BRITISH COMPRESSED GASES ASSOCIATION
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TECHNICAL INFORMATION SHEET 23

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BCGA POLICY REGARDING INTERNAL EXAMINATION AND PROOF PRESSURE TESTING OF STATIC CRYOGENIC LIQUID STORAGE TANKS

This document covers static tanks specifically designed for the purpose of storing cryogenic liquid and only applies to those that are in liquid oxygen, nitrogen or argon service.

The type of storage tank generally conforms to one of the following designs:

(i) Spherical or cylindrical inner containment, sometimes multiple, supported within an inert gas purged outer jacket at atmospheric pressure, and with insulation in the inter-space.

(ii) Vertical cylindrical inner containment with a fixed roof and flat bottom resting on an insulating base, placed within an inert gas purged outer jacket at atmospheric pressure, and with insulation in the inter-space.

(iii) As (i) but with full vacuum and insulation in the inter-space.

The practice of the industrial gases industry is not to carry out periodic internal examination or proof pressure testing of in-service cryogenic storage tanks.

This policy has been established over many years based upon operating experience and an absence of the recognised potential causes of failure, namely corrosion, erosion, fatigue, excessive mechanical or pressure loading and brittle fracture of the inner vessel.

The reasons why internal examination or proof pressure testing of storage tanks is not considered necessary to maintain the required levels of safety and integrity are as follows:

1. The inner containments of cryogenic tanks are constructed from corrosion resistant materials, namely austenitic stainless steel, aluminium alloy or 9 % nickel steel. These materials retain their corrosion resistance at all temperatures below ambient and experience shows that corrosion does not occur in cryogenic service.

2. The product being stored is dry, clean and non-corrosive. The production process removes all possible corrosion contaminants from the feedstock and any inter-space moisture near the inner tank can only exist in the form of inert ice. The outer jacket also protects the inner tank from any adverse climatic or environmental conditions and the inter-space vacuum ensures a non-corrosive environment.

3. The design and construction is carried out to well established and internationally recognised design codes, and installations conform with relevant Codes of Practice. The design allows for all the pressure and environmental conditions met in service and the contractions due to temperature changes during start up and normal operation.

4. Tanks are constructed in line with a documented Quality Assurance system. The design drawings, calculations, construction methods, fabrication procedures, welder qualifications, weld procedures, material identification, material certification, pressure testing and the comprehensive schedule of non-destructive examination are checked and witnessed by relevant Competent Persons.

5. The pressure control and safety relief systems are designed in accordance with internationally recognised design codes and standards and are therefore adequately sized to cope with reasonably foreseen process and environmental conditions.

6. The normal operating mode of storage tanks is such that significant pressure and temperature cycles do not occur. Tanks in user premises operate within a narrow band around the working pressure by vaporisation of stored liquid at cryogenic temperature. The only cycles are those due to liquid level fluctuations which do not represent significant pressure or temperature cycles.

7. The materials used in construction of the inner vessel, namely aluminium alloy, austenitic stainless steel or 9 % nickel steel have high fracture toughness. The critical size of defects for initiation of unstable fracture propagation are large and would be detected with the degree of examination employed during manufacture.

8. The materials used in construction of the inner vessel have significantly enhanced mechanical properties at normal working temperatures, compared to ambient temperatures. As an example, at cryogenic temperatures the ultimate tensile strength of stainless steel is approximately double the ambient temperature value. These enhanced properties are not normally taken in to account during the design of the inner vessel and therefore represent a significant additional margin of safety.

9. All tanks undergo periodic external visual examinations in accordance with a Written Scheme of Examination as required by the Pressure Systems Safety Regulations (1) to confirm the satisfactory condition of the outer containment, supports and ancillary equipment. In addition, safety checks are carried out in line with BCGA Leaflet 11, Safety checks for vacuum insulated storage tanks (2). In the event that a defect developed in the inner vessel by some unanticipated mechanism, leakage into the inter-space would be readily detectable by loss of vacuum, frost spots, external condensation (sweating) or increased boil-off losses.

10. There are approximately 60 000 cryogenic tanks in service within Europe; some having been in service since the 1960's. They have accumulated a very large number of safe operating hours without failure of the inner vessel during this time.

Throughout the history of the BCGA, member companies have periodically destructively and non-destructively examined inner vessels of tanks to verify the case for the 'absence of recognised potential causes of failure'. Results of a number of these examinations are

included in Appendix 1. This evidence supports the ongoing policy as set out in this document for non-invasive periodic examinations of tanks in service.

EIGA have carried out similar research amongst their international members and reached the same conclusion as detailed in EIGA Document 119/04, Periodic inspection of static cryogenic vessels (3).

This document and the provision of evidence will remain under review by the BCGA.

Summary
For tanks designed, manufactured and inspected in accordance with a recognised code, operated and maintained for cryogenic service, with the absence of failure mechanisms outlined above, the probability of failure is extremely low.

This is a clear statement supporting the industry conclusion that correctly designed, constructed, approved, operated and maintained cryogenic tanks do not deteriorate in service and therefore internal examination and proof pressure testing are not required.

The BCGA will continue to collate the results of inner vessel examinations in support of this policy for static tanks and update the data tables in Appendix 1 on a periodic basis.

References

	Document Number	Title
1	SI 2000 No. 128	The Pressure Systems Safety Regulations 2000.
2	BCGA Leaflet 11	Safety checks for vacuum insulated storage tanks
3	EIGA IGC Doc 119/04/E	Periodic inspection of static cryogenic vessels.

For more information:

Please refer to our website: www.bcga.co.uk

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EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Bulk Storage	Sphere 11.3 m Diameter	1989	19	Al Alloy	Full Internal / External	Visual	Satisfactory. No service defects evident	Yes
Vacuum Insulated	2.3 m Diameter x 3.3 m	1990	23	18/8 Stainless	Full Internal / External	Visual	Satisfactory. No service defects evident	No
Bulk Storage	Sphere 11.3 m Diameter	1989	20	Al Alloy	Full Internal / External	Visual	Satisfactory. No service defects evident	Yes
Bulk Storage	Sphere 11.3 m Diameter	1989	20	Al Alloy	Full Internal / External	Visual plus selected dye pen and mechanical testing	Satisfactory. No service defects evident	Yes
Bulk Storage	10.7 m Diameter x 14.3 m	1979	14	Al Alloy	Full Internal / External	Visual, dye pen. radiography plus proof testing	Satisfactory. No service defects evident	Yes
Vacuum Insulated	3.9 m Diameter x 9.1 m	1981	7	9 % Nickel	Full Internal / External	Visual, dye pen. radiography plus proof testing	Satisfactory No service defects evident	Yes
Bulk Storage	10.7 m Diameter x 14.2 m	1978	9	18/8 Stainless	Full Internal / External	Visual, ultrasonic plus proof testing	Satisfactory. No service defects evident	Yes

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Vacuum Insulated	1.7 m Diameter x 4.4 m	1985	27	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography plus proof testing	Satisfactory. No service defects evident	Yes
Bulk Storage	10.7 m Diameter x 14.2 m	1986	25	Al Alloy	Partial Internal / External	Visual, dye pen. radiography plus sample testing	Satisfactory. No service defects evident	No
Bulk Storage	21.3 m Diameter x 18.7 m	1986	19	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography plus proof testing	Satisfactory No service defects evident	Yes
Bulk Storage	15.2 m Diameter x 14.6 m	1986	16	18/8 Stainless	Partial Internal / External	Visual, dye pen.	Satisfactory. No service defects evident	No
Bulk Storage	10.7 m Diameter x 14.2 m	1987	23	Al Alloy	Partial Internal / External	Visual, dye pen. radiography plus sample testing	Satisfactory. No service defects evident	Yes
Bulk Storage	21.3 m Diameter x 18.7 m	1987	18	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography plus proof testing	Satisfactory. No service defects evident	No
Vacuum Insulated	3.9 m Diameter x 6.7 m	1987	7	9% Nickel	Full Internal / External	Visual, dye pen. radiography plus proof testing	Satisfactory. No service defects evident	Yes

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Bulk Storage	10.7 m Diameter x 14.2 m	1990	34	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography plus proof testing	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.7 m Diameter x 4.4 m	1964	6	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography plus ultrasonic & proof test	Satisfactory. No service defects evident	No
Vacuum Insulated	1.7 m Diameter x 4.4 m	1971	13	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography ultrasonic & proof test	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.7 m Diameter x 4.4 m	1977	19	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography ultrasonic & proof test	Satisfactory. No service defects evident	Yes
Bulk Storage	10.7 m Diameter x 14.3 m	1980	19	18/8 Stainless	Partial Internal / External	Visual	Satisfactory. No service defects evident	No
Bulk Storage	10.7 m Diameter x 14.3 m	1984	15	Al Alloy	Partial Internal	Visual plus limited dye pen.	Satisfactory. No service defects evident	No
Bulk Storage	10.7 m Diameter x 14.3 m	1986	24	Al Alloy	Partial Internal and External	Visual, dye pen. radiography sample testing	Satisfactory. No service defects evident	No

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Bulk Storage	15.2 m Diameter x 14.6 m	1986	16	18/8 Stainless	Full Internal / External	Visual, dye pen.	Satisfactory. No service defects evident	No
Bulk Storage	15.2 m Diameter x 14.6 m	1993	31	Aluminium Alloy	Full Internal / External	Visual, dye pen. radiography plus pressure testing	Satisfactory. No service defects evident	Yes
Bulk Storage	10.7 m Diameter x 14.2 m	1994	32	Aluminium Alloy	Full Internal / External	Visual, dye pen. radiography plus pressure testing	Satisfactory. No service defects evident	Yes
Vacuum Insulated	3.5 m Diameter x 20.2 m	1994	31	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography plus pressure testing	Satisfactory. No service defects evident	Yes
Vacuum Insulated	3.5 m Diameter x 20.2 m	1994	30	18/8 Stainless	Full Internal / External	Visual, dye pen. radiography plus pressure testing	Satisfactory. No service defects evident	Yes
Bulk Storage	10.7 m Diameter x 14.2 m	1996	34	Aluminium Alloy	Partial Internal / External	Visual	Satisfactory. No service defects evident	Yes
Bulk Storage	21.3 m Diameter x 18.7 m	1997	28	18/8 Stainless	Partial Internal / External	Visual	Satisfactory. No service defects evident	Yes

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Bulk Storage	21.3 m Diameter x 18.7 m	1997	28	18/8 Stainless	Partial Internal / External	Visual	Satisfactory. No service defects evident	Yes
Vacuum Insulated	2.5 m Diameter x 7 m	1991	27	9% Nickel	Full Internal / External	Visual, dye pen. radiography plus ultrasonic thickness test	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.2 m Diameter x 2.5 m	1991	23	18/8 Stainless	Full Internal / External	Pressure test, then cut for visual & dye pen	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1 m Diameter x 2 m	1991	23	18/8 Stainless	Full Internal / External	Pressure test, then cut for visual & dye pen	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.2 m Diameter x 2.5 m	1991	27	18/8 Stainless	Full Internal / External	Pressure test, then cut for visual & dye pen	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1 m Diameter x 2 m	1991	24	18/8 Stainless	Full Internal / External	Pressure test, then cut for visual & dye pen	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.8 m Diameter	1995	30	18/8 Stainless	Full Internal / External	Visual	Satisfactory. No service defects evident	Yes

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Vacuum Insulated	Sphere 2.1 m Diameter	1995	32	18/8 Stainless	Full Internal / External	Visual	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.2 m Diameter x 2 m	1995	33	18/8 Stainless	Full Internal / External	Visual	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.8 m Diameter	1995	30	18/8 Stainless	Full Internal / External	Visual	Satisfactory. No service defects evident	Yes
Vacuum Insulated	1.7 m x 4.7 m	1998	32	Stainless Steel	Pressure Test: Demolition: Internal & External	Visual and Selected Dye Pen Inner 100% Radiography	Satisfactory	No
Vacuum Insulated	3.38 m x 8.9 m	2000	29	Stainless Steel	Demolition: Internal & External	Visual and Selected Dye Pen	Satisfactory	No
Vacuum Insulated	2.6 m x 8.2 m	2000	30	Stainless Steel	Demolition: Internal & External	Visual and Selected Dye Pen	Satisfactory	No
Vacuum Insulated	2.6 m x 7.4 m	2000	22	Stainless Steel	Demolition: Internal & External	Visual and Selected Dye Pen	Satisfactory	No

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Vacuum Insulated	2.44 m x 7.3 m	2000	35	Stainless Steel	Demolition: Internal & External	Visual and Selected Dye Pen	Satisfactory	No
Vacuum Insulated	1.4 m x 3.4 m	2001	40	Stainless Steel	Demolition: Internal & External	Visual and 'T' Joints X rayed.	Satisfactory	No
Vacuum Insulated	3.4 m x 9.5 m	2001	21	Stainless Steel	Demolition: Internal & External	Visual and 'T' Joints X rayed.	Satisfactory. No service defects evident	No
Vacuum Insulated	2.44 m x 7.3 m	2001	35	Stainless Steel	Demolition: Internal & External	Visual and 'T' Joints X rayed.	Satisfactory. No service defects evident	No
Vacuum Insulated	1.8 m Diameter x 4.3 m	1994	30	18/8 Stainless	Full internal	Visual	Satisfactory. No service defects evident	Yes
Vacuum Insulated	2.1 m Spherical	1994	31	9% Nickel	Full internal	Visual	Satisfactory. No service defects evident	Yes
Vacuum Insulated	0.95 m Diameter x 2.8 m	1994	32	18/8 Stainless?	Full internal	Visual	Satisfactory. No service defects evident	Yes

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Vacuum Insulated	1.8 m Diameter x 2.6 m	1994	30	18/8 Stainless?	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated Dumpy type	3.3 m Diameter x 1.4 m	2000	33	9% Nickel	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	2.3 m Diameter x 6.5 m	2000	30	9% Nickel	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	2.6 m Diameter x 9.6 m	1998	?	9% Nickel	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	1.2 m Diameter x 3.7 m	1998	27	18/8 Stainless	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	0.95 m Diameter x 2.8 m	1998	26	18/8 Stainless	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	1.56 m Diameter x 5 m	1998		Aluminium	Full internal	Visual	Satisfactory - no surface defects evident	Yes

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Vacuum Insulated	2.6 m Diameter x 6.7 m	1998	28	9% Nickel	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated Dumpy type	2.0 m Spherical	1998	37	?	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	2.6 m Spherical	1998	35	9% Nickel	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	2.6 m Diameter x 6.6 m	1998	?	9% Nickel	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	2.6 m Diameter x 6.6 m	1998	23	9% Nickel	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	2.6 m Diameter x 3.7 m	1998	36	18/8 Stainless	Full internal	Visual	Satisfactory - no surface defects evident	Yes
Vacuum Insulated	1.6 m Diameter x 5.0 m	1998	28	Aluminium	Full internal	Visual	Satisfactory - no surface defects evident	Yes

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Vacuum Insulated	1.22 m Diameter x 3.7 m	1998	22	18/8 Stainless	Full internal	Visual	Satisfactory. No surface defects evident.	Yes
Vacuum Insulated	1.0 m Diameter x 2.8 m	1998	27	18/8 Stainless	Full internal	Visual	Satisfactory. No surface defects evident.	Yes
Vacuum Insulated	2.2 m Diameter x 4.8 m	2001	35	9% Nickel	Full internal	Visual	Satisfactory. No surface defects evident.	Yes
Vacuum Insulated	2.6 m Diameter x 10 m	2001	32	9% Nickel	Full internal	Visual	Satisfactory. No surface defects evident.	Yes
Vacuum Insulated	1.2 m Diameter x 3.2 m	2001	31	18/8 Stainless	Full internal	Visual	Satisfactory. No surface defects evident.	Yes
Vacuum Insulated	2500 litre	2009	35	Stainless	Full internal and directed X-ray on “T” joints thickness and dye pen/Mag particle on vessel and jacket supports.	Visual and part X-ray, ultrasonic, dye pen and mag particle	Satisfactory in all respects.	No

EXAMINATION SUMMARY OF CRYOGENIC TANKS

Type of Tank	Approximate Size	Date of Examination	Years in Service	Material of Construction	Extent of Examination	Method of Examination	Result of Examination	Independent Authority Present
Vacuum Insulated	9300 litre	2009	38	9Ni	Full internal, X-ray on "T" joints thickness, dye pen/Mag particle on vessel and jacket supports	Visual and part X-ray, ultrasonic, dye pen and mag particle	Satisfactory in all respects	No
Vacuum Insulated	18000 litre	2009	41	9Ni	Full internal, X-ray on "T" joints thickness, dye pen/Mag particle on vessel and jacket supports	Visual and part X-ray, ultrasonic, dye pen and mag particle	Satisfactory in all respects	No
Vacuum Insulated	35000 litre	2009	44	9Ni	Full internal, X-ray on "T" joints thickness, dye pen / Mag particle on vessel and jacket supports	Visual and part X-ray, ultrasonic, dye pen and mag particle l	Satisfactory in all respects	No