

Respiratory Protective Devices (RPD) in ISO TC94 SC15 – a new approach

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Introduction

Existing standards for respiratory protective devices (RPD) worldwide are product or design orientated. The Sub Committee 15 (SC 15) within ISO TC 94 has been founded in 2002 to start performance orientated standardisation based on the demands of wearers in their working environments. Human factors are the drivers for deriving the performance characteristics of future RPD.

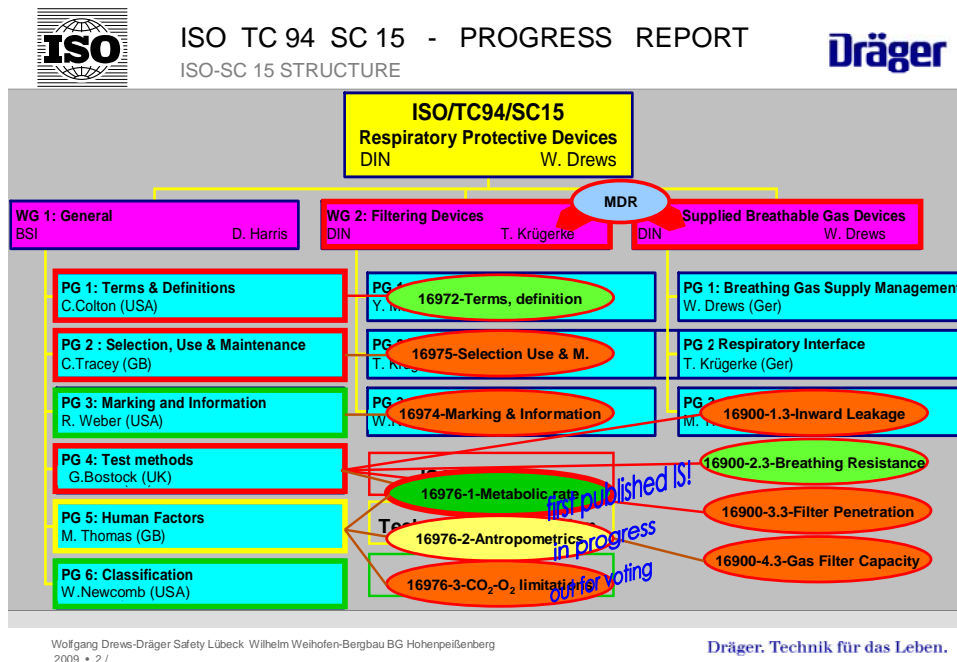


Figure 1

Organisation

SC 15 has structured its task by installing 3 Working Groups, WG2 and WG3, with their Project Groups, are responsible writing the two main standards for filtering devices and supplied breathable gas devices. WG1 handles the general topics such as human factors and classification of RPD's. It was and still is essential that this WG is ahead of the standard writers work and supports defining the performance criteria of RPD. The core of these criteria are the documents prepared by PG5. The

first of a series of 5 titles related to Human Factors has been published in 2007 as ISO 16976-Part 1-metabolic rates.

Part 2 and 3 , Anthropometrics and CO₂- and O₂- limitations will follow soon. Topics such as breathing resistance, work of breathing are already under consideration and ergonomic characteristics will be considered in near future. All performance criteria will be tested according test methods which will be listed separately under one series of standards called ISO 16900-series. The first 4 test method standards are in the voting routine. The standard "Terms and Definition" is in the final consideration and the selection process, documented in the Standard "Selection, Use and Maintenance" follows the new classification scheme.

Metabolic Rates

Writing the appropriate performance characteristics of an RPD, standard writers have to understand the relation of human breathing and the work load the humans are faced with whilst wearing an RPD. The oxygen uptake of wearers is related to the ventilation rate of the lungs and directly linked to these metabolic rates. 8 levels are defined from resting to exhaustive rate which reflects for example the metabolic rate of a firefighter in the application of structural fire fighting running up stairways. The corresponding minute volume for this activity for a large wearer will be 116 l/min. To cover a wide range of wearers individual ventilation profile the second standard error value is given as well which leads to 150 l/min. It has been identified that speaking during ventilation is associated with high peak flows which have to be considered by the standard writers accordingly.

From these human factors the project group "classification" has derived 7 classes of work rates, where "resting" is not deemed to be a class. Taking into account one standard error of the metabolic rate of a large wearer this work rate class leads to a minute volume of 135 l/min in the highest class, which is possible for highly trained people for some minutes. The figure 2 shows the 7 classes which have been reduced to three working rates level for use in the classification, moderate, very heavy and maximal.

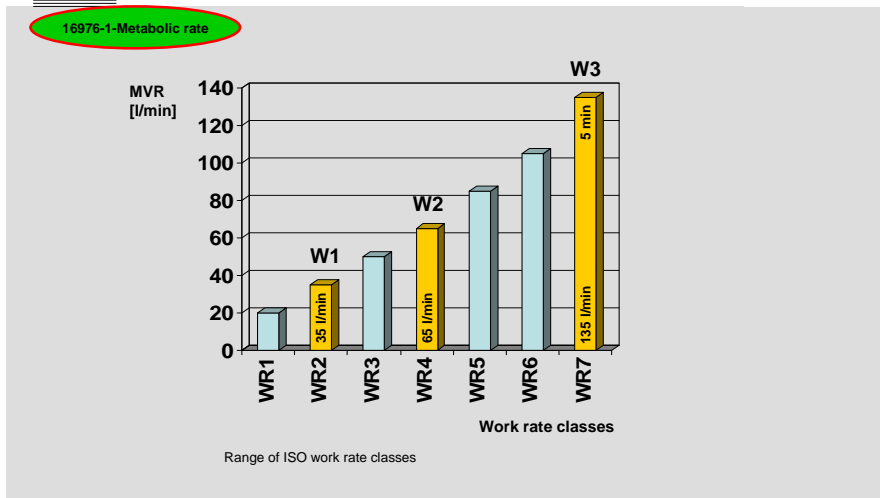


Figure 2

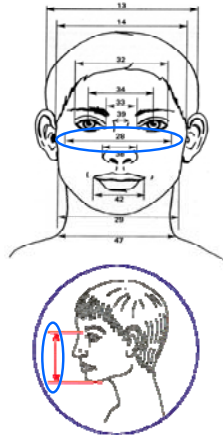
Compared with the existing requirements for testing RPD's the maximum ventilation rate can be found in the NFPA-Standard (USA) with a test level of 105 l/min. With the highest work rate of 135 l/min the performance level of future RPD's will be roughly 30% higher once that RPD claims to fulfill the highest work rate class.

Anthropometrics

A very important area is the respiratory interface of the human faces and the RPD. Based on the scope of this ISO-Subcommittee to derive performance characteristics of future RPD, which fits 5 to 95 percentile of the total wearer population, the face shape and geometry, its anthropometric data, have been analysed. A new concept, the Principal Component Analysis derived from 10 significant anthropometric measurements including face width and face length of wearer faces- see Figure 3- has been developed. The PCA-distribution panel was generated.



16976-2-Anthropometrics



- 1 Minimum Frontal Breadth
- 2 Face Width
- 3 Bigonial Breadth
- 4 Face Length
- 5 Interpupillary Breadth
- 6 Head Breadth
- 7 Nose Protrusion
- 8 Nose Breadth
- 9 Nasal Root Breadth
- 10 Menton-Subnasale Length

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Figure 3

All the 10 data points of the same 3000 test subjects were modelled by the PCA-analysis algorithm. The result of the 2 components of each person are shown in Figure 4. The 95-percentile of the wearer will be outlined by an ellipse. The 50-percentile distribution is formed by the inner ellipse which represents the medium size. By cutting the ellipses diagonally 4 additional segments were generated. Each of the segments will have their center contours by calculating the arithmetical means of all the data points within those segments.

5 new head sizes are derived – besides small "S", medium "M" and large "L" two additional head forms are defined - the head with short noses and wide head breadth, "SW" and the opposite, long noses and narrow face, "LN". These head forms are modelled by using 5 scans from persons heads very close to the center of the mathematical means. By an overlay of all 5 contours a new size, a neutral size, was created. No longer a test head will be a copy of one individual person!

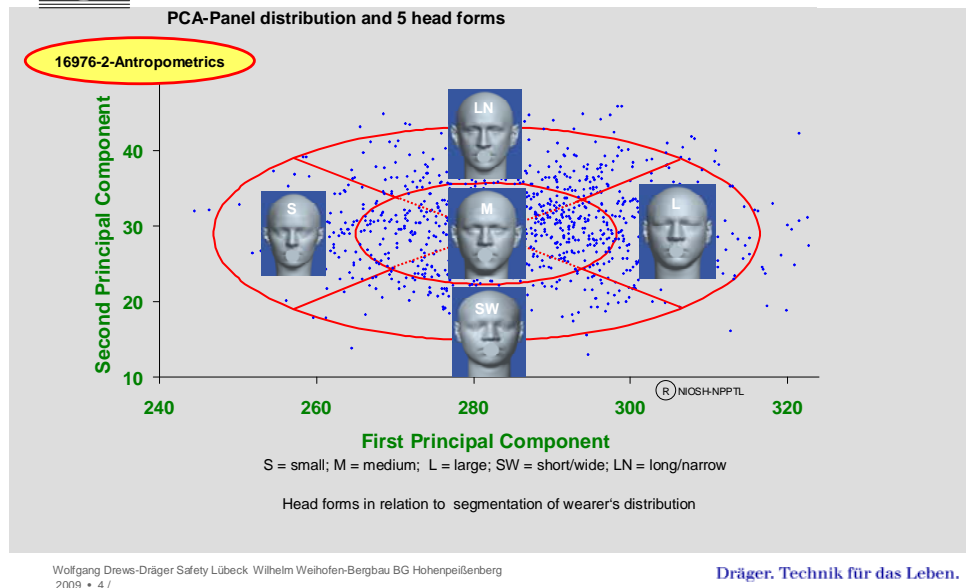


Figure 4

Classification Scheme

The RPD's of tomorrow will be classified according to their performance characteristics which will result in a new scheme valid for both standards the filtering device standard and the standard for supplied breathable gas devices.



Basic Performance Characteristics									
A respiratory interface and filter with standardized connector shall be marked with their classification and this symbol (●) for Standardized connector.					The addition of a + in the classification designation indicates that efficiency test or gas filter validation test is done at 180 l/min; no indication means testing at 110 l/min				
<div>Maximal 135 (340)</div> <div>Extremely heavy 105 (270)</div> <div>Very, very heavy 85 (225)</div> <div>Very heavy 65 (180)</div> <div>Heavy 50 (125)</div> <div>Moderate 35 (110)</div> <div>Light 20 (70)</div> <div>W3</div> <div>W2</div> <div>W1</div>					<div>Chemical symbol</div> <div>Any Chemical As specified</div> <div>PH</div> <div>Phosphine</div> <div>ETO</div> <div>Ethylene Oxide</div> <div>CO</div> <div>Carbon Monoxide</div> <div>200 eq. 100</div> <div>CO₂</div> <div>Chlorine Dioxide</div> <div>HF</div> <div>Hydrogen Fluoride</div> <div>As</div> <div>Arsine</div>				
<div>0.001</div> <div>10</div> <div>10000</div> <div>PL6</div> <div>0.01</div> <div>5</div> <div>2000</div> <div>PL5</div> <div>0.1</div> <div>4</div> <div>250</div> <div>PL4</div> <div>1</div> <div>3.33</div> <div>30</div> <div>PL3</div> <div>5</div> <div>2</div> <div>10</div> <div>PL2</div> <div>20</div> <div>1.25</div> <div>4</div> <div>PL1</div>					<div>F6</div> <div>99.999</div> <div>NOX</div> <div>Nitrous oxides</div> <div>1 2 3</div> <div>F5</div> <div>99.99</div> <div>OD</div> <div>Organic Gases</div> <div>1</div> <div>F4</div> <div>99.9</div> <div>AC</div> <div>Acidic</div> <div>1 2 3 4</div> <div>F3</div> <div>99</div> <div>HCN</div> <div>Hydrogen Cyanide</div> <div>1 2 3 4</div> <div>F2</div> <div>95</div> <div>BC</div> <div>Basic</div> <div>1 2 3 4</div> <div>F1</div> <div>80</div> <div>OV</div> <div>Organic Vapours</div> <div>1 2 3 4</div> <div>Minimum Particle Filter Efficiency [%]</div> <div>Group Gas Filter Type</div> <div>Class</div> <div>Specific Gas Filter Type</div> <div>Class</div>				
<div>Mode of Operation</div> <div>Mode of Complete Device - lab test [%]</div> <div>Safety factor (SF)</div> <div>Protection Level (PL)</div> <div>$PL = \frac{1}{TR_{min}} \cdot 100 \cdot \frac{1}{SF}$</div> <div>Work Rate [l/min] min vol (Peak)</div> <div>Application work rate</div>					<div>XXXX</div> <div>Breathable gas volume in XXXX litres</div> <div>SY</div> <div>Y = indication for air line devices</div> <div>Supplied Breathable Gas Capacity</div>				
System					Filtration				
System					Breathable Gas Supply				

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Figure 5

The first column in this scheme represents the "Mode of Operation" as primary function telling us whether the RPD filters hazardous substances or whether it

supplies the wearer with breathable gas. The second column deals with the Total Inward Leakage (TIL), a value given in percent as a result of a laboratory test with test subjects wearing the RPD. 6 levels from 20% to 0,001% were established. The third column reflects the appropriate work rate a wearer has to maintain and described above.

The fourth and fifth column in between shows how the protection level has been derived from the laboratory inward leakage testing and a safety factor. For the user the classification will only contain the mode of operation, protection level and application workrate. These 3 columns will describe the basic system characteristic of an RPD.

In the example in Figure 6 the "CCBA 4h" clearly identifies this device to be a "supplied" breathable gas device with a high TIL-value PL 5 means a protection level of 2000 and with a very heavy work rate "W2" (65 l/min). The "S 8400" shows that there is 8400 l breathable gas, which would last for 4 h at a minute volume of 35 l/min. This CCBA will be marked with "PL5 W2 S8400"

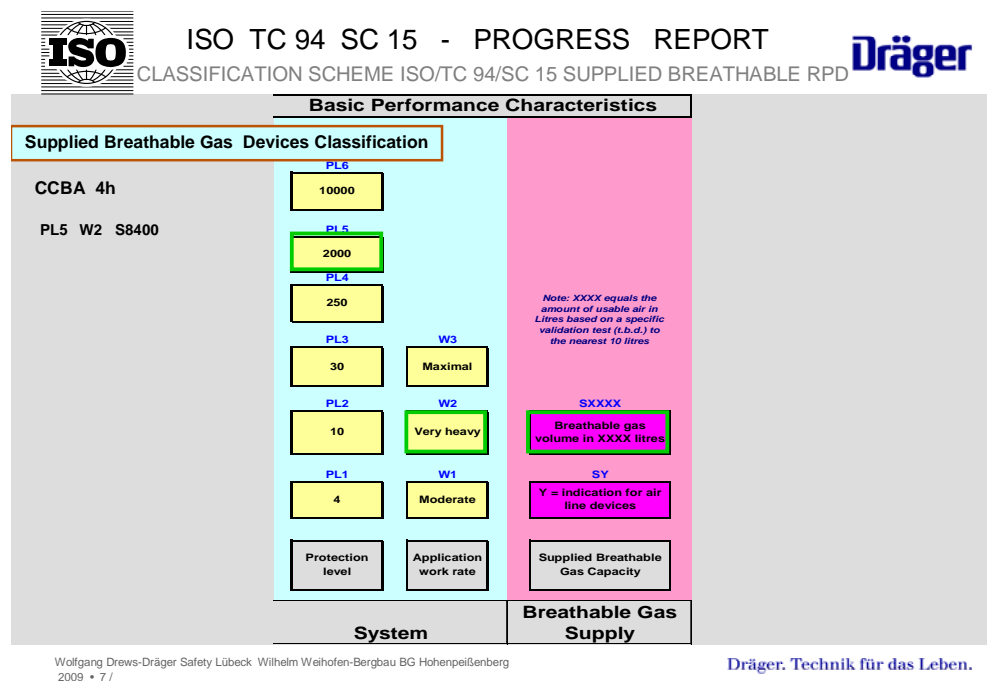


Figure 6

Besides the basic characteristics special application driven characteristics such as requirements from firefighting in underground mining might exist-see Figure 7. That RPD will be classified by adding MN3 "Special Application Mining Firefighting 3" where "MN stands for Mining and 3 stands for Mining fire fighting. The total classification in this example "PL5 W2 S8400 MN3" tells the wearer all about the overall characteristics of the RPD needed to protect wearer in their working environments.

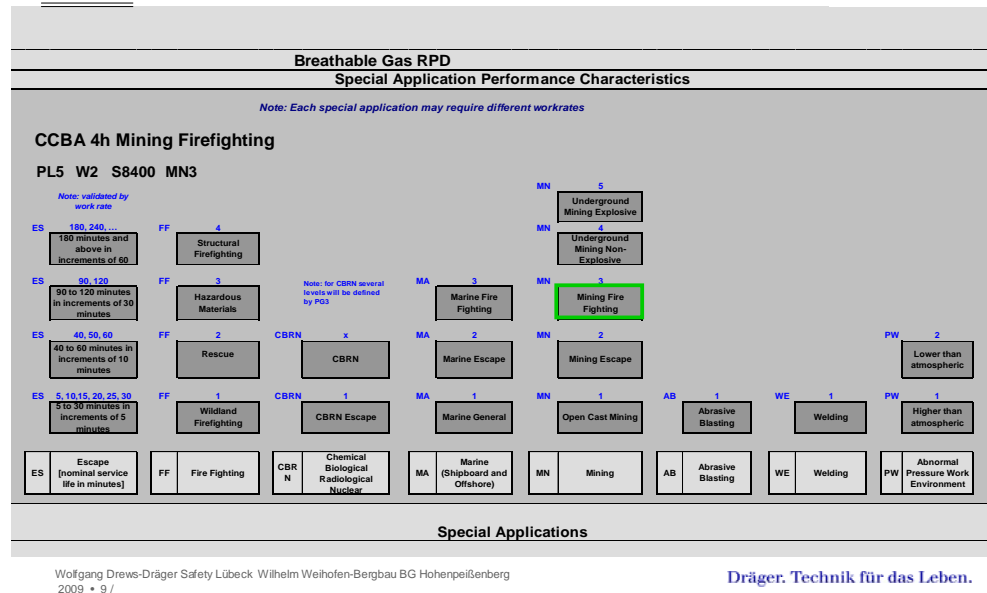


Figure 7

The Product standard is drafted as the "Master document of requirements (MDR)" and at the moment divided into Filtering RPD and Supplied breathable gas RPD .

The dokument is subclassified in five main sections for the requirements

- 5.1 Respiratory requirements
- 5.2 Non-Respiratory requirements
- 5.3 Special Application requirements
- 5.4 Requirements for Optional features
- 5.5 Combined or Multifunctional Requirements

For the special application requirements the matrix in figure 8 und 9 give you an impression what the additional requirements for special applications in mining deals with.



ISO TC 94 SC 15 - PROGRESS REPORT
SPECIAL APPLICATION MATRIX



Special Application Requirement Matrix – page 1 - 2009 06 25																	
Requirement	Special Application	Escape		Firefighting				CBRN		Marine		Mining				Abrasive Blasting	Welding
		Escape from Fire	Escape except CBRN, Marine and Mining	Structural Firefighting	Hazardous Materials	Rescue	Wildlands Firefighting	CBRN	CBRN Escape	Shipboard and Off-shore	Marine Escape	Underground Explosive Atmosphere	Underground Non-explosive Atmosphere	Open Cast (Pit) Mining	Firefighting & Rescue		
Abrasion Resistance-Visor				X	X	X	X	X		X		X	X	X			
Abrasion Resistance-Abrasive blasting RPD						X	X	X	X	X					X		X
Chemical resistance of Materials						X	X										
Chemical resistance of Materials-structural						X	X			X					X		
Chemical resistance of Materials-CBRN									X	X							
Resistance to smoke		X	X	X	X		X	X	X	X	X				X	X	
Six burner flame test				X						X					X		
1 Six burner flame test- static				X						X					X		
2 Six burner flame test-dynamic	X					X		X	X		X					X	X
Flame Engulfment				X													
Flame resistance of material				X		X	X	X	X	X					X		X
Single burner test	X																
Intrinsic Safety - explosive atmosphere					X			X	X	X	X						
Intrinsic Safety - firefighting				X						X							
Intrinsic Safety - Mining												X			X	X	
Permeation				X	X	X	X	X	X	X							
Protection to radioactive particles / gases				X	X	X		X	X	X							
Radiant heat																X	
1 Radiant heat (level 1) 1.25 KW/m² for 30 minutes				X	X	X	X	X		X					X		X
2 Radiant heat (level 2) 8.0 KW/m² for 5 minutes				X	X	X	X	X		X					X		
3 Radiant heat (level 3) 84 KW/m² for 8 seconds				X					X						X		
Resistance to Biological Agents				X	X	X		X	X	X							
Resistance to hot particles (embers, sparks, ash)				X			X										X
Resistance to UV (welding)				X	X	X											X
Resistance to Water Spray / Splash				X	X	X		X	X	X	X	X	X	X	X	X	X

Figure 8



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SPECIAL APPLICATION MATRIX



Special Application Requirement Matrix (SARM)- page 2 – 2009 06 25																	
Requirement	Special Application	Escape		Firefighting				CBRN		Marine		Mining				Abrasive Blasting	Welding
		Escape from Fire	Escape except CBRN, Marine and Mining	Structural Firefighting	Hazardous Materials	Rescue	Wildlands Firefighting	CBRN	CBRN Escape	Shipboard and Off-shore	Marine Escape	Underground Explosive Atmosphere	Underground Non-explosive Atmosphere	Open Cast (Pit) Mining	Firefighting & Rescue	Mining Escape	
Heat resistance of material 260°C				X			X			X					X		
1 Temperature of operation -32 to +71°C continuous				X	X	X	X	X	X	X	X	X	X		X	X	
2 Temperature of operation 100°C (30 minutes)				X	X	X	X	X	X	X	X	X	X		X	X	
3 Temperature of operation 255°C (5 minutes)				X						X					X		
4 Temperature of operation 950°C (10 seconds)				X						X					X		
Connections other than to the Respiratory Interface				X	X	X		X		X		X	X	X	X	X	
Vibration Resistance				X	X	X	X	X	X	X	X	X	X	X	X	X	
Material avoidance of frictional sparks				X	X	X		X	X	X	X	X	X	X	X	X	
Ready to use packaging	X							X	X		X				X	X	
Antistatic properties				X	X	X		X	X	X	X	X			X	X	
Enhanced Corrosion Resistance				X	X			X	X	X	X	X	X		X	X	
1 Enhanced Corrosion Resistance - Intermittent test												X	X	X	X	X	
2 Enhanced Corrosion Resistance - Constant test												X	X	X	X	X	
3 Enhanced Corrosion Resistance - Acidic test												X	X	X	X	X	
Practical performance according to its class				X	X	X	X	X				X	X	X	X	X	

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Figure 9

At the moment there are five different special applications for mining –see Figure 7:

Underground Explosive Atmosphere
Underground Non-Explosive Atmosphere
Open Cast Mining
Firefighting and Rescue

Mining Escape

It may be doubted, that open cast mining as a special application is needed but for now the actual classification scheme shows it.

The requirements for these special applications are still under discussion. Today in Germany there are no differences between RPD for fire fighting, what means fire fighting structural in this paper and mine rescue.

There are still some open questions.

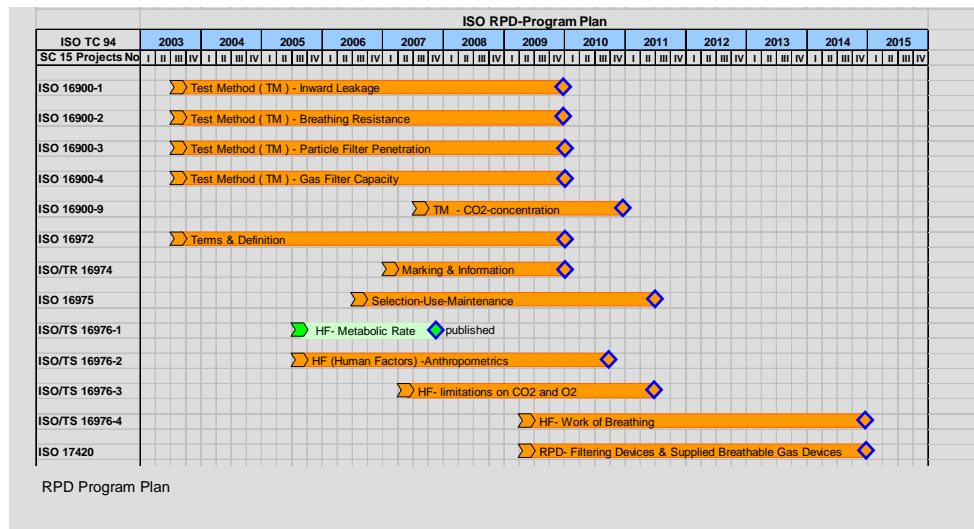
Do our mine rescue teams need RPD with the same level for chemical resistance as is needed for structural fire fighting?

Which level for corrosion is sufficient?

Don't we need also the ability to withstand sparks as demanded for fire fighting?



ISO TC 94 SC 15 - PROGRESS REPORT PROGRAM PLAN



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Figure 10

The project plan –see Figure 10 opens the view into this near future. Parallel to finalize the baseline documents, such as human factors, the work items for the main performance standard will be envisioned in Oktober this year with a running time of 4 to 5 years.

The future of RPD has started already. You still have the chance to participate and contribute to the generation of a world wide accepted new standard based on the wearers demands and their capability to wear suitable RPD –fit for purpose.

If you want give your contribution to it contact your national standard organisation and ask for information about this subject.

The process is still open and any contribution is welcome to reach the targets.

The public information to this work you can read on ISO Web-page

http://www.iso.org/iso/standards_development/technical_committees/list_of_iso_technical_committees/iso_technical_committee.htm?commid=291088.