

Guidance on Diving Cylinder and Valve Thread Compatibility



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IMCA D 064

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Date	Reason	Revision
May 2020	Initial publication	

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IMCA D 064 – May 2020

1	Background	1
2	Aims.....	1
3	Application	1
4	Cylinder and Valve Threads	1
5	Marking.....	2
	5.1 General.....	2
	5.2 Cylinder Marking.....	2
	5.3 Cylinder Valve Marking.....	3
6	Procedures and Mitigation	4
7	Conclusions	6
8	References.....	6
Appendices		
1	Example of a Diving Cylinder Thread Size Verification Register.....	7

1 Background

There is a risk with any high pressure system of failure where the resultant gas expansion and release of stored energy may cause injury. An area of particular risk is the use of high pressure gas cylinders. IMCA Safety Flashes have informed members of five instances where cylinder valves have been forcefully ejected from diving cylinders. World-wide there have been many more instances. These ejection events have caused serious injuries and in one case five commercial divers were injured during a single ejection event.

Unfortunately, although IMCA information (e.g. [IMCA D 02-14](#) [Ref. 1]) and other industry publications (e.g. UK HSE DVIS 10 [Ref. 2]) have been issued to try and prevent these incidents they continue to occur. In each case the primary cause of the incident was that a cylinder valve had been fitted to the cylinder that had a thread that was incompatible with the cylinder thread; the thread on the cylinder valve being smaller in diameter than the thread in the neck of the cylinder thus allowing the valve to be ejected at high pressure.

2 Aims

The main aims of this document are to provide information and guidance to IMCA Diving Division members on:

- 1) the risk of cylinder valve ejection when incompatible cylinder valves are fitted to diving cylinders;
- 2) how to identify cylinder and cylinder valve threads and indicate how they may be checked;
- 3) procedures that may be used to mitigate and control the risk of cylinder valve ejection.

3 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.

4 Cylinder and Valve Threads

A number of different threads are used on compressed gas cylinders and cylinder valves although they may be considered in two broad categories: parallel and tapered. It is the parallel threaded valves used on diving cylinders that have been involved in the valve ejection events and are those addressed directly in this guidance. The parallel threaded cylinders and valves may be further classified as either metric or imperial:

- ◆ Metric threads are used internationally, and standardised in Europe for diving cylinders, with the preferred threads being M25 x 2.0 for typical diving cylinders and M18 x 1.5 for smaller cylinders, e.g. those used in buoyancy devices (EN 250 [Ref. 3] and EN 15333 [Ref. 4]), the thread detail being identified in EN 144-1 [Ref. 5] and ISO 15245 [Ref. 6].
- ◆ A more diverse collection of imperial threads have been used with only subtle differences between some of them. The pre-metric thread in Europe being ISO G3/4 (ISO 228-1 [Ref. 7], formally known as 3/4" British Standard Pipe (BSP) or 3/4" British Standard Pipe Parallel (BSPP)); this thread became obsolete in the 1990s. Diving cylinders and valves manufactured to American Department of Transportation (DOT) standards use the 3/4" National Pipe Straight – Mechanical (NPSM) thread – (ANSI/ASME B1.20.1 [Ref. 8]). There are other threads not directly identified in this guidance.

Whilst there are appreciable differences between the thread forms (shape and dimensions of the thread), e.g. NPSM has a 60° Sellers' thread form and G3/4 has a 55° Whitworth thread form, it is the diameter of the different threads that is a major factor in the cause of valve ejections. The M25 x 2 thread has a significantly smaller diameter than the ISO G3/4 thread which in turn is slightly smaller, although not discernible by visual inspection, than the 3/4" NPSM thread (see Figure 1 and 2).

Although Figure 1 shows a difference in the valve threads the difference is not apparent in Figure 2. The essential safety aspect is that a simple visual inspection of both the male and female threads is inappropriate to identify them and must not be used in practice.



Figure 1 – Visual comparison of M25 x ISO G3/4 threads showing smaller diameter of M25 x 2 thread



Figure 2 – Visual comparison of 3/4" NPSM and ISO G3/4 threads showing similarity

Investigation of the valve ejection events has consistently identified that a cylinder valve with a smaller diameter stem thread than the cylinder neck thread had been used, e.g. a valve with a M25 x 2 stem thread inserted into a cylinder with a 3/4" NPSM neck thread. It is therefore imperative that the cylinder neck and valve stem threads are identical.

5 Marking

5.1 General

A method of increasing the safety of pressurised gas systems particularly where threads and fittings are used is to permanently mark the thread on the relevant components so as to inform a user. This has been embodied in European and ISO standards to specify both the marking on diving cylinders and cylinder valves.

5.2 Cylinder Marking

Historically there have been many different requirements for marking cylinders. The American DOT standards do not require the thread to be marked and unfortunately some older cylinders to other standards are also not marked with the neck thread.

The current international standard for marking of cylinders (ISO 13769 [Ref. 9]) requires the thread, along with other information, to be stamp marked on the shoulder of the cylinder. It also requires that the thread is marked at the left hand side of the first line of the stamp marking (see Figure 3 and Figure 4).

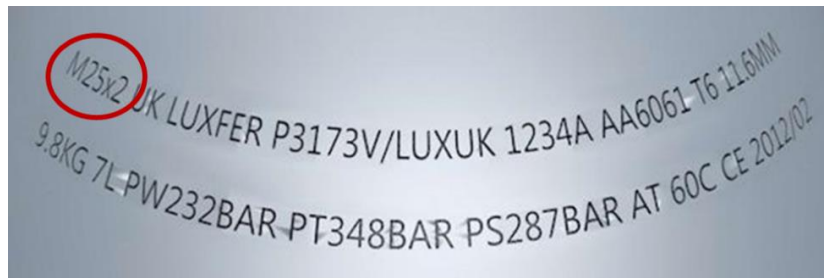


Figure 3 – Illustration of cylinder shoulder stamp marking showing thread at left side of top row



Figure 4 – Example cylinder shoulder stamp marking showing M25 x 2 thread at left side of top row

5.3 Cylinder Valve Marking

The situation in respect of marking cylinder valves is similar to the cylinder marking, with many different requirements for marking cylinder valves. American DOT standards do not require the valve to be marked and some older valves to other standards are also not marked.

The current international standard for marking of cylinder valves (ISO 10297 [Ref. 10]) requires both the inlet connection thread (i.e. the stem thread for fitting the valve to the cylinder) together with the outlet connection thread (i.e. the thread for fitting a regulator to the cylinder) to be marked (see Figure 5).

Examples of different inlet connection thread markings are illustrated in Figure 6.



Figure 5 – Example cylinder valve showing marking of M25 x 2 inlet (stem) connection thread and G5/8 outlet connection thread



Figure 6 – Example cylinder valves showing 3/4 NPSM (left) and M25 (right) inlet (stem) connection marking

Note: ISO 12209 does not require valves to be marked with the inlet (stem) connection, only the number of the standard, the working pressure and the date of manufacture. Many 3/4" NPSM valves marked with ISO 12209 may not have the connection marked.

6 Procedures and Mitigation

The incident information clearly indicates that mistakes have been made with the insertion of cylinder valves. The following should be applied to mitigate the risks of valve ejection:

- ◆ Removal and insertion of cylinder valves should only be undertaken by appropriately trained, equipped and competent persons.
- ◆ Where Contractors use third-party organisations for cylinder maintenance, they should ensure that the organisation is either accredited for the work being undertaken or their procedures are subject to independent audit and that they use appropriately trained and competent persons.
- ◆ Whenever a cylinder valve is inserted the marking on both the cylinder and cylinder valve should be checked to identify if they are the same thread. However, it may be that the marking on the cylinder and cylinder valve may not be present or legible.
- ◆ Even if the relevant markings on the cylinder and cylinder valve are present, legible and correct, before insertion the threads should be cleaned and checked by a competent person using at least a GO/NO GO ring gauge for the cylinder valve (see Figure 7 and Figure 8) and a GO / NO GO plug gauge for the cylinder thread (see Figure 9 and Figure 10).
- ◆ By design parallel threads are sealed by an O ring and do not require force to be inserted. If any resistance is felt on insertion the cylinder valve should be removed and both threads re-checked.
- ◆ Ideally, all cylinders used should be permanently marked by the manufacturer as per ISO 13769 [Ref. 9] and all cylinders' valves as per ISO 10297 [Ref. 10]. If the thread sizes are not marked consideration should be given to marking the cylinders and cylinder valves with the thread used.
- ◆ When cylinders are filled the inspection procedures in ISO 24431 [Ref. 11] should be applied. If the thread sizes are not clearly marked or legible the operator should not fill the cylinder until it has been checked and appropriately marked.
- ◆ All cylinders and cylinder valves at a given location should have the same cylinder and valve thread.
- ◆ Contractors should consider:
 - replacing cylinders and valves that do not have the threads permanently marked.
 - creating a single universal system with only one type of valve inlet (stem) and cylinder neck thread.
- ◆ Contractors should create a management system that:
 - ensures cylinder removal and refitting is only conducted by appropriately trained, equipped and competent persons.
 - keeps records to show that all high pressure gas cylinder threads and cylinder valve threads have been appropriately checked using at least GO/NO GO gauges for compatibility (see Appendix I for an example of a Diving Cylinder Thread Size Verification Register, based on system provided by an IMCA Diving Division Member);

- uses a unique identification for each cylinder and cylinder valve, ideally this will be the serial number but may be a bespoke user number. The identification to be permanently visible and traceable;
- records the gas cylinder and cylinder valve identification in the periodic examination certificates for [Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment \(IMCA D 018\)](#) [Ref. 12] compliance and [IMCA Diving Equipment Systems Inspection Guidance Note \(DESIGN\)](#) audits as per [Guidance on auditing of diving systems \(IMCA D 011\)](#) [Ref. 13].



Figure 7 – Example M25 x 2 cylinder valve ring gauges – Left NO GO – Right GO



Figure 8 – Cylinder valve GO ring gauge (Left – PASS. Right – Fail)



Figure 9 – Example 3/4" NPSM cylinder plug gauge – Left side GO – Right side NO GO



Figure 10 – M25 x2 cylinder plug GO gauge – PASS (fully inserted)

7 Conclusions

Although industry guidance has been provided, incidents continue to occur where cylinder valves have been forcefully ejected from diving cylinders. These ejection events have caused serious injuries.

To mitigate the risk of future cylinder valve ejection incidents the procedures identified in Section 6 above should be implemented.

Contractors should review and revise where appropriate their procedures so as to reduce the risk of incidents and serious injury when using and filling high pressure gas cylinders.

8 References

- 1) [Metric thread standards, gas cylinders and valves \(IMCA D 02/14\)](#)
- 2) [Guidance on auditing of diving systems \(IMCA D 011\)](#)
- 3) [Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment \(IMCA D 018\)](#)
- 4) UK HSE Diving Information Sheet No 10, 12/07 - Diving cylinders: Guidance on internal corrosion, fitting valves and filling. <https://www.hse.gov.uk/pubns/dvis10.pdf>
- 5) EN 250:2014 - Respiratory equipment – Open-circuit self-contained compressed air diving apparatus – Requirements, testing, marking
- 6) EN 15333-1:2007 - Respiratory equipment – Open-circuit umbilical supplied compressed gas diving apparatus – Part 1: Demand apparatus
- 7) EN 144-1:2000 - Respiratory protective devices – Gas cylinder valves – Part 1: Thread connections for insert connector
- 8) ISO 15245:2001 - Gas cylinders – Parallel threads for connection of valves to cylinders – Part 1: Specification
- 9) ISO 228-1:2008 - Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation
- 10) ANSI/ASME B1.20.1:2013 - Pipe Threads, General Purpose, Inch
- 11) ISO 13769:2018 – Gas cylinders – Stamp marking
- 12) ISO 10297:2006 – Transportable gas cylinders – Cylinder valves – Specification and type testing
- 13) ISO 24431:2016 - Gas cylinders - Seamless, welded and composite cylinders for compressed and liquefied gases (excluding acetylene) - Inspection at time of filling

