

The Development and Status of Respiratory Protection in the Federal Republic of Germany

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I. Development of Respiratory Protective Equipment in the Federal Republic of Germany

Equipment for Hard Work and Rescue

Closed-Circuit Breathing Apparatus. Closed-circuit breathing apparatus operate independent of the ambient atmosphere. The exhaled air is re-inhaled by the user once carbon dioxide has been absorbed and consumed oxygen has been replaced. The oxygen can be carried along in gaseous, liquid, or chemically bound form.

The first closed-circuit breathing apparatus with compressed oxygen was developed in 1853 by Dr. Schwann (Lüttich), as shown in Figure 1. Essentially, the configuration of the unit has remained unchanged until now. It consisted of a facepiece, the regeneration cartridge, the breathing bag, and the oxygen-supply cylinder. Oxygen supply was effected upon the user's discretion by opening and closing a manually actuated valve.

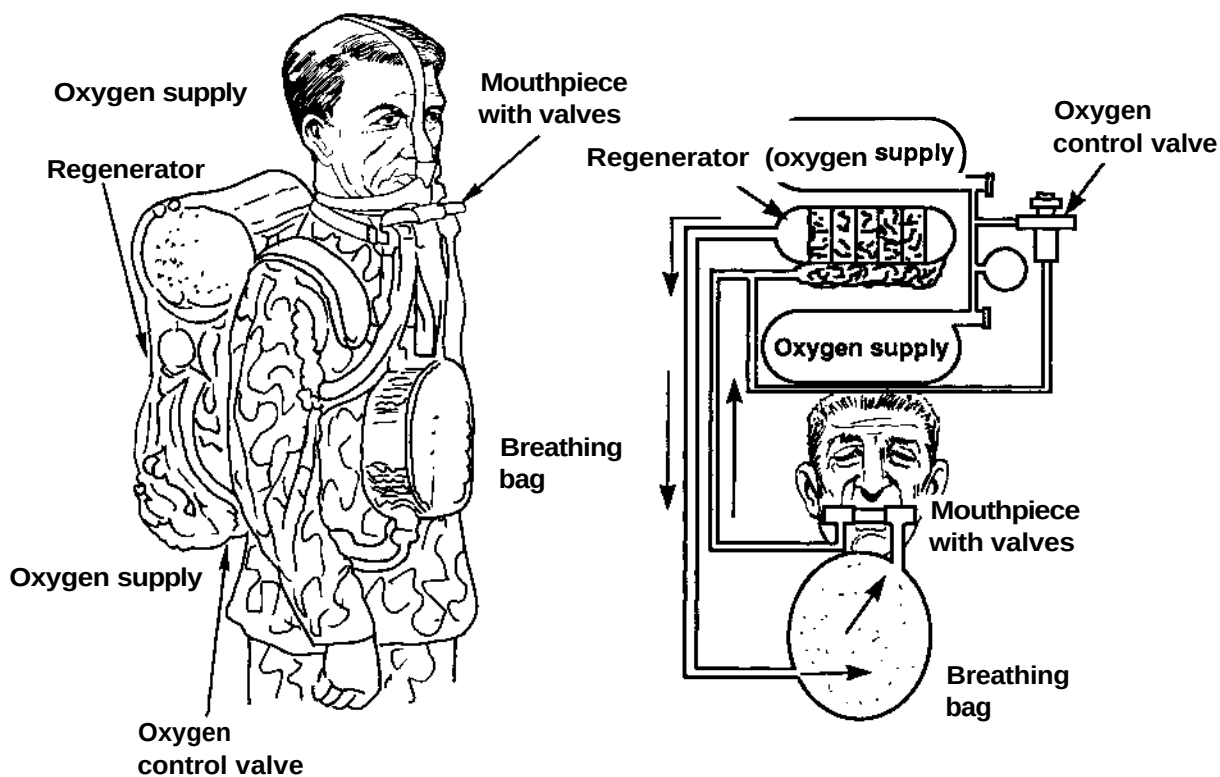


Figure 1. Aerophor according to Professor Schwann, 1853.

The problems encountered in those days were to find a way of increasing the charging pressure in cylinders and an appropriate flow control of oxygen. Such difficulties, however, have been reduced with the years. In 1901 Dragerwerk constructed the very first closed-circuit breathing apparatus in Germany that featured a constant-flow-pressure limiting valve. Oxygen supply was effected via an injector, which simultaneously reduced the respiratory resistances (Figure 2).

The units were further developed in the times that followed until it was revealed that, due to leaks in the units, harmful gases from the atmosphere had entered the breathing circuit via the injector. This was the actual beginning of the lung-assisted equipment where the flow was solely controlled by the individual's lung demand. There were problems with these units also, since oxygen deficiency occurred in the circuit, primarily as a result of leaking masks. This in turn prompted the construction of units featuring a constant and lung-governed flow control.

In the early 1930s, the Auer company developed the MR II/32, and Dragerwerk AG developed the BG 160-A (Figures 3 and 4). Both units featured a lung-governed demand valve and a constant oxygen flow control of 1.5 L/min. The

oxygen supply for both units was 300 L (2 L/150 bar), thus affording a use period of 2-3 hours. The weight amounted to 17.5 kg. The BG 160-A featured an alarm signal that would sound when the cylinder was closed.

The accident in the Grimberg Mine in 1946 initiated the demand for units with extended use periods. This was reason enough for Dräger to construct the BG 170/400, which at a weight of 17.5 kg provided a use period of four hours in the case of hard work or 12 hours if the user remained at rest. This could be achieved by increasing the cylinder pressure to 200 bar and by dispensing with the constant flow control. The Auer company constructed a similar unit in 1954. In addition to a lung-governed flow control, this also featured a 0.7 L/min constant flow control. The usage period thus amounted to 4-8 hours. In order to prevent nitrogen enrichment of the breathing air, these units were equipped with a pre-flush and a flushing device to compensate for the nonexistent or reduced constant-flow control.

Although these units were well accepted for practical use, their complicated construction, plus involved test and maintenance procedures, prompted the demand for a simplified version.

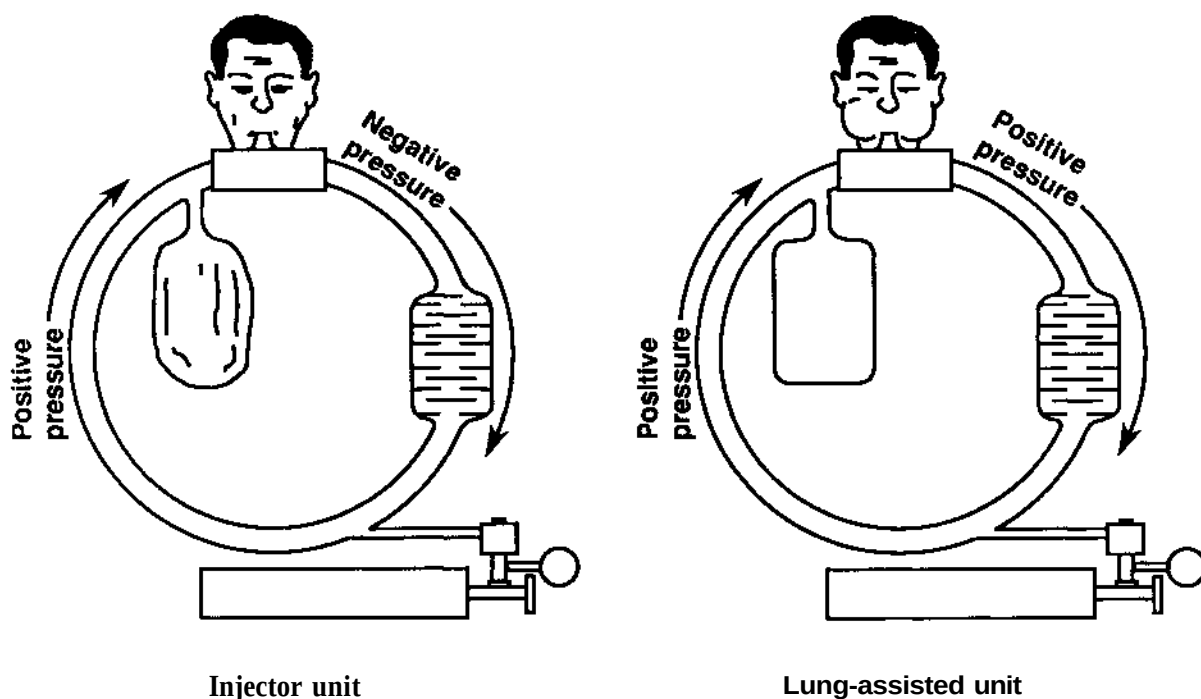


Figure 2. Injector unit and lung-assisted unit.

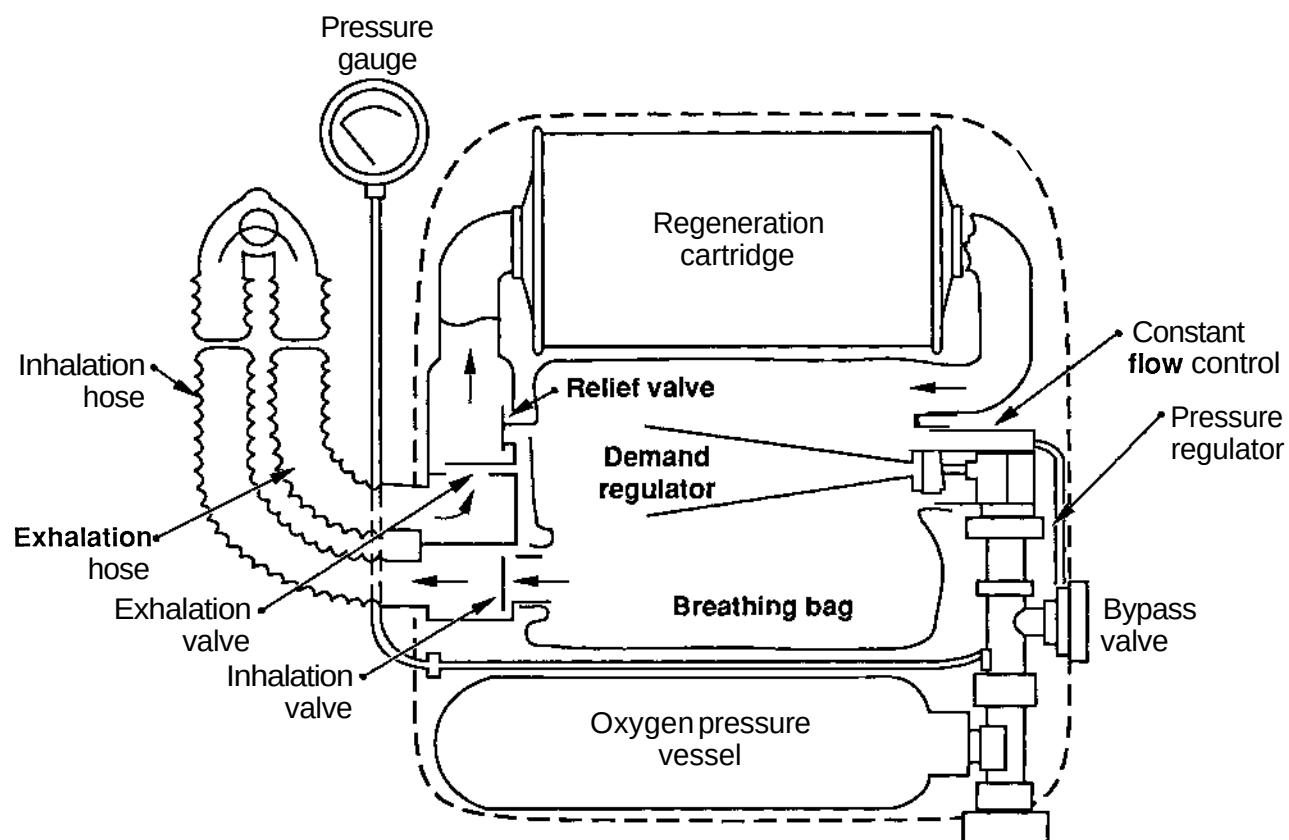


Figure 3. Oxygen-breathing apparatus MR 11/32.

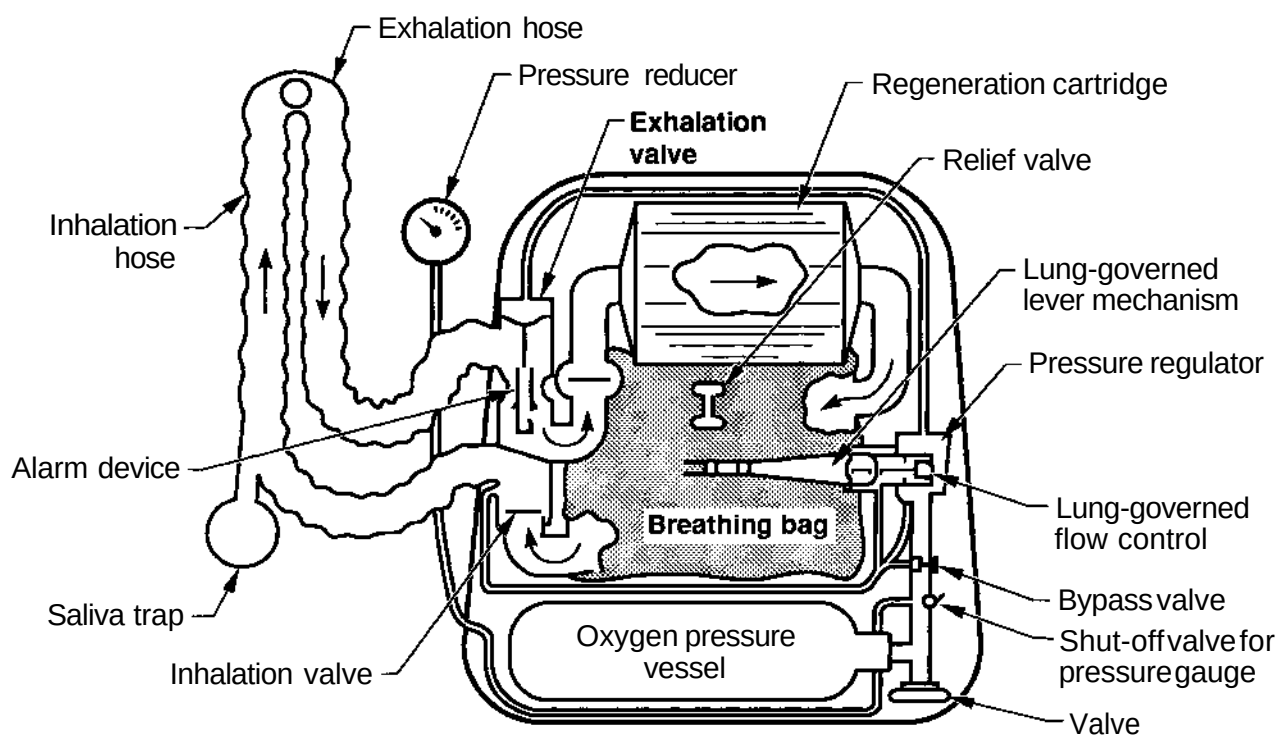


Figure 4. Oxygen-breathing apparatus BG 160 A, developed by Drägerwerk AG.

This requirement was satisfied by the Auer and Dräger companies in their Models MR 56/400 and BG 172, respectively. These units featured both lung-governed and constant-flow control of 1.5 L/min, which made them standard equipment for more than ten years for mine rescue teams, fire brigades, and industry. However, the request for reducing both the weight of the unit and the inhalation temperature still existed, which finally led to the construction of the BG 174 in the mid-1960s. The unit weighed only 12.5 kg, and its inhalation temperature was 5°C lower than that of its predecessors. The advance in development can best be demonstrated by the following comparison: Related to the oxygen consumption of 1.5 L/min, the weight of the unit per minute of use period was 88 g for BG 160 A, 63 g for BG 172, and 47 g for BG 174. The BG 174 is the standard unit for mine rescue teams not only in the Federal Republic of Germany, but all over the world.

Units using chemical and liquid oxygen are also called closed-circuit breathing apparatus. Where chemical oxygen units are concerned, the oxygen is chemically bound in the form of a solid substance. It is released by thermal activation (independent of demand) or by reaction with exhaled air. Chlorate (NaClO_3) or KO_2 are the typical representatives. The development of such units commenced toward the end of the last century. In the unit constructed in 1902, a clockwork controlled the administration of sodium peroxide. This dropped into a water container whereby oxygen was generated and the CO_2 was bound by the lye. Other units were later developed but without success, and this must be attributed to the following reasons:

- Expensive chemicals;
- Chemicals unsuitable for storage;
- High inhalation temperature;
- Breathing effort required for pre-breathing;
- Problems in low temperatures.

In spite of some progress, the Federal Republic of Germany has not yet seen the development of a chemical oxygen unit featuring lengthy use periods for rescue purposes. However, when it comes to escape units, there is a distinct trend in favor of chemical units.

Where liquid oxygen units (Figure 5) are concerned, the liquid oxygen is carried along in

appropriate containers. As a rule, the interior of such a container is equipped with asbestos wool, while its exterior is insulated in order to achieve slow vaporization. Following elimination of CO_2 , the warm breathing air is routed around the container where it effects controlled oxygen evaporation and is cooled at the same time. Drägerwerk AG constructed its first liquid oxygen apparatus as early as 1923. However, this unit, as well as the LOX 120 constructed after the Second World War, has not been successful. This must primarily be attributed to the fact that these units could not be stored ready for use. The evaporation process commences once the devices have been charged with oxygen, which means they would have to be charged immediately prior to use. Because of this disadvantage, this type of device did not gain a share in the market.

Self-Contained Open-Circuit Breathing Apparatus. The development of self-contained open-circuit breathing apparatus—the compressed-air breathing apparatus—reaches back into the middle of last century. The initial version was a breathing bag filled with air, which served as the breathing-air supply for the wearer.

Interest in this apparatus increased considerably once it was possible to charge the storage containers under high pressure. The construction of this apparatus is simple. The breathing air is administered to the facepiece from the storage cylinder via a pressure reducer and a lung-governed air valve (demand regulator), and is released to the open through an exhalation valve. The first technically suitable apparatus in Germany was the AUDOS OR (Figure 6), produced in 1925. The unit stored 540 L of oxygen at a pressure of 150 bar, which resulted in a use period of 15 minutes.

Not until the 1950s, as a result of an increased container pressure (200 bar) and reduced container weight, could compressed-air breathing apparatus be introduced for use in industry and surface work. The actual breakthrough however was achieved in the 1970s when the 300 bar/6 L cylinder afforded lengthy use periods while the demand regulator was directly attached to the mask. Thanks to the introduction of the positive-pressure system, compressed-air breathing apparatus have gained even more importance; they are now standard equipment for fire brigades and industry.

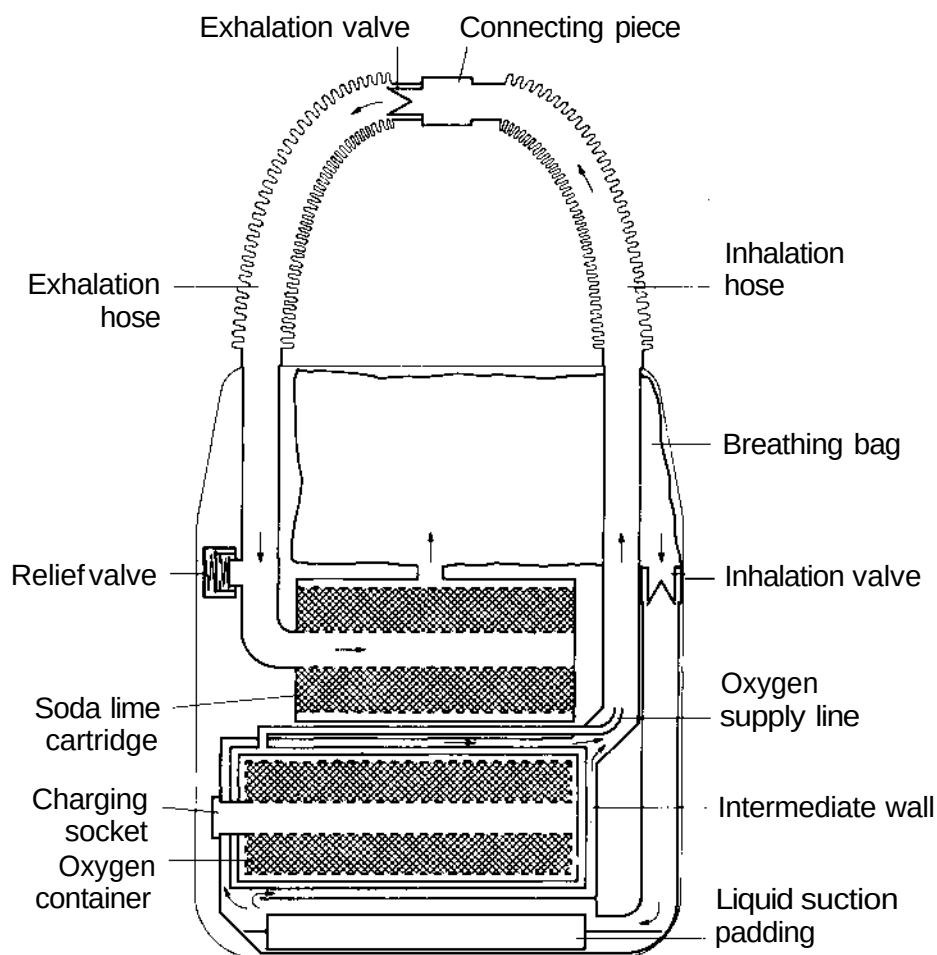


Figure 5. Liquid-oxygen apparatus LOX 120 from Dragerwerk AG.

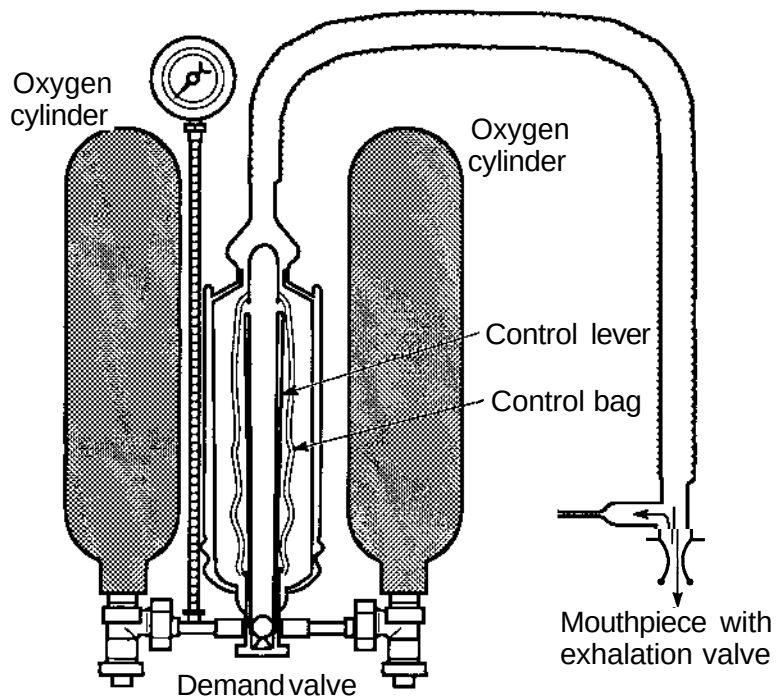


Figure 6. Self-contained open-circuit breathing apparatus Audos AR, Model 25.

Fresh-Air Hose Breathing Apparatus. Fresh-air hose breathing apparatus have been part of the equipment for mine rescue and gas-protection teams and industry for a long time. Because of safety reasons, assisted fresh-air hose breathing apparatus with breathing bag and compressed-air line breathing apparatus with demand valve have gained wide acceptance (Figures 7 and 8).

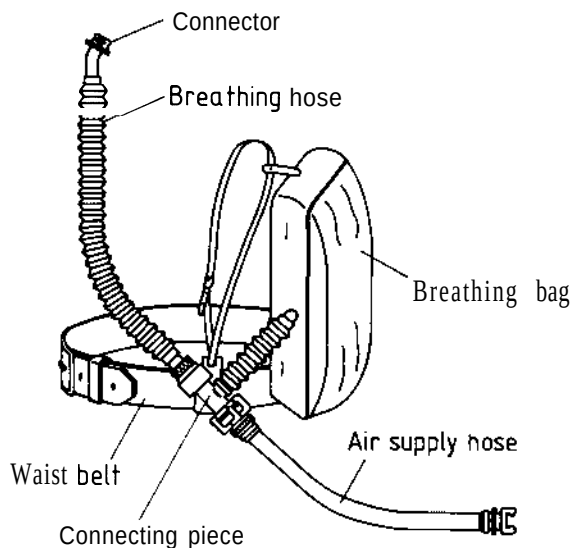


Figure 7. Assisted fresh air hose breathing apparatus.

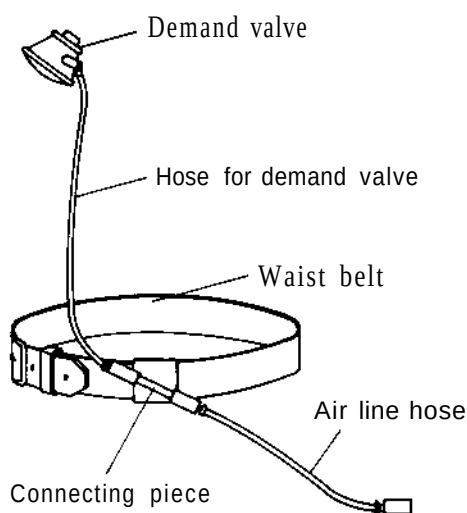


Figure 8. Compressed-air line breathing apparatus.

With assisted fresh-air hose breathing apparatus, the breathing air is routed to the wearer in excess at a slight pressure. Low breathing resistances are an advantage, while heavy air-supply hoses are a disadvantage. For this reason the handy compressed-air line breathing apparatus have been widely accepted, and they are in fact a good choice for lengthy stationary work in mining and industry.

Filtering Devices. Whereas the protective equipment described until now operates independently of the ambient atmosphere, the use of filtering devices is only permissible when an adequate oxygen concentration is available. Filtering devices have been developed in answer to the use of toxic gases used during the First World War. The great variety of filters developed in the following years was used only in industry and not in mining.

In the 1920s, the American Hopkins invented a catalyzer that facilitated the transformation from CO into CO₂ in the 1920s. This was the beginning of filter self-rescuers and hard-work CO devices. The differing filters (gas and particle filters) have since been successfully introduced in the individual fields of industry. They are now used for purposes of industrial safety and escape. Use of such equipment, however, requires an adequate oxygen concentration and knowledge of the substance to be filtered.

Special Equipment. Although respiratory protection technology has achieved a high standard of development, there is yet a demand for equipment that is suitable for special applications. In many a field of industry, people still must work under most unfavorable climatic conditions.

To this end, Drägerwerk AG developed a combined cooling and respiratory protective device (Figure 9) for use by mine rescue teams, fire brigades, and in industry. This unit facilitates work to be carried out at 70°C and comparatively high relative humidity for the period of one hour. By replacing the outer suit with a chemical protective suit, missions can even be carried out in a chemically contaminated atmosphere.

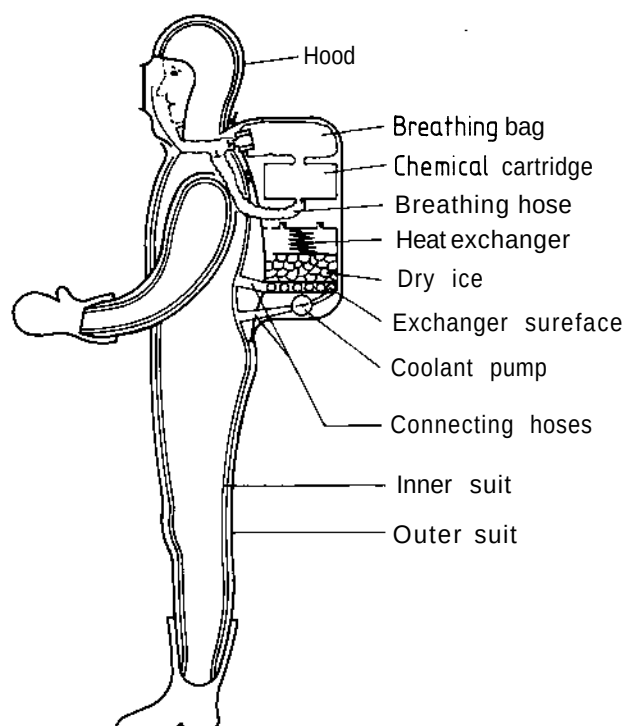


Figure 9. Cooling and respiratory-protective device from Drägerwerk AG.

Respiratory Protective Equipment for Self-Rescue

Filtering Devices. As has already been mentioned, specific filters are currently used in all fields of industry. In mining it is the filter self-rescuer whose development must be attributed to the catalyzer invention by Hopkins. The entire German hard-coal mining industry is now equipped with this unit.

A great variety of filters are used in industry and by fire brigades for protection against harmful substances. Suppliers of these units are renowned German companies.

Oxygen Self-Rescuer. Oxygen self-rescuers were already being constructed at the turn of the century. As a rule, these were small versions of hard-work devices of the time. The development was continued, though, because their safety standard and size did not satisfy the existing safety requirements.

In Germany, the request for oxygen self-rescuers was established after an accident in the Belgian mine Bois-de-Cazier in 1956. At this point, Dräger developed the OXY-SR 45 and Auer developed the SSR 16 B (Figure 10), based on pressurized O_2 or KO_2 , respectively. Their weight was approximately 2.5 kg and the escape period was about 30–40 minutes. They were primarily used in potassium carbonate and salt mines, but in a modified version they have also been introduced in industry. The units for long-term use that were later developed (e.g., AUER SSR 120) did not meet with significant approval because of their great weight and volume (Figure 11).

On account of increasing dangers particularly in the mining field, more and more people ask for oxygen self-rescuers that can be carried along. We hope that this desirable development will not be halted before it has really begun because of excessive demands. Presently available oxygen self-rescuers that afford lengthy use periods are too large and too heavy to be constantly carried along.

Compressed-Air Escape Apparatus

The use of compressed-air breathing apparatus for escape purposes does not, at present, occur very frequently in the field of industry. Although their construction is comparatively simple, the relatively short usage period and the weight of the cylinders prevents the spreading of this type of equipment.

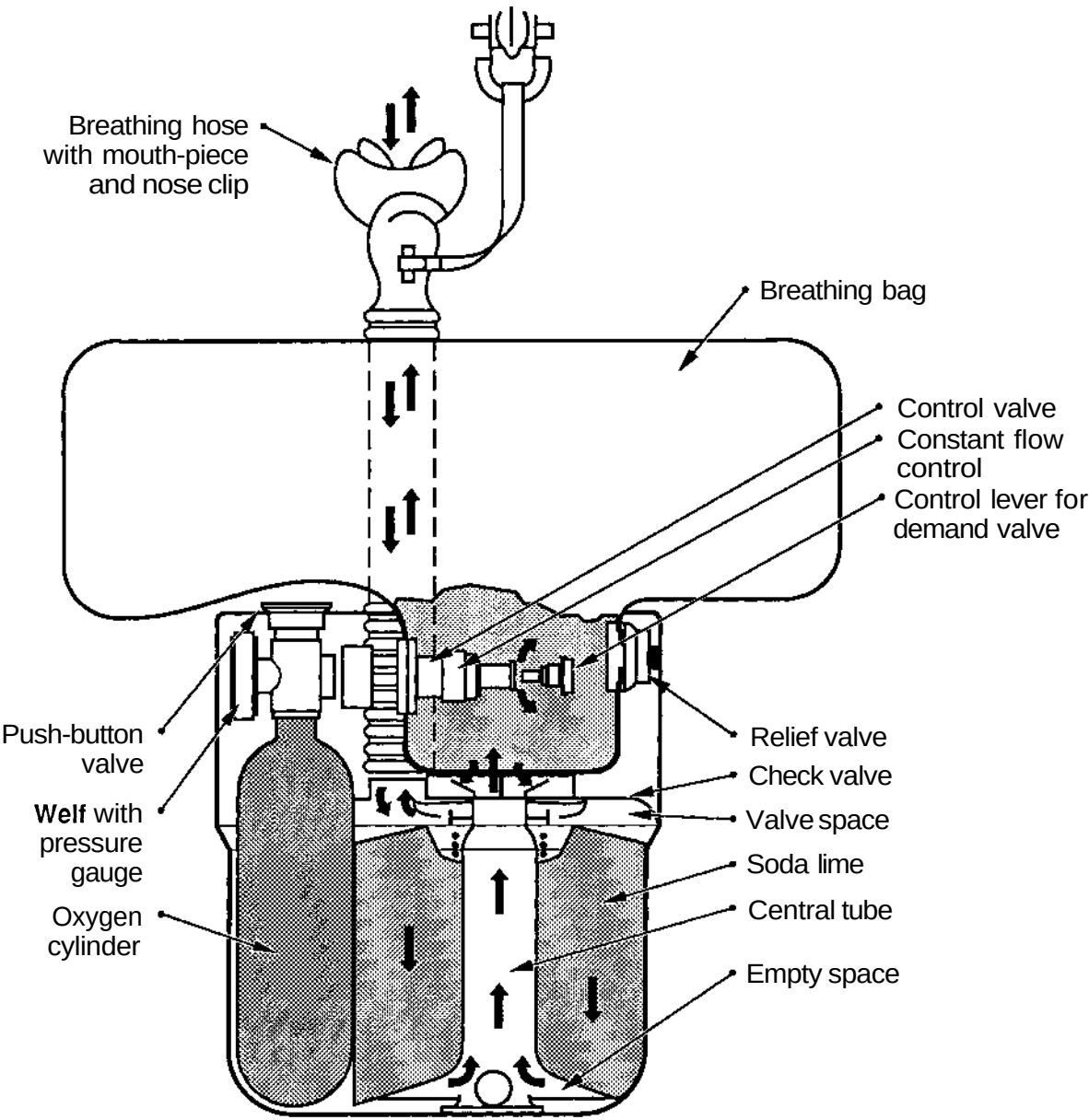


Figure 10. Oxygen self-rescuer OXY-SR 45 from Dragerwerk **AG**.

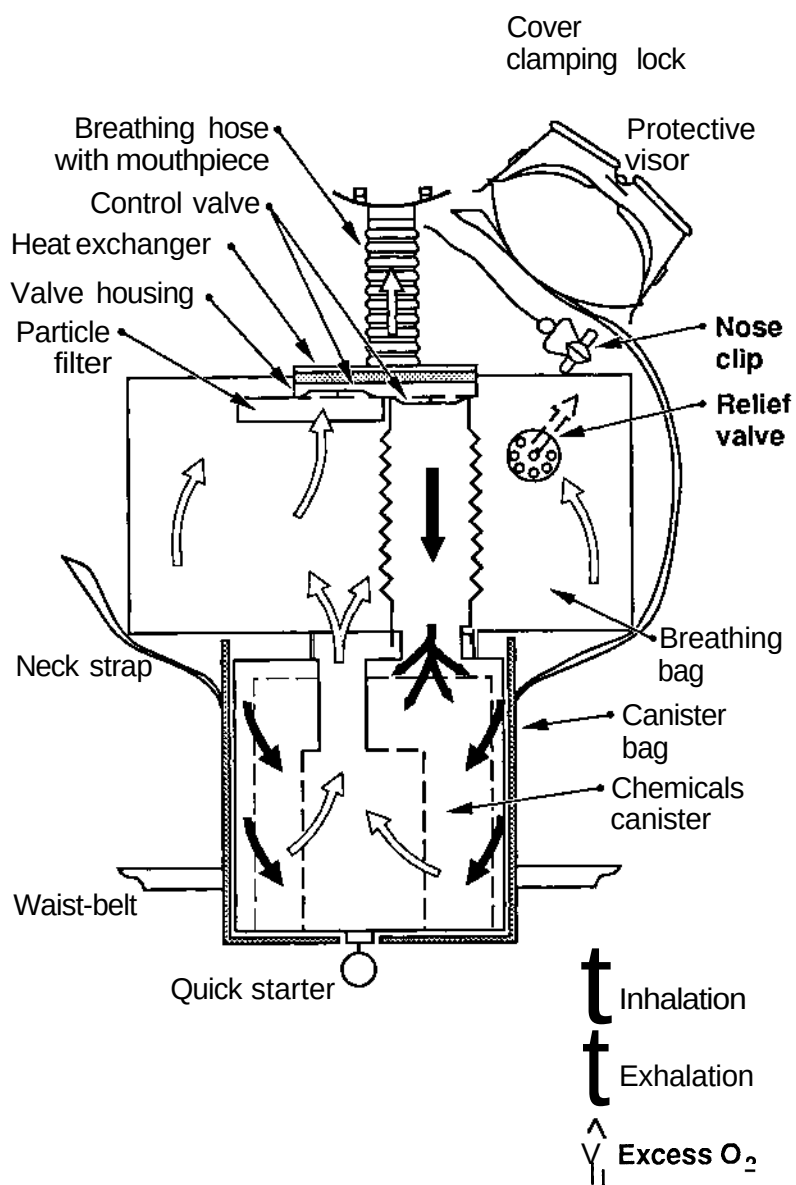


Figure 11. SSR 120, developed by the Auer Company.

//. Respiratory Protection Equipment in the Federal Republic of Germany

Respiratory protective equipment must be worn in areas subject to harmful substances or oxygen deficiency. Such circumstances occur not only in mining, but also in industry and in fire fighting.

In the Federal Republic of Germany, respiratory protective equipment is divided into two major groups, according to the German Standard DIN 3179 (Figure 12):

- Respiratory protective equipment for hard work and rescue;
- Respiratory protective equipment for self-rescue.

Respiratory protective devices for hard work and rescue are primarily used by rescue teams (i.e., by trained personnel), whereas equipment for self-rescue is, after they undergo appropriate training, used by all persons in dangerous situations.

Procedure for Approval of Respiratory Protective Equipment

Where testing and approval of respiratory protective equipment in the Federal Republic of Germany are concerned, differing proceedings are laid down for fire brigades, mining, and industry, with respect to application, testing, and approval.

Procedure for Approval in Mining. The manufacturer applies to the German committee of Mine Rescue Services (DAGR) to test the respiratory protective device with respect to its suitability for use in mines. The DAGR in turn appoints the two test authorities (Essen and Hohenpeißenberg) to carry out the test procedure independent of each other. Based on the result of the two test reports, the managing director of DAGR prepares a joint test report which is presented to the assembly of members of the DAGR (Figure 13)

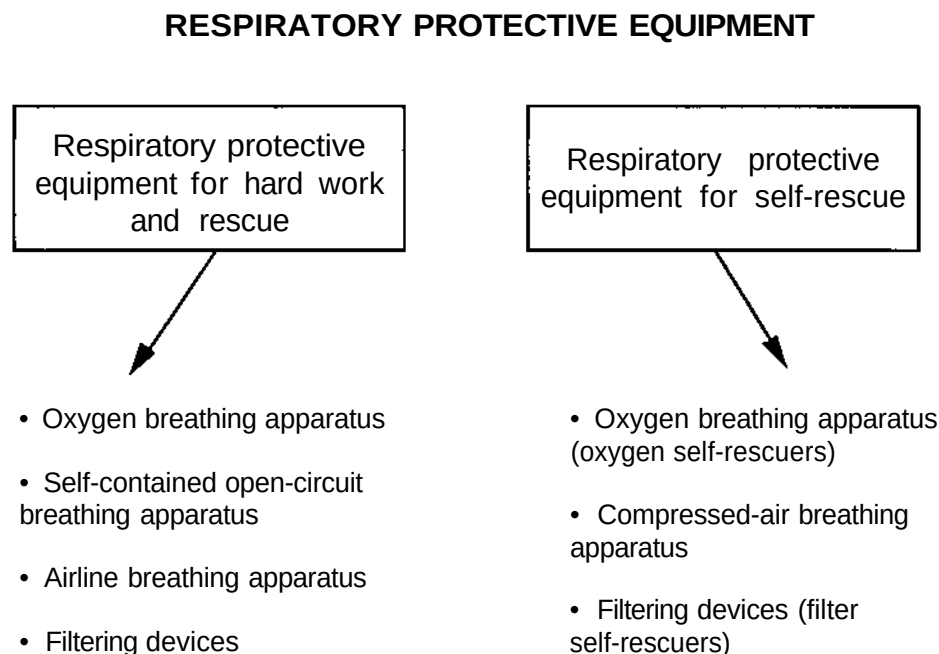


Figure 12. Breakdown of respiratory protective equipment.

- Lands of the Federal Republic of Germany
- Representatives of GRW headquarters
- German Miners' Accident Insurance Fund
- Trade Association Mining
- Industrial Trade Unions, Mining and Energy
- German Employees' Association, Mining Section
- Guests:
 - Federal Ministry of Labour
 - Trade Association Natural Oil and Gas Production
 - Kali und Salz AG

Figure 13. Members of the DAGRW.

for decision. Should approval be granted, the managing director is entitled to issue a document of suitability. Having this document of suitability in hand, the manufacturer is free to apply to the Mine Safety Administration.

Procedure for Approval by Fire Brigades.

The headquarters of the Mine Rescue Services in Essen (HGRWE) is the responsible test body for respiratory protective equipment used by fire brigades, and this is where the manufacturer applies for testing. The test is carried out by the main rescue station in Essen, in cooperation with the Essen fire brigade and in accordance with the guidelines laid down by the Minister of the Interior of North Rhine-Westphalia. In the case of an acceptable test result, the manufacturer receives a test certificate, which is the basis for approval by the Minister of the Interior of North Rhine-Westphalia. Because of an administrative agreement, the approval is valid throughout the Federal Republic of Germany.

Procedure Within the Scope of Industries.

The manufacturer applies for a respiratory protective device to be tested by a test board of his own choice; this board must be authorized by the Federal Ministry of Labour. The unit is tested in accordance with existing DIN standards. In the event of an acceptable result, the board issues a test certificate granting the GS symbol, which

represents certified safety. An approval is not required (Figure 14).

Future Procedures. The common market will take effect in 1992/93 for a certain part of Europe. This implies that new procedures with respect to certification must be provided for. It is expected that the Technical Committee TC 79, which is responsible for the preparation of European Standards (ENs), will also have a decisive say in the procedures concerning the approval of respiratory protective equipment. Basically, there are the following possibilities:

- Self-certification by the manufacturer;
- Testing for type approval by a test authority and final checks of goods by the manufacturer, according to approved guidelines;
- Testing for type approval and final checks of goods by a test authority.

It is assumed that the latter proposal will be given preference, since it is to a good extent in line with present-day practice (Figures 15 and 16).

Preparation of Test Regulations

The establishment of test regulations (i.e., standards) is the task of the German Standardization Institute (DIN). In establishing such standards, DIN cooperates with DIN committees, the

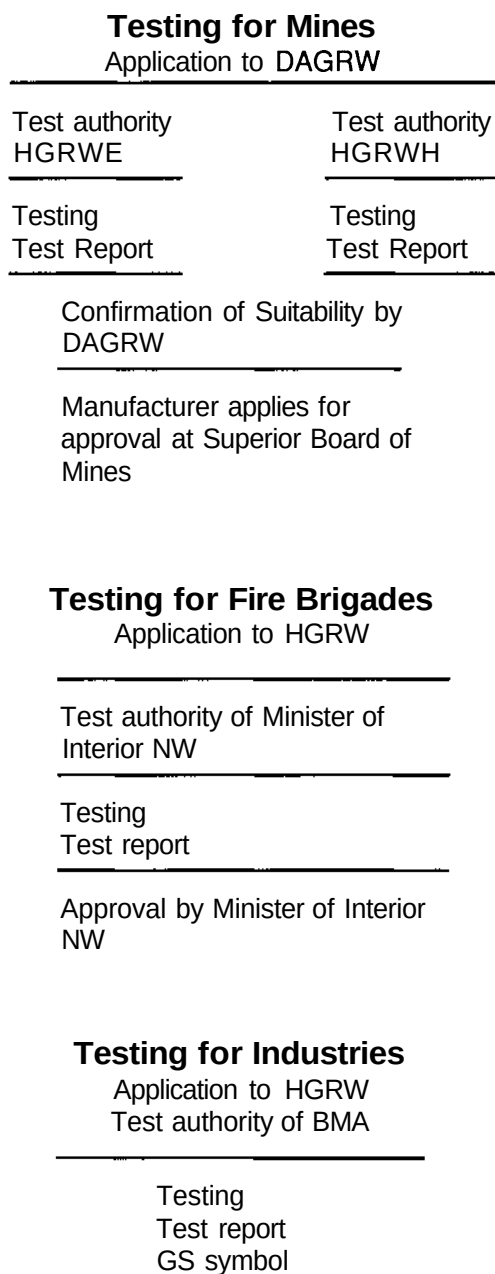


Figure 14. Procedure to approve respiratory protective equipment presently applicable in the Federal Republic of Germany.

EC certificate of conformity

Manufacturer's certificate
of suitability

EC test for type approval

Application to EC test
authority

Test for type approval
certificate, EC symbol

EC test

Application to EC test
authority

Test for type approval
certificate, EC approval

Supervision of
manufacture by test
authority

Figure 15. Future procedures within the European community.

TEST AUTH.	UNITS					
	Masks Half-masks	Oxygen breath. app.	Compressed- air breath. app.	Fresh-air hose breath. app.	Filter devices	Diving app.
Main rescue station, Essen f. industry	X	X	X	X		
Mining	X	X	X	X	X	
Fire brigades	X	X	X	X		X
Main rescue station, Hohenpeißenberg f. industry	X	X	X	X		X
Mining	X	X	X	X	X	
Federal Labour Institute BIA St. Augustin	X				X	

Figure 16. Testing respiratory protective equipment in the Federal Republic of Germany.

members of which are recruited from ministries, test authorities, manufacturers, and users. These committees prepare the DIN drafts that are submitted to the public for comments, whereupon consideration is given to practical modifications. Thereafter, the modified proposal will be declared a DIN standard.

If the requirements of certain ranges—e.g., mining or fire brigades—go beyond the normal industrial concern, these will be considered in self-assessed test conditions or additional DIN standards, respectively. Where the field of fire brigades is concerned, it is the responsibility of Section 8 of the VFDB, and in mining of the DAGRW, to establish relevant test regulations. It is a general trend, however, that all parties concerned with standardization strive for an intense exchange of experience with the objective of creating uniform standards for all fields.

Such endeavors are essential with a view to the forthcoming European Domestic Market. This calls for standards that combine and unify the differing demands beyond national borders. This task has already been assumed by the TC 79, and the result is reflected in a number of applicable European Standards. It should be imperative for any EC country to adopt such European Standards as a national standard. The Federal Republic of Germany, for instance, has already adopted European Standards on compressed-air and closed-circuit breathing apparatus as national DIN standards.

As has already been mentioned, the procedures with respect to testing and approvals within Europe have not yet been clearly defined.

Summary

As has been explained, the procedures for approval of respiratory protective equipment are rather complicated in Germany, but they are unambiguously ruled. Standardization has achieved a high quality level. However, with a view toward the Common European Market, standardization matters must be newly defined to provide uniform conditions for all manufacturers.

With respect to technical engineering, the German products have achieved a high standard. Yet further developments must continue to be made to improve both the physical and carrying comfort.