Pressure Gauges and Other Forms of Pressure Monitoring Equipment Used in Conjunction with Diving Operations

IMCA D 062
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IMCA D 062 – Version History

Date	Reason	Revision
January 2021	Revised to become IMCA D document	Rev. 0
May 1994	Initial publication as AODC document	

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1 Scope

This guidance addresses:

a) operational parameters;

b) factors relevant to testing and certification;

c) periodic examination and test criteria;

of all forms of pressure monitoring equipment used in conjunction with diving operations.

2 Application

This guidance is intended to apply internationally, but it is recognised that some countries will have legislation that requires different standards or practices to be followed. Where local or national laws are more stringent than the advice contained herein, they will always take precedence over this guidance.

3 The Competent Person

The categories of competent person appropriate to carry out examination, test and certification of equipment are defined in Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment (IMCA D 018).

4 Periodic Examination and Test Criteria

Examination and test criteria are defined in Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment (IMCA D 018).

Note: The frequency and nature of the calibration of pressure sensors and gauges integral to automated functions may be defined in a scheme prepared by a competent person.

5 Categories of Gauge

The categories of gauge used are defined in Appendix 1.

6 Certified Test Instrument

All testing and certification of gauges should be carried out in comparison with a certified test instrument. This is defined as follows:

“A certified and calibrated test instrument is a master gauge or other testing device which meets the requirements on traceability (see section 7 below) and has a level of accuracy greater than or equal to the gauge being calibrated, taking full account of the accumulation of error.”

This does not apply to dead weight testers, however, which should be calibrated in line with the manufacturer’s recommendations.

7 Traceability of Measurement Standard

Testing and certification of test instruments/gauges should be traceable to a national standard. It is recognised that for every additional instrument used in the calibration/comparison chain there will be an increase of error which may be cumulative. However, this level of error should be assessed against the required gauge accuracy and noted on the calibration certificate for the certified test instrument. Consideration should be given to reducing possible accumulation of error by minimising the number of steps in the traceable link.

8 Water Density

For gauges measuring water depth, standard calibration should be for normal saltwater application using a specific gravity of 1027 kg/m^3. Any variation in water salinity should be noted by the user in order that the appropriate correction factor can be applied by the competent person. The salinity should be stated on the calibration certificate.

9 Analogue Gauges – Operational Parameters

9.1 Gauge Scale Selection

Gauges should be appropriate to the duty and particular attention should be given to the following:

- The dial should be of sufficient diameter to enable scale divisions to be read with an accuracy appropriate to their duty;
- Gauges should be selected so that the normal pressure reading will be in the range 25-75% of full scale. However, it is recognised that during initial pressure increase or final decrease, gauges will use the 0-25% part of the range;
- Gauges which are used in the final stages of decompression should have scale divisions not greater than 2 ft/0.5 m.

9.2 Gauge Orientation

Where gauges are mounted at an angle to assist read out, the angle of inclination of the dial face from the vertical should be advised to the competent person to enable calibration to be carried out at the same approximate angle.

9.3 Safety Considerations

Where gauges are recording pressure above 40 bar it is recommended that they be fitted with a safety blow out device or, consideration given to adopting suitable practices or employing protection to reduce the potential hazard. Consideration should also be given to applying this recommendation to all gauges.

Some types of gauge require clearance behind the panel to permit the bursting disc to blow out and in such cases, care should be taken to ensure that the manufacturer's instructions in this respect are adhered to.

Gauges used on oxygen lines should be compatible with such application.

9.4 Fluctuations in Gauge Setting

Gauges are susceptible to slight fluctuations due to temperature etc. Many gauges have a facility for moving the scale, which is often used for re-zeroing, although this should not normally be carried out when pressure is applied to the gauge. A 1% error on the 'zero' reading may be adjusted without recalibration, but this must be recorded in a register to ensure that only a single 1% adjustment is carried out in any six-month certification period. Such adjustment should only be carried out by a competent technician with an understanding of the operation of the gauge.

This resetting or adjustment is not a method of calibration.

9.5 Isolation of Gauges

The failure of certain dive system gauges could put the diver(s) at risk due to loss of breathing gas supply. Where practicable, such gauges should have a means of isolation fitted.

Where it is not practicable to fit an isolation valve, a flow restrictor can be fitted to limit gas losses in the event of gauge failure. If a flow restrictor is fitted then it should be clearly marked on the panel/schematic.

9.6 Testing and Calibration

It is recommended that suitable test points be installed to enable in situ calibration/comparison. The range of calibration used should be clearly stated on the calibration certificate.

9.7 Pressure Limiting Device

Various methods are available to control or limit over pressurisation. Consideration should be given to installing such a device to ensure that gauges such as therapeutic depth gauges cannot be exposed to pressure beyond their range.

9.8 Fluid Filled Gauges

In applications where, excessive vibration or shock is experienced, consideration should be given to using fluid filled gauges to protect the movement.

10 Digital Gauges – Operational Parameters

10.1 Gauge Scale Selection

Gauges should be appropriate to the duty and particular attention should be given to the following:

- The meter digits should be of sufficient size and clarity to enable them to be easily read;
- Gauges should be selected with the appropriate unit of measurement i.e. feet or metres, which should be identified by a sticker or tally if necessary. Gauges should not be adjusted to alter the unit of measurement unless the scale is altered at the same time, or a suitable tally fitted. Any such adjustment must be carried out by a competent person and the unit recalibrated;

- Gauges should be selected so that the normal pressure reading will be in the range where accuracy for the transducer/meter system is appropriate for the duty;
- Gauges used in the final stages of decompression should have output readings in feet or metres showing one decimal point. Gauges should be selected with the appropriate unit of measurement i.e. feet or metres, which should be identified by a sticker or tally if necessary. Gauges should not be adjusted to alter the unit of measurement unless the scale is altered at the same time, or a suitable tally fitted. Any such adjustment must be carried out by a competent person and the unit recalibrated.

10.2 Fluctuations in Gauge Setting

See section 9.4, which is also applicable to digital gauges. In the case of transducers exposed directly to a helium environment, helium seepage into the transducer will occur and could affect the accuracy of the reading.

10.3 Isolation of Transducers

Consideration should be given to isolation of those transducers which, if they failed, could put the diver at risk due to loss of gas supply.

10.4 Pressure Limiting Device

Consideration should be given to protection of digital gauges as for analogue gauges (see section 9.7). However, in most cases digital gauges and transducers are normally able to withstand a higher maximum system operating pressure.

10.5 Testing and Calibration

It is recommended that suitable test points be installed to enable in situ calibration/comparison for both the meter and the transducer. Digitals should be calibrated throughout the range of reading required in operation and not necessarily over the full pressure capability of the gauge or transducer. The range of calibration used should be clearly stated on the calibration certificate.

11 Divers' Wrist-Mounted Depth Gauges

Wrist-mounted depth gauges would not ordinarily have a level of accuracy sufficient for them to be used as a primary means of depth measurement for the determination of appropriate decompression procedures.

12 Training of Personnel

Personnel should be properly trained and competent to carry out testing and certification of gauges whether employed by a test house or in-house by contractors, or, as required by the relevant certification body. When personnel are required to test and certify gauges classified as "depth gauges", a formal record of their training should be kept and held readily available, in order to establish competence. No formal engineering qualification is, however, considered necessary.

13 References (Legislation & Guidance)

1. IMCA international code of practice for offshore diving (IMCA D 014). Diving at Work Regulations 1997 (L103) Commercial diving projects offshore.
2. Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment (IMCA D 018).
3. BS ISO 5781:2016. Hydraulic fluid power. Pressure-reducing valves, sequence valves, unloading valves, throttle valves and check valves. Mounting surfaces.
4. Original Equipment Manufacturers (OEM) guidance.

Appendix 1: Categories of Gauge and Periodic Examination and Test Criteria

	Categories of Gauge (Analogue and Digital)	**Gauge Application**	**Examination and Test Criteria**	**Compt. Person**	**Certification/Recording**
1	**Depth** Gauges used to measure the depth/pressure at which divers are operating to provide information essential to decompression routines. NOTE: Wrist-mounted depth gauges would not ordinarily have a level of accuracy sufficient for them to be used as a primary means of depth measurement for the determination of appropriate decompression routines.	Panel gauges with the following applications: - Divers depth (including excurting divers) - Chamber depth - Bell depth internal/external (surface panel) - Transfer trunking depth	Calibrate against a certified test instrument to an accuracy of ± 0.25% of maximum scale value, at a minimum of 5 points within the scale. Gauges outside the required accuracy must be adjusted or replaced (see Note 1).	2,3,4	Certificate to be issued by the competent person stating: 1) the actual readings taken at each point in comparison to the test instrument. 2) the gauge under test and test instrument.

2	**Life Support** This refers to gauges which read pressures critical to the life support function, including caisson gauges used to indicate depth to the divers. Such gauges are bell and bail out charging panel gauges and the last gauge monitoring pressure to the divers' breathing apparatus (including BIBS).	- Bell/bail out bottle charging panel gauge - The last gauge monitoring pressure to the divers breathing apparatus, including BIBS.	Check by comparison only against a certified test instrument to an accuracy of +/- 2.5% of maximum scale value at a minimum of 4 points within the scale, or to manufacturer specification (whichever is lower). Gauges outside the required accuracy must be replaced (see Note 1).	All	EITHER a certificate signed by a competent person, OR a record in the planned maintenance system (PMS) stating: 1) readings are taken and recorded at each point, and recorded as being within/outwith the required accuracy; 2) the gauge under test and the test instrument.
3	**Indicating** All gauges other than Cats 1 and 2 used to indicate that pressure is available from a supply system e.g. bottle storage or gas manifold.	These gauges do not require calibration and the required level of accuracy will be appropriate to the duty.	Examine for physical condition, function check throughout normal operating range. Replace if faulty.	All	Record in the PMS.

Notes:

In instances where pressurised gauges are inaccessible (i.e. located within the diving chamber or bell) and are not providing information essential to decompression routines, then the examination may be undertaken by a diver under the supervision of the diving supervisor or life support supervisor.

There are two types of caisson gauge; the sealed environment caisson (SEC) gauge which can be tested at atmosphere, and the evacuated type caisson (ETC) gauge which cannot. The air dive caisson (ADC) gauge is a variation of the latter type as an alternative for use in shallow diving operations. It is recommended that SEC type gauges be used as these can be tested in situ.

Appendix 2: Examples of Gauge Accuracy Tolerance

1. Accuracy Calculation of a 0 - 300 msw Depth Gauge:

Depth Gauges - Accuracy of ± 0.25% of maximum scale value, at a minimum of 5 points within the scale (see IMCA D 018 Detail Sheet 18).

Accuracy is calculated using the full scale of the gauge.

Gauge Accuracy = 0.25% Full scale of gauge = 300 msw

Therefore, 0.25 x 300/100 = **0.75 msw**

The allowable accuracy tolerance of a 300 msw depth gauge (± 0.25% of maximum scale value) is **0.75 msw**

Depth reading on Master Gauge (msw)	Accuracy tolerance (msw)	Allowable reading on gauge under test (msw)
0	0.75	-0.75 – 0.75
75 msw	0.75	74.25 – 75.75
150 msw	0.75	149.25 – 150.75
225 msw	0.75	224.25 – 225.75
300 msw	0.75	299.25 – 300.75
225 msw	0.75	224.25 – 225.75
150 msw	0.75	149.25 – 150.75
75 msw	0.75	74.25 – 75.75
0	0.75	-0.75 – 0.75

Example of a Gauge Calibration Field Test Sheet 0 - 300 msw Depth Gauge (± 0.25% of maximum scale value).

UUT (Unit Under Test) Details						
Type:						
Brand/Model:			Serial:			
Full Scale Range:	300		Accuracy:	0.25%	(in %)	
Unit per Division:			Accuracy:	0.75	(in unit of measure)	
Reference Standard Details:						
Brand/Model:			Serial:			
Full Scale Range:			Accuracy:		(in %)	
Test Details/Conditions:						
Pressure Medium:			Remarks:			
Pressure Unit:						
Temperature °C *(Before/After)* :						
Relative Humidity % *(Before/After)* :						

Test Results							
Indicated Pressure	Applied Pressure						Accuracy within Specifications
	Run 1	Error (%)	Run 2	Error (%)	Run 3	Error (%)	
0	0	0.00%	0	0.00%	0.1	0.03%	YES
75	75.1	0.03%	75.1	0.03%	75.1	0.03%	YES
150	149.8	0.07%	149.9	0.03%	149.9	0.03%	YES
225	225	0.00%	224.9	0.03%	224.7	0.10%	YES
300	300.2	0.07%	300.2	0.07%	300.2	0.07%	YES
225	224.8	0.07%	224.8	0.07%	224.9	0.03%	YES
150	150	0.00%	150	0.00%	150	0.00%	YES
75	75.1	0.03%	75.2	0.07%	75.2	0.07%	YES
0	0	0.00%	0.1	0.03%	0.1	0.03%	YES

2. Accuracy Calculation of a 0 - 230 fsw Life Support Gauge:

Life Support Gauges - Accuracy of ± 2. 5% of maximum scale value, at a minimum of 4 points within the scale (see IMCA D 018 Detail Sheet 19)

Accuracy is calculated using the full scale of the gauge.

Gauge Accuracy = 2.5%

Full scale of gauge = 230 fsw

Therefore, 2.5 x 230/100 = **5.75 fsw**

The allowable accuracy tolerance of a 230 fsw life support gauge (± 2.5% of maximum scale value) is **5.75 fsw**

Depth reading on Master Gauge (fsw)	Accuracy tolerance (fsw)	Allowable reading on gauge under test (fsw)
0	5.75	-5.75 – 5.75
50	5.75	44.25 – 55.75
100	5.75	94.25 – 105.75
150	5.75	144.25 – 155.75
230	5.75	224.25 – 235.75
150	5.75	144.25 – 155.75
100	5.75	94.25 – 100.75
50	5.75	44.25 – 55.75
0	5.75	-5.75 – 05.75

Example of a Gauge Calibration Field Test Sheet – 230 fsw Life Support Gauge (± 2.5% of maximum scale value)

CALIBRATION DATA

Pressure Range:	230	**Units:**	FSW
Gauge Accuracy:	2.50%	**Allowable (+/-):**	5.750

Applied	Upscale	Downscale	Upscale Accuracy	Downscale Accuracy
0	0	0	0.00 (%)	0.00 (%)
50	52	52	-0.87 (%)	-0.87 (%)
100	103	102	-1.30 (%)	-0.87 (%)
150	147	148	1.30 (%)	0.87 (%)
230	233	233	-1.30 (%)	-1.30 (%)