

**Guidance on  
Stainless Steel in  
Oxygen Systems**



**The International Marine Contractors Association (IMCA) is the international trade association representing offshore, marine and underwater engineering companies.**

IMCA promotes improvements in quality, health, safety, environmental and technical standards through the publication of information notes, codes of practice and by other appropriate means.

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- ◆ Lifting & Rigging
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There are also five regional sections which facilitate work on issues affecting members in their local geographic area – Asia-Pacific, Central & North America, Europe & Africa, Middle East & India and South America.

## **IMCA D 012 Rev. 1**

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# Guidance on Stainless Steel in Oxygen Systems

IMCA D 012 Rev. 1 – October 2016

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## 1 Background

There is normally approximately 21% oxygen in the air we breathe. Oxygen systems are systems intended to handle gases with a higher oxygen percentage than 21. Oxygen supports combustion.<sup>1</sup> In systems where elevated percentages and pressures of oxygen are present there will be an increase in the ease of ignition and the rate of combustion of a fuel, i.e. there will be an increased risk of fire and explosion. In such environments substances may act as fuels and burn when they would not do so in air at atmospheric pressure.

In the 1960s there was a disastrous oxygen (O<sub>2</sub>) fire during the Apollo moon programme when three astronauts died on the launch pad. Like many O<sub>2</sub> fires, there was nothing left after the fire so the accident investigation team looked at all possible causes rather than identifying one specific cause.

One of the possible causes identified by the Space Agency was the use of a particular grade of stainless steel and the manner in which it had been configured for use.

As a result of that 1960s research the diving industry has long held reservations about the use of low-grade stainless steel in O<sub>2</sub> systems, and certain restrictions on the use of stainless steel within diving systems have been suggested.

## 2 Aims

The main aims of this document are to provide information and guidance to diving contractors and others on:

1. the general precautions that should be observed when designing, assembling and operating an oxygen system that forms part of a diving system;
2. matters that should be considered when selecting an appropriate build material for instrumentation or pipework that will be used as part of a gaseous oxygen system within a diving system;
3. the risks associated with using stainless steel as a build material for dive system components in gaseous oxygen service.

## 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 General Precautions when Working with Oxygen Systems

It is assumed that the cleanliness of instrumentation and pipework for oxygen service (as addressed in [IMCA D 031](#) [Ref. 1]) and appropriate initial and periodic inspection and testing (as specified in section 24.2 of [IMCA D 018](#) [Ref. 2]) is the accepted norm for industry practice. Therefore, this guidance note will not deal with these matters in detail.

Since the early days the offshore diving industry has developed a more comprehensive understanding of what needs to be done, and what should be avoided, when working with gaseous oxygen systems. There is agreement that the main precautions to follow are:

- ◆ Design – The oxygen system should be designed by a competent person/engineering specialist. Consideration of the piping design should take into account materials used, soft goods used and the possible effects of adiabatic compression.<sup>2</sup>

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1 A sequence of chemical reactions between a fuel and an oxidant accompanied by the evolution of heat and, usually, by the emission of light.

2 Adiabatic compression is a hazard often encountered in gas pumping and delivery systems. The phenomenon can occur if gas flow paths are such that local pressurisation occurs rapidly. Under these conditions, momentary gas temperatures well in excess of that required to ignite many materials can occur. Adiabatic compression can be controlled by valve and regulator design and by controlling the rate at which systems are pressurised. Experience has shown that an operator can open a quarter turn ball valve quickly enough to cause a catastrophic adiabatic compression reaction in high pressure oxygen systems.

- ◆ All changes to an oxygen system must be carried out through a management of change/design review process.
- ◆ Treat any gas with a 25% or more O<sub>2</sub> content as if it was pure O<sub>2</sub>.
- ◆ Reduce pressure at source if possible. In general, try to reduce to 40 bar gauge pressure or less at the quad.
- ◆ Ensure all materials, equipment, greases, etc. are stated by the manufacturer as being compatible for use with O<sub>2</sub>.
- ◆ Ensure that all traces of hydrocarbons are removed and everything is O<sub>2</sub> cleaned in accordance with a suitable industry standard procedure.
- ◆ Do not use quarter turn valves except in low pressure return lines.
- ◆ Eliminate sharp corners or tight bends from the pipework system.
- ◆ Train personnel in the hazards associated with O<sub>2</sub>.
- ◆ Ensure that there are no restrictions to the flow of O<sub>2</sub>. Examples of common restrictions are Teflon thread tape or blocked filters, etc.

This list is not exhaustive but covers the main points.

## 5 The Selection of Stainless Steel for Use in Oxygen Systems

### 5.1 Grades and Material Specification

A specific question often asked is: “What grades of stainless steel are suitable for use when designing, assembling and operating a gaseous oxygen system that forms part of a diving system?”

It is difficult for any guidance to recommend particular stainless steel grades as suitable for use in all types of oxygen systems forming part of a diving system. Such systems are quite varied in design and intent. A further complication is that the same steel may have been designated a different grade number under different national systems e.g. British, American, German, etc.

When considering what type of stainless steel to use for components of a gaseous oxygen system forming part of a diving system, it is best to consider the duties of the material within the proposed system and then prepare an appropriate material specification. This should be used to help identify the correct stainless steel product for the job.

Classification society rules include specific requirements for the suitability of instrumentation and piping for use within oxygen rich systems. These should also be consulted during the design appraisal process to help develop the necessary material specification for the system application (see also section 5.2).

### 5.2 Oxygen Shock Testing

The following extracts from documents produced by a respected international classification society are relevant:

“402 In systems conducting oxygen, all materials in contact with this gas shall be oxygen shock tested according to *EN 738-1, -2 and -3:1997/1998 “Pressure regulators for use with medical gases”* or equivalent standard applicable to the particular component. (See also *EN 849:1996, EN ISO 11114-3:1997 and EN ISO 2503:1998 ...*).

403 For piping systems of copper, copper alloys and austenitic steels with chromium-nickel content above 22%, the test can be waived.”<sup>3</sup>

“... Where stainless steel is used for oxygen lines with operating pressures above 40 bar only high-alloyed Cr-Ni steels with a content of Cr and Ni of together at least 22% or Cr-Si-steels with a Cr content of at least 22% are acceptable.”<sup>4</sup>

3 Offshore Standard DNV-OS-E402, Offshore Standard for Diving Systems, October 2010, Section 8: A402 & 403.

4 DNV GL Rules for Classification: Underwater Technology (Edition) December 2015. Part 4 Machinery & Systems; Chapter 6 Piping Systems, pumps and Compressors. Section 5.8.

The purpose of oxygen shock testing is to simulate the adiabatic compression that can be applied to fittings, valves, pressure reducers, gauges and flexible hoses made from stainless steel and other materials. The test then qualifies the validity of the equipment subjected to testing for oxygen use at a given pressure. This process will allow for alternative types of stainless steel, outside of those excluded from oxygen shock testing in the above extracts, to be tested and qualified for specific applications in oxygen systems.

## 6 Identification and Marking

Failure to identify the instrumentation and pipework in a manner that is traceable to material certification presents a risk to the ongoing use of the system for oxygen rich applications.

The designer and manufacturer have an obligation to retain the certification in the production quality record in a manner that is traceable to the design specification and the installed instruments and pipework. Should the design be appraised by a classification society then a surveyor may be required to identify the hardware and review and stamp the certification as verification of the design specification in the production quality record.

During in service maintenance instruments or pipework must be replaced on a like-for-like basis so as not to deviate from the original design intention and approval of material specification for the oxygen rich environment. Like-for-like replacements may or may not need to be verified by a surveyor. Appropriate clarification should be sought from the relevant classification society. Should an improved material be selected for a replacement part then due consideration must be given to design change control, appraisal and survey interventions. In some instances, like-for-like may mean that replacement parts must come from a specific batch of fittings or valves, due to the potential differences that manufacturing changes can introduce. Industrial equipment manufacturers can sometimes change equipment specifications and designs without notice.

Instruments and pipework should always be marked in accordance with IMCA guidance. Regular inspections of the markings on oxygen system pipework should be carried out to prevent a situation where identification marks become illegible or are inadvertently erased.

Problems can occur when the markings on pipework or fittings become illegible or disappear entirely. In such cases the identification of each component's detailed material content may be difficult.

## 7 Conclusions

For simplicity and safety many contractors simply use 'Tungum' for all O<sub>2</sub> systems, normally with flared fittings. Tungum is a non-magnetic bronze copper alloy with non-sparking properties. IMCA endorses this policy as the safest, as well as the most convenient, way of proceeding.

However, where a contractor has used a suitable material specification of stainless steel, or validated the equipment through appropriate oxygen shock testing, and can demonstrate that the pipework and fittings etc. are fully certified for use in the relevant oxygen system, this may also be considered as providing an equivalent level of safety.

## 8 References

1. [IMCA D 031](#) – *Cleaning for oxygen service: Setting up facilities and procedures*
2. [IMCA D 018](#) – *Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment*