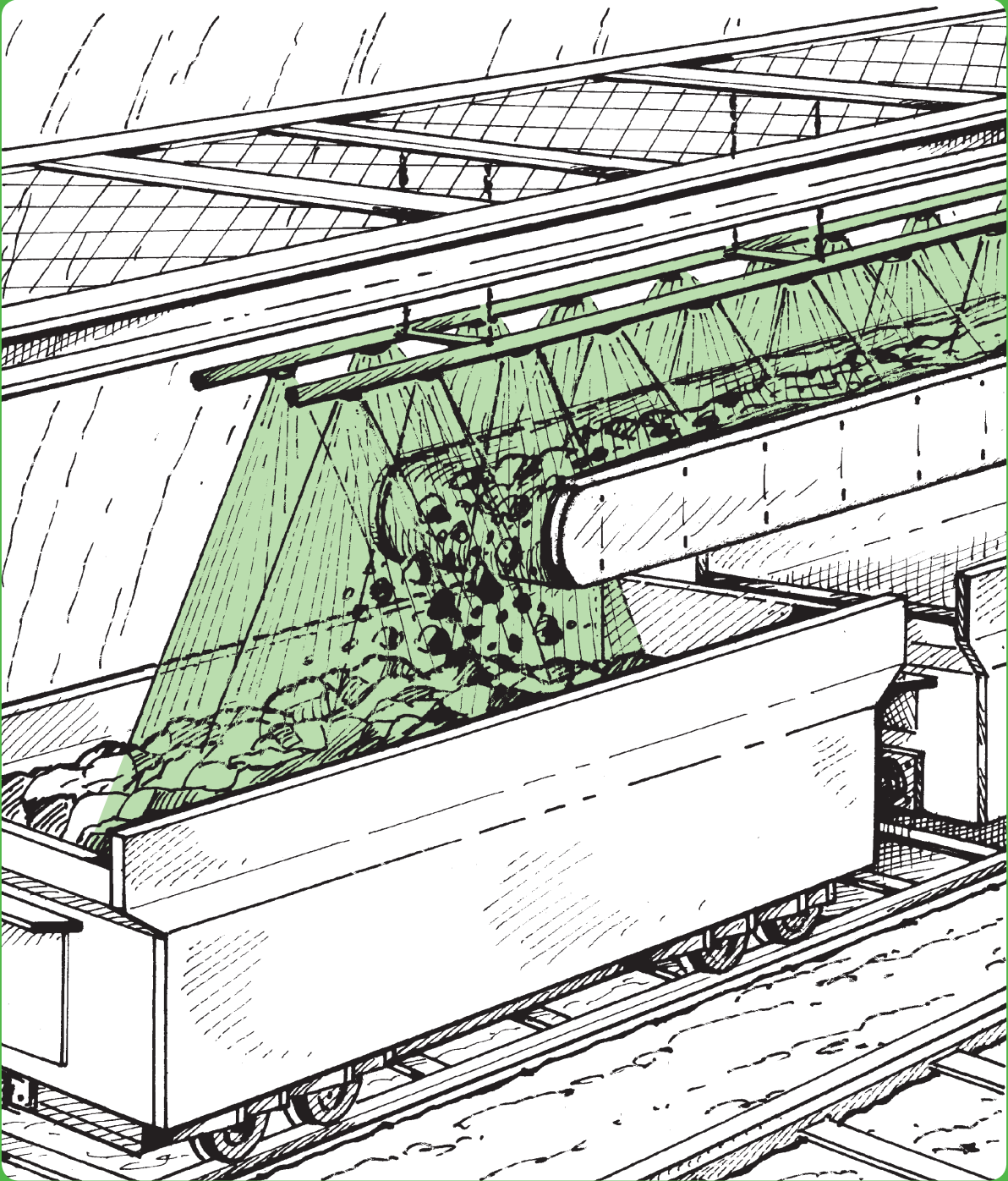
Protection

- protection against drawing in
- conveyor belt and walkways should be delimited / separated
- place safety switches at regular space interval



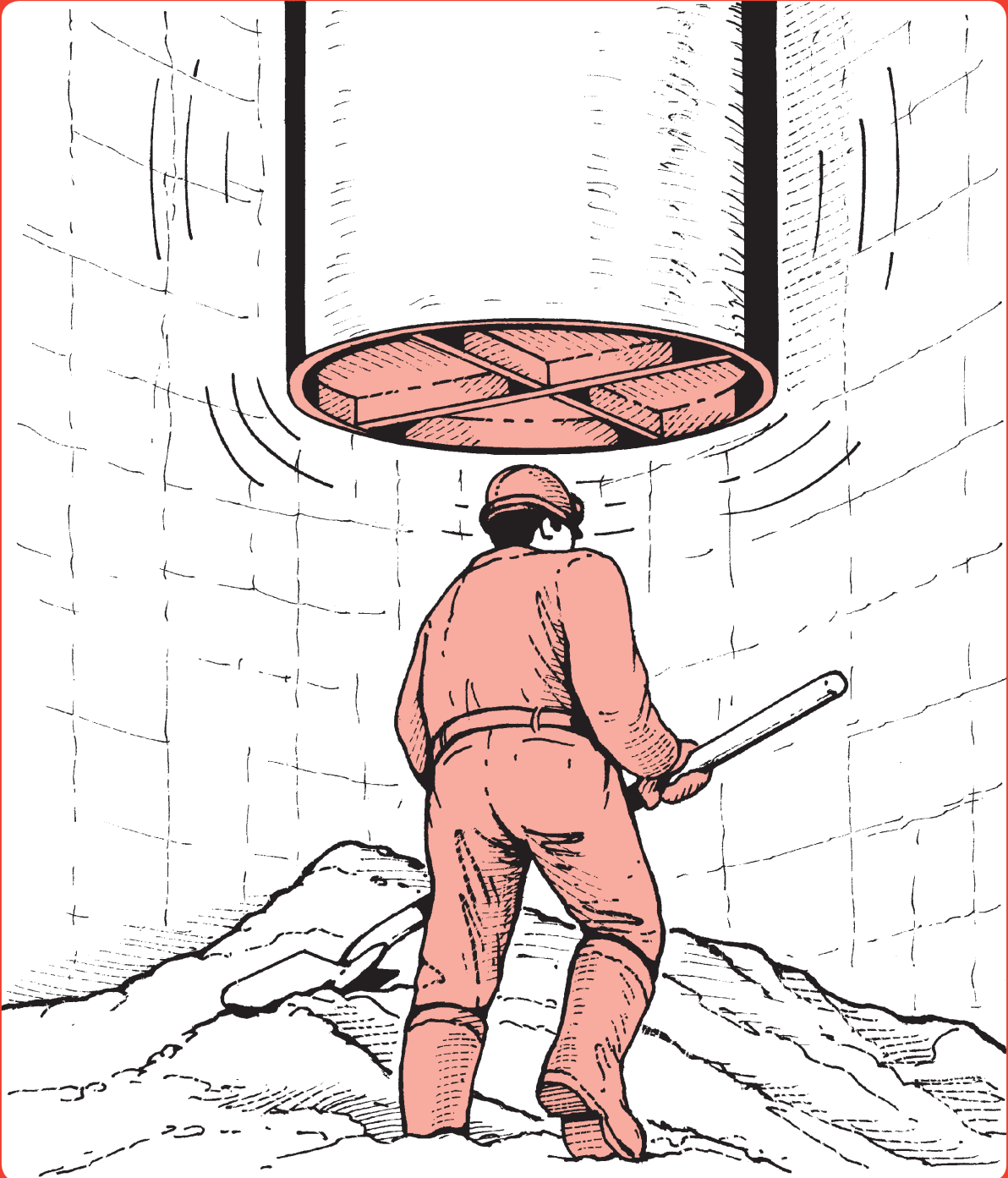
- harmful dust

Belt Transport (belt transfer points)



Protection

- transfer points should be equipped with a waterspray system
- alternative: housing in with dust extraction system

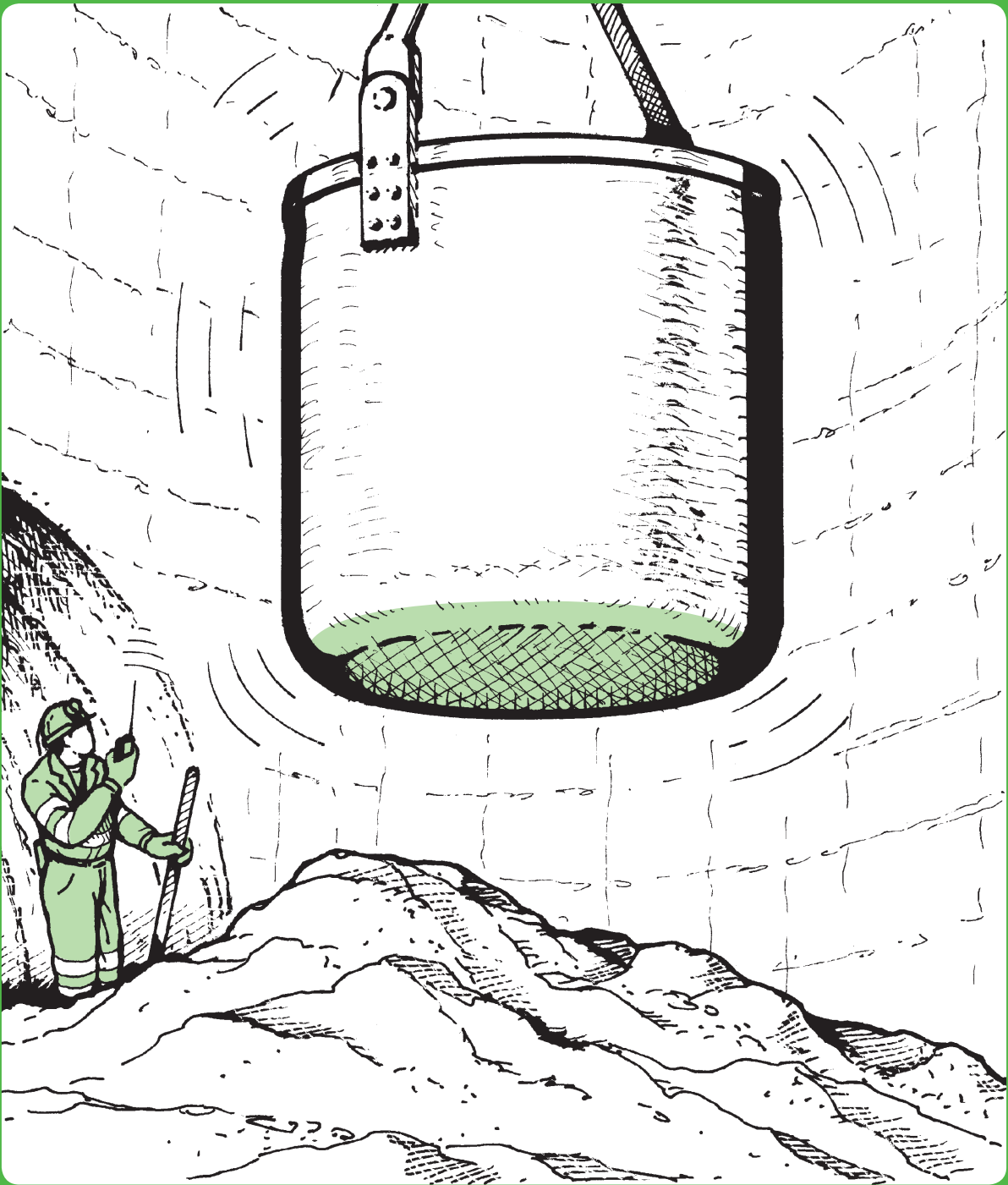


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Danger

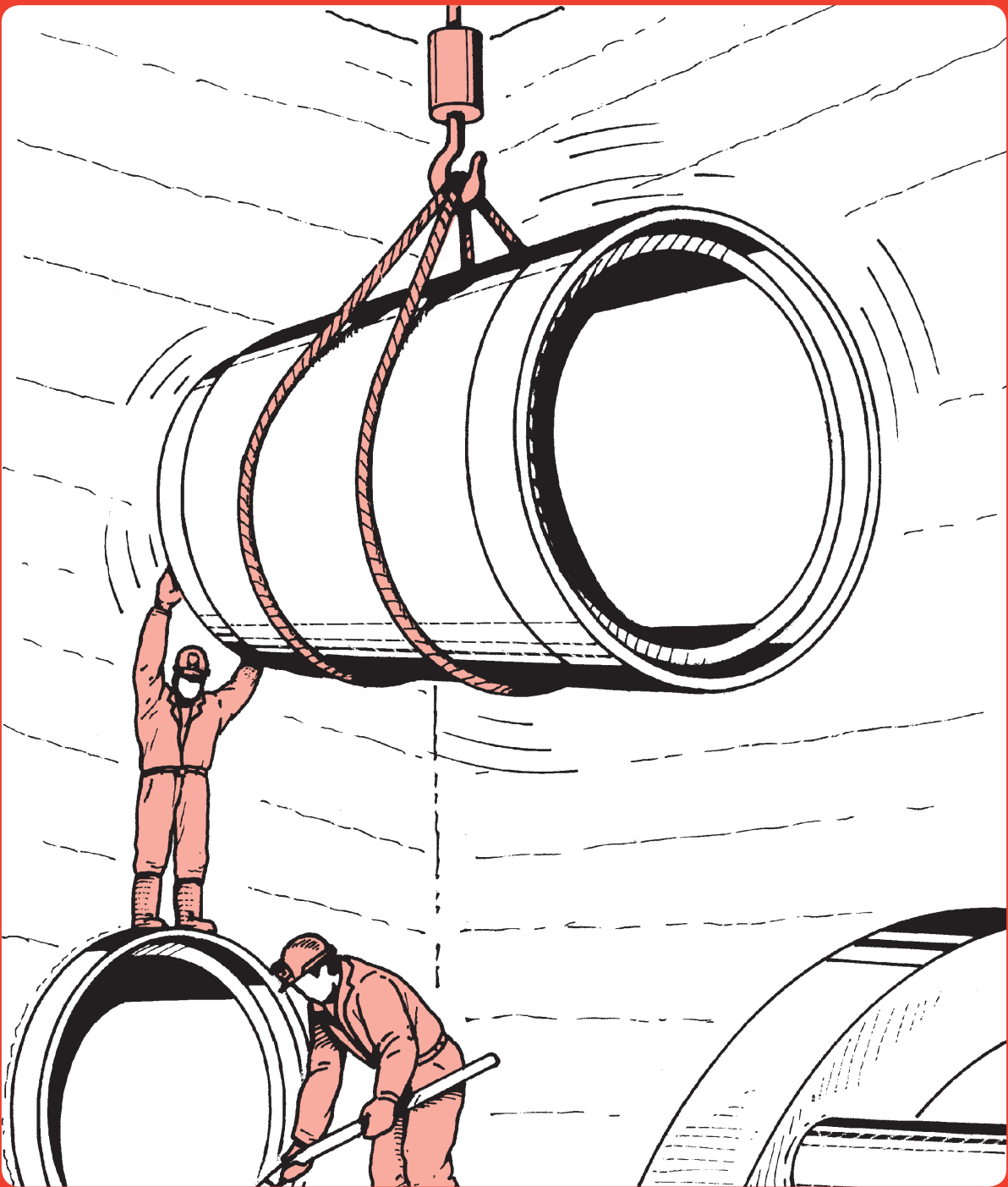
- being crushed
- falling material

Shaft Transport (removal of excavated material)



Protection

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

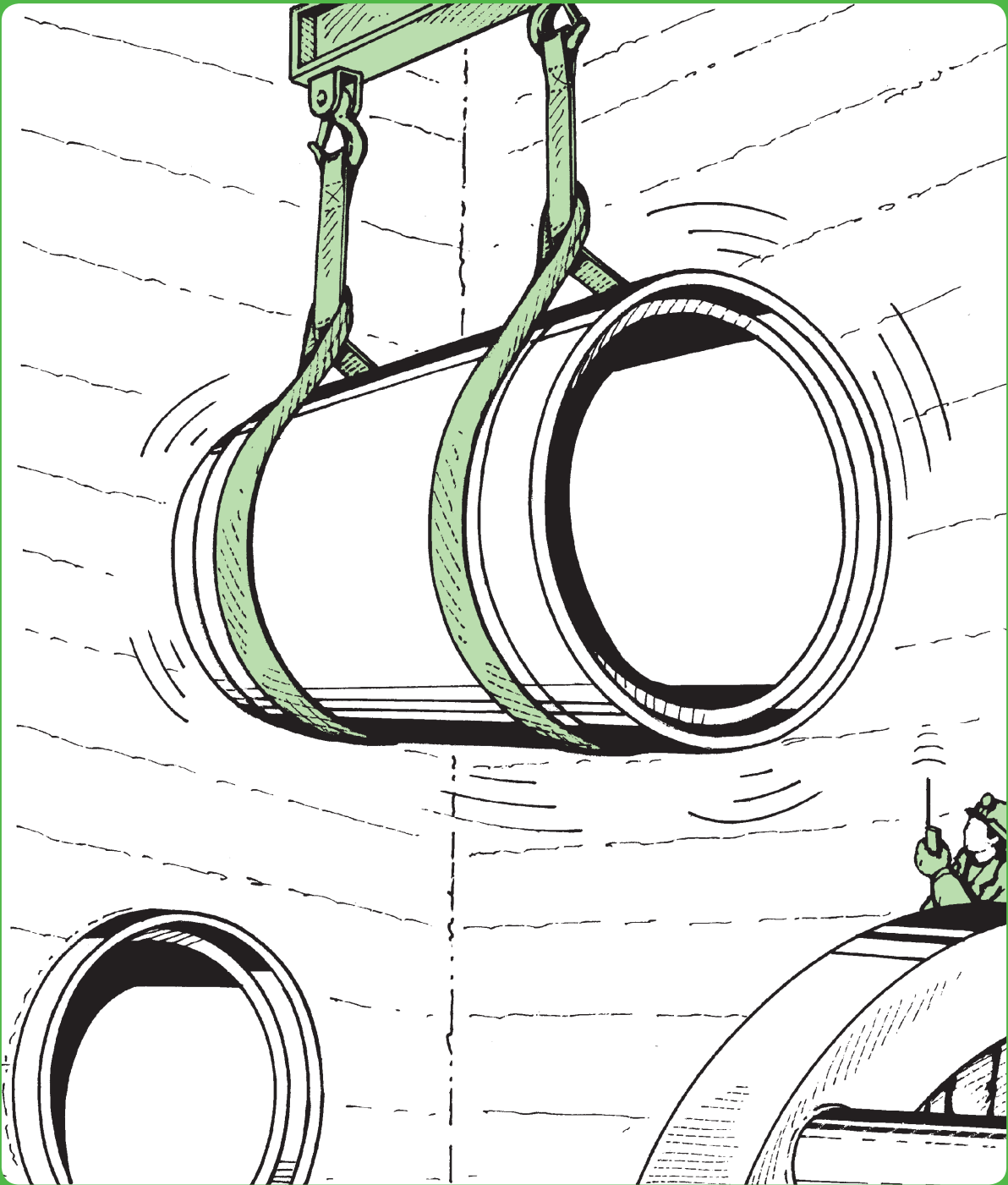


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Danger

- being injured by falling or swinging load

Shaft Transport (bulk loads)

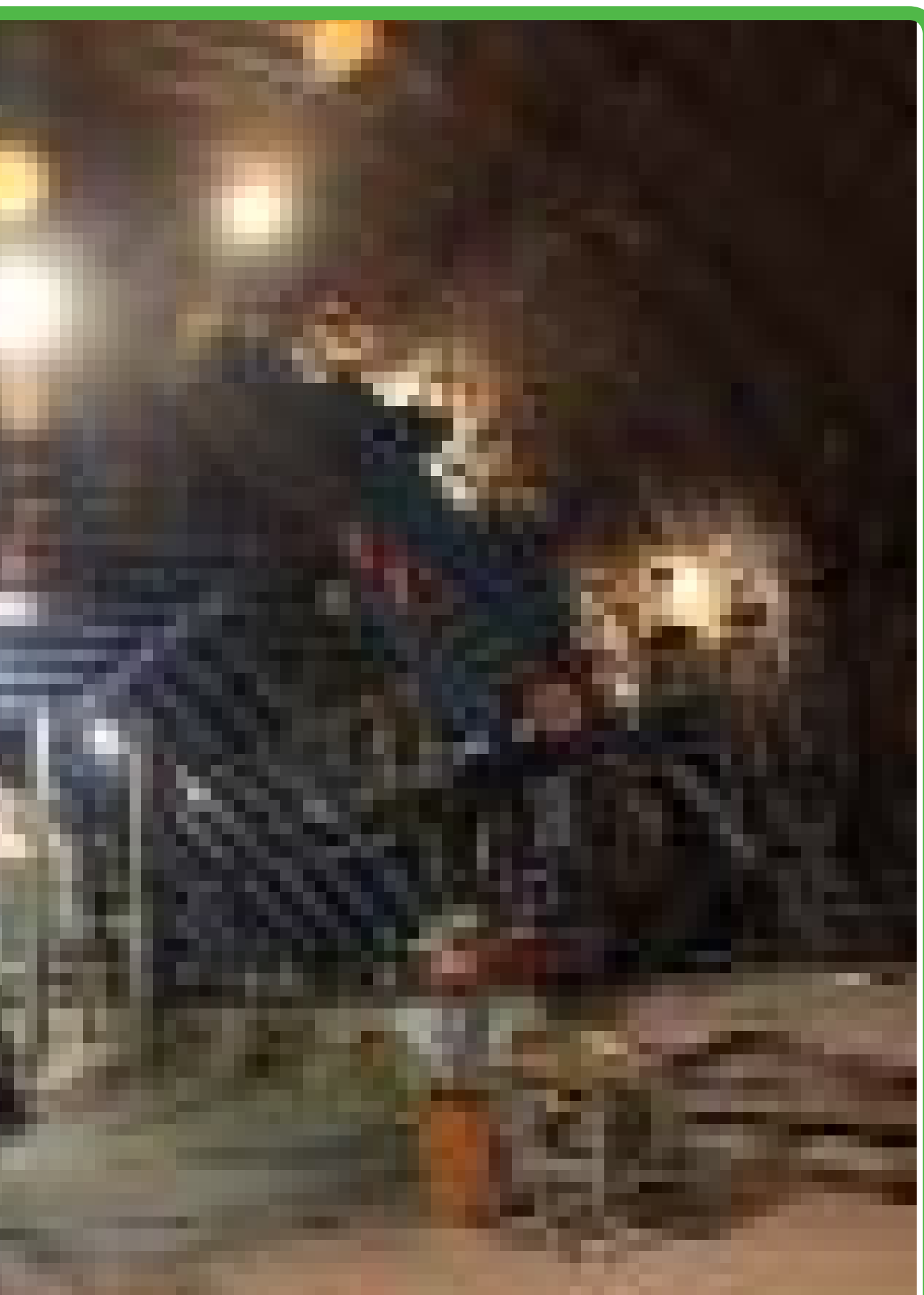


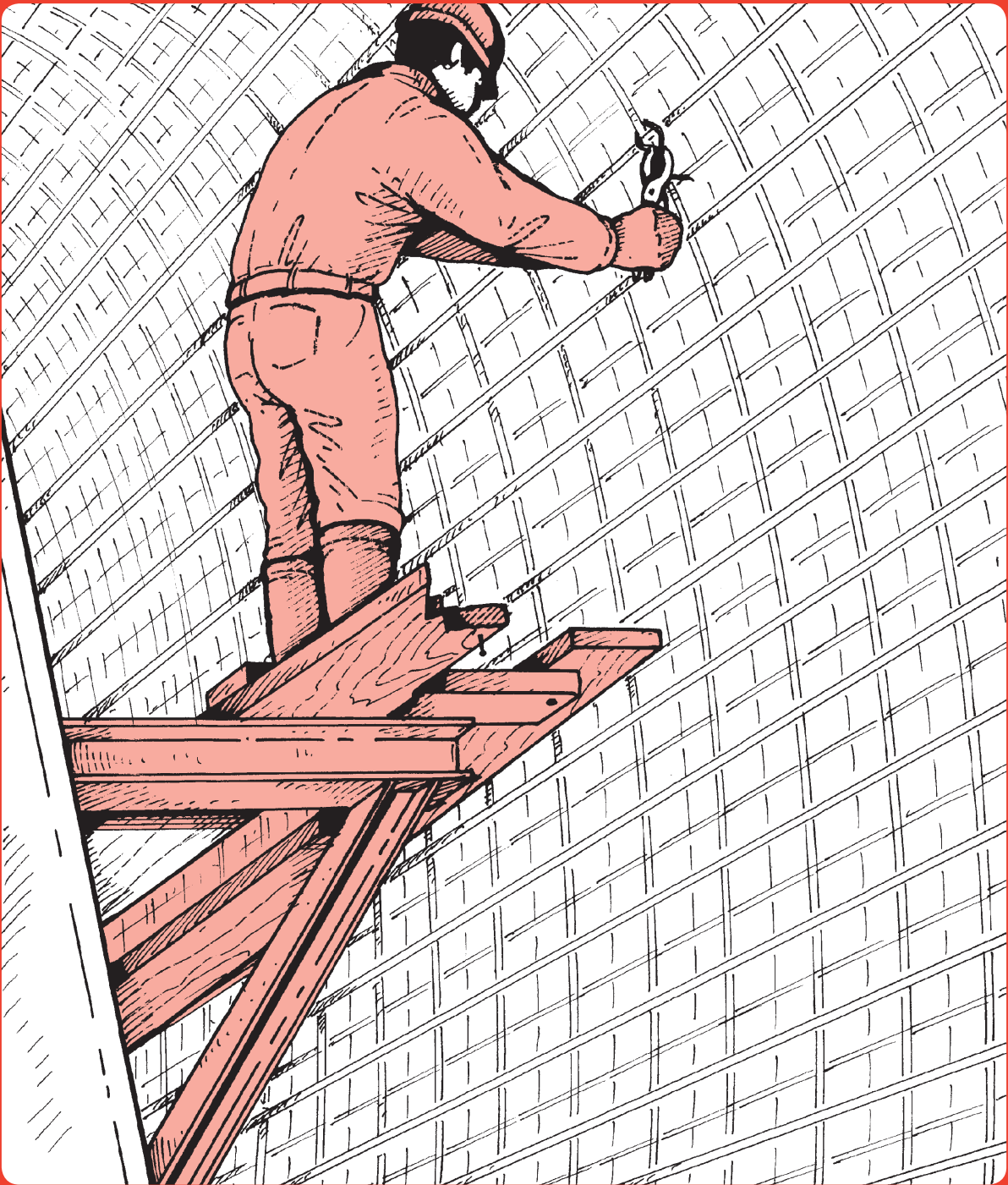
Protection

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

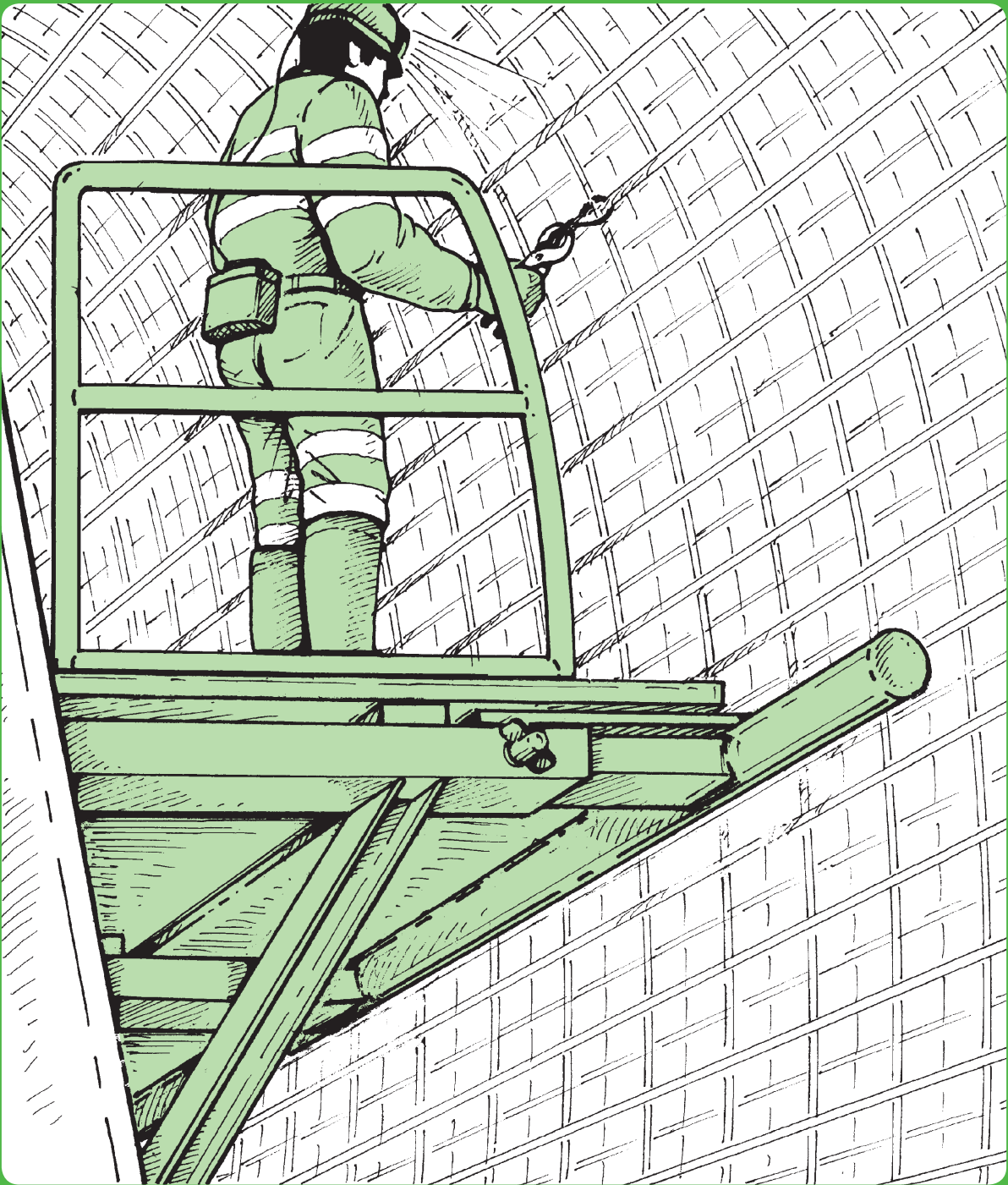


Final Lining



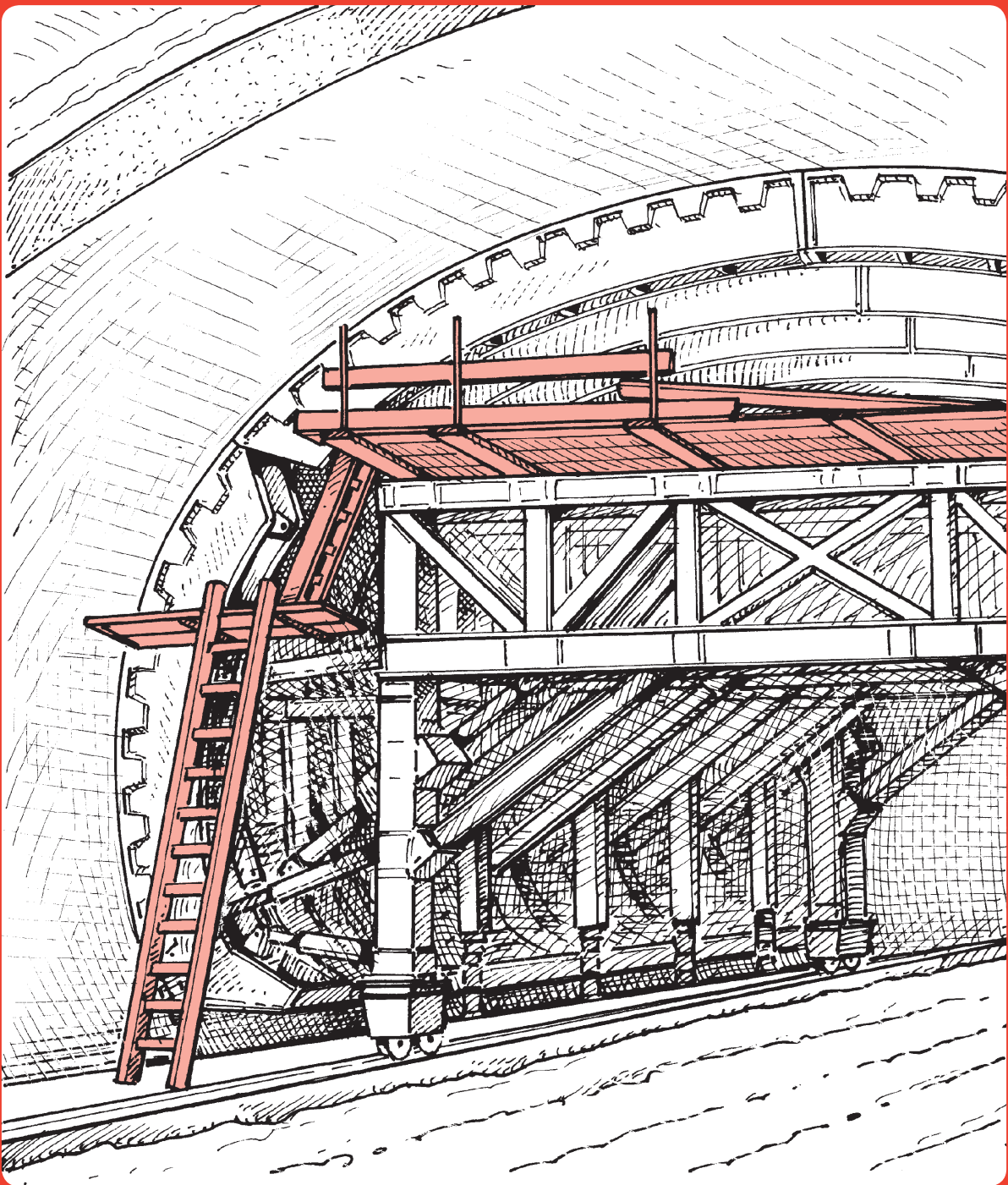


Installing Steel Reinforcement

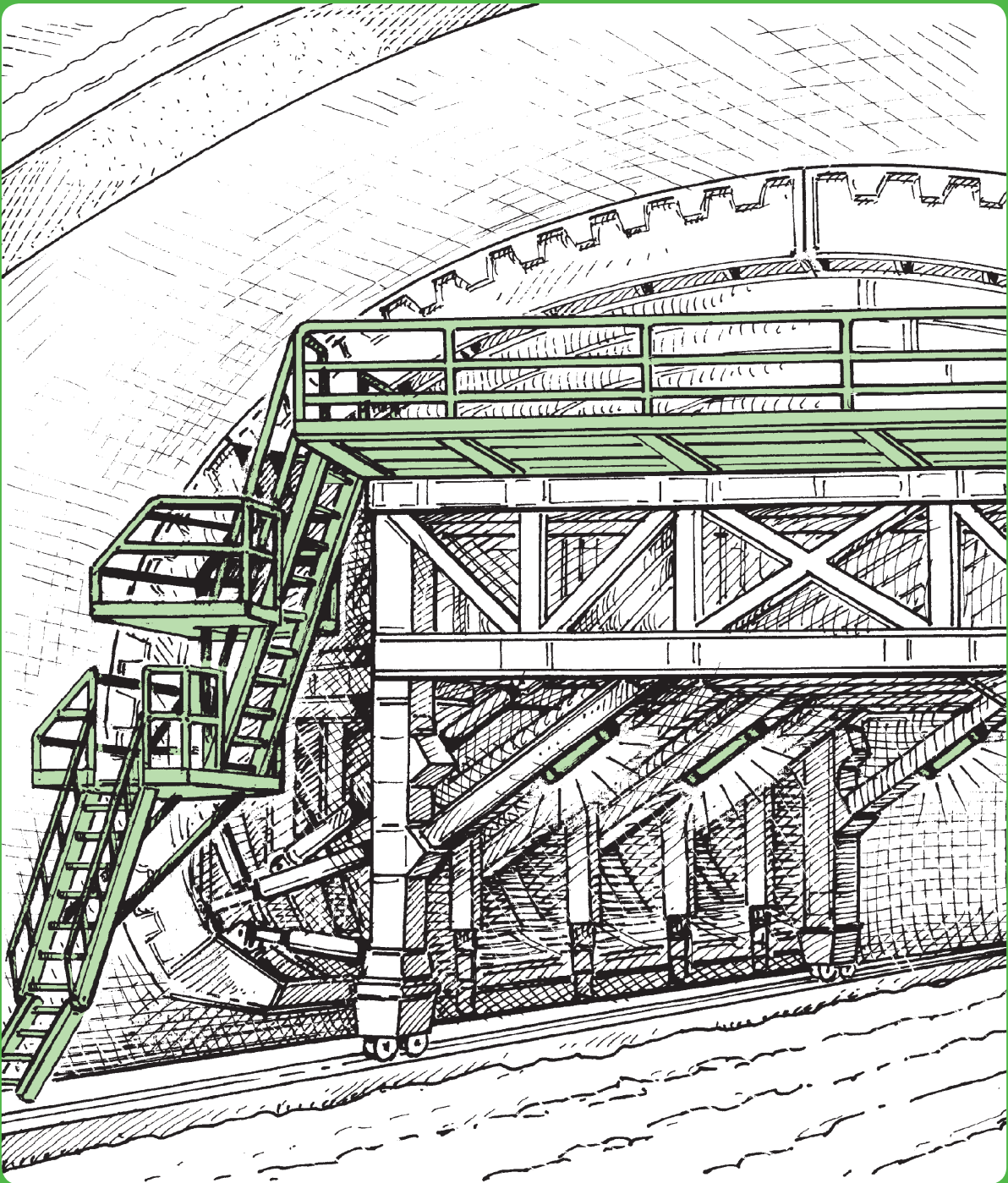


Protection

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

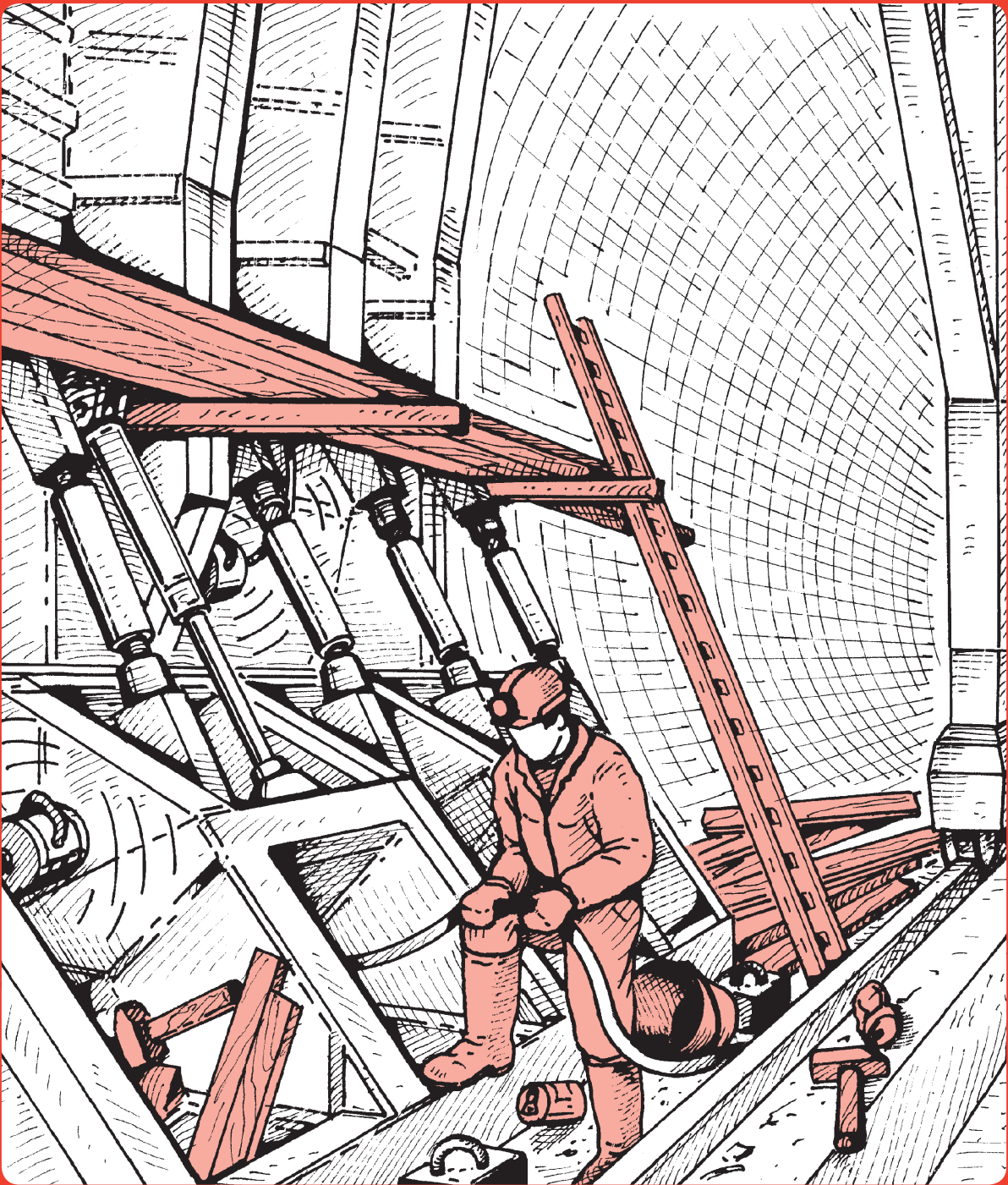


Tunnel Formwork Access



Protection

- access ways should be properly constructed and guarded

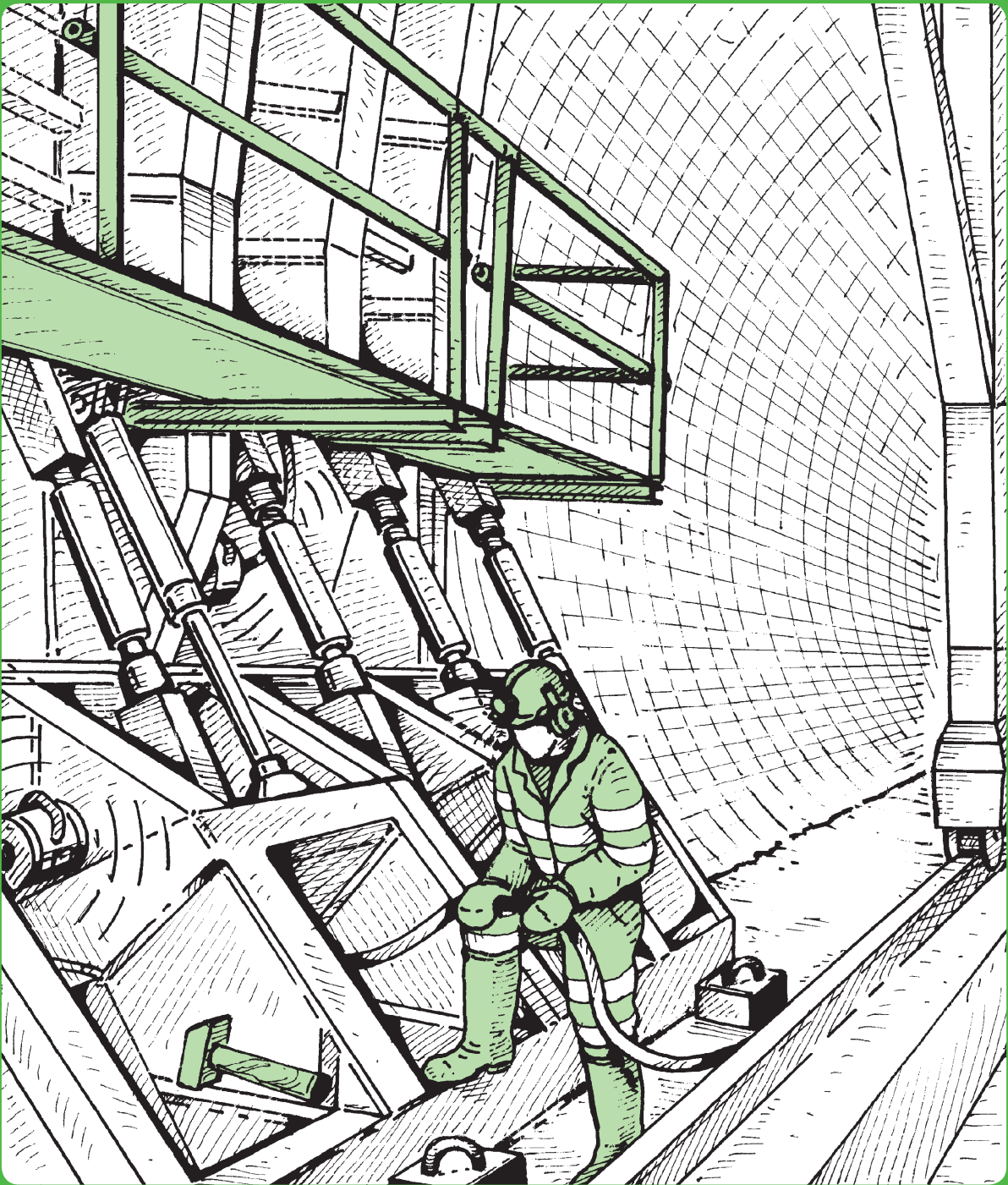


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Danger

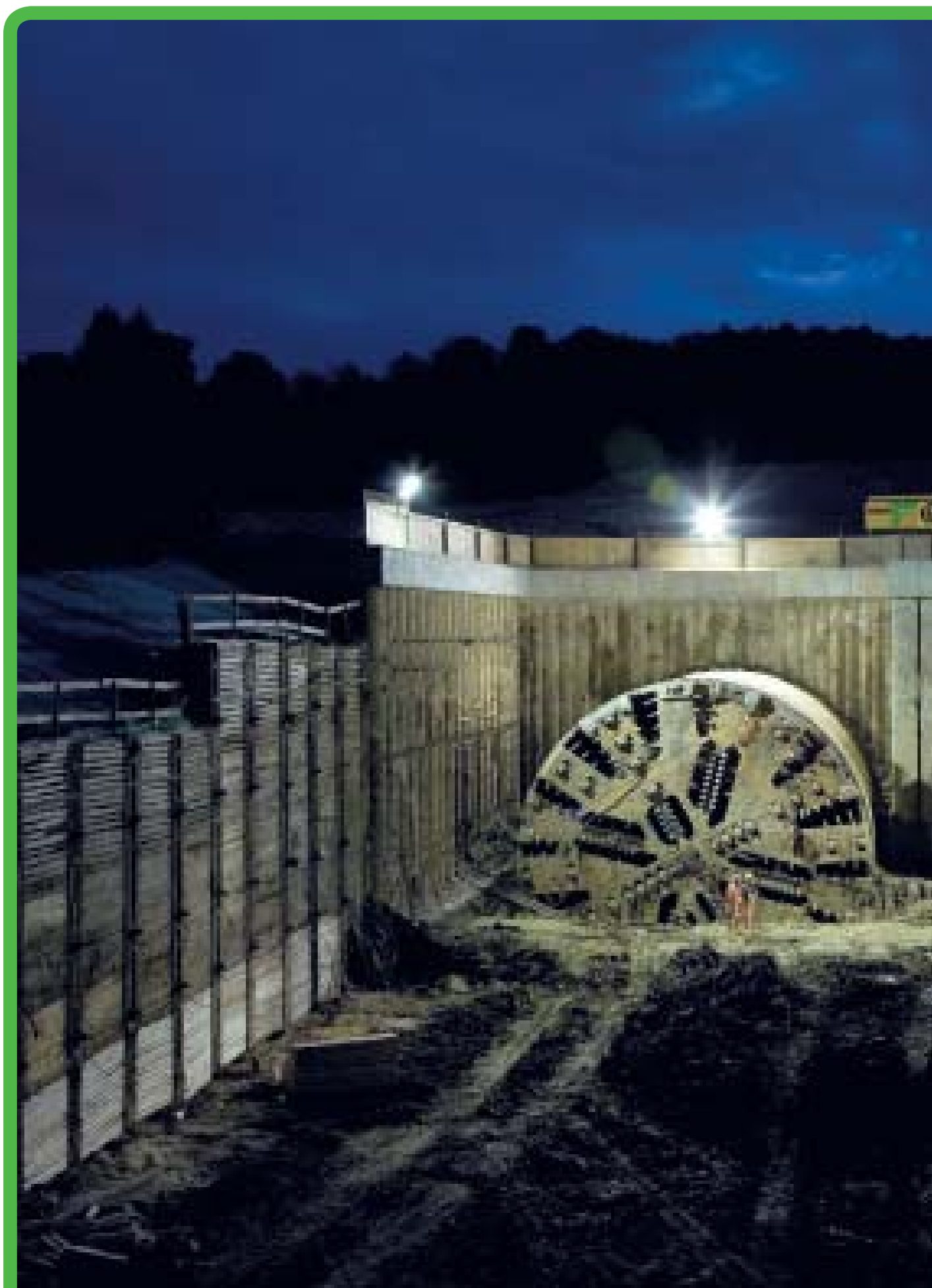
- tripping and falling
- noise resulting from the external vibrator
- unsafe access and working places

Working in the Tunnel Formwork



Protection

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



TBM-Work





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Danger

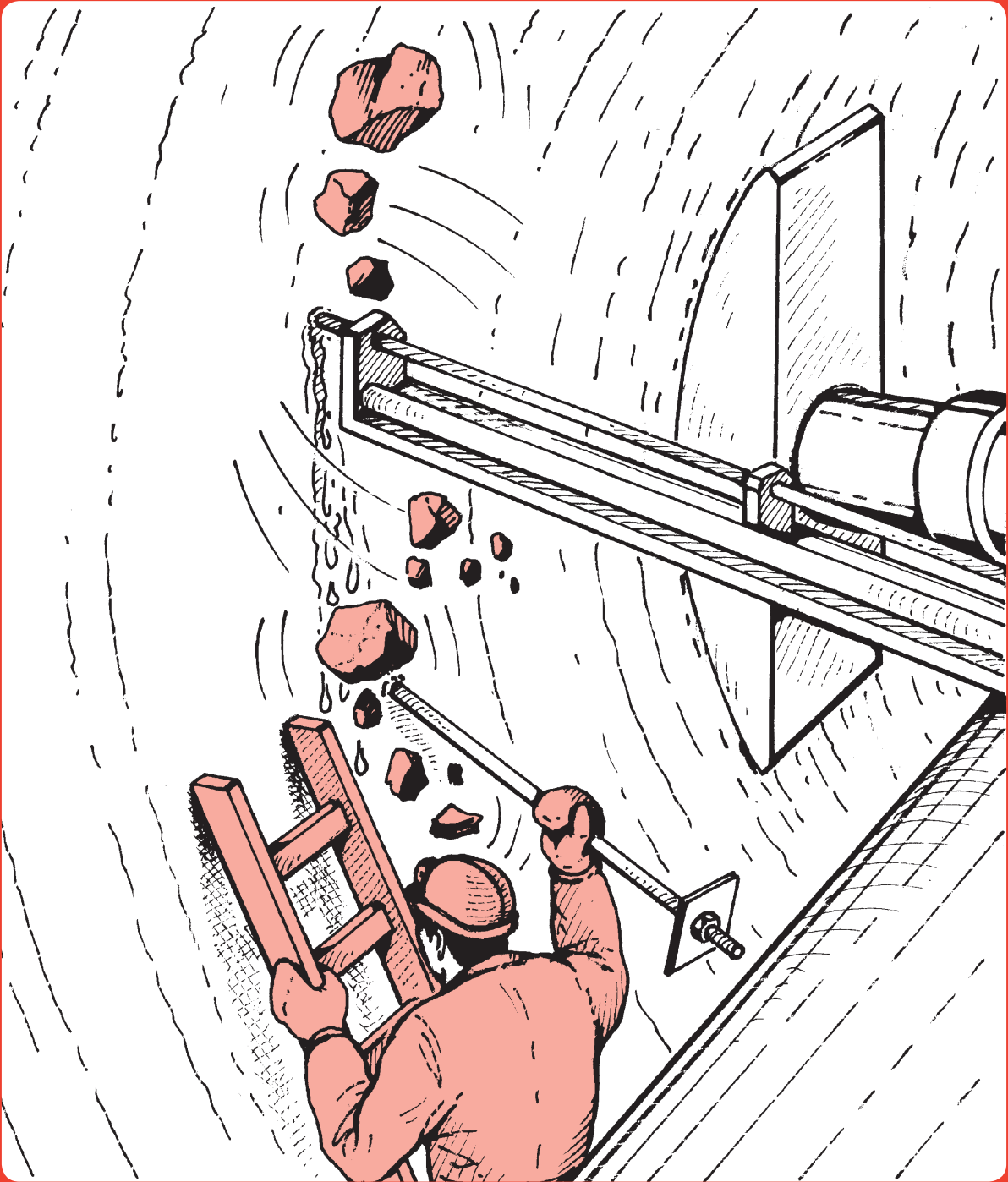
- falling
- drowning in bentonite
- collapse of excavated faces

Maintenance Work in Cutterhead Area



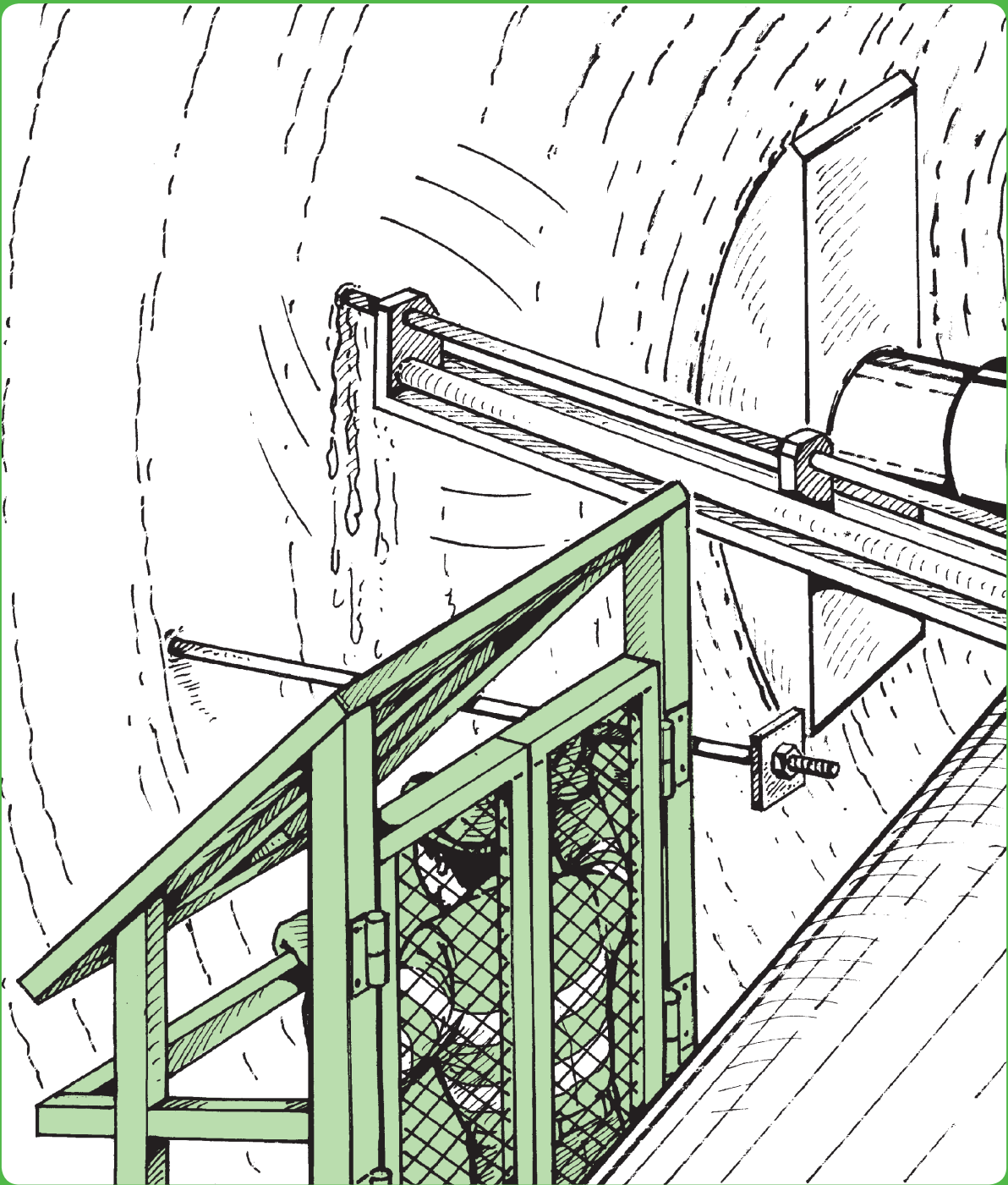
Protection

- use the platform provided by manufacturer
- ensure face stability
- sheeting plates at workface should be driven up hydraulically where required

**Danger**

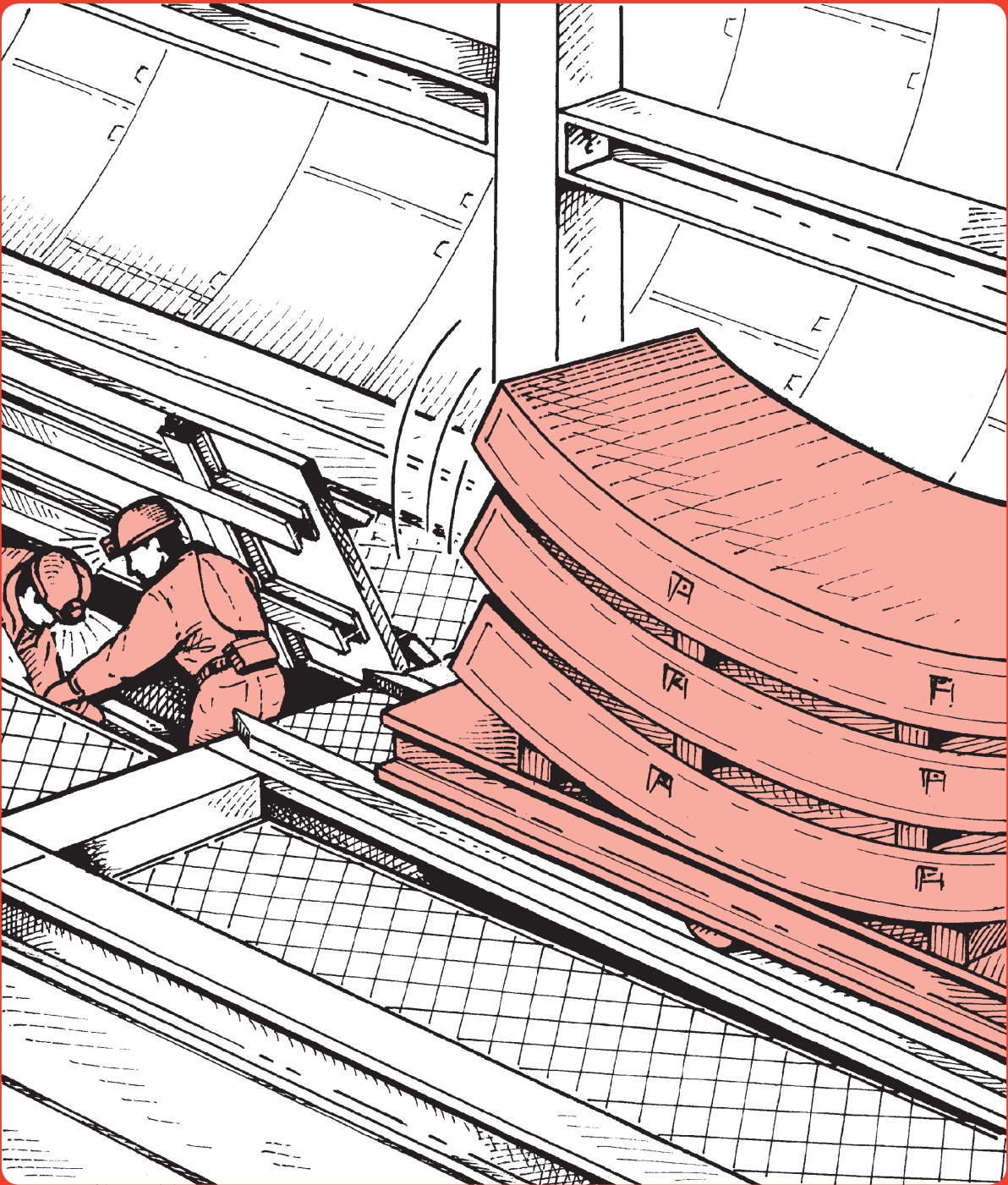
- rock fall and cave-in
- falling

Installing Rockbolts in TBM Tunnels



Protection

- provide safe, defined working place
- keep out of danger zone

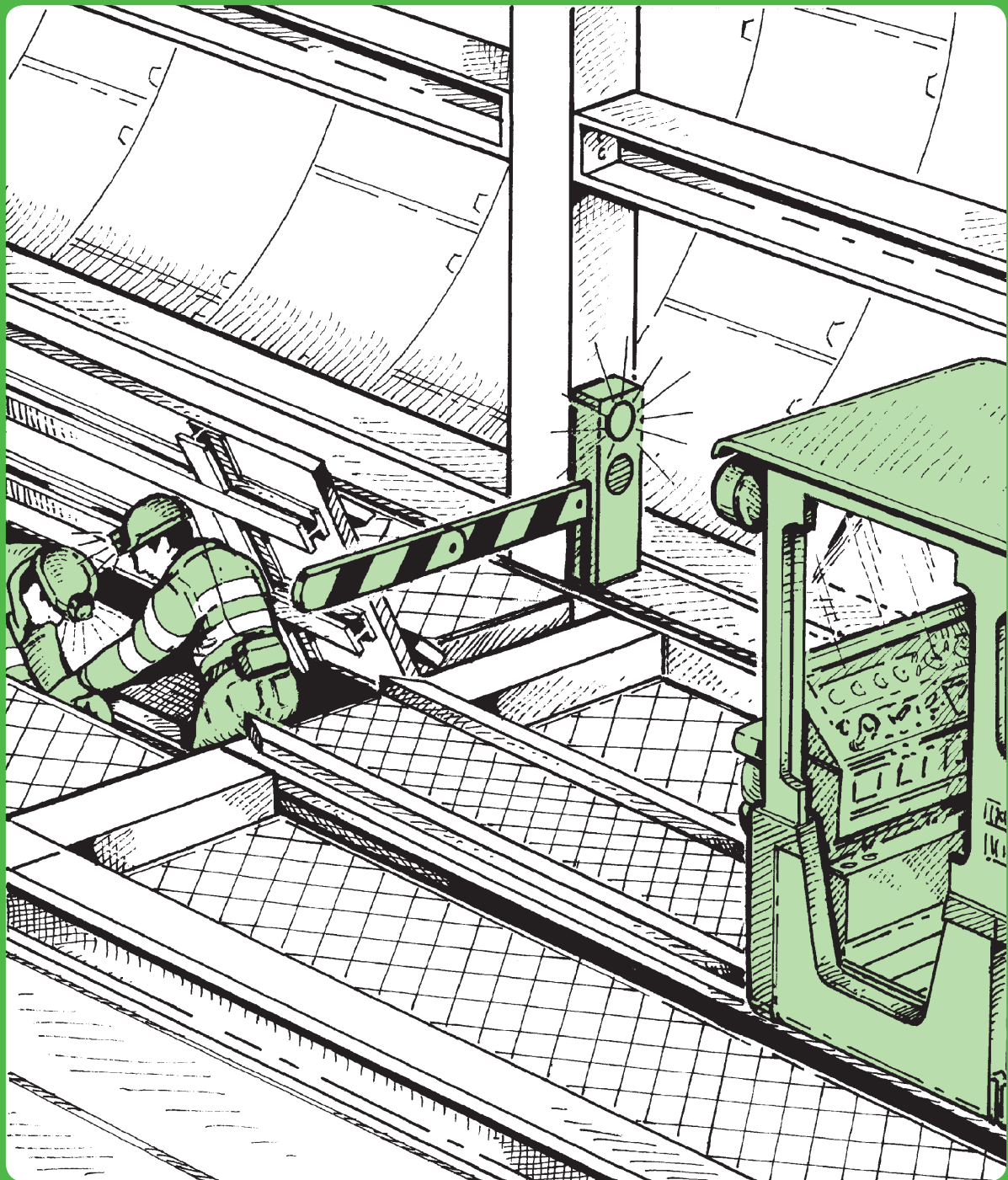


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Danger

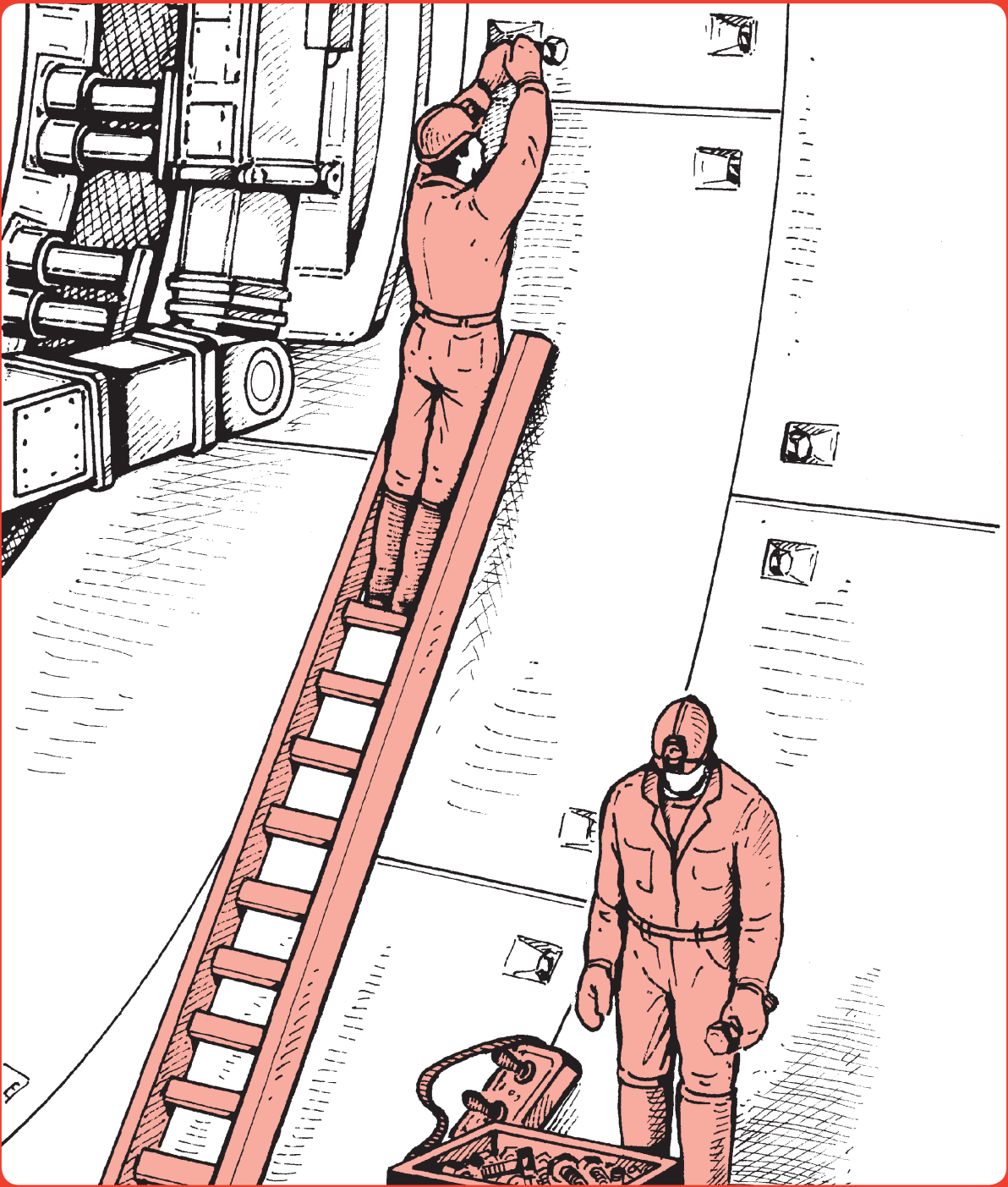
- being crushed
- being struck / run over

Track Laying in TBM Tunnels



Protection

- track laying operation shall be stopped during transport works
- use gates or signalling system (stoplights)
- driving cabs at both ends of train
- driving cab at one end, visual monitoring at the other end of train

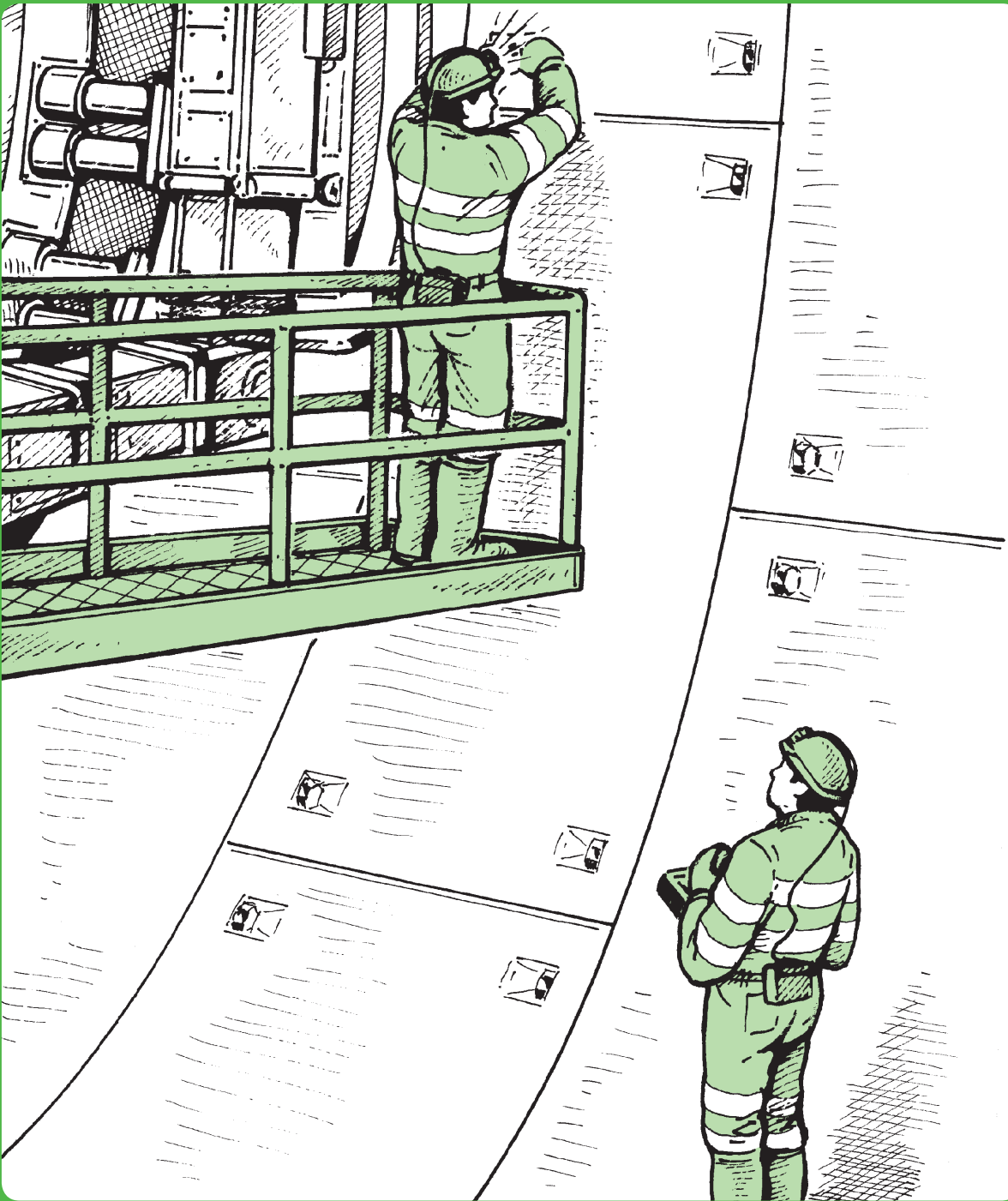


108

Danger

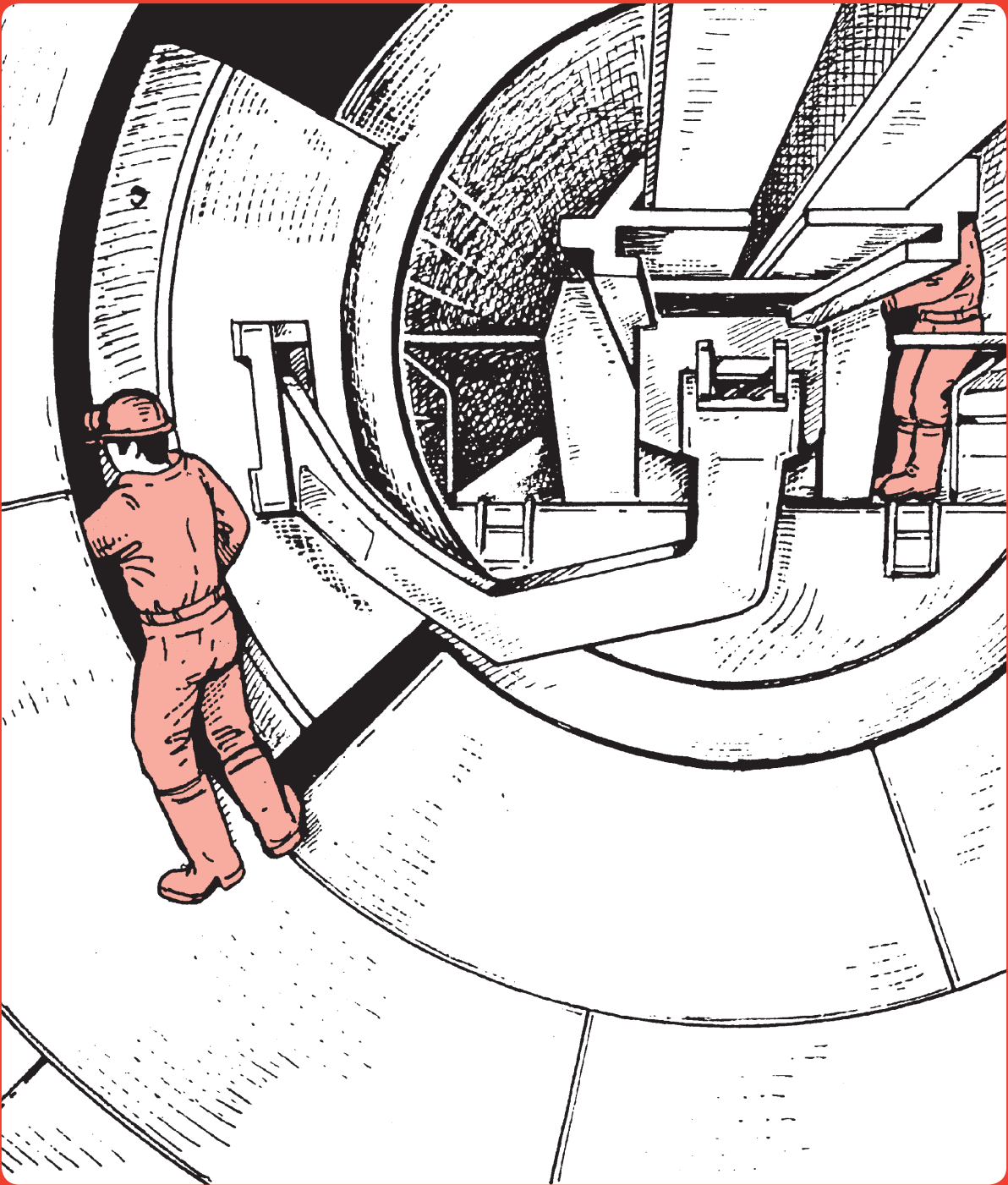
- falling
- being crushed

Installing Segments (big tunnel)



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

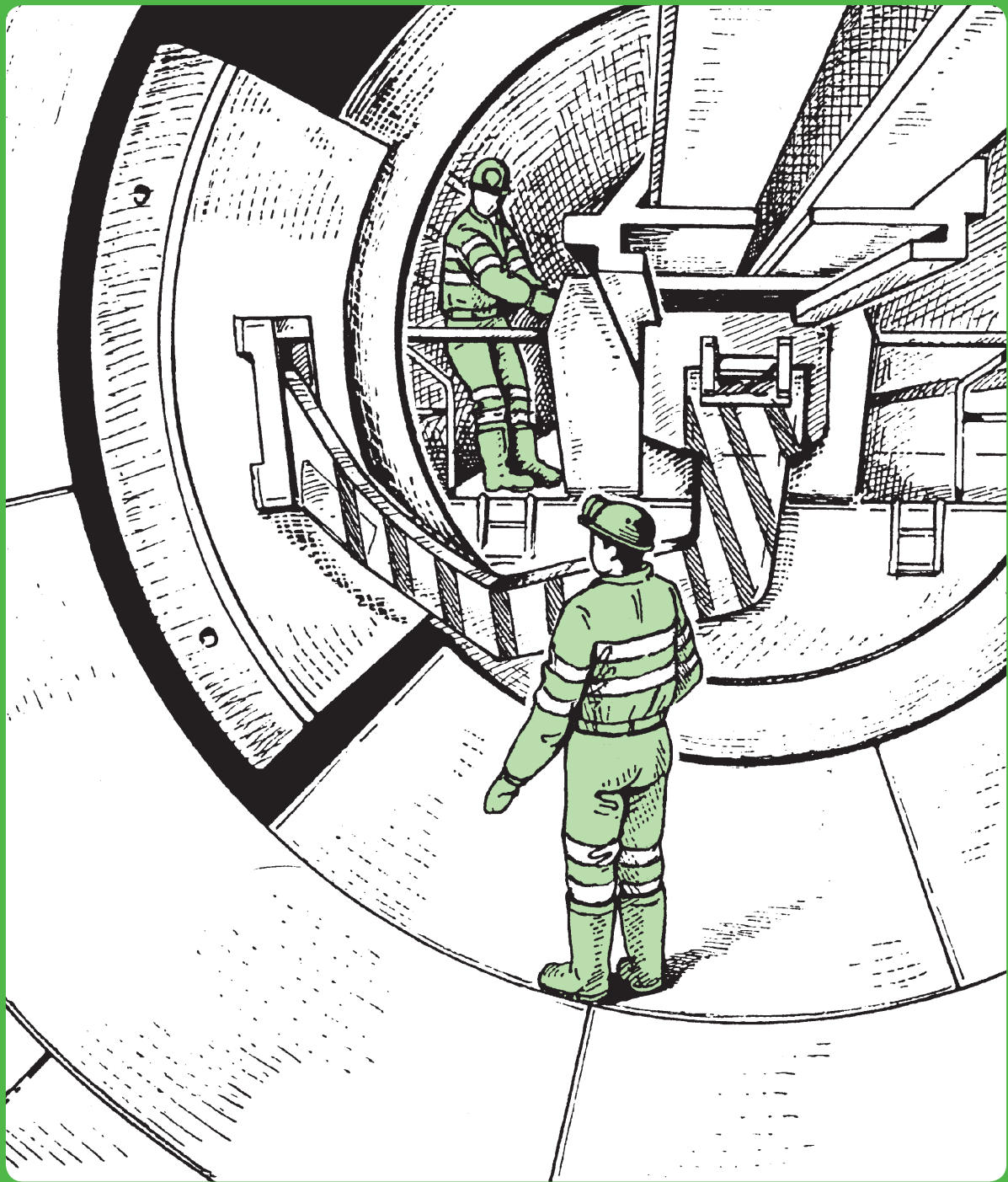


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Danger

- being crushed
- being knocked down

Installing Segments (small tunnel)



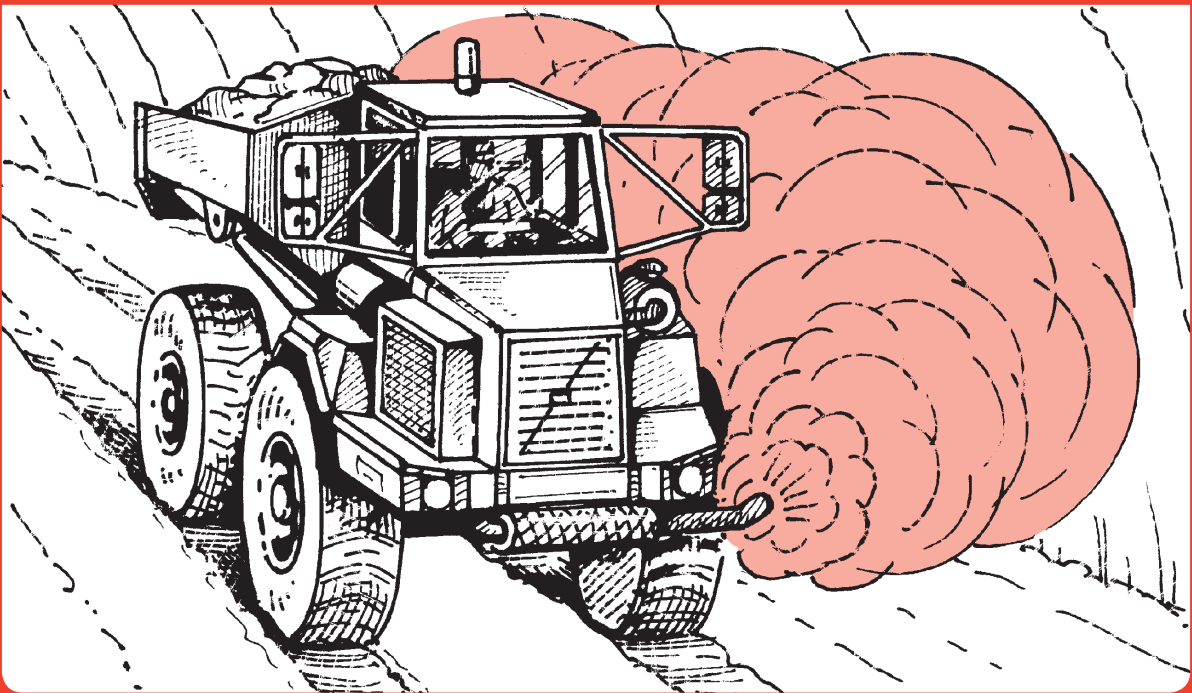
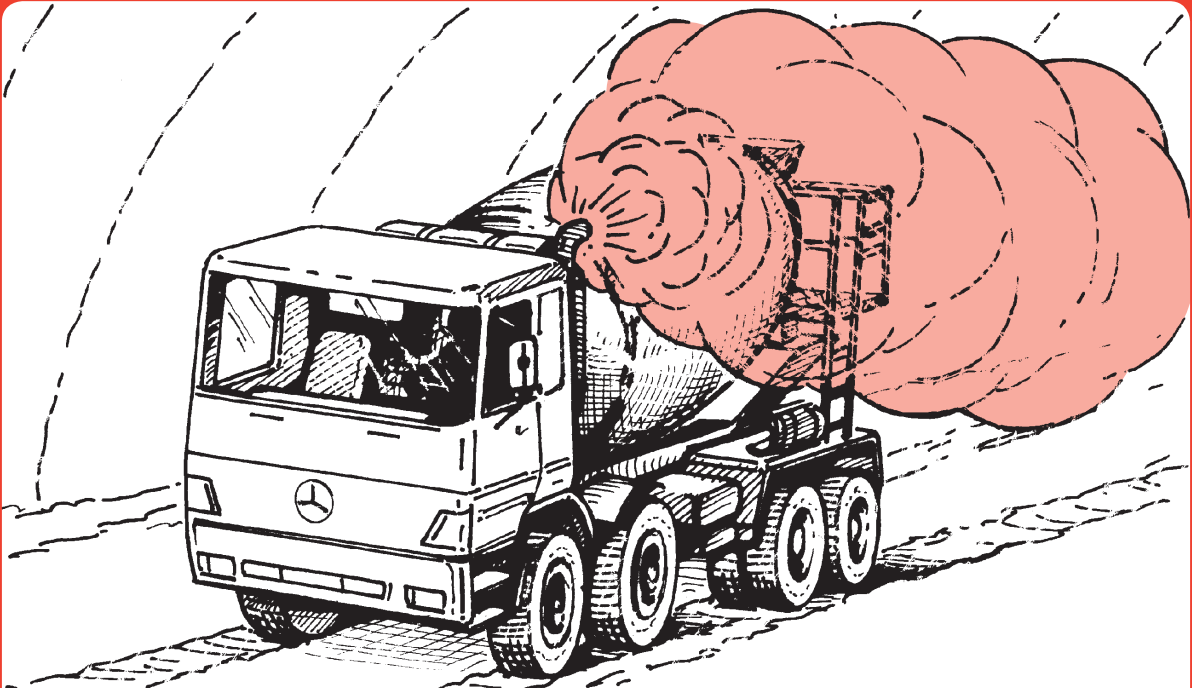
Protection

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



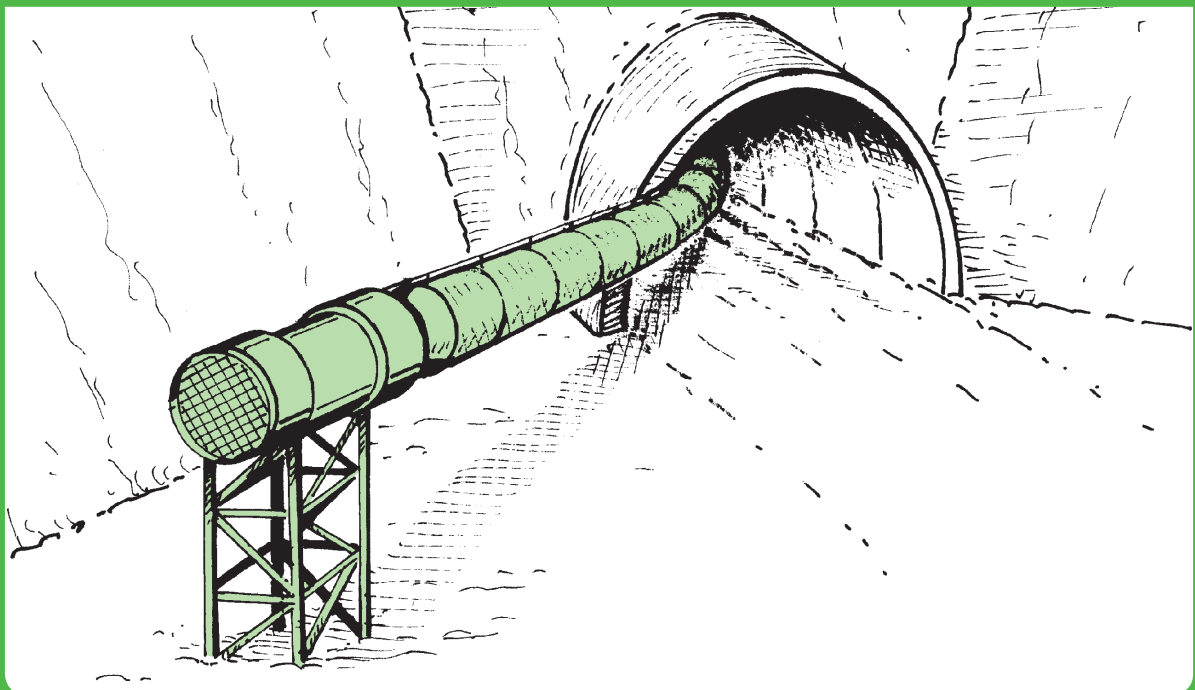
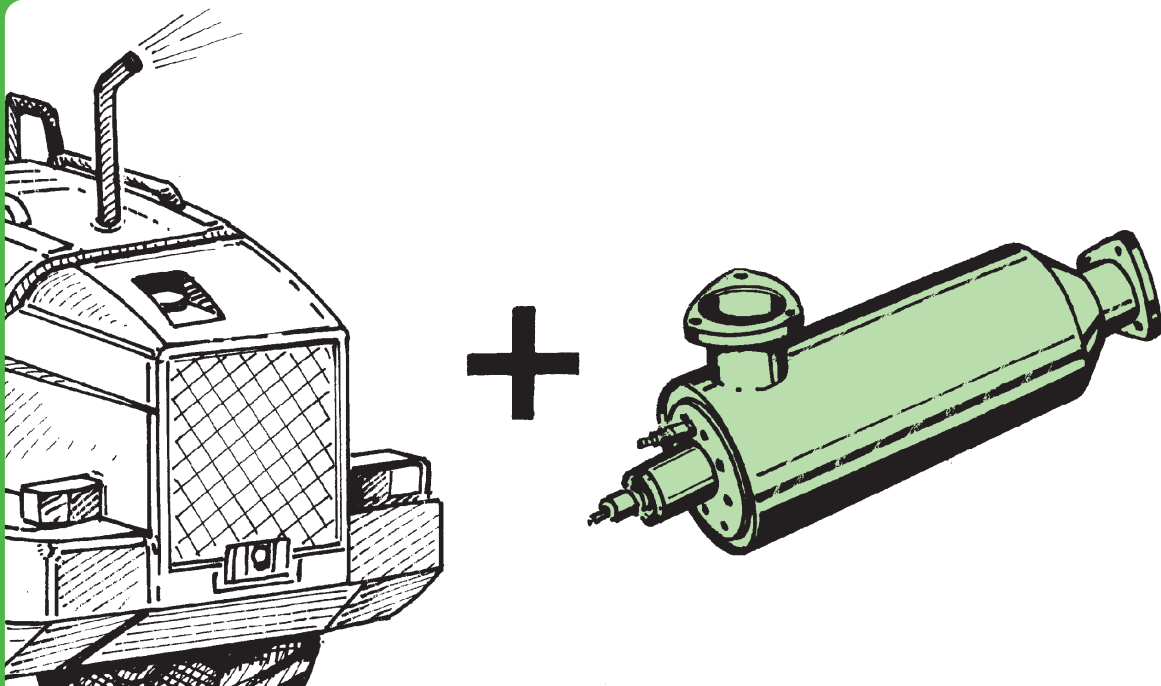
Toxic Substances in the Breathing Air



**Danger**

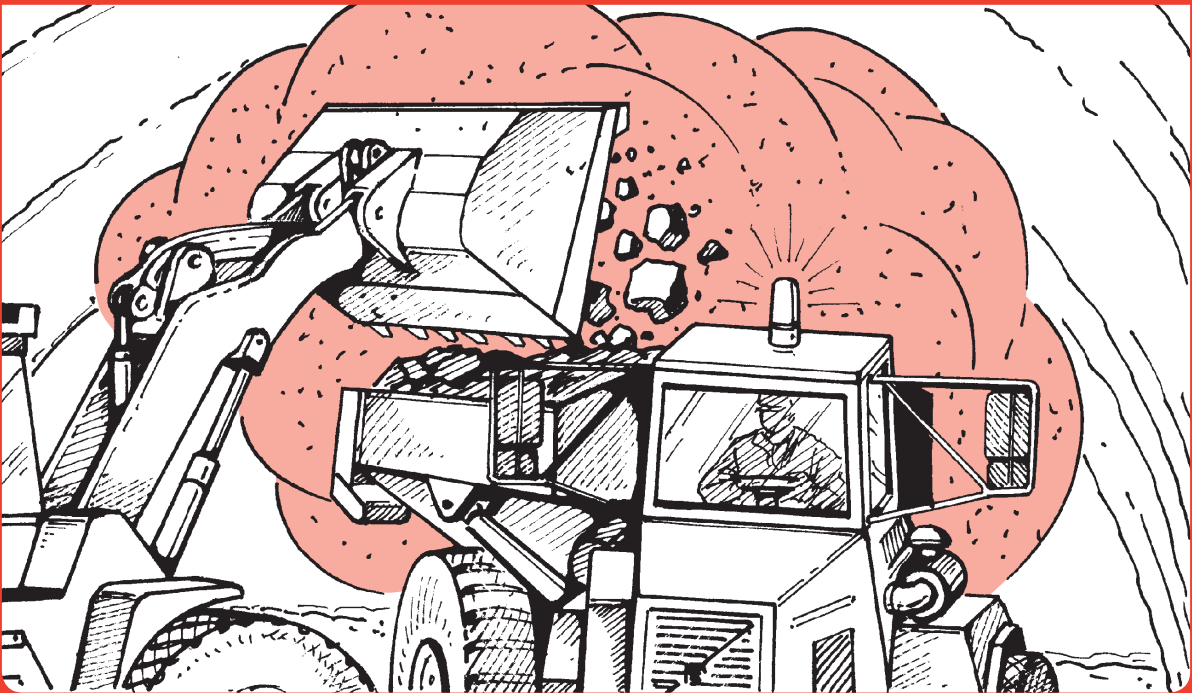
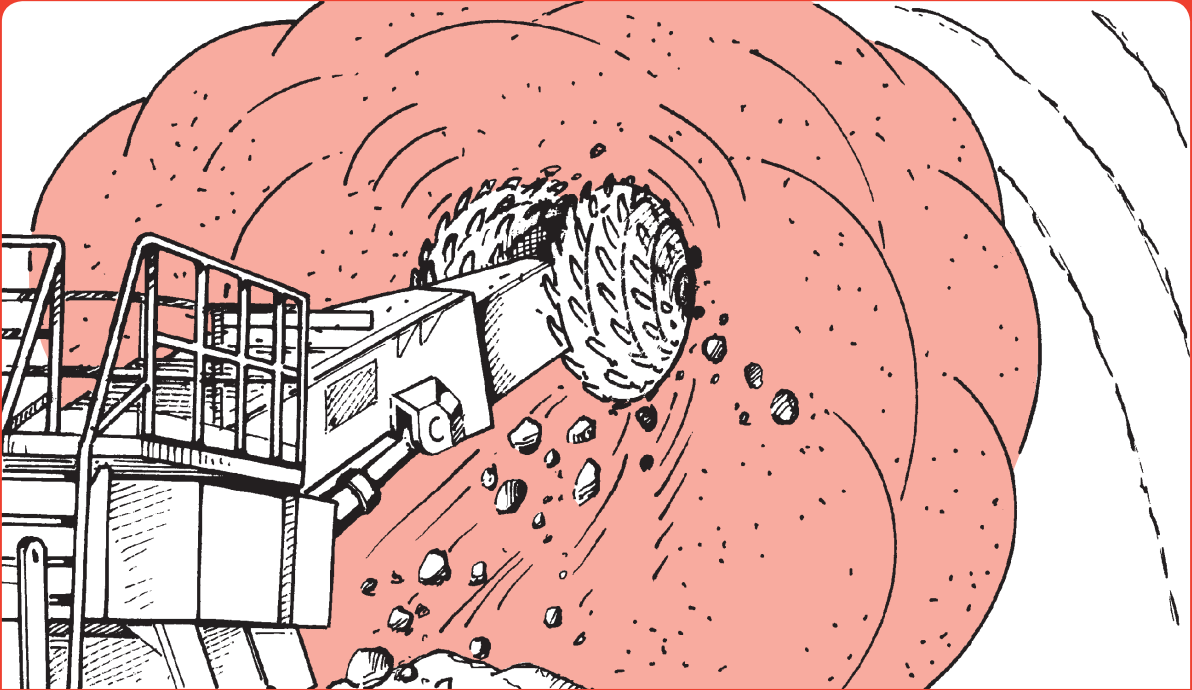
- diesel engine exhaust gas

Diesel Vehicle Emissions



Protection

- equip machinery with particle filters
- use low emission diesel engine
- stop engines when idling
- provide sufficient ventilation

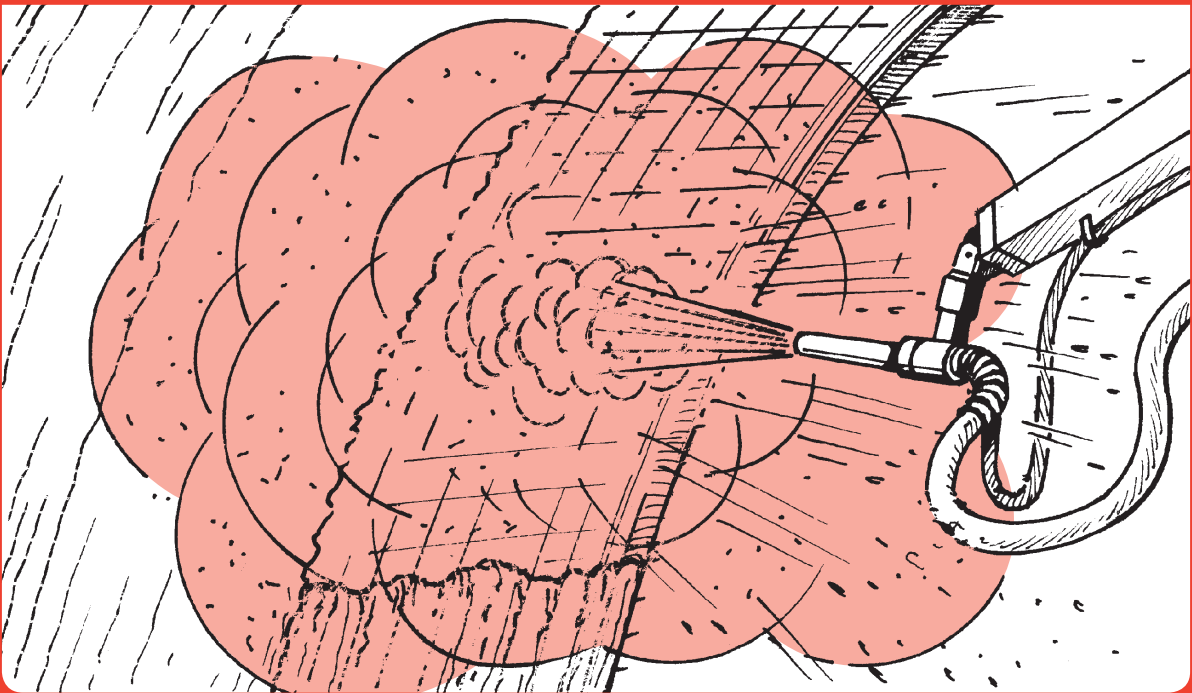
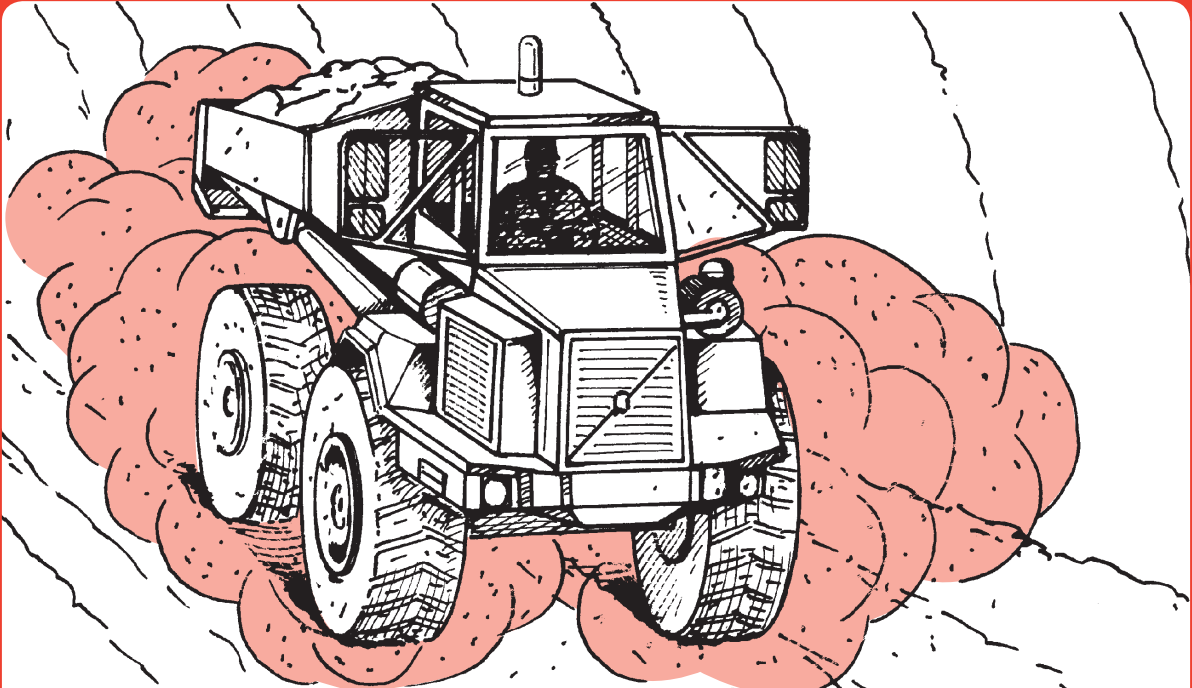


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Danger

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

Dust Emission



Danger/Protection

- provide sufficient ventilation
- extract dust
- wet spray dusty areas
- use appropriate respiratory protection



First Aid



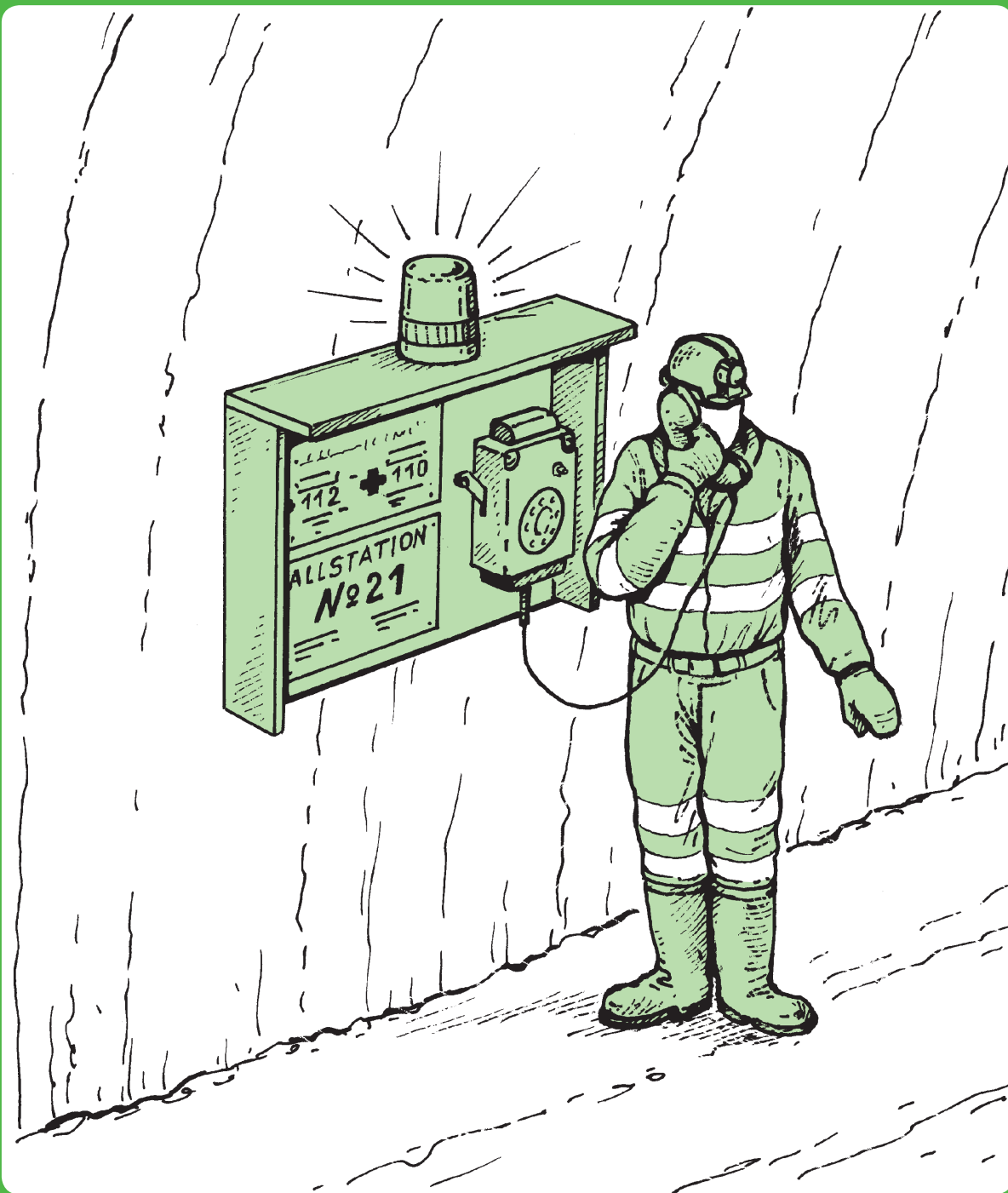


120

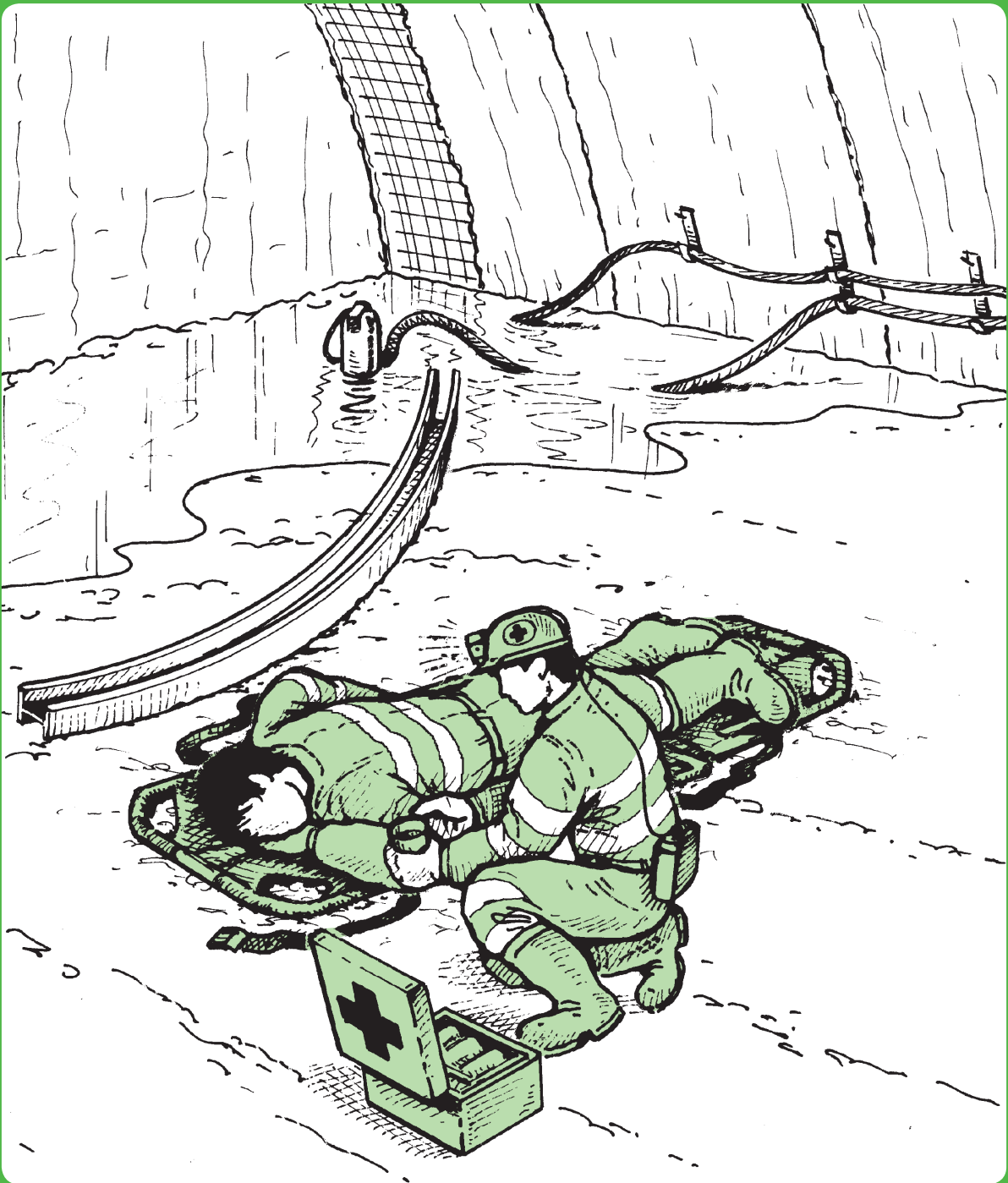
Provide first aid and rescue equipment

- do not move injured person unless in further danger

Rescue Chain



Emergency call



- if casualty unconscious turn head to side to prevent suffocation

Rescue Chain



Transport to medical centre

Picture Proof

Front page

Tunnel Jagdberg, Photo: BUNG Ingenieure AG, Knut Johnsen

Last page

Kopswerk II Kavernenkrafthaus, Photo: Jäger Bau GmbH

Page 4: Geodata

Page 12: Tunnel Baumleite, Photo: Wolfgang Sitter

Page 22: Philipp Holzmann AG

Page 34: Tunnel Jagdberg, Photo: BUNG Ingenieure AG, Knut Johnsen

Page 48: Tunnel Baumleite, Photo: Wolfgang Sitter

Page 70: Tunnel Baumleite, Photo: Wolfgang Sitter

Page 92: Tunnel Jagdberg, Photo: BUNG Ingenieure AG, Knut Johnsen

Page 100: Katzenbergtunnel, Photo: Wayss & Freytag Ingenieurbau AG

Page 112: BG BAU Prävention

Page 118: Fluchtstollen Saukopftunnel, Photo: Dr. Uwe Klein

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