



Site inventory of operational mines– fire and smoke spread in underground mines.

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Summary

This report is part of the research project “Concept for fire and smoke spread prevention in mines”, conducted by a research group at Mälardalen University.

The project is aimed at improving fire safety in mines in order to obtain a safer working environment for the people working for the mining companies in Sweden or for visitors in mines open to the public.

This report deals with the second step in the project: the site inventory in operational mines.

The main purposes of the inventory are:

- To get a clear picture of the risks in the different mines.
- To get a clear picture of the protective measures of each mine.
- Optimize the choice of design fires for each mine.

To find out what the present situation was at the operational mines, a site inventory was conducted at the two LKAB mines.

The site inventories were conducted through actual visits to the specific sites and through e-mail correspondence with LKAB personnel responsible for the different sections and areas. During the inventories, predefined forms for each type of item were used in order to facilitate the work.

The following items were examined:

- Combustible materials in general, for example large amounts of wood.
- Vehicles
- Cables
- Fire barriers
- Ventilation systems
- Extinguishing systems

Besides the above items, earlier fires and fire incidents were also examined.

As the two LKAB mines are tremendously large with a large amount of equipment etc, only the most common vehicles were listed and examined further. Also, only the sites with the largest amount of cables and other combustible materials were listed.

The following conclusions were made based upon the findings of the inventory:

- With respect to earlier fires and fire incidents for the two LKAB mines, the most common causes and the causes to focus on are: electrical cause, flammable liquid or material on hot surface, hot works and equipment running hot.
- Both the production area and the infrastructure part should be regarded in the future studies as fires are almost identically frequent in both areas.
- When it comes to combustible material in general, the amount of combustibles seems to be more frequent in the Malmberget mine. In the Kiruna mine, the places with wood and conveyor belts seems to be interesting enough for further investigation. Even though self extinguishing conveyor belts means a limited fire in size, the amount of smoke emitted can be quite extensive. Also the storage of tyres at the contractor's depots could be worthwhile investigating due to the sensitive surroundings.
- Regarding the Malmberget mine, the sites with wood combustibles, tyres and conveyor belts are all interesting for further investigation due to the large amount of combustibles and the surroundings.
- With respect to flammable liquids:

- The tank stations in the Kiruna and the Malmberget mine should be looked into with respect to potential pool fires.
- The larger workshops and warehouses in the Kiruna mine and the Malmberget mine should also be investigated with respect to pool fires.
- The crusher levels and draw points in the two mines should be investigated with respect to spray fires.
- The diesel tanks in the main ramps and the production areas should be investigated with respect to pool fires.
- The media drifts, distribution levels, shaft hoisting levels and pumping stations should be investigated with respect to pool fires.
- With respect to fire barriers, as the main ramps of each mine does not contain any fire barriers the impact of a vehicle fire in the main ramp would be interesting to investigate. It would also be interesting to validate the ventilation strategy in the Malmberget mine regarding preventing smoke spread to adjacent compartments.
- With respect to vehicles, all the common heavy vehicles listed in this report would be worthwhile to try to reconstruct a possible fire scenario for each type of vehicle. The reason for this is to have better tools when working on possible scenarios of each mine.
- Regarding cables, all listed sites with a high load of electrical cables would be interesting to investigate. Even though the immediate surroundings are not sensitive, an extensive smoke spread would make a large impact on a large portion of the mine.
- When looking into the ventilation system of the Kiruna mine, both the mine production area and the infrastructure part should be investigated due to the differences in each system and their surroundings. Also, the difference in systems whether you are below or above level 775 should be considered. The function and impact of oversteering should also be included in the investigations.
- The impact of a ventiflex PVC-tube being burned up on the fire behaviour in a production area should be investigated. The different fire scenarios in a production area depending on the position of the fire with respect to the ventilation should also be investigated.
- One scenario should put the fire right at the end of the intake air tube, other scenarios should be at a certain length interval from the end of the intake air tube. The likelihood of the power cables to the intake and exhaust air fans being burned off should be looked into. The impact on the surroundings should also be investigated. The return air fan capacity should be examined with respect to fires, such as vehicle fires.

Preface

This report is part of the research project “Concept for fire and smoke spread prevention in mines”, conducted by a research group at Mälardalen University.

The project is aimed at improving fire safety in mines in order to obtain a safer working environment for the people working for the mining companies in Sweden or for visitors in mines open to the public.

The following organisations are participating in the project: Mälardalen University, LKAB, Sala Silvergruva, Stora Kopparberget, Brandskyddslaget and Swepro Project Management.

The project has been funded by KK Stiftelsen.

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1. Introduction

Research regarding fire safety in mines has so far mainly been directed towards coal mines. Thus the need for recommendations, models, engineering tools etc for non-coal underground mines are in great demand.

The aim of the current research project “Concept for fire and smoke spread prevention in mines” is to improve fire safety in mines in order to obtain a safer working environment for the people working for the mining companies in Sweden or for visitors in mines open to the public. The fire safety record in mines in Sweden is in general good with very few fire accidents occurred. The main reason is that there is a great awareness of the fire safety problems in mines. The awareness comes from the fact that escape routes from mines are generally limited. The reason why there is a limited amount of escape routes is that it is expensive to construct extra escape routes which are not a part of the tunnel mining system. The costs to build extra escape tunnels may be better spent on different safety equipment or systems for fire prevention or evacuation. Such systems can be ventilation systems, fire fighting equipment or rescue chambers located at different places in the mines.

The output of the project will mainly consist of: performed tests, written reports and recommendations within the mining companies regarding fire safety work, recommendations and the engineering tools for calculation of fire development and smoke spread in mines, and the mathematical models and the test results for future validation.

The project consists of different steps, where each step is based on results and knowledge from the earlier steps. The steps are: literature survey, inventory of technical and geometrical conditions, calculation of design fires and smoke spread, model and full scale tests and reports and recommendations. All results will be compared and evaluated against earlier experiences.

This report deals with the second step in the project: the literature survey.

The main purposes of the inventory are:

- To get a clear picture of the risks in the different mines.
- To get a clear picture of the protective measures of each mine.
- Optimize the choice of design fires for each mine.

1.1 Delimitation

The inventory covers the LKAB mines in Kiruna and Malmberget in northern Sweden. As the two LKAB mines are tremendously large, with a large amount of equipment etc, only the most common vehicles were listed and examined further. Also, only the sites with the largest amount of cables and other combustible materials were listed.

2. Background

The problems with fires in mines are similar to them in tunnels under construction. In case of fire, evacuation of people can be extremely difficult. Rescue operation is hard to perform when the attack routes often are equal with the possible path for smoke to reach the outside. The possibilities for a safe evacuation and a successful fire and rescue operation are strongly linked to the fire development and the smoke spread in these kinds of constructions.

For mining companies the problems with evacuation and fire and rescue operations in case of fire are closely linked to policies, work environment protection and their systematic fire safety work. An accident not only can cause injuries, or in the worst case deaths, but also large costs due to production losses, reparations and loss in good-will.

The fire safety problems in mines are in many ways very similar to the problems discussed in road, rail and metro tunnels under construction. There is usually a limited amount of escape routes and the only safe havens are the safety chambers consisting of steel containers with air supply within and rescue rooms which have a separate ventilation system and will withstand a fire for at least 60 minutes.

The main problem with mines today is that they have become more and more complicated, with endless amount of shafts, ramps and drifts, and it is difficult to control the way the smoke and heat spread in case of a fire. The ventilation strategy is of the greatest importance in such cases in combination with the fire and rescue strategies. Since there are very few fires that occur, the experience of attacking such fires in real life is little. New knowledge about fire and smoke spread in complicated mines consisting of ramps is therefore of importance in order to make reasonable strategies for the personnel of the mining company and the fire and rescue services. The main experience from fighting mine fires comes from old coal mines, which are usually quite different in structure compared to mines in Sweden which mainly work with metalliferous rock products. In Sweden the mines consist of either active working mines with road vehicle traffic and elevator shafts for transportation of people and products or old mines allowing visitors. In some cases it is a combination of both types.

As the mine industry is changing and the challenging techniques are developed, the measures to guarantee the safety of personnel need to be adjusted. The new technology means new types of fire hazards, which in turn requires new measures to cope with the risks. New equipment means new types of fire development. The knowledge about fire developments in modern mines is relatively limited. The fire development of vehicles transporting material inside the mines is usually assumed to be from ordinary vehicles, although the vehicles may be considerably different in construction and hazard. The difference may mainly be in the amount of liquid (e.g. hydraulic oil) and the size of the rubber tyres.

A relatively straightforward conclusion here is that the need for improvements is great and so is the challenge ahead of us.

2.1 The production in the LKAB mines

Sublevel caving is the mining method used in LKAB's mines. The crude ore is loaded to trucks or trains, crushed in a central crushing plant, and then hoisted to surface level for further processing by sorting-, concentrating- and pelletizing plants.

Underground rail transports in Kiruna are remote-controlled, as are some other operations, for example, production drilling and loading. This degree of automation enables greater efficiency in process control.

Kiruna

The ore body in Kiruna is a single, enormous slice of magnetite. It is about four kilometres long, has an average width of 80 meters and extends to an estimated depth of two kilometres. It is inclined at roughly 60 degrees.

The main level is at a depth of 1045 meters below surface level. Mining of the ore body takes place between the 775 and 1045-meter levels. About 26 Mt of crude ore is mined each year.

Malmberget

The Malmberget mine consists of about 20 ore bodies, of which ten are currently mined. Most of the deposit consists of magnetite ore, but non-magnetic hematite also occurs. The present main level of the Malmberget mine is at a depth of 1000 meters. About 14 Mt of crude ore is extracted from the ore bodies each year.

Development

The first stage of mining is drift development. A drift is a tunnel that is driven into the rock. Development involves construction of new areas of the mine where ore can be extracted. A development project begins with construction documents prepared by the mine planning department. Each year, the mine planning department orders development work on the basis of the forecast demand for products as well as current knowledge of the status of the ore body. A development drift goes right through the ore body. Drifts are driven with electric-hydraulic drill rigs. For each charge, as many as 60 holes are drilled. Each hole is about 5 meters deep. When all the holes are drilled, they are charged with explosives.

The charge is blasted at night. The loose ore is then hauled out by a front loader. This procedure is repeated until the entire development drift has been driven. The drifts can be up to 80 meters long. If necessary, the walls and ceiling of the drift are reinforced with rock bolts and/or shotcrete.

When development is complete, i.e., when several drifts have been driven in the same area, the next stage of mining can begin; namely, production drilling.

Production drilling

Slices of ore are drilled up with remote-controlled production drilling rigs. From their control rooms, the operators (drillers) operate several drill rigs out in the production areas via remote control.

The rig drills upwards into the ore, forming fan-shaped patterns of holes. There are 10 drill holes in each series. They are normally about 40-45 meters deep. The holes are straight, so that subsequent charging with explosive and blasting can be done efficiently. When a pattern of holes has been drilled, the rig is moved back three meters, and then drilling of the next pattern begins. About 20 of these patterns will be drilled in an 80-meter drift. Once drilling is completed in the entire drift, the holes can be charged with explosive.

Blasting

A robot injects explosive into the drill holes in one pattern. The explosive is manufactured by LKAB's own explosives company. Blasting is done every night. Each round brings down about 10,000 tonnes of ore.

When the blast has been ventilated, loading with wheeled loaders can begin. Then, the next pattern is charged, etc. The procedure is repeated until the entire drift has been mined out.

Loading

Electric wheeled loaders load and carry the ore to vertical shafts (ore passes) located along the ore body. Each loader carries a bucket payload of 17-25 tonnes and tips its load down an ore pass. By gravity, the ore falls down to bins located just above the main level.

In the Kiruna mine there are also electric loaders which are remote-controlled. The operator sits in front of monitors, in a control room, and 'drives' the machines in the production area. The machines navigate with the help of rotating lasers and reflectors on the walls of the drifts.

Information, e.g., the position of the machine, is sent via a number of wireless base stations to the control system in the control room computer.

Main-level haulage

Kiruna

The main level is at a depth of 1045 meters below surface level. Ore is tapped via remote control from the bins into railway cars. Driverless trains, consisting of an engine and 24 cars, haul the ore to one of four discharge stations.

When the trains pass the station, the bottoms of the cars open; the ore falls down into a crusher bin and is then fed to one of four crushers. The ore is crushed into lumps of about 100 mm in diameter. Nine locomotives and about 185 cars are operated on the main level. Each train carries about 500 tonnes of ore.

Malmberget

Mining in Malmberget takes place at several different levels, since there are many ore bodies. The main haulage levels are at 600, 815 and 1000 meters. There are crushers at each level. 12 huge mine trucks, with payload capacities of 70 to 120 tonnes, are operated at these levels. The trucks are driven to vertical shafts. Drivers control loading from inside the cab of the truck.

The fully-loaded truck is then driven to a discharge station and the ore is emptied into a crusher bin. The trucks are emptied sideways. This is also controlled from the cab of the truck. The ore is fed into the crusher and crushed into lumps of about 100 mm in diameter.

Hoisting

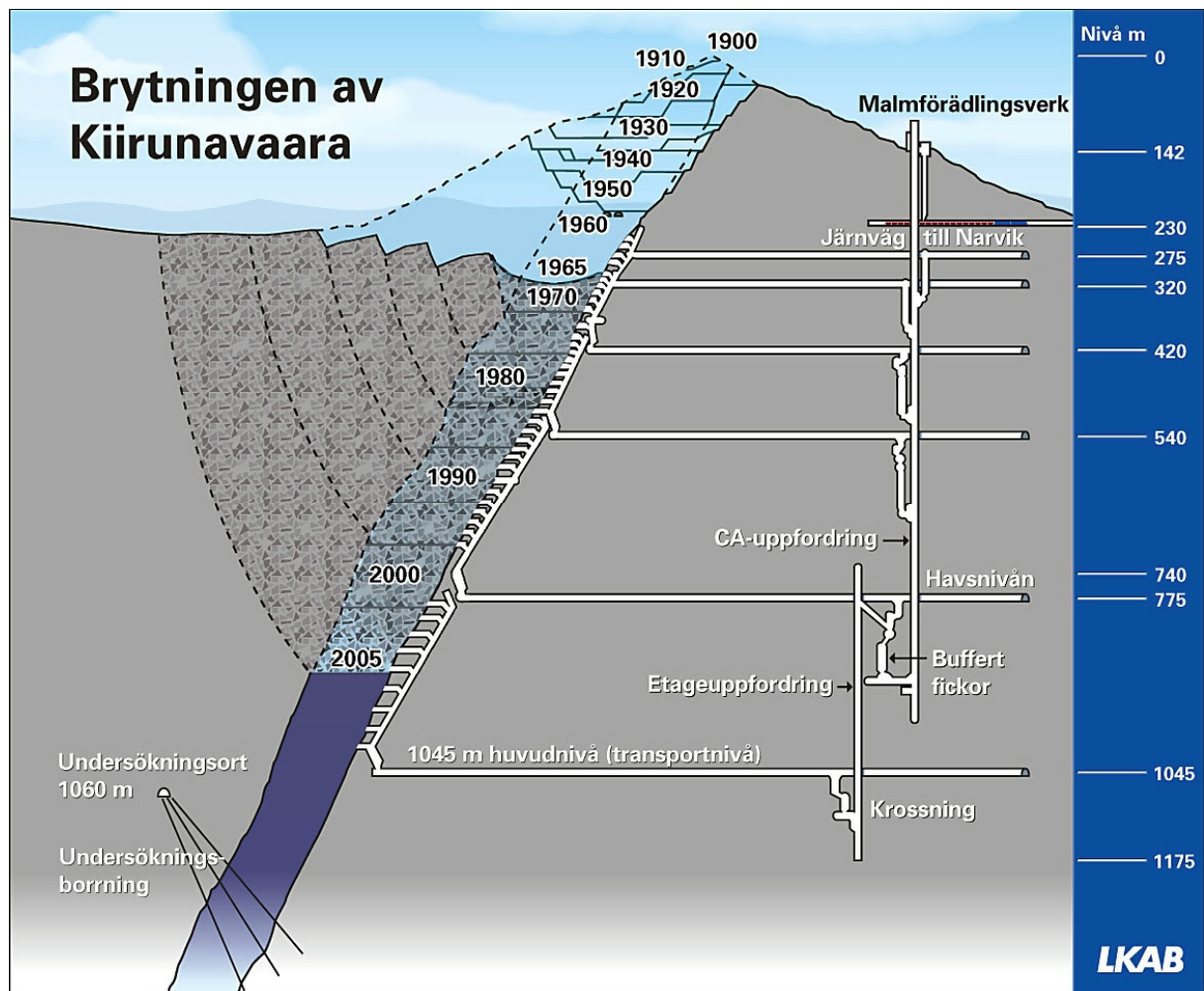
When the ore has been crushed it is carried by a belt conveyor to the ore elevators (skips). The ore is loaded to the skip automatically and hoisted, at a speed of 17 meters per second, up to processing plants at the surface. Each skip carries 40 tonnes of ore.

In the Kiruna mine, hoisting is done in two stages: first, via one of four skips to level 775, where it is transferred and then carried up to the processing plants in one of six skips.

In Malmberget, another method is used, since there are many ore bodies.

From main level 1000, the crushed ore is hauled by a 1.7-km-long conveyor to a skip shaft at the 815-meter level. From there, the ore is lifted to the surface by two skips. Final transport to the processing plants is via belt conveyor. There is also a crusher and hoisting station at level 600, for ore mined in the Western field, where there is also hematite ore.

In both Kiruna and Malmberget, crushing and hoisting are monitored and controlled from control rooms.



Picture 1. The Kiruna mine.

LKAB Malmberget



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3. Method

The method used during the work on the report was mainly through actual visits to the specific sites and through e-mail correspondence with LKAB personnel responsible for the different sections and areas.

During the inventories, predefined forms for each type of item were used in order to facilitate the work. The forms are found in appendix 1.

Some pictures were taken during the inventory work and are included in this report. The further work with the most common vehicles included contacts with the manufacturer in order to obtain additional information and possibly sketches of the vehicle in question.

When working on the earlier fires and fire incidents, existing LKAB statistics were gone through and used.

Information about existing fire barriers – besides performing actual visits – was also found in the earlier established fire protection documentation (in accordance with the new Swedish legislation).

Existing plans with respect to where flammable liquid is stored were also studied.

4. Earlier fires and fire incidents

4.1 Kiruna

The table below lists the fire incidents in the Kiruna mine during the period 2004-2007:

Table 1. Fire incidents in the Kiruna mine.

Date	Incident required action from	Place	Evacuation	Object and cause	Injuries/damages	Additional info	Sequence
2004-02-25	-	Level 849; production area 16, drift 158.2	No	Electrical part; short-circuit	Electrical part burned up	-	Plugged in the electrical part, turned on the power and arcing occurred.
2004-03-04	-	Level 230; Hoist repair workshop	No	Filter; hot surface	-	-	Filter had come loose and went into the fan part resulting in smoke being evolved
2004-04-28	-	Level 1045; draw point 33	No	Cable; short-circuit	Melted cable coating	-	Short-circuit in a 400V electrical container, one phase running hot, whereas the coating of the cable had melted and emitted smoke
2004-04-28	Personnel on the site	Main ramp towards the entrance to the mine	No	Vehicle; hot surface	-	-	Fire in a VW bus, engine started to pull in the main ramp, extinguished the fire with fire extinguisher and snow
2004-09-17	Personnel on the site	Level 878; mine production area	No	Cable; electrical fault	-	-	Cable fire in loader (Toro 567)
2004-	Personnel	Level 878;	No	Hydraulic	-	-	Drilling rigg

11-17	on the site	road 34		pump; electrical fault			BK303, flames occurring at the hydraulic pump for oil refill. Button for oil refill was stuck, running hot.
2005-01-03	-	Production area 9	No	Cable; short-circuit	-	-	During ongoing charging operation a 1000V cable caught fire. The distribution box was incorrectly set or possibly a cable damage
2005-01-04	-	Production area 16	No	Electric power station; electrical fault	-	-	When a Toro 570 was connected to a mobile electric power station a fuse of the electric power station melted. When the electric power station was restarted a bang was heard and smoke was emitted.
2005-01-21	-	Production area 9	No	Distribution box; electrical fault	-	-	Fire in a distribution box on a diamond drilling machine, probable cause is the contact.
2005-01-31	-	Media drift	No	Exhaust pipe; hot surface	-	-	Charging vehicle 990 was driven from the production

							area to the explosives storage, when the vehicle had been parked smoke was seen being emitted from the vehicle. Probable cause was a rag on the exhaust pipe that caught fire.
2005-02-15	-	Level 775; workshop	No	Cable; incorrect grounding	-	-	During the maintenance work on a Toro 593 the electrical cable to the fan motor was found to have been burned off. Probable cause was incorrect grounding during welding work.
2005-02-28	Personnel on the site	Media drift	No	Cabin (on vehicle)	-	-	After the charging at the production area 33 (level 878) with charging vehicle 993 flames were discovered from the cabin. The charging vehicle was driven to the flushing pit and flushed with water until the fire

							was extinguished.
2005-04-21	-	Production area 9	No	Feeding central; electrical fault	-	-	Smoke was emitted from the feeding central. Probable cause was loose contact
2005-05-24	Personnel on the site	Media drift	No	Casing; hot works	-	-	During the cutting of a nut for the main shaft to a crusher, sparks hit the casing that caught fire.
2005-08-24	Personnel on the site	Level 775; workshop	No	Turbo; hot surface	-	-	A large amount of smoke was emitted from underneath the cab of charging vehicle Volvo 718, the sprinkler system was activated and using a fire extinguisher a fire was prevented. Probable cause was a protection felt that had been placed wrongly during maintenance and covered the turbo.
2005-08-26	Personnel on the site	Level 320	No	Engine; running hot	-	-	Were supposed to lift a cable drum onto the truck platform, the drum was too heavy and the

							back of the vehicle hit the roof of the drift and flattening the exhaust pipe. The engine got hot and was over heated and resulting in a fire in the engine.
2005-09-15	-	Level 640; production area 9	No	Cable; electrical fault	-	-	Cable fire at a splice on the cable to a Toro loader. The fire occurred during the loading.
2005-10-06	-	Production area 45	No	Chain feeder; running hot	-	Fire investigation exists	A chain feeder running hot on a charging vehicle. Flames occurred for a few seconds and then self extinguished. Probable cause was over heating in some part of the chain case.
2005-10-12	-	Main ramp; road 16	No	Cable; hot surface	-	-	Flames came out from the side of the charging vehicle. The vehicle stopped and the lights went out. Probable cause was short-circuiting; the cable from

							the main switch had fallen down on the exhaust pipe and burned off.
2005-11-01	-	Production area 28	No	Distribution box; short-circuit	-	-	Were supposed to turn the power of the machine off, when the arcing in the box occurred.
2005-12-19	-	Level 1060	No	Leading in; short-circuit	-	-	Smoke was emitted from the leading in on a diamond drilling machine 125 amps fuse. Probable cause was a loose contact between electrical part and leading in on the machine.
2006-01-10	-	Production area 16	No	Cable; short-circuit	-	-	Cable to loader caught fire in longitudinal drift.
2006-02-20	-	U-NIO	No	Noise-heat protection; hot surface	-	-	The noise-heat protection in a charging vehicle came loose and fell down on the exhaust system and started to glow and emitting smoke.
2006-03-18	Personnel on the site	Main ramp; road 16	No	Engine compartment ; fuel leakage	-	-	When driving the bus a fire occurred in

							the engine compartment. A distributor pipe started to leak fuel. The fire was put out using a fire extinguisher.
2006-04-26	-	Production area 25	No	Cable; short-circuit	-	-	When turning the switch for cable A in the container, the cable started burning after 10 seconds.
2006-05-23	Personnel on the site	Road 21	No	Turbo; hot surface	-	-	Fire in a loader where a large amount of smoke was emitted as oil was sprayed on a hot surface. Probable cause was a broken turbo that caused an oil leakage into the exhaust system where the oil caught fire.
2006-05-28	-	Level 878; production area 37	No	Cable; short-circuit	-	-	Short-circuit in the high voltage.
2006-08-08	Personnel on the site	Level 878; production area 25	No	Cable; short-circuit	-	-	Were loading when the cable to the Toro 602 caught fire. Put out the fire with a fire extinguisher.
2006-10-16	-	Level 740; media drift	No	Noise insulation; oil spill	-	-	Smoke was emitted from noise insulation

							behind the cab of the charging vehicle, caused by oil spill.
2006-10-22	-	Level 714; production area 12	No	Cable; short-circuit	-	-	A Toro 597 loader was started but then went dead; at the same time the cable to the loader started emitting smoke.
2006-12-04	-	Level 500; road 16	No	Turbo; hot surface	-	-	Smoke being emitted. Probable cause was oil on the turbo.
2006-12-13	-	Level 740; media drift	No	Start engine; short-circuit	-	-	Fire in the start engine on a charging vehicle Volvo FM9.
2007-02-01	-	Main ramp; road 22	No	Cable; short-circuit	-	-	Fire in a 400 V cable with fans as load, probably due to damage on the cable that caused it to run hot and evolve into a fire.
2007-02-27	-	Level 907; production area 33	No	Distribution box; short-circuit	-	-	When switching on a fan, the distribution box caught fire. Probable cause was moisture entering the distribution box.
2007-09-11	Personnel on the site	Level 907; production area 33	No	Cable; short-circuit	-	-	The cable lay on the ground about 30 m from

							the machine and caught fire in a splice. Switched off the power and put out the smouldering fire using slings.
2007-10-14	-	Production area 45	No	Capacitor fans; oil	-	-	The workshop was notified that the fuses to the air-conditioning fan melted constantly on loader 598. When working on the malfunction, the lid to the climate system was opened and plastic smoke was emitted. During an examination it was discovered that it had burned with high temperatures in the box. Both capacitor fans had burned and the box was full of oil.

4.2 Malmberget

The table below lists the fire incidents in the Malmberget mine during the period 2004-2007:

Table 2. Fire incidents in the Malmberget mine.

Date	Incident required action from	Place	Evacuation	Object and cause	Injuries / damage	Other info	Sequence
2004-03-09	-	-	No	Engine compartment ; short-circuit	-	-	Short-circuit in the engine compartment on a vehicle.
2004-05-03	Personnel on the site	-	No	Cable; hot works	-	-	Were cutting with gas. A bolt fell down on a cable tray and a cable caught fire.
2004-09-14	Personnel on the site	-	No	Engine part; oil leak/hot surface	-	-	Oil leaked onto a hot surface. The vehicle was a Jama scaler.
-	-	-	No	Diesel generator; short-circuit	-	-	Short-circuit in a diesel generator to a loader.
2005-01-04	Personnel and the industrial fire brigade on the site.	Level 962; Alliansen	No	Engine; short-circuit	-	Incident report exists.	Scaler rig Bask had a fire around the engine. The fire was caused by short-circuit. The fire was put out by the industrial fire brigade.
2005	-	Level 1000	No	Fuse box ; short-circuit	-	-	During maintenance work on the engine, short-circuit occurred in the fuse box. Smoke was emitted.
2005	Personnel on the site	Level 932; Alliansen	No	Loader	-	-	Toro loader started emitting smoke but was quickly stopped when the driver

							activated the extinguishing system.
2005	Personnel and industrial fire brigade on the site.	Level 906; ViRi	No	Loader	Person inhaled smoke.	Incident report exists.	The driver on a loader discovered smoke from the rear part of the vehicle. He alerted the industrial fire brigade, activated the extinguishing system and used a fire extinguisher. The fire was put out and he then left the area to meet up with the arriving fire brigade.
2006-02-03	-	Level 815; workshop	No	Interior heater	-	-	Smoke being emitted from the interior heater on a vehicle.
2006-02-16	-	Shaft	No	Fan; electrical fault	-	-	During the start up of a fan a fire occurred.
2006-06-10	Personnel on the site.	Level 815; workshop	No	Loader; hot works	-	-	Fire occurred during cutting out of a mechanical part. Grease and lubricant involved.
2006-07-27	Personnel on the site.	Level 400	No	Relay interlocking plant; electrical fault.	-	-	A bang occurred when a switch was activated in a relay interlocking plant. Fire occurred in an electrical compartment but could

							quickly be extinguished with a fire extinguisher.
2006-08-03	Personnel and industrial fire brigade on the site.	Level 790; Alliansen	Total evacuation of the mine.	Drilling rig	-	Incident report, fire investigation and photos from the site exist.	Fire in a drilling rig (Atlas Copco) in a service drift. Large amount of smoke emitted, total evacuation of the mine. There were gas bottles in the drift which hampered the rescue operation.
2006-10-24	-	Level 300; Malmberget	No	Cable; arcing	-	-	During cleaning the excavator came in contact with a high voltage cable. Arcing occurred, resulting in a cable fire.
2007-01-29	Personnel on the site.	Main ramp; level 815-1000	No	Turbo; turbo breakdown	-	-	Turbo breakdown on a lorry. Large amount of smoke emitted. Fire was put out by the driver.
2007	Personnel on the site.	Level 1000; pump-station	No	Compressor	-	-	The fire was put out with a fire extinguisher.
2007-04-08	Personnel on the site.	Level 902; Alliansen	No	Cable; electrical fault	-	-	A loader hit a high voltage cable with the scoop. Flames occurred. The driver extinguished fire with fire

							extinguisher.
2007-06-05	-	Level 400; Baron	No	Contactor; electrical fault	-	-	Arcing from engine protection. Contactor burned up.
2007-08-10	Personnel on the site.	Level 815; LHD workshop.	No	Loader	-	Incident report exists.	Fire in a loader in the workshop. Personnel on the site put out the fire.
2007-11-02	Personnel and industrial fire brigade on the site.	Main ramp; level 450.	No	Rear shaft; running hot.	-	Incident report exists.	A fire occurred in the rear shaft on a concrete lorry in main ramp. Probable cause was the cardan shaft running hot. The fire was put out by driver and the vehicle was cooled down by the fire brigade before towing the vehicle.
2007-08-20	-	Parta	No	Between beam fixing point	-	-	Smaller fire between beam fixing point beneath the cab. Fire put out by fire extinguisher.
2007-08-23	-	Level 600	No	Solenoid valve	-	-	A fire occurred in a solenoid valve during transport. The fire was put out when the machine stopped.
2007-08-27	Industrial fire brigade on the	Level 930; ViRi	One person had to evacuate.	Loader	-	-	Fire in a loader. The driver had to evacuate. Fire

	site.						was put out by the fire brigade. The ViRi area between level 815 and 930 had to be evacuated.
2007-09-08	Industrial fire brigade on the site.	Level 978; ViRi	No	Shotcrete gun	-	-	Fire in a Jama shotcrete gun. Caught fire while parked. Fire was put out by the fire brigade. Parts of the ViRi area were filled with smoke.

5. Combustible material in general

5.1 Kiruna

In the Kiruna mine larger amount of wood are found at the 1045 level (a larger shed), at each draw area a smaller shed for the loading personnel is found and at the 540 level a storage shed is found at the mining construction group. In the mining museum at level 540 some wooden constructions – such as older huts – are found.

In most of the warehouses, wooden pallets with occasionally wooden frames are found.

Smaller amount of tyres are found at the 740 and the 775 level, being stored at the depots of the contractors.

Conveyor belts (self extinguishing) are found at the 833, 898 and the 1110 level.

Larger amounts of flammable liquids are found in the following places:

- In workshops at level 540, 775 and 1045: hydraulic oil, grease, engine oil etc.
- Diesel is handled at fuel stations at level 650, 740, 775, 833, 897, 910, 1028 and 1045.
- In warehouses at level 775 are larger amounts of oils and diesel found.
- Media drift: diesel tanks ($\sim 3\text{-}6\text{ m}^3$), containers with engine oil, hydraulic oil ($\sim 2\text{ m}^3$) and washer fluid (a few hundred litres).
- Main ramps: diesel tanks ($\sim 3\text{-}6\text{ m}^3$).
- Pumping stations: a few hundred litres of diesel and oil.
- Crusher level: container underneath every crusher with hydraulic oil and grease under pressure ($\sim 1\text{-}2\text{ m}^3$); oil and grease depot in crusher hall ($\sim 3\text{ m}^3$).
- At every draw point: a hydraulic container ($\sim 1\text{ m}^3$ hydraulic oil).
- Distribution level (level 1110): various types of oil (hydraulic, transmission etc.) $\sim 2\text{ m}^3$.
- Shaft hoisting level (level 740): various types of oil (hydraulic, silicon, transmission etc.) $\sim 3\text{ m}^3$.

Acetylene gas is found throughout the whole mine, either as single bottles or included in a centralized system using pipes.

5.2 Malmberget

In the Malmberget mine larger amount of wood are found in the Malmberget shaft, the Baron shaft, the Uppland shaft and the Allians shaft. In all the cases the stairs in the shafts are found to be composed of wood. At the Josefin level 487 some wooden benches are found.

In most of the warehouses, wooden pallets with occasionally wooden frames are found.

In the workshops at the 600 level, the 815 level and the 1000 level large amount of tyres are stored. At the workshop at the 1000 level, the tyres are stored inside steel containers.

Conveyor belts (self extinguishing) are found at the loading areas to the hoists of the Allians level 672 and the Malmberget level 890, at the larger transport drifts between M1000 and the crushes at the 815 level and at the hoists at the Malmberget 278 level to the Lappkyrkan.

Larger amounts of flammable liquids are found in the following places:

- Fuel stations at level 815 and 1000 ($\sim 40\text{ m}^3$ diesel).
- In workshops at level 600, 815 and 1000: hydraulic oil, grease, engine oil etc.
- In warehouses at level 600 and 815 are larger amounts of oils and diesel found.
- Main ramps: diesel tanks ($\sim 3\text{-}6\text{ m}^3$).
- Production areas: diesel tanks ($\sim 3\text{-}6\text{ m}^3$).
- Pumping stations: a few hundred litres of diesel and oil.
- Crusher level: container underneath every crusher with hydraulic oil and grease under pressure ($\sim 1\text{-}2\text{ m}^3$); oil and grease depot in crusher hall ($\sim 3\text{ m}^3$).

- At every draw point: a hydraulic container ($\sim 1 \text{ m}^3$ hydraulic oil).
- Shaft hoisting level: various types of oil (hydraulic, silicon, transmission etc.) $\sim 3 \text{ m}^3$.

Acetylene gas is found throughout the whole mine, either as single bottles or included in a centralized system using pipes.



Picture 3. Wooden benches at Josefin level 487 (Malmberget mine).



Picture 4. Wooden construction in the Malmberget shaft.

6. Vehicles

6.1 Kiruna

The following four types of heavy vehicles were found to be the most common types of heavy vehicles used in the Kiruna mine:

- Toro 2500E (16 vehicles).
- Scania P94 (5 vehicles).
- Jama SBU 8000 (4 vehicles).
- Simba W469 (3 vehicles).

Examining further the four types of vehicles above, the following data were obtained:

Simba W469: [1]

Fuel tank: 130 l

Hydraulic oil tank: 385 l

Oil:

Diesel engine: 15 l

Hydraulic transmission: 30 l

Axle beam side: 23 l

Axle, engine side: 23 l

Dimensions on tires:

14.00 x 24 (XKA Michelin)

Length during transport: 13 m

Length during drilling operations: 14.1 m

Width and height: 3 m

Weight: 40 ton

Toro 2500E: [2]

Hydraulic oil tank: 800 l

Dimensions on tires:

40/65-39 D-LUG L5 56 ply

Dimensions: see Appendix 2

Operating weight: 77.5 ton

Total loaded weight: 101.6 ton

Jama SBU 8000:

Hydraulic oil tanks: 700 l

Fuel tank: 250 l

Hydraulic transmission: 30 l

Oil, forward shaft: 20 l

Oil, rear shaft: 20 l

Tires: 14.00x24

Dimensions: see Appendix 3

Scania P94: [3]

Cab dimensions:

Height: 2.79 m

Width: 2.43 m

Length: 1.99 m

Hydraulic oil tank: 50 l

Fuel tank: 200 l

Tires: 295/80 R22.5

See appendix 4 for more details.

6.2 Malmberget

The following eight types of heavy vehicles were found to be the most common types of heavy vehicles used in the Malmberget mine.

- CAT Elphinstone (7 vehicles).
- Scania P92M (5 vehicles).
- Volvo FH12 8x4 (5 vehicles).
- Simba W469 (5 vehicles).
- Jama SBU 8000 (5 vehicles).
- Volvo FM12 6x4 (4 vehicles).
- Toro 0011 (3 vehicles).
- Ljungby L14 (3 vehicles).

The data on the Simba W469 and Jama SBU 8000 are found above as it is among the most common types of vehicles in the Kiruna mine as well. The following data were found for the other six types of vehicles:

CAT Elphinstone: [4]

Hydraulic oil tank: 140 l

Fuel tanks: 854 l + 571 l

Tires: 35/65-R33

Width: 3.454 m

Height: 2.996 m

Length: 11.483 m

Weight: 56 ton

See appendix 5 for more details.

Volvo FH12 8x4: [5]

Hydraulic oil tank: 150 l

Fuel tank: 330 l

Tires: 13-22,5

Cab dimensions:

Height: 3.2 m

Width: 2.55 m

Length: 9.5 m

Volvo FM12 6x4: [5]

Hydraulic oil tank: 150 l

Fuel tank: 330 l

Tires: 13-22,5

Cab dimensions:

Height: 2.9 m

Width: 2.55 m

Length: 8.5 m

Toro 0011: [2]

Hydraulic oil tank: 450 l

Fuel tank: 620 l

Tires: 35/65-R33 DL L-5, Bridgestone 42 ply

Dimensions: see Appendix 6

Operating weight: 56.8 ton

Total loaded weight: 77.8 ton

Scania P92M: [3]

Cab dimensions:

Height: 2.79 m

Width: 2.43 m

Length: 1.99 m

Hydraulic oil tank: 50 l

Fuel tank: 200 l

Tires: 295/80 R22.5

See appendix 4 for more details.

Ljungby L14: [6]

Hydraulic oil tank: 210 l

Fuel tank: 255 l

Tires: 20,5-25

As no general dimensions were found specifically for Ljungby L14, it was decided to go ahead with the dimensions of Ljungby L15 as the differences in dimensions between the two models are very small:

Width: 2.515 m

Height: 3.27 m

Length (excluding bucket): 4.515 m

Weight: 16 ton

See appendix 7 for more details (Ljungby L15).

Besides the listed vehicles above for Kiruna and Malmberget, it was also decided to include another drilling rig in the inventory as the three types of vehicles that are most common in fires are: loaders, service vehicles and drilling rigs. The drilling rig Rocket Boomer was selected and the following data was found:

Fuel tank: 110 l

Hydraulic oil tank: maximum 390 l, minimum 290 l

Dimensions on tires:

14.00 x R24

Length during drilling operations: 14.565 m

Width: 2.55 m

Height: 3.179 m

Weight: 38-39 ton

See appendix 8 for more details.

7. Cables

7.1 Kiruna

In the Kiruna mine a large amount of cables are found:

- In the media shaft where the amount of cables are very high due to the protection of redundancy.
- At the 740 and 775 level (relay interlocking plant).
- At the 1045 level (relay interlocking plant at the track level).
- At each pumping station in the mine.
- At each draw point at train level.
- At the 898 and 1110 level (intermediate level between the two hoisting systems).
- At the 1078 level (crushing level).

The Halogenated cable type dominates in the Kiruna mine.

7.2 Malmberget

In the Malmberget mine the larger concentrations of cables are found in the large shafts and at the larger signal cabins:

- At the Malmberget 600 level (relay interlocking plant).
- At the Malmberget 815 level (relay interlocking plant).
- At the M1000 level (relay interlocking plant).
- In the media shaft.

The halogenated cable type dominates in the Malmberget mine (compared with the non-halogenated cable type), but papercable with tar and oil are also found in the media shaft (as the cables are from the period 1950-2008).



Picture 5. Relay interlocking plant at the Malmberget level 815.



Picture 6. Relay interlocking plant at the Malmberget level 1000.

8. Fire barriers

8.1 Kiruna

The table below lists the fire barriers that are found in the Kiruna mine:

Table 3. The existing fire barriers in the Kiruna mine.

Compartment	Level	Fire rating	Plan number
Relay interlocking plant	230	EI60	1040361
Hydraulics container	230	EI60	1040361
Relay interlocking plant	275	EI60	1040362
Relay interlocking plant	275	EI60	1040362
Relay interlocking plant	524	EI60	1040364
Transformer compartment	524	EI60	1040364
Assembly hall	540	EI60	1040365
Visitors mine	540	EI60	1040365
Mining museum	540	EI60	1040365
Shaft hoisting level	740	EI60	1040369
Relay interlocking plant	740	EI60	1040369
Cable vault	740	EI60	1040369
Tone filter	740	EI60	1040369
Relay interlocking plant	Y20	EI60	
Level 775 towards the main ramp	775	EI60	1040371
Oil storage	775	EI60	1040371
Canteen (including ventilation compartments)	775	EI60	1040372
Control system room (including offices)	775	EI60	1040372
Offices	775	EI30	1040372
Relay interlocking plant	775	EI60	1040372
Fan room at the canteen	775	EI60	1040372
Elevator shaft	775	EI60 (is opened towards level 898 but otherwise sealed)	
Relay interlocking plants (2)	802	EI60	
Cable vaults (2)	802	EI60	
Relay interlocking plants (containers)	833	EI60	1040375

Relay interlocking plant	898	EI60	1040376
Relay interlocking plant	898	EI60	1040376
Relay interlocking plant	966.9	EI60	
Level 1045 towards the main ramp	1045	EI60	1040379
Relay interlocking plant	1045	EI60	1040379
Oil storage	1045	EI60	1040379
Relay interlocking plant	1078	EI60	1040379
Cable vault	1078	EI60	1040379
Hydraulics container (4)	1078	EI60	1040379
Level 1110 towards the main ramp	1110	EI60	1040381
Relay interlocking plant	1110	EI60	1040381
Level 1121 towards the main ramp	1121	EI60	1040382
Level 1180 towards the main ramp	1180	EI60	1040383

8.2 Malmberget

The table below lists the fire barriers that are found in the Malmberget mine:

Table 4. The existing fire barriers in the Malmberget mine.

Compartment	Level	Fire rating	Plan number
Canteen	500	EI60	1-3354-03701
Conference room & offices	500	EI60	1-3354-03701
Relay interlocking plant	600	EI60	1-3354-03703
Oil storage	600	EI60	1-3354-03703
Workshop (vehicles)	600	EI60	1-3354-03703
Pump station	600	EI30	1-3354-03703
Oil storage	600	EI60	1-3354-03704
Switch room	815	EI60	1-3354-03705
Relay interlocking plant	815	EI60	1-3354-03705
Cable vault	815	EI60	1-3354-03705
Storage compartment at the loader workshop	815	EI60	1-3354-03705
Control system room	815	EI60	1-3354-03705
Oil storage	815	EI60	1-3354-03705

Workshop	815	EI30	1-3354-03705
Workshop	1000	EI30	1-3354-03708
Relay interlocking plant	1000	EI60	1-3354-03708
Communications compartment	1000	EI60	1-3354-03708
System room	1000	EI60	1-3354-03708
Cable vault	1000	EI60	1-3354-03708
Pump station	1000	EI30	1-3354-03708
Refuge chamber	1000	EI60	1-3354-03708
Level 1000 (towards the main ramp)	1000	EI60	1-3354-03708

The shafts in the Malmberget mine are not enclosed by fire barriers. But if the ventilation operates as planned and together with some existing walls and doors, the smoke spread to adjacent compartments will be prevented.

9. Ventilation system

9.1 Kiruna

There are presently two ventilation systems operating in the mine production area of the Kiruna mine and one system that operates the facilities of the infrastructure part.

The shafts look similar independently of what part you are looking at. When it comes to the amount of blower or exhaust fans at the different levels, it varies from one to two fans per level and if it is a blower or exhaust fan you are considering. The area above the 775 level is supplied by fresh air from an older ventilation system which is complicated to steer at a possible fire. There are no fire detection systems in the longitudinal/transversal drift or the main ramp. But there is a fire detection system in the infrastructure part, for example the visitors mine, workshops etc. [7]

Along the main ramps (road 22 and road 16) the intake air is taken from intake air shafts and pushed upwards along the main ramp using fans (with a diameter of 1000 or 800 mm). PVC tubes are connected to the fans in order to obtain a better effect. The fans are positioned at certain positions along the main ramp.

It is not possible to steer the ventilation along the main ramps [8].

9.1.1 Mine production area

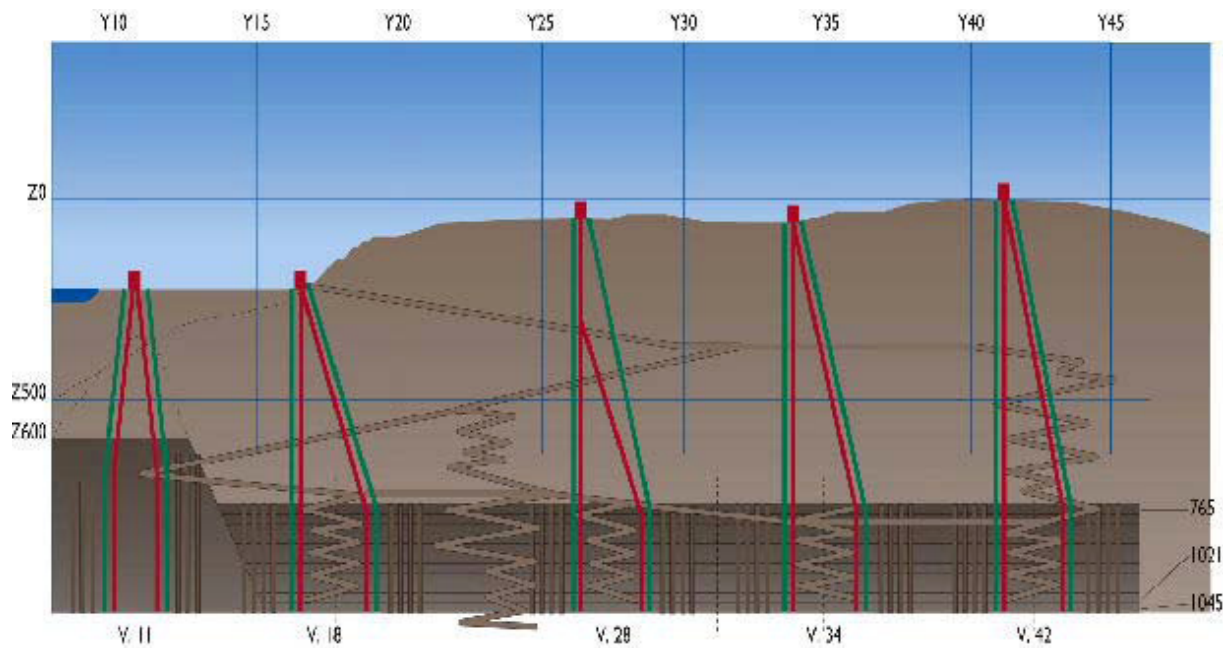
The main ventilation system consists of 20 shafts with a diameter of 3 m, where 10 shafts are for intake air and 10 shafts are for return air from the drifts. Each production area has one shaft for intake air and one shaft for return air. The shafts are drilled from ground level down to the main level at 1045. At ground level the intake air shafts and return air shafts are well separated in order to prevent the intake air from sucking in exhaust gases from the return air. The main fans of the shafts – positioned above ground – are monitored and steered by a system called VISONIK. The system calculates how much air that is needed in the drifts, by “feeling” how many fans in the drifts that are currently running.

The dimensioned flow from the main fans is 150 m³/s and 3700 in statical pressure (each).

Approximately 80% of the ventilation system in the shafts can be oversteered from PC5 which is situated above ground, while approximately 40% is steered using a so called command-variable signal (which is steered with automatic signals from the transport level at 1045). These 40% of the ventilation in the ventilation shafts is positioned around the transport level and can also be oversteered by the train control managers at the control system room below ground at the level at 775. [7]

Also fans at the 1020 and 1045 level (included in the so called SATT-system) can be steered from the control system room at the level at 775 and from the main control system room above ground. [8]

A so called kink on the level is located at level 765.



Picture 7. The twenty ventilation shafts [7].

9.1.1.1 The intake air fans

At the entrance to each production area intake air is taken from the intake air shaft. The intake air is further distributed to the longitudinal drift, using fans connected to a flexible PVC-tube (also known as a ventiflex cloth). The tube has a length of approximately 200 m in each direction in the longitudinal drift. The intake air fans in the drift are dimensioned for a flow of 10 m³/s and 5 m³/s, at full speed respectively half speed. The ventiflex cloths are flame resistant but during a fire they will most likely burn up and the intake air to the drifts will cease. At the end of the tube where the air is ejected, approximately 6-8 m³/s is delivered depending upon if the tube is intact or has received damages during the latest blasting operation.

The power supply to the intake and exhaust air fans are delivered through electrical cables found at the roof of the entrance to the production area. If a fire would occur at the entrance to the production area the risk of losing the ventilation is obvious and thus also the smoke spread to the adjacent main ramp. [7]



Picture 8. Intake air in PVC-tubes [7].

9.1.1.2 The fans in the transversal drifts

The air distribution to the transversal drifts is done by a fan with a capacity of 3-4 m³/s. The fan distributes the air using a PVC tube with a diameter of 0.6 m, distributing the air into the transversal drift and extracting the air approximately 30 m from the end of the transversal drift. If the fan is placed too far in the transversal drift its capacity is decreased and the air ventilation is made worse. The power supply to the fans in the transversal drifts are delivered through electrical cables found at the roof, the cables are drawn from the relay interlocking plants found at the entrance to the production area. Thus the same risk of losing the ventilation during a fire as for the intake air fans exist. [7]



Picture 9. Fan in a transversal drift [7].

9.1.1.3 Return air fans

The exhaust air at the shaft is performed by one or two fans with a max capacity of approximately 15 m³/s each. The intake air and return air ventilation is placed opposite each other at the entrance to the production area, at a height of approximately 3 m.

The system is not dimensioned with respect to a fire, the system is dimensioned to take care of the exhaust from vehicles, radon gases etc.

Today the ventilation in the drifts is entirely steered from the control system room above ground. But in the future a system of CO-transmitter will be placed at the entrance to the production area, close to the return air fans. These CO-transmitters will aid in the steering of the return air ventilation and activating the fans when the CO concentration gets too high in the drift. [7]

9.1.2 Infrastructure part

The system in the infrastructure part consists of two systems today and three systems in the near future.

The system at the 775 level and upwards consists of an old system that uses drifts when ventilating.

The system at the 1045 level and upwards consists of a newer and separate system. The system consists of two shafts for the intake and the return air.

The capacity of the intake air today is approximately 500 m³/s.

The distance between the production area and the infrastructure part is approximately 1 km.

The future system of the 1365 level will also consist of two shafts; the difference is that the two shafts will run all the way from the surface.

At the 775 level there is a smoke exhaust fan, which will suck smoke into an exhaust shaft in the mountain. The fan is activated from the control room at the same level or from the fire alarm control unit outside the canteen at the same level. [8]

At the 1045 level there are two separate reversible smoke fans positioned at each one end of the transport level. The fans can be activated from the fire alarm control unit at the entrance to the level or from the rescue room at the same level. [8]

9.2 Malmberget

A description of the mine ventilation in the Malmberget mine is currently being worked out by LKAB.

10. Extinguishing systems

10.1 Kiruna

Below is a table that lists the places in the Kiruna mine that are protected by an extinguishing system and it also list the type of extinguishing system.

Table 5. Extinguishing systems in the Kiruna mine.

Level	Compartment	Type of system	Remark
524	Relay interlocking plant and the two transformer compartments	Gaseous system (Inergen)	
540	Wooden sauna in the visitors mine	Water sprinkler	
775	Relay interlocking plant and corresponding cable vault CH3	Carbon dioxide	
775	Workshops	Water sprinkler	
775	Parking lots	Water sprinkler	
1045	Parking lots	Water sprinkler	

10.2 Malmberget

Below is a table that lists the places in the Malmberget mine that are protected by an extinguishing system and it also list the type of extinguishing system.

Table 6. Extinguishing systems in the Malmberget mine.

Level	Compartment	Type of system	Remark
500	Parking lots	Water sprinkler	Manual activation
600	Workshop	Water sprinkler	
600	Parking lots	Water sprinkler	Manual activation
815	Workshops	Water sprinkler	Manual activation
815	Parking lots	Water sprinkler	Manual activation
815	Oil room	Water sprinkler	Manual activation
815	Refuge room	Water sprinkler	Manual activation
815	Relay interlocking plant and corresponding cable vault	Gaseous system (Inergen)	
890	Conveyor belt drifts	Water sprinkler	Manual activation
1000	Workshop	Water sprinkler	

11. Analysis and discussion

When studying earlier fires and fire incidents for the two LKAB mines, the most common causes were electrical cause (50%), flammable liquid or material on hot surface (22%), hot works (5%) and equipment running hot (5%).

One difference between fires due to electrical cause versus flammable liquid/material on hot surfaces is that fires caused by flammable liquid/material on hot surfaces are generally larger in size and cause a more extensive smoke spread.

Fires caused by hot works and equipment running hot, generally seems to be small. In the earlier case, it is probably due to the fact that personnel with fire extinguishers are present on the site. In the latter case, probably due to that the amount of combustible material is limited.

With respect to the size of the fires, 52% occurred in the infrastructure part of each mine and 48% occurred in the production areas. With respect to vehicle fires, 47% occurred in the infrastructure parts (including for example workshops, storage areas, canteen etc.) and 53% occurred in the production areas. With respect to large and severe fires (i.e. large amount of smoke being emitted or fire put out by the fire brigade), 44% occurred in the infrastructure part and 56% occurred in the production areas (75% of the large or severe fires in the infrastructural part was caused by broken turbo).

A clear majority of the fires did not require assistance from industrial or local fire brigade (only 6 fires required assistance), they were either self extinguished or put out by personnel on site. Only during two fires evacuation occurred.

When it comes to combustible material in general, the amount of combustibles seems to be more frequent in the Malmberget mine. In the Kiruna mine, the places with wood and conveyor belts seems to be interesting enough for further investigation. Even though self extinguishing conveyor belts means a limited fire in size, the amount of smoke emitted can be quite extensive. Also the storage of tyres at the contractor depots could be worthwhile investigating due to the sensitive surroundings.

Regarding the Malmberget mine, the sites with wood combustibles, tyres and conveyor belts are all interesting for further investigation due to the large amount of combustibles and the surroundings.

With respect to flammable liquids:

- The tank stations in the Kiruna and the Malmberget mine should be looked into with respect to potential pool fires.
- The larger workshops and warehouses in the Kiruna mine and the Malmberget mine should also be investigated with respect to pool fires.
- The crusher levels and draw points in the two mines should be investigated with respect to spray fires.
- The diesel tanks in the main ramps and the production areas should be investigated with respect to pool fires.
- The media drifts, distribution levels, shaft hoisting levels and pumping stations should be investigated with respect to pool fires.

With respect to fire barriers, as the main ramps of each mine does not contain any fire barriers the impact of a vehicle fire in the main ramp would be interesting to investigate. Another reason would be the fact that the main ramps are the main egress routes for the personnel as well as attack routes for the rescue services. It would also be interesting to validate the ventilation strategy in the Malmberget mine regarding preventing smoke spread to adjacent compartments. The majority of the extinguishing systems in the Malmberget mine are activated manually, which decreases the chance of successful operation in case of a fire.

As not all workshops and larger parking lots in both mines are equipped with extinguishing systems, the impact on their surroundings should be investigated.

12. Conclusions

With respect to earlier fires and fire incidents for the two LKAB mines, the most common causes and the causes to focus on are: electrical cause, flammable liquid or material on hot surface, hot works and equipment running hot.

Both the production area and the infrastructure part should be regarded in the future studies as fires are almost identically frequent in both areas.

When it comes to combustible material in general, the amount of combustibles seems to be more frequent in the Malmberget mine. In the Kiruna mine, the places with wood and conveyor belts seems to be interesting enough for further investigation. Even though self extinguishing conveyor belts means a limited fire in size, the amount of smoke emitted can be quite extensive. Also the storage of tyres at the contractor's depots could be worthwhile investigating due to the sensitive surroundings.

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- The crusher levels and draw points in the two mines should be investigated with respect to spray fires.
- The diesel tanks in the main ramps and the production areas should be investigated with respect to pool fires.
- The media drifts, distribution levels, shaft hoisting levels and pumping stations should be investigated with respect to pool fires.

With respect to fire barriers, as the main ramps of each mine does not contain any fire barriers the impact of a vehicle fire in the main ramp would be interesting to investigate. It would also be interesting to validate the ventilation strategy in the Malmberget mine regarding preventing smoke spread to adjacent compartments.

With respect to vehicles, all the common heavy vehicles listed in this report would be worthwhile to try to reconstruct a possible fire scenario for each type of vehicle. The reason for this is to have better tools when working on possible scenarios of each mine.

Regarding cables, all listed sites with a high load of electrical cables would be interesting to investigate. Even though the immediate surroundings are not sensitive, an extensive smoke spread would make a large impact on a large portion of the mine.

When looking into the ventilation system of the Kiruna mine, both the mine production area and the infrastructure part should be investigated due to the differences in each system and their surroundings. Also, the difference in systems whether you are below or above level 775 should be considered. The function and impact of oversteering should also be included in the investigations.

The impact of a ventiflex PVC-tube being burned up on the fire behavior in a production area should be investigated. The different fire scenarios in a production area depending on the position of the fire with respect to the ventilation should also be investigated.

One scenario should put the fire right at the end of the intake air tube; other scenarios should be at a certain length interval from the end of the intake air tube. The likelihood of the power cables to the intake and exhaust air fans being burned off should be looked into. The impact on the surroundings should also be investigated. The return air fan capacity should be examined with respect to fires, such as vehicle fires.

The majority of the extinguishing systems in the Malmberget mine are activated manually, which decreases the chance of successful operation in case of a fire. As not all workshops and larger parking lots in both mines are equipped with extinguishing systems, the impact on their surroundings should be investigated.

13. References

- [1] Electronic correspondence with Evald Andersson, Atlas Copco CMT Sweden AB, 2008-06-17
- [2] www.toro.sandvik.com , 2008-06-05
- [3] www.scania.com , 2009-01-20
- [4] Electronic correspondence with Ronnie Hansson, LKAB, 2009-01-19
- [5] Electronic correspondence with Håkan Darehed, Eriksson Bil AB, 2008-12-16
- [6] www.ljungbymaskin.se , 2009-01-19
- [7] Linnsén H. (2001), *Brandventilation i Kiruna järnmalmshögskola*, Högskolen Stord/Haugesund
- [8] Electronic correspondence with Hans Lindberg, LKAB, 2008-10-03

Brännbart material:

Uppskattad vikt: kg eller volym m³

Fordon:

Fordon nr:

Tillverkare:

Typbeteckning:

Tillverkningsnummer:

Tjänstevikt:

Typ av drivmedel:

Bränsletank: m^3

Hydraulolja: m^3

Övrigt:

Uppställningsplats:

Arbetsområde:

Installationer:

Installation nr:

Tillverkare:

Typbeteckning:

Tillverkningsnummer:

Placering:

Brandcell nr:

Typ av brännbart material:

Uppskattad vikt på brännbart mtr: kg

Ev. hydraulolja: m³

Övrigt:

Kablar:

Kabelstråk nr:

Kabelstegens bredd: mm

Antal kabelstegar i nivå: st

Placering:

Brandcell nr:

Typ av kablar: Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Antal:

Inträffade händelser:**Händelse nr:**

Datum då händelsen inträffade:

ÅÅ MM DD

Händelsen krävde insats från:

- ☐ Personal på plats
☐ Industribrandkår
☐ Kommunal räddningstjänst

Händelsen inträffade på nivå:

Plats:

Användes räddningskammare:

☐ Ja ☐ Nej

Antal personer som berördes av utrymning:

Startobjekt:

Brandorsak:

Personskador:

☐ Ja ☐ Nej

Antal skadade:

Typ av skador:

Beskriv materiella skador:

Finns insatsrapport?

☐ Ja ☐ Nej

Finns brandutredning?

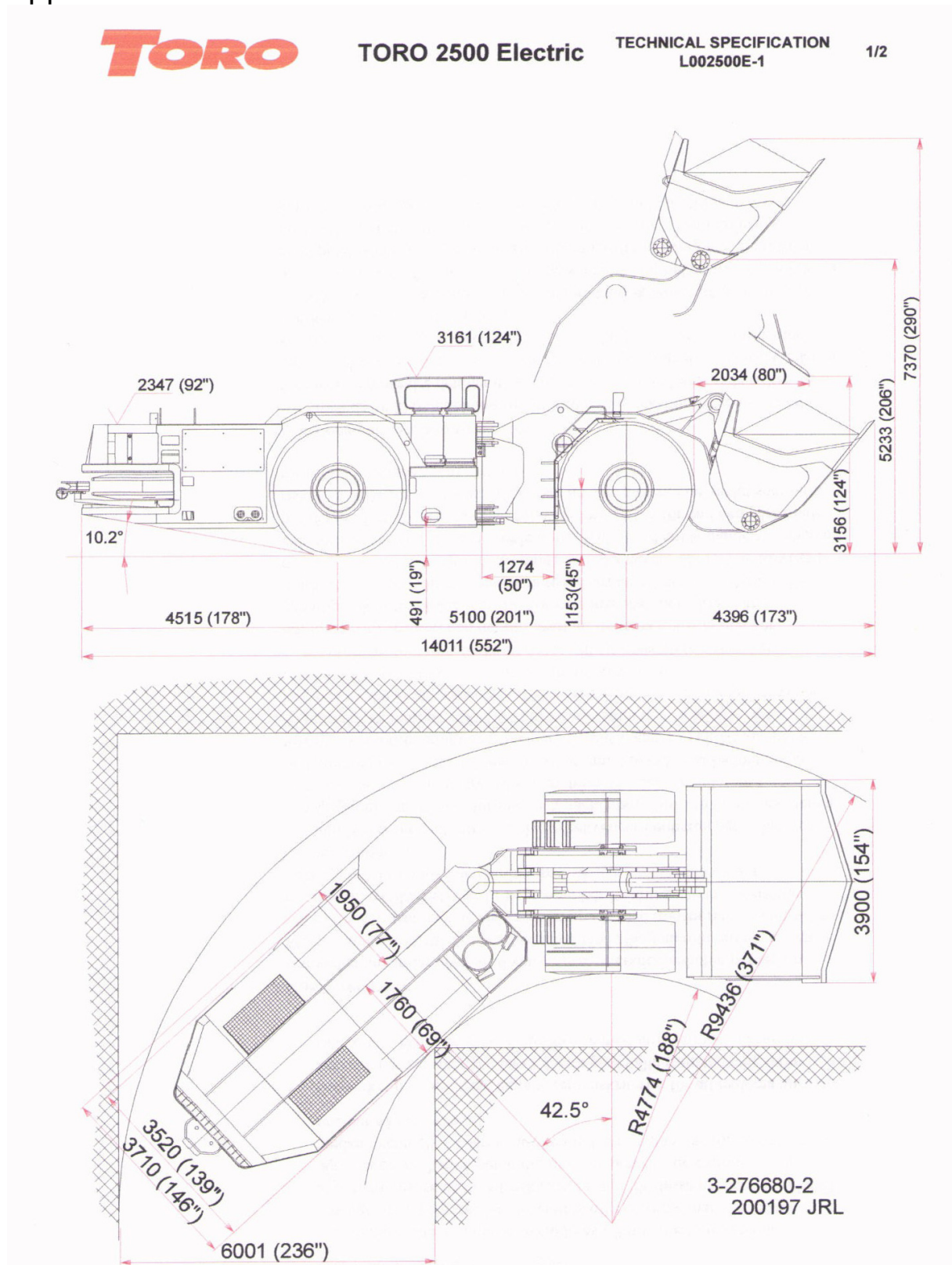
☐ Ja ☐ Nej

Finns foton?

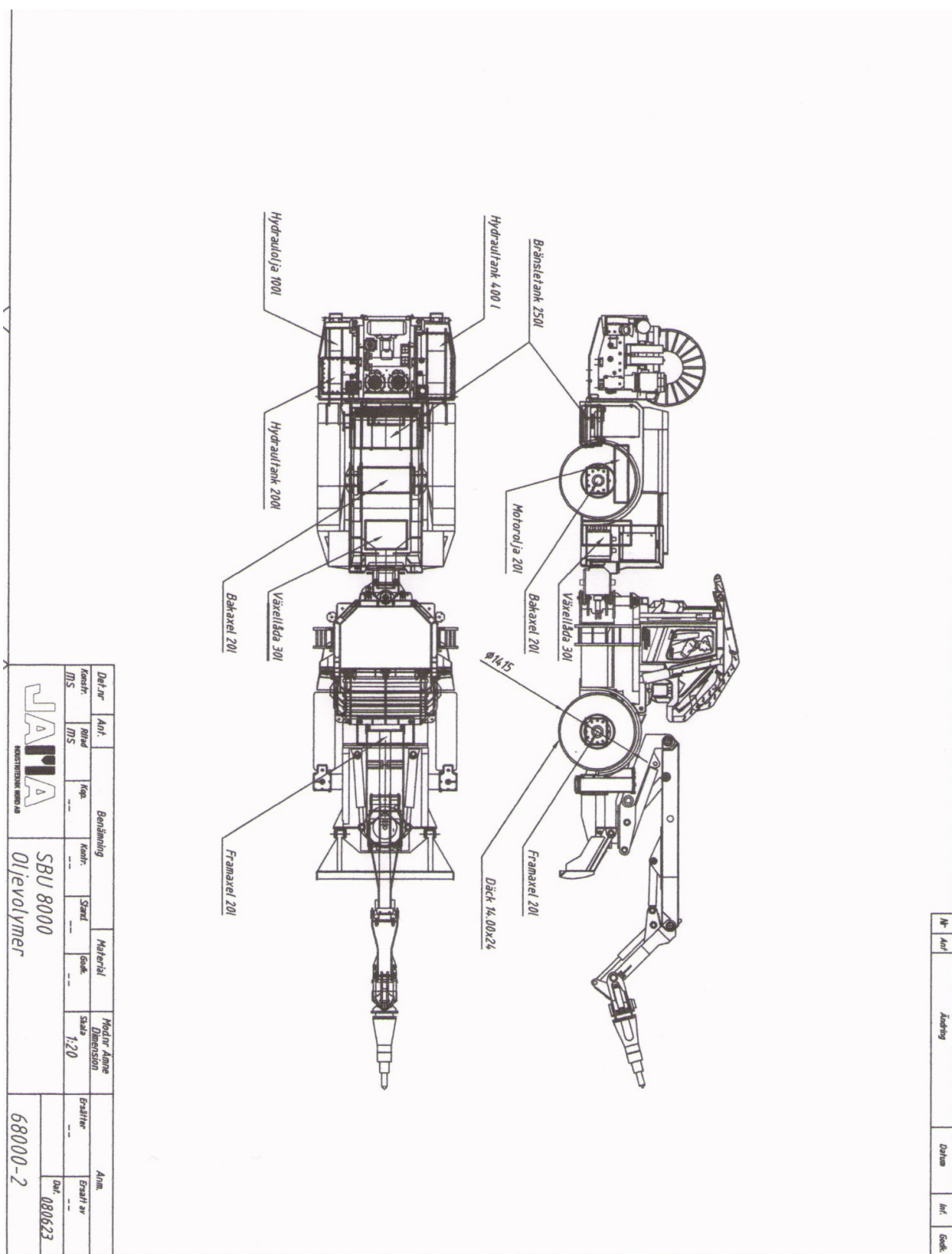
☐ Ja ☐ Nej

Beskrivning av händelseförloppet:

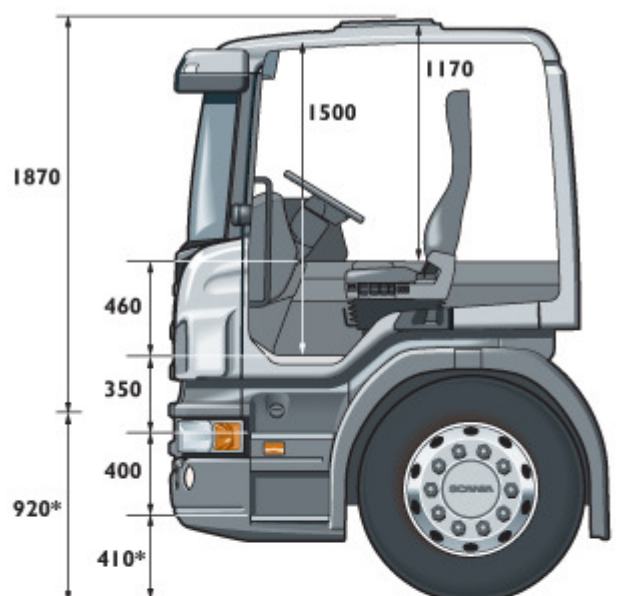
Appendix 2.



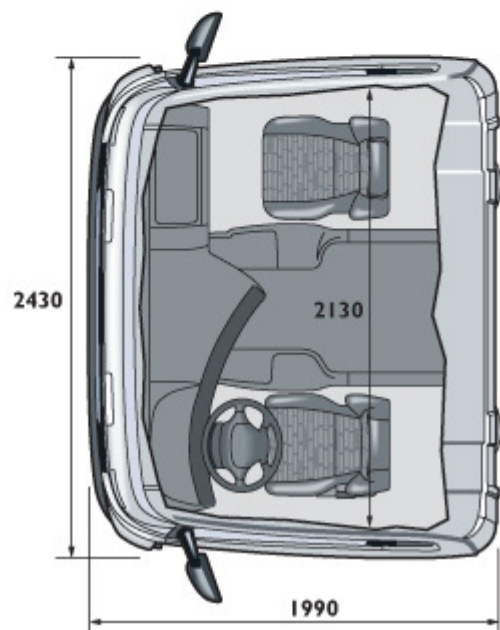
Appendix 3.



Appendix 4.



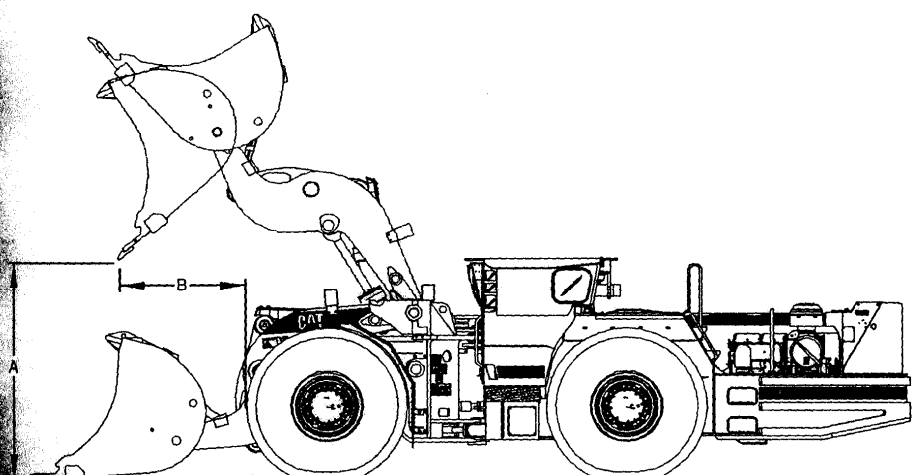
* Can vary depending on tyre size and chassis height



Appendix 5.

WBU7333

27
Produktinformation
Modellvyer och specifikationer



g01130741

(A) motsvarar dumphöjden. Måttet (B) motsvarar räckvidden.

Tömningshöjden och räckvidden gäller för samtliga maskiner vid maximal lyfthöjd och 45 graders tömningsvinkel. Tömningshöjden (A) är avståndet från marken till skopakanten när skopan är i helt UPPPAT läge. Räckvidden (B) är avståndet från maskinens framkant till skopakanten när skopan är i UPPPAT läge.

I denna tabell anges tillåten arbetslast för maskin i förhållande till lastförande.

Arbetslast					
Maskinmodell	Slitgods	Märkvolym	Nominell arbetslast	Tömningshöjd A	Räckvidd B
9200G Arbetslastare	Skärstål med enkelfasad spets	7,2 m ³ (9,4 yard ³)	17 200 kg (37 920 lb)	2871 mm (113,0 tum)	1666 mm (65,6 tum)
920G XTRA Arbetslastare	Skärstål med enkelfasad spets	8,9 m ³ (11,6 yard ³)	20 000 kg (44 090 lb)	2694 mm (106,1 tum)	1849 mm (72,8 tum)

Tabell 2

R2900G XTRA Underjordslastare	
Vikt (cirka) ⁽¹⁾	56 324 kg (124 173 lb)
Längd (max)	11 483 mm (452,1 tum)
Bredd (max)	3454 mm (136,0 tum)
Bredd (över däck)	3228 mm (127,1 tum)
Höjd över ROPS-/FOPS-skyddet	2996 mm (118,0 tum)

⁽¹⁾ I vikten ingår full bränsletank, förare med en vikt av 75 kg (165,3 lb), en sluten förarplats och standardskopa. Har extrautrustning installerats på din maskin, kan dess vikt förändras.

i02391703

Arbetslast för skopa

SMCS-kod: 6700

VARNING

Om arbetslasten överskrider kan person- och materiella skador uppstå. Kontrollera redskapets arbetslast innan det används. Justera arbetslasten om så behövs vid användning av icke-standardkonfigurationer.

Anm. Arbetslaster ska användas som vägledning. Redskap, ojämn och mjuk mark samt andra dåliga markförhållanden kan påverka märklaster. Föraren måste känna till dessa förhållanden.

Märklaster baseras på en standardmaskin enligt följande:

- korrekta smörjmedel
- full bränsletank
- slutet ROPS-skydd
- 75 kg (165 lb) tung förare
- 29.5x29 34PR L-5 däck eller motsvarande för R2900G Underjordslastare
- 35/65 R33 Two Star L-5 däck eller motsvarande för R2900G XTRA Underjordslastare

Tillåten arbetslast varierar beroende på redskap. Kontakta din Caterpillar återförsäljare beträffande arbetslast för ett visst arbetsredskap.

Tillåten arbetslast definieras enligt ISO 5998 (1986) som 50 % av statisk tipplast vid full sväng.

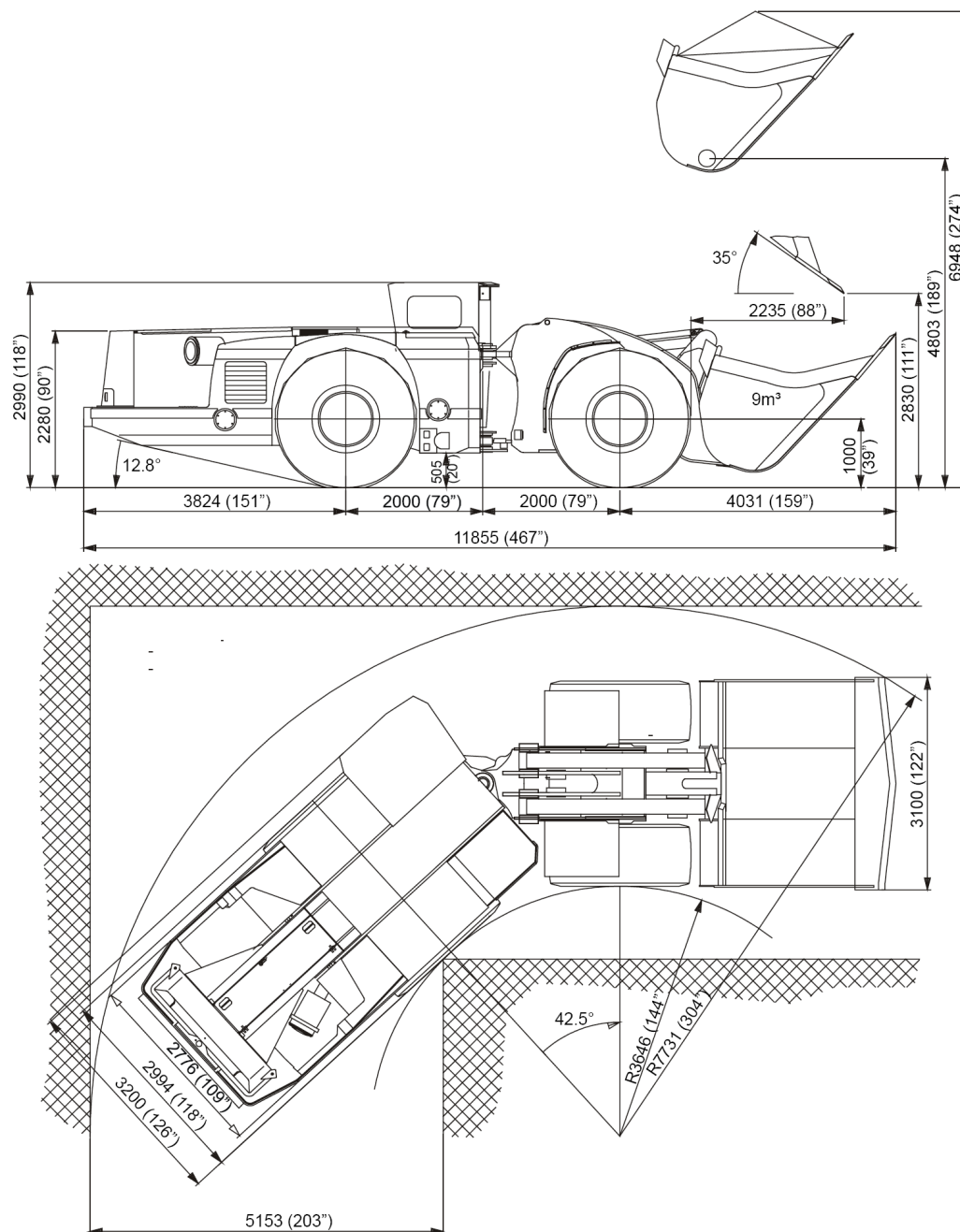
Appendix 6.

TORO

TORO 0011

**TECHNICAL SPECIFICATION
L000011-1**

1/3



3-29601609-4
160300 JJT

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Fax. +358 20544130
E-mail: toro@sandvik.com
Internet: www.toro.sandvik.com

Main dimensions

Total length	11 853 mm (467")
Width without bucket	3 197 mm (126")
Maximum width	3 253 mm (128")
Std. height with safety cabin	2 990 mm (118")
Ground clearance	505 mm (20")

Weights

Operating weight	56 800 kg (125 220 lb)
Total loaded weight	77 800 kg (171 520 lb)
Shipping weight	56 400 kg (124 340 lb)
Axle weights without load:	
Front axle	23 600 kg (52 030 lb)
Rear axle	33 200 kg (73 190 lb)
Axle weights with load:	
Front axle	56 600 kg (124 780 lb)
Rear axle	21 200 kg (46 740 lb)

Capacities

Tramming capacity	21 000 kg (46 300 lb)
Breakout force, lift	378 kN (84 880 lb)
Breakout force, tilt	344 kN (77 380 lb)
Tipping load	47 700 kg (105 160 lb)
Bucket std.	9,0 m ³ (11.8 yd ³), HB500/400

Bucket motion times

Raising time	8,4 sec.
Lowering time	4,5 sec.
Tipping time	1,8 sec.

Driving speeds forward and reverse

1st gear	4,6 km/h (2.9 mph)
2nd gear	8,2 km/h (5.1 mph)
3rd gear	14,2 km/h (8.8 mph)
4th gear	25,5 km/h (15.8 mph)

Frame

Rear and front frame	Welded steel construction
Material	Raex 355N (St 52-3)
Central hinge	Adjustable upper bearing
Material	Raex 355N (St 52-3)
Hydr. tank and cabin base	bolted and welded to the frame

Standard engine

Diesel engine	Detroit Diesel S-60 DDEC IV
(Euro Stage II / Tier II)	
Output	354 kW(475 hp) / 2100 rpm
Torque	2102 Nm / 1350 rpm
Number of cylinders	In line 6
Displacement	12,7 liters
Cooling system	Water cooled
Combustion principle	Four stroke, direct injection, turbo with intercooler
Electric system	24 V starter and accessories
Air filtering	Donaldson
Exhaust system	HTI insulated exhaust manifold & Turbo, Double wall exhaust pipe, Catalytic purifier and muffler
Fuel tank capacity	620 l (164 gal)

Standard converter

Dana SOH CL 9652	Offset 1,323
------------------	--------------

Standard gearbox

Dana SOH 8421H	Power shift (electrical gear shift control) gear box with modulation, 4 + 4 speeds
----------------	--

Standard axles

Front axle	Dana SOH 53R312 LCB, with Posi-Torq differentials, fixed
Rear axle	Dana SOH 53R312 LCB, with Posi-Torq differentials, oscillating $\pm 8^\circ$.

Standard brakes

Service brakes – Hydraulically operated liquid cooled (LCB) multidisc brakes in all wheels. Separate brake circuits for front and rear axle. Separate oil tank for brake circuit.

Parking brake – Spring operated multidisc liquid cooled brake on the input shaft of the front axle. Brake is released by oil pressure from the hydraulic system. The oil flow is controlled with a button in the cabin. The parking brake engages automatically if engine, transmission (optional) or brake accumulator oil pressure is too low or if the electric current is cut off. Automatic brake activation, ABA.

Emergency brake – The emergency brake uses the same brakes as the service brake and is controlled by a button in the cabin.

Main components in the brake system:

Pressure accumulator	Bosch
Brake pedal valve	Rexroth
Brake valve	Parker
Charging valve	Parker
Parking brake	TORO
Brake tank capacity	75 l (56 gal)

Standard tyres

Size and type	35/65-33 DL L-5, Bridgestone 42ply, tubeless
---------------	--

Air pressure, front 675 kPa (6.75 bar) (98 PSI)

Air pressure, rear 475 kPa (4.75 bar) (69 PSI)

Other type of tyres available to user's choice. In certain applications the productive capabilities of the loader may exceed the TKPH value given by tyre manufacturer.

Sandvik Tamrock recommend that the user consult their tyre supplier to evaluate conditions and to find the best solution for application.

Standard cabin

ROPS / FOPS tested & certified, rubber mounted, pressurized, air-conditioned and noise proofed, $\pm 25^\circ$ swivel seat & controls, height 2990 mm (115"), CEN approved

Controls

Joystick bucket & steering, gear selector buttons on the joystick
Heavy duty switches

Steering hydraulics

Hydraulic, centre-point articulation, power steering with two double acting cylinders. Steering controlled by stick, interlock protection. Emergency steering is optional.

Turning angle $\pm 42,5^\circ$
Turning radius with std bucket inner left 3650 mm (144")
outer 7730 mm (304")

Main components in steering system:

Main valve	Danfoss
Servo control valve	Danfoss
Steering hydraulic cylinders	2 pcs, 140 mm (5.5"), TORO
Steering pump	piston type, Rexroth

Steering servo pump

Pressure settings:

Steering hydraulics, main relief valve	15 Mpa(150 bar)
Shock load valves	24,0 Mpa(240 bar)

Bucket hydraulics

Monostick bucket and boom control. The bucket hydraulics has two pumps. One is for the servo circuit and other delivers oil to the bucket hydraulic main valve. The oil flow from steering hydraulic pump is directed to bucket hydraulics when steering is not used.

Boom system	Z-link
Lift cylinders	2pcs, $\varnothing 200$ mm (7.9")
Tilt cylinder	1pcs, $\varnothing 250$ mm (9.9")

Pressure setting for:

Servo circuit	3,5 Mpa (35 bar)
Bucket hydraulics	28 MPa (280 bar)
Shock load valves	30 MPa (300 bar)

Main components:

Bucket hydraulic cylinders	TORO
Servo control valve	Rexroth
Main valve	Rexroth
Pump for pilot hydraulics	gear type, Rexroth
Pump for bucket hydraulics	piston type, Rexroth
Fittings	ORFS
Oil coolers for hydraulic and transmission oil to handle up to 55 dec. ambient temperature	2 pcs

Hydraulic oil tank capacity 450 l

Standard Lubrication system

Automatic central lubrication,
Dog bone pins with grease chamber

Electrical equipment

Alternator	140 A, Bosch
Batteries	2 x 12 V, 160 Ah
Starter	24V
Driving and working lights	front, 4 pcs rear, 4 pcs
Electrical gauges	Digital gauges, fuel gauge, signal light for hydraulic oil level
Electrics	CAN open –bus gear selection & hydraulic control with display unit in the dash, rest of wiring & components TORO std.

Others

Fire audited.

Decal language ENG/FIN/SWE/RUS/SPA/DEU/FRA.

Standard manuals

3pcs Spare part manual:

Operation instructions	main European languages
Maintenance instructions	main European languages
Engine spare part information	English
Machine spare part information	English
Workshop manual	
Operation instructions	main European languages
Maintenance instructions	main European languages
Engine workshop manual	Original
Power train components manual	Original
Optional equipment instructions	English

Optional equipment

* replaces standard equipment

- * Bucket size 8.0 m³ (10.5yd³), width 3100 mm (122"), HB 500/400
- * Bucket size 9.0 m³ (11.7yd³), width 3300 mm (130"), HB500/400.
- * Bucket size 9.8 m³ (12.8yd³), width 3300 mm (130"), HB500/400.
- * Bucket size 10.7 m³ (14.0yd³), width 3300 mm (130"), HB500/400.
- * Hydr. tanks & cabin base NOT welded to the frame
- * Automatic gear selection.
- * Emergency steering (CEN).
- * Electronic spare part manual.
- Electrical fill-up pump for hydraulic oil.
- Fire suppression system ANSUL, two-tank system with 8 nozzles (CEN).
- Fire suppression system ANSUL, two-tank system with 8 nozzles, CHECKFIRE.
- Auto engine shut down, ANSUL/DDEC.
- Fire extinguisher 12 kg (CEN).
- Additional spare part manuals. ____ pcs
- TORO RRC, complete. ____ MHz
- RRC interface (TORO Std.).
- RRC recovery kit, hook included.
- Load weighing device, Tamtron PKV 200.
- Ride control system with piston accumulators.
- Spare wheel 35/65 -33, DL, L-5, Bridgestone 42 ply
- Spare rim (35/36-33)
- Accordance with CE-norms (CEN).
- Disassembly needed shaft dim: ____ mm x ____ mm.

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Appendix 7.

Drivlina

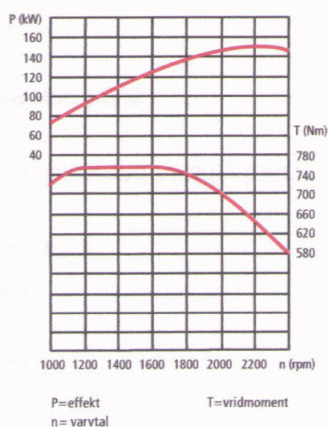
Motor	Mercedes OM 906 LA
Effekt	150 kW@2200 rpm
Vridmoment	750 Nm@1200-1600 rpm
Oljekylning	Integrerad
Växellåda	ZF Ergopower WG190
Momentförstärkning	2,5:1
Framaxel	ZF MTL 3085
Bakaxel	ZF MTL 3085
Diffbroms fram och bak	Standard
Färdbroms	Tvåkrets hydraulisk
Parkeringsbroms	Hydraulisk
Bromsskivor	Efter planetreduktion
Axelkylning	Intern oljecirkulation
Fläkt	Hydrostatiskt driven

Rymduppgifter

Kylsystem	35 l
Motor	25 l
Hydraulsystem	185 l
Bränsletank	235 l

Styrsystem

Styrvinkel	45°
Styrcylinder	40/80 mm
Slag styrcylinder	557 mm
Nödstyrning	Direktrev växellåda
Pendling bakaxel	+/- 15°



Hydraulsystem

Hydraulpump	Parker/Sauer-Danfoss
Flöde	356 l/min vid 2300 rpm
Tryck	250 bar
Lyftcylinder	60/115 mm
Slag lyftcylinder	925 mm
Tiltcylinder	60/115 mm
Slag tiltcylinder	895 mm
Hydraulkylning	Standard

Elsystem

Batteri	2 x 12 V, 105 A
Generator	80 A

Kraft och vikt

Brytkraft, standardskopa	11 900 kg
Tipplast 0°	10 900 kg
40°	9 350 kg
45°	9 100 kg
Tjänstevikt	14,5-16,0 ton
Skopa	2,4-2,8 m³
Timmergrip	2,0 m²

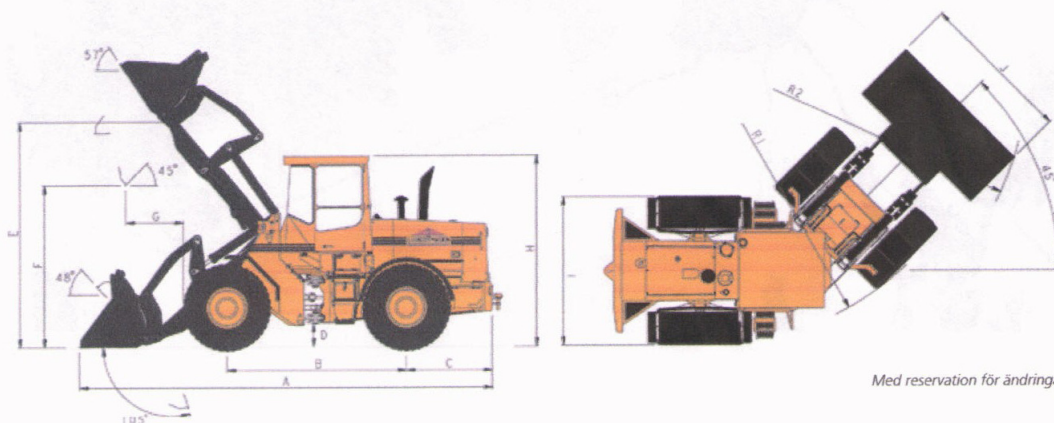
Dimensioner

Måtten refererar till figuren nedan.

A	7 040 mm
B	3 050 mm
C	1 465 mm
D	405 mm
E	4 075 mm
F	2 850 mm
G	1 180 mm
H	3 270 mm
I	2 515 mm
J	2 630 mm
R1	4 980 mm
R2	5 630 mm

Hjul

Standarddäck	Yokohama RB31
Dimension	20,5R25



Med reservation för ändringar

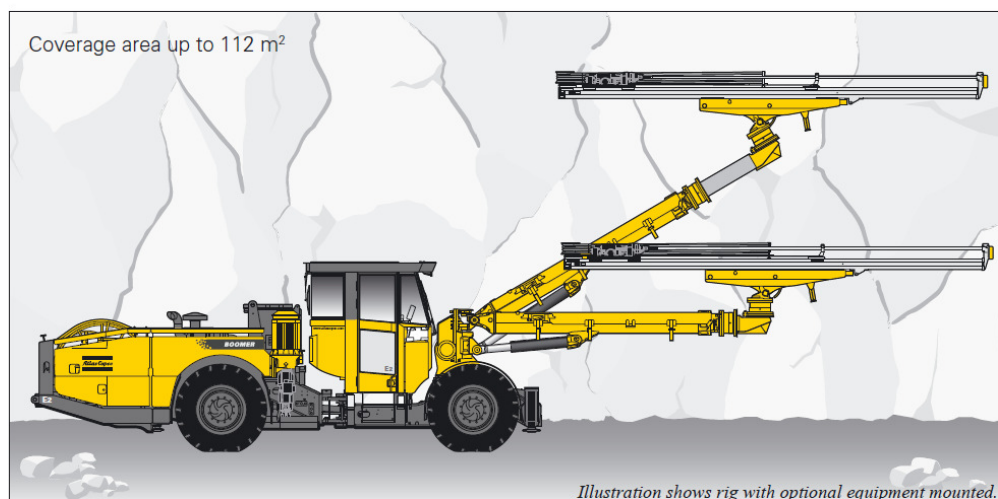
Appendix 8.

Atlas Copco Face drilling rigs

Technical specification

Boomer E2 C

Equipped with COP 3038 rock drills



Two boom hydraulic tunnelling and mining rig with an advanced Rig Control System, COP 3038 rock drills and heavy-duty BUT 45 booms for superior productivity.

Standard features

» Rock drill

- High-frequency COP 3038 rock drills with dual-damping system for optimal consumable life
- Pressurized housing and mating surfaces to reduce internal contamination of the rock drill

» Hydraulic boom

- BUT 45 heavy-duty booms for direct, fast and accurate positioning between holes
- Double rotation unit for 360 degrees feed rotation and roll-over

» Hydraulic feed

- BMH 6900-series heavy-duty aluminium feed with high bending and torsional resistance for maximum durability
- Snap-on stainless steel sleeves and polymer contacts

» Control system

- Advanced Rig Control System (RCS) allowing several levels of automation to suit customer requirements
- Standard functions include soft collaring and the anti-jamming function Rotation Pressure Controlled Feed (RPCF)
- Integrated diagnostic and event logging system to assist in equipment maintenance
- Interactive operator panel with full-colour display

» Carrier

- Sturdy, articulated carrier with four-wheel drive
- Powered by a 4-cylinder, EPA III/COM III (Tier 3/Stage IIIA) approved diesel engine
- Four jacks for stable set up

» General

- FOPS-approved telescopic protective roof
- Hydraulically driven water booster pump
- Hydraulically driven compressor
- Cable reel
- Working lights

Atlas Copco

Optional equipment

» Rock drill/Drilling system

- Hole blowing kit excluding air receiver

» Feed

- Feed prepared for Rod Adding System (RAS), 10' extension rods
- Rod Adding System, RAS
- Feed prepared for Rod Handling System (RHS E), 10' extension rods
- Rod Handling System E, RHS E
- Water spraying kit on cradle
- Hole depth sensor, hydraulic flow meter in place of standard fishing line sensor

» Boom

- Automatic boom lubrication

» Software

- Advanced Boom Control, ABC Regular
- Advanced Boom Control, ABC Total
- Tunnel Manager software
- Rig hydraulically prepared for ABC Total
- Boom equipped for Measure While Drilling, MWD
- Measure While Drilling logging and analyzing drill data
- Electronic parallel holding (ABC Regular)
- Bolt view
- Water loss measurement instruments installed in service platform
- Rig Remote Access (RRA)
- RRA server

» Protective roof

- Mounting height -80 mm/+30 mm/+310 mm
- Manual spotlight, left and/or right
- Swingable seat for drilling and tramming (one operator panel only)
- Two operator panels for standing operation only

» Cabin

- FOPS-approved cabin, noise level <80 dB(A), height 3,044 mm including:
 - Air conditioning unit
 - Fixed seat
 - CD-changer
 - Boot washing kit
- Cabin body made of stainless steel
- Hydraulic cabin lift system, 0–600 mm
- Mounting height -60/-140/+250 mm
- Front window, 24 mm
- Heating function for air conditioning (water transferred)
- Electrical heater, 1.2 kW, 230 V (CE)

- Joystick-controlled spotlights left and/or right, 70 W
- Swingable seat for drilling and tramming
- Two operator panels (for standing operation only)

» Air system

- Compressor, GAR 30

» Water system

- Water hose reel

» Hydraulic system

- Biodegradable hydraulic oil
- Heater kit for hydraulic oil tank, diesel engine and electric motors

» Carrier

- Deutz TCD 2013 L06 2V
- 16xR25 tyres
- Fire suppression system ANSUL (manual or Checkfire)
- Fire suppression system FORREX (manual or automatic)

» Electrical system

- Stainless steel electrical enclosure
- Electric cable type (Buflex 690/1,000 V)
- Plug for cable
- Switch gear
- Electric outlet for accessories, 16 A (CE)
- Extra transformer 3-phase, 15kVA (230/400 V outlet)

» Miscellaneous

- Service platform, SP 2
- Swingable basket for service platform
- Retractable protective roof for service platform
- Water and air outlet in service platform
- Hose/cable guiding at water/cable reel
- Hydraulic Swellex pump type H1 for manual installation
- Manual lubrication kit
- Rig washing kit
- Ni-Cr plated piston rods (limitations exist)
- Boot washing kit
- Hydraulic outlet for charging with Mini SSE

For information about drill consumables, please consult your Atlas Copco Customer Center.

Specifications

ROCK DRILL

	COP 3038
Shank adapter	TC45
Height over drill centre	84 mm
Length without shank	970 mm
Impact power	30 kW
Impact rate	102 Hz
Hydraulic pressure	200 bar
Rotation system	Separate rotation
Rotation speed	0–380 (615) rpm
Rotation torque, max	190 Nm
Lub. air consump. at 4 bar	5 l/s
Flushing water	20–40 bar
Water consumption, max	2.2–3.2 l/s
Weight	165 kg
Sound level	<106 dB(A)

FEED

BMH 6900	BMH 6914	BMH 6916	BMH 6918	BMH 6920	BMH 6921
Total length	5,988 mm	6,598 mm	7,208 mm	7,778 mm	8,078 mm
Drill steel length	4,310 mm	4,920 mm	5,530 mm	6,100 mm	6,400 mm
Hole depth	4,040 mm	4,650 mm	5,260 mm	5,830 mm	6,130 mm
Weight, incl. drill	666 kg	700 kg	731 kg	756 kg	785 kg
Feed force	22.0 kN	22.0 kN	22.0 kN	22.0 kN	22.0 kN

» Boom

- BUT 45 M
- Feed extension 1,800 mm
- Boom extension 2,500 mm
- Parallel holding complete
- Feed roll-over ±190°
- Feed cross-cut ±135°
- Max. lifting angle +55°/-42°
- Max. swinging angle ±42°
- Weight, boom only 3,050 kg

» Air system

- Hydraulically driven screw compressor... Atlas Copco GAR 5
- Capacity, max at 9 bar 26 l/s
- Adjustable speed
- Air pressure gauge
- Hole blowing kit with 80 l air receiver

» Water system

- Hydraulic water booster pump Johnson MCVS 16-7
- Water booster pump max capacity at 30 bar 400 l/min
- Min water inlet pressure at 400 l/min, 2 bar
- Water pressure gauge
- Water flow guard
- Pressure compensated water pump

» Control system

- Rig Control System (RCS) – versatile and upgradeable to a higher degree of automation
- One adjustable, electronic control panel with colour display
- PC-card for transfer of data and backup settings
- Integrated diagnostic system
- Separate battery for electronic system

» Electrical system

- Total installed power 198 kW
- Main motors 2x95 kW
- Voltage 690–1,000 V
- Frequency 50–60 Hz
- Starting method star/delta
- Electronic overload protection for electric motors
- Percussion hour meter on operator display
- Digital voltmeter/ampere meter in electric cabinet
- Phase sequence indicator
- Earth fault indicator
- Battery charger
- Transformer 8 kVA
- Cable reel, diameter 1,600 mm
- Dual controls for cable reel

» Hydraulic system

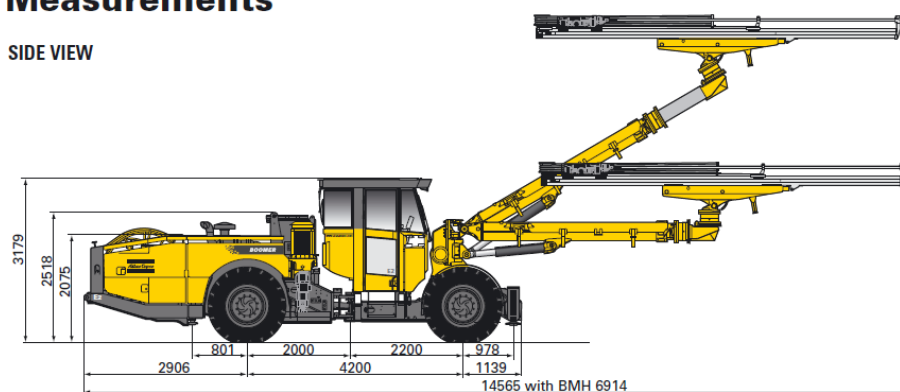
- Hydraulic pumps 2 separate units, one for each boom
- Pumps unloaded at start
- System pressure, max. 250 bar
- Hydraulic oil tank, volume max/min 390/290 l
- Low oil level indicator
- Oil temperature gauge on oil tank
- Electrical oil filling pump
- Oil filter indicator
- Water cooled oil
- Filtration 16 µm
- Mineral hydraulic oil

» Carrier

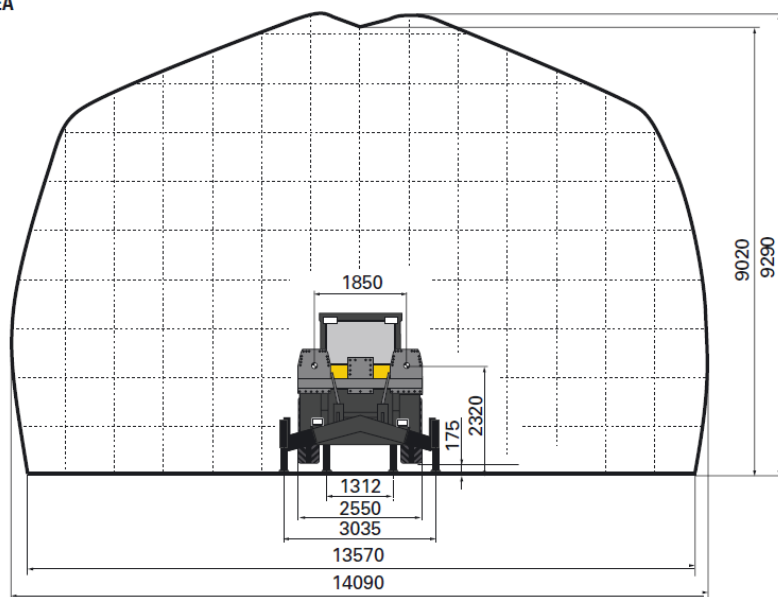
- Deutz 4-cylinder, TCD 2013 L04, EPA III/COM III (Tier 3/ Stage IIIA) approved 4-stroke prechamber diesel engine
- Power rating at 2,300 rpm 120 kW (160 hp)
- Torque at 1,600 rpm 618 Nm
- Articulated steering ±38° steering angle
- Four-wheel drive
- Hydrostatic power steering system
- Hydrodynamic transmission Clark 24000
- Front axle Dana 114
- Rear axle Dana 114, ±8° oscillation
- Automatic differential lock on front axle, limited slip
- Tyres 14.00xR24
- Clearance outside axles 16° rear, 23° front
- Hydraulic jacks, front 2 extendable
- Hydraulic jacks, rear 2
- Service brakes 2 separate circuits
- Emergency and parking brakes SAHR
- Fuel tank, volume 110 l
- Exhaust catalyser
- Silencer
- Electric system 24 V
- Batteries 2x125 Ah
- Trimming lights 8x70 W
- Working lights 2x1,000 W
- Brake lights
- Illuminated stairs for platform 2x70 W
- Fire extinguisher
- Central lubrication system
- Spirit level one for longitudinal, one for sideways
- Gradeability at max. load on drive wheels 1:4
- Horn, beacon and reverse alarm
- Shelf for drill bits and tools

Measurements

SIDE VIEW



COVERAGE AREA



Parallel coverage BUT 45 M

DIMENSIONS

mm		
Width		2,550
Height with cabin		3,179
Height roof up/down		3,144/2,518
Length with BMH 6914 feeds		14,565
Ground clearance		341
Turning radius outer/inner		8,400/4,800

TRAMMING SPEED

km/h		
On flat ground (rolling resistance 0.05)		>15
On incline 1:8		>5

RECOMMENDED CABLE SIZE AND LENGTH

Voltage	Type	Dimension, mm²	Diameter, mm	Length, m
660–690V	H07RN-F	4X120	60	75
	Butflex	3x150+3G25	52	100
1,000 V	Butflex	3x95+3G16	45	155

Recommendations are given for surrounding temperature of 40° C and up to a height of 2,000 m.

WEIGHT

gross weight, depending on configuration		
kg		
Total		30,000–39,000
Boom side		24,000–29,000
Engine side		6,000–10,000

