**Accidents to Mines Rescue Team Members Wearing Breathing Apparatus
During the period 1935 – 1982
Mines Rescue HQ for West Germany, Essen, 1983**

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| 1. **Introduction**

R. Goldbeck was instructed in 1962 to undertake a mine works study on behalf of the HQ of Mines Rescue Services in Essen.  This study was to summarise the "Accidents to members of mines rescue teams wearing breathing apparatus" over the period 1935 – 1961 and to compile a critical review and assessment of the accidents.This study was then extended to the period 1961 – 1982 and was to be used as a training aid for mines rescue teams.As found from recent experience with rescue team operations, similar accidents could still happen today under comparable circumstances, since there has scarcely been any change in human behaviour under exceptional conditions.  Consequently, incidents which occurred a long time ago, still relate to actualities of current significance.  Admittedly, the theoretical discussion can in no way substitute for practical experience, but the rules for behaviour when wearing breathing apparatus can be usefully substantiated.  The evaluations contained in the present summary are based essentially on the work carried out by R. Goldbeck.1. **Assessed accidents**

The assessment concerns only those accidents involving the wearers of breathing appliances during rescue operations and relating to such appliances which are still used or the mode of operation of which is comparable with present day appliances.  The following appliances are involved;

|  |  |
| --- | --- |
| **Type of appliance** | **Date authorised** |
| Auer MR II/32 | 1932 |
| Auer 54 / 400 | 1954 |
| Auer 56 / 400 | 1956 |
| Drager BG160A | 1934 |
| Drager BG170 / 400 | 1949-1953 |
| Drager BG172 | 1956 |
| Drager BG174 | 1966 |
| Fresh air compression hose appliance |
| Compressed – air hose appliance |
| CO – Filter working appliances |

Only those accidents are described which occurred during a serious call out or during underground exercises.  Accidents which occurred during exercises in exercise buildings, and accidents suffered by rescue team members in breathing appliances, due to mine fires or explosions, are not included in this review.1. **Dangers during rescue team call outs**.

When rescue teams are called out in irrespirable atmospheres (toxic gasses or lack of oxygen) and under difficult climatic conditions, the following dangers may arise;* + CO-poisoning
	+ CO2 poisoning
	+ Lack of oxygen
	+ Circulatory control failures
	+ Heat build up

These dangers will not be enumerated individually at this point because the subject has been dealt with comprehensively in Section 1 of "Training of Mines Rescue Teams" (2) or in the "Reports for Rescue Team Supervisors" (3).Human error, self-overestimation, lacking physical condition, nervous stress as well as leaking breathing tube connections and faulty equipment or accessories may lead to accidents.The accidents described in Appendix 3 are arranged in the following accident causes;* + Faulty mouthpiece breathing, face mask not seated properly
	+ Incorrect manipulation of appliances and accessories
	+ Over exertion
	+ Carelessness
	+ Exceeding the bounds of an order
	+ Failure to observe climatic conditions

Appendices 1 & 2 list the accident consequences and accident causes of the individual incidents.  In order to make the tabulated summary more readily appreciable, the accidents are grouped within the periods 1935 – 1955 and 1956 – 1982.  It will be seen that no accidents occurred in breathing appliances during the 11 years between 1962 and 1972.1. **Accident reporting**

According to section 4.4.1. of the Programme for Mines Rescue Teams, Issue Sept. 82’, the supervisor of a rescue team must immediately report by telephone, all accidents to the Mines Management and the HQ for Mines Rescue Services, where such accidents could be related to the wearing of breathing appliances and caused thereby.The procedure in such accidents is as follows;The team leader or his deputy, after noting the oxygen supply pressure, must close the oxygen cylinder of the appliance in question.  The breathing connection must be left as it is on the double folding hose.  The appliance must then be made available immediately, via the supervisor, (with the consent of Mines Management) to the HQ for Mines Rescue Services, without further adjustment to the appliance.  In the test laboratory of the HQ, the appliance will be examined in accordance with the "Directives for the Construction and Testing of Mines Breathing Appliances" (4), to determine possible technical faults on the appliance.  The findings will be recorded in a test report.1. **Assessment of the Accident**

During the period 1935 – 1982, a total of 83 accidents occurred.  21 members of Rescue Teams lost their lives as the result.The accident causes related to the accident consequences are listed below;**5.1.  Accident Consequence, CO Poisoning**In 57 cases (8)\* (= 67% of all accidents) CO poisoning occurred.  As shown in the table, these CO poisonings stemmed from the following causes;

|  |  |  |
| --- | --- | --- |
| **Cause** | **Number of Accidents** | **Percentage** |
| Faulty mouthpiece breathing, leaking facemask fitting | 37 (3) | 65% |
| Faulty appliance and accessory | 7 (1) | 12% |
| Incorrect manipulation of appliance and accessory | 4 (1) | 7% |
| Over exertion | 1 (1) | 2% |
| Carelessness | 4 (0) | 7% |
| Exceeding an order | 4 (2) | 7% |
| **TOTAL** | **57 (8)** | **100%** |
| Bracketed values = number of fatal accidents |

**5.2 Accident Sequence - CO2 Poisoning**One case resulted in CO2 poisoning, caused through using a CO filter working appliance in low oxygen atmospheres (case No. 66)**5.3 Accident Sequence – Oxygen Shortage**In 9 cases (6) (= 11%) there was oxygen shortage.  The following table lists the causes of the accidents which preceded the oxygen shortage;

|  |  |  |
| --- | --- | --- |
| **Cause** | **Number of Cases** | **Percentage** |
| Faulty appliance | 1 | 11.0% |
| Incorrect manipulation of appliance and accessories | 3 (2) | 33.5% |
| Carelessness | 1 | 11.0% |
| Exceeding an order | 3 (3) | 33.5% |
| Not heeding climatic conditions | 1 (1) | 11.0% |
| **Total** | **9 (6)** | **100%** |

**5.4 Accident sequence – Circulatory problems**In 6 cases (2 fatal) (=7%) circulatory problems were incurred;

|  |  |  |
| --- | --- | --- |
| **Cause** | **Number of Cases** | **Pencentage** |
| Over exertion | 4 (1) | 66% |
| Exceeding an order | 1 (1) | 17% |
| Not heeding climatic conditions | 1 | 17% |
| **Total** | **6 (2)** | **100%** |

**5.5 Accident sequence – heat storage**Heat storage from the following causes occurred in 10 cases (5 fatal) (= 12%)

|  |  |  |
| --- | --- | --- |
| **Cause** | **Number of Cases** | **Percentage** |
| Exceeding an order | 1 (1) | 10% |
| Not heeding climatic conditions | 9 (4) | 90% |
| **Total** | **10 (5)** | **100%** |

1. **Rescue team members involved in accidents**

The following team members were involved in accidents;

|  |  |
| --- | --- |
| Supervisors | 10 |
| Team leaders (Captain) | 18 |
| Team members | 55 |

Of the above, the following were fatal accidents

|  |  |
| --- | --- |
| Supervisors | 6 |
| Team leaders (captain) | 5 |
| Team members | 10 |

The following table lists the accidents according to the above causes.  This also indicates position within the rescue team;

|  |  |  |
| --- | --- | --- |
| **Accident causes** | **Team Position** | **Total** |
| **Super** | **Captain** | **Member** |
| faulty mouth piece breathing mask not fitting properly | 1 | 8 (1) | 28 (2) | 37 (3) |
| Faulty appliance and accessory | - | - | 8 (1) | 8 (1) |
| Incorrect Manipulation of appliance and accessory | 2 | 2 | 4 (3) | 8 (3) |
| Over exertion | 1 (1) | 2 | 3 (1) | 6 (2) |
| Carelessness | - | 1 | 4 | 5 |
| Exceeding an order | 2 (2) | 3 (3) | 4 (2) | 9 (7) |
| Not heeding climatic conditions | 4 (3) | 2 (1) | 4 (1) | 10 (5) |

In this breakdown of personnel according to their position in the Rescue Team or in the mine, it will be seen that the involvement of rescue team captains (team leaders) in accidents within "Exceeding an order" and "Not heeding climatic conditions" is disproportionally high.The outcome of such accidents was often fatal for all personnel involved.The responsible supervisor and team captain (leader) should therefore observe the enumerated basic working procedures laid down for mines rescue work for each particular instance, since not only is he putting his own life at risk, but also that of his team members.1. **Causes of accidents to team members**

The causes of accidents to rescue team members over the period 1935 – 1982 are described in greater detail in the following chapters.**7.1 Faulty mouthpiece breathing, facemask not properly sealed**Of the 83 accidents, the cause in 37 (3 fatal) cases, i.e. 45% of all accidents, was found to be faulty mouthpiece breathing and / or facemasks not fitted tightly over the face, the inevitable consequence was CO poisoning.This indicates the importance when operating in CO atmospheres, as well as on all work of this nature, the strict rule of "NO TALKING" must be observed when using mouthpieces, and facemasks must be fitted correctly before going into action.  After putting on the mask, it should be checked that it fits correctly and is air tight.  This should be done by sealing off the breathing connection with the ball of the hand or to fold the inhale hose tightly after the mask is fitted.  When attempting to breathe, the wearer will notice if the mask is tight fitting or not.  In addition, the proper fitting of the mask should be checked from time to time during wearing, because the mask could slip slightly with perspiration.  This could cause the straps to loosen.  Any slackness in the straps should be rectified.During instruction and exercises, the dangers of an "un-tight" breathing apparatus should be clearly indicated and working with and handling of the facemasks should be practiced.  This is particularly the case for such personnel who wear breathing masks only occasionally.  In this connection, it should be borne in mind that an adequate number of rescue team members are trained in handling and working with breathing masks, in order to comply with the operational guidelines laid down in the Mines Rescue Organisation programme.  These guidelines stipulate that in every team, in addition to the team captain (leader), a second man is to be equipped with a breathing mask and he will have a telephone mask to allow for constant speech communication.**7.2 Faulty equipment and accessories**Eight accidents (= 10%), one of with fatal consequences, were caused due to defective breathing appliance or accessory to the apparatus.These accidents all occurred during the period 1943 – 1959, since then there has been no accidents from this cause.**7.3 Incorrect handling of equipment and accessories**Eight accidents (= 10%), of which 3 were fatal, were attributed to incorrect handling of the appliance and accessories.  The reasons which led to these accidents were; a closed cylinder valve, empty oxygen cylinder, a missing gasket on the breathing connection and the use of a CO working appliance in a low oxygen atmosphere (accident 66).  No one particular point is common to these accident causes.**7.4 Over exertion**Six men (= 7%) were involved in accidents due to over exertion.  In two of these cases it resulted in fatalities.The accidents occurred, amongst other things, due to men engaged on strenuous work in humid atmospheres, not being in good physical condition.  It is important therefore, that when allocating team members to participate in duties, especially when very strenuous work is involved and in poor climatic conditions, only such men who are used to inclement working conditions and are known to be in good physical shape should be called upon for duties.  Before going into action, rescue team members should be made aware of the dangers and be acquainted with the indications of heat build up.**7.5 Carelessness**A total of five accidents (= 6%) occurred due to carelessness.Some of those involved had their masks, mouthpieces or nose-clips caught up in obstacles or fittings within the mine, with the result that the breathing appliances have been torn away from the face.One team member approached too close to the nitrogen outlet when rendering a roadway inert, so that the nitrogen issuing from the outlet was able to penetrate his mask from behind.With these accidents, which were due to insufficient attention being payed by the persons involved, no serious consequences were incurred, thanks to the prompt and correct reaction by other team members.**7.6 Exceeding an order**Nine team members (= 11%) were involved in accidents due to exceeding an order.  Of these, seven proved fatal: 2 supervisors, 3 team captains, and 2 team members.These accidents occurred mainly during operations in humid atmospheres with high CO content, combined with very poor visibility and difficult roadway conditions.  The nine members of the mines rescue teams, despite the poor conditions, exceeded their orders, or undertook work without orders.  The consequence of exceeding the orders was that their strength failed on the way out due to the poor visibility and sometimes worsening roadway conditions.  As a result, the persons involved could not return to the stand by position (Fresh air base) under their own strength and had to be rescued by the stand by team.Some team members had already succumbed by the time they were reached.  The causes of these accidents were lack of oxygen and CO poisoning, because some appliances had been completely consumed.When giving instructions on rescue operations under difficult conditions, in the organisation of planned exercises and in the allocation of duties in severe circumstances, it should be clearly emphasised that work instructions must not be exceeded, or in the event of inability to carry out a certain task, a team captain (leader), at his own discretion and responsibility, may and should prematurely withdraw his team from the operation.**7.7 Not heeding atmospheric conditions**There were ten accidents (5 fatal) (= 12%), 4 (3) supervisors, 2 (1) team leaders (captain), 4 (1) team members – reported where atmospheric conditions had not been heeded.The consequences in all cases were heat build up combined with collapse of the men.  The reasons for heat build up were to be found mainly in that the prescribed working times under warm, humid conditions had not been heeded.  In one case, the person’s collapse may also have been due in part to a not completely cured cold.Under this heading also, it is vitally important to stress to all concerned that they should conform strictly to the work times prescribed for humid conditions, as laid down in the Mines Rescue Organisation manual, in order to prevent further accidents of this nature.1. **Suggestions for preventing further accidents when wearing breathing apparatus (these proposals of 1962 still apply today).**

1.  Strict adherence to rules governing rescue operations* + No action without orders
	+ No exceeding orders
	+ No going into action without a complete team (by agreement with the rescue chief organiser, the supervisor may deviate from this maxim if it appears acceptable following clarification of local conditions).
	+ No team should go into action without a reserve team on stand – by (the supervisor may deviate from this to save life – he may send a team to rescue even if a reserve team is not on stand – by but is expected in the near future).

2.  The supervisor is responsible in detail for sending / taking a rescue team into action.After agreement with the rescue organiser, he should go into action wearing equipment and should delegate supervision of the stand – by team to another team leader for this period.3.  Men wearing mouthpieces should conform strictly to the "NO TALKING" rule.4.  A constant speech link should be carried in all operations under difficult conditions.5.  Well defined duties following examination of the prevailing conditions, especially when working in humid conditions.6.  The team should be equipped with at least two breathing masks (full face masks); when talking on a constant speech link, two telephone masks should be used.Mask wearers should carry out all exercises to accustom themselves to the breathing masks.Team members who have not been accustomed to wearing facemasks should not be sent into action in a serious incident with facemasks.7.  Every team should take in at least one oxygen self rescuer on every operation; when working in inert areas, at least two oxygen self rescuers should be used.  In addition, when working in inert atmospheres, oxygen self rescuers should be located in the mine at certain intervals in readily visible locations, for emergencies.1. **Conclusions**

This review covers 83 accidents involving rescue team men wearing breathing appliances occurring in the period 1935 – 1982.  Initially these accidents have been examined numerically according to their cause and consequences.It was found that in 37 of the 83 accidents, ie. 45% of all cases, the causes were attributable to defective mouthpiece breathing and / or faulty fitting facemasks.  In all cases, CO poisoning ensued with three fatalities.An important feature which emerged related to "Exceeding of orders" and " Not heeding atmospheric conditions".  In these accidents, the percentage of fatalities at 78% in the case of "Exceeding of orders", and 50% for "Not heeding atmospheric conditions" is very high.  It will be seen from the assessment of "Rescue team members involved in accidents" that a disproportionately high number of team leaders / supervisors were involved in this particular type of accident.It is known that the "Proposals for preventing further accidents when wearing breathing appliances" as indicated under section 8, have largely incorporated in the revised version of the Rules for Mines Rescue Team Procedures (5) as standard procedures.  The importance of strictly adhering to these fundamental rules during serious call – outs and when training, cannot be stressed too emphatically in order to prevent accidents to rescue team personnel and to ensure safest possible working for all personnel involved.**Selected accidents (No’s 80 – 83)****Accident No. 80**Name; J.; Deputy supervisorDate; 25-3-1979Appliance; BG174 with facemaskCause; Mask not fitted tightly enoughOutcome; CO poisoning, not fatalDeputy supervisor J, with four teams, during the afternoon shift on 25-3-79, assumed responsibility for the advanced stand-by station relating to a roadway fall in section 7. aAfter the roadway fall had been rendered safe, J, as the 6th man of a team reconnoitred the roadway beyond the fall.  In the branch road to the rock heading, this team found the four missing miners dead.  Since the team was still in good physical condition, J assisted in carrying one of the dead miners.  This operation lasted about 35 minutes.  After the second dead miner was brought out by another rescue team, J went into action again with the next team in order to bring out the third man.  Shortly before this team reached the fall at the roadway branch, J attempted to plug in the telephone line junction some 25 metres back.  During this attempt, J lost consciousness.The team, which had first noticed J’s absence due to their involvement in excavation work, broke off this work obviously to help J.  Whilst the dislodged facemask was being properly placed to J, the reserve team was called up.With the help from the reserve team, J was revived with the aid of the Pulmotor (oxygen resuscitator).  These efforts proved successful within a short time.  The mine’s doctor, who arrived on the scene very quickly, took over further medical attention.  After bringing J. to the surface, he was taken to hospital.  Blood analysis showed a CO – Hb – content of 27%.The accident was attributed to the fact that J suddenly noticed his illness and attempted to plug in the rescue telephone line and, in doing so, he stumbled and his facemask became dislodged.  His illness was due either to delayed reaction to the stressing mental experience of finding the dead miners, or due to physical over – exertion.**Accident No 81**Name; J. Team leader (captain)Date; 16-8-79Appliance; BG174Cause; Not heeding atmospheric conditionsOutcome; heat build up, not fatalOn 16-8-1979, at about 7am., three rescue teams moved into shaft 2 to reconnoitre the former conveyor roadway from seam B III, which descended from the heading road seam B II via a cross road.  Following the cessation of coal cutting, it had only been cleared of equipment.  The rescue team were instructed to examine whether assumed standing water was still present.The rescue team was equipped with the Drager BG174.  After measuring the temperature (45.5°C (114°F) – 41°C (105°F)) and the gas concentration (CO; 500ppm, CO2 >6%, CH4 >5%), the first team had travelled about 23 m along the disused road.  After a working time of 20 minutes, the first team was relieved by the second.  This team, under the leadership of J. had instructions to explore the roadway further; at this point, it had only about 70 – 80cm headroom.  The second team had explored about 46m.  when team leader J emerged from the cross road into the heading road after 20 minutes, he became unconscious.  After the telephone mask had been removed from him, he was laid down, and to ease his breathing and to cool him was given oxygen from a resuscitator.  He recovered after a short while, then was brought to the surface and examined by a doctor.J. was an experienced mines deputy who, because of his regular employment underground under severe conditions, was accustomed to heavy work.  According to his own statement, J. presumed that he had become unwell due to a slight cold which had not completely cleared at the time of this action.**Accident No 82**Name; CH. Deputy supervisorDate; 13-9-80Appliance; Drager BG174 with facemaskCause of accident; Working under inclement atmospheric conditionsOutcome; Heat build up and shock; FATALFour teams were to explore whether there was stagnant water in a roadway which was not ventilated (coal mine).  The roadway in question was about 450m long with an average incline of 6gon.  Atmospheric measurements showed a dry temperature of 36°C (96°F) and a wet bulb temperature of 32°C (89°F) giving a calculated work time of 60 minutes.After the first team went in, the speech connection was broken after about 34 minutes.  The second team went in, and after repairing the fault in the telephone system, relieved the first team.  This means that the team 1 returned to the stand by station (fresh air base).  Team 2 advanced further.  After 45 minutes (450m) team 2 reached standing water and advised the supervisor accordingly.  One minute later, the supervisor instructed the team to return to the fresh air base.Shortly thereafter, the team captain of the 2nd team reported that one of his team was vomiting.  Because heat build up was assumed, the supervisor ordered teams 3 & 4 to give assistance.  Teams 2, 3 and 4 met up about half way.  The man presumed to be suffering from heat build up, was helped by his mates; the remainder were in good shape.  The three teams started to withdraw.After a further 6 minutes, the deputy supervisor CH. (who was in team 2) collapsed without prior recognisable symptoms, 20m short of reaching the fresh air base.  He was assisted by 2 mates to the fresh air roadway and the Pulmotor (oxygen resuscitator) was used to try to revive him.  When it was found that he was breathing, the treatment was changed to inhalation.  Ch. recovered and could be questioned.  A nurse at the stand by station measured his pulse and blood pressure: Pulse 120/min, B/P: 120/80.  When the blood pressure fell within a short time to 100/80, the mine doctor was called.  Ch. lost consciousness.  After medical attention, he was brought to the surface and taken to hospital – he died there 3 days later.  Cause of death according to autopsy was heat build up combined with shock.**Accident No. 83**Name; R. team leader (captain)Date; 25 – 5 – 1981Apparatus; BG174 with facemaskCause of accident; over exertionOutcome; Hyperventilation, not fatalDuring an underground exercise, a rock heading, still under construction and sloping from 680m to 1050m was to be explored.  At the time of the incident the roadway length was 1700m with an incline of 16 gon.  The highest temperature was found at a distance of 700m to be 29c (82f) and 24c (73f).  Below this point the atmosphere was more amenable due to the effect of an air cooler.The rescue team exercise was carried out by four teams, two supervisors and another ancillary man (team member).  The actual exercise started about 9am.  The third team with leader R. donned their facemasks at 09.05 and commenced their planned task at 09.10.  At 10.37, the team had reached the turn around point at position 1530m according to the plan, without particular incident.  After a period of 3 hours and 27 minutes, team 3 completed the climb to the point at 310m.  From this station, R. reported to the stand by station (fresh air base) on the rescue telephone that he would probably not be capable of completing the exercise.  Thereupon, the stand by station ordered the team to take a longer break.  However, he did not heed this instruction.  After a further 80m climb, R. was obviously at the end of his strength and handed over leadership to his deputy team leader (vice captain).  He then sat down to recover himself.  The other team members removed his facemask, at this instant he collapsed unconscious.  Initially R. was resuscitated at station 230m with a "Pulmotor" (oxygen resuscitator) brought from the stand by station.  Later through the assistance of a medical man and the mine’s doctor, R. was brought to the surface.The mine’s doctor diagnosed a cramp / spasm type condition, which had obviously been brought on by the hyperventilation condition due to severe loss of fluid.  In addition, a shock state was impending.  R. was sent to hospital; after he had been asleep for some hours he then consumed 6 bottles of mineral water and there was spontaneous improvement in his health, being released from hospital after several days observation.  The hyperventilation condition, due to severe fluid loss, is attributable to the fact that R. had restricted his fluid intake for some days prior to the exercise, in order not to suffer excessive perspiration losses during the coming exercise.This is taken from a direct translation that was done for our British mines rescue service in the 1980’s, and unfortunately only describes a few of the incidents in detail.  However, it can certainly be seen that it still has a bearing on rescue training and incidents even today, and as such I hope it is useful to all.Here in Europe, most rescue teams also utilize a safety time factor, dictated by reading both wet & dry thermometers, and referring to a table giving the safe working time, they do differ from country to country, and even type of apparatus used.  I have a few for different types of equipment if anyone would like to refer to them.Brian RobinsonMines rescue consultantmailto:Rescue1UK@aol.com |