

# **Demolition of vertical cylindrical steel storage tanks and LPG spheres**

**PUBLICATION 154**

**Edition 3**

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# Demolition of Vertical Cylindrical Steel Storage Tanks and LPG Spheres

## Publication 154

**Edition 3**

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# 1. Introduction and Scope

## 1.1 Introduction

The demolition of vertical cylindrical storage tanks and column-supported spheres requires specialised knowledge and experience. An ordinary demolition contractor would require some degree of technical guidance to handle this work. Each tank should be considered individually and specific consideration given to age, design, condition, service history and location. This will allow a full assessment to be made of the tank and its condition so that a comprehensive contract specification can be drawn up. The need to demolish a storage tank is not always determined by its condition; it is therefore essential, for the owner/user, from hereon referred to as “the owner\*” and the contractor to carry out a detailed inspection prior to the start of demolition. The type and strength of the structure and site conditions may influence the preferred demolition method. Various alternatives are possible and each will have its advantages depending on the limitations imposed by the location, etc. This document describes the various phases of the work and highlights some of the pitfalls that may be encountered.

## 1.2 Scope

### 1.2.1 General

In the last thirty years many vertical steel storage tanks have been demolished worldwide. In some cases the owners of such tanks entered into contracts with demolition contractors without sufficient knowledge of the problems involved. As a consequence a number of serious and sometimes fatal accidents have occurred. The causes amongst others have included inadequate contract specification, insufficient inspection and supervision, shortcomings in the site safety arrangements and unsafe demolition procedures.

This document provides guidelines for the following types of structures:

- Vertical cylindrical, non-refrigerated, storage tanks built in accordance with BS 2654<sup>(1)</sup>, API 650<sup>(2)</sup> or an equivalent code
- Vertical cylindrical, refrigerated storage tanks built in accordance with BS 7777<sup>(13)</sup>, API 620<sup>(3)</sup> or an equivalent code
- Column supported LPG or Ammonia spheres built in accordance with BS 5500<sup>(4)</sup>, ASME Section VIII<sup>(5)</sup>, Division 1 or 2 or other national pressure vessel code

These guidelines are written particularly for the owners of storage tanks and spheres and outline the steps necessary to achieve a satisfactory and safe demolition. Although some information is included on demolition procedures, this document does not provide a comprehensive list of all methods that may be proposed by demolition contractors. This guidance is intended to assist the owner in evaluating the acceptability of the methods proposed.

This document assumes that the tank material will not be re used to construct a new tank.

\*Throughout this text the term ‘owner’ is used for the party having the ultimate responsibility for the safe demolition of the tank. To avoid subsequent difficulties it is essential that should a party other than the owner be assigned this responsibility, this is clarified and understood prior to detailed contract discussions and the commencement of any site work.

### 1.2.2 Refrigerated Storage Tanks

While at present there is no immediate industry need for recommendations on the demolition of refrigerated storage tanks, a section has been included covering this type of tank (Section 10).

## 2. Responsibilities of Owner and Contractor

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The responsibilities and obligations of Owner and Contractor should be clearly set out in the contract to ensure a clear understanding of the responsibilities and obligations by all parties involved.

The contract must be consistent with legal requirements. For example, in the UK, the Construction (Design and Management) Regulations 2015<sup>(9)</sup> will apply. These regulations require the Owner to appoint a Principal Designer and to appoint the Principal Contractor. The CDM Regulations specify the responsibilities of the Owner, the Principal Designer and the Principal Contractor. For example, the Principal Designer is to ensure that a "Pre-Tender Stage Health and Safety Plan" is prepared. The Principal Contractor is then required to develop the health and safety plan before works starts on site and to keep it up to date throughout the construction phase.

Other regulations, which may be applicable, are The Management of Health and Safety at Work Regulations 1999 and the Environmental Protection Act 1990.

The Contractor must take steps to ensure prevention of contamination of the ground, groundwater and sewers etc. both during preparatory works and the demolition works.

### 2.1 Owner's Responsibilities

The owner shall ensure that all required external permits are in place before the Contractor begins work. It may be necessary to operate within Planning and Building Regulations and if the tank is adjacent to residential property, further conditions or Public Notices may be required.

The owner shall also ensure any environmental permits that may be required are in place, particularly if contamination is present in the tank and/or foundations.

The owner has the responsibility to appoint the demolition contractor and he must satisfy himself that the contractor is capable of providing the supervision, labour and equipment consistent with the needs of the task. He must also be satisfied that the contractor will conduct his operations in accordance with good demolition practice. Documents such as BS 6187:2011<sup>(7)</sup> and the H&SE Guidance on GS29/4<sup>(8)</sup> provide basic guidance in this regard.

In addition the owner should take particular note of the following:

The agreed demolition procedure should take account of all the requirements set out in this document as well as recognising the special requirements of the individual tank, its location and local conditions and constraints. This must include establishing the boundaries of the site within which the demolition contractor will work.

All relevant site details as well as design and operating data for the tank to be demolished should be made available prior to the development of the demolition procedure.

Appropriate supervision should be provided throughout the demolition period. A project engineer should have overall responsibility for all technical aspects and a safety inspector should provide the detailed day-to-day safety checks. These should include checking the contractors' compliance with the agreed procedures, gas tests in and around the tank, scrutiny of hot work procedures and general safety measures.

Arrangements should be made in advance for the safe disposal of all materials. Legislation concerning the removal of poisonous or contaminated materials from the site must be carefully followed. The importance of the correct removal and disposal of lead contaminated materials is

highlighted here, as these should never be sold for re-use but should be sent to a steel works for re-melting.

A record of the demolition proceedings should be kept for future reference and to facilitate investigations in the event of an accident.

A permit to work procedure will usually be required for demolition of storage tanks, particularly to ensure the essential checking of the tank and its connected services prior to the commencement of the work or parts of the work.

## **2.2 Contractor's Responsibilities**

The Contractor will normally be required to establish and observe safe working practices and to comply with the relevant site instructions.

He should prepare a demolition procedure defining the approach to be used taking full account of all aspects of the site, its access, conditions and any limitations or constraints imposed by local regulations.

The safety of equipment used should be regularly checked and all necessary maintenance should be carried out before the equipment is used.

The approved safety equipment (e.g. safety clothing, harnesses, life lines, breathing equipment, helmets, etc.) should normally be provided by the contractor and kept in a secure and dry place when not in use. Work should not be undertaken until all certificates and permits have been read, authorised and accepted. The contractor's method statement should include all necessary details (see Section 6.3).

## 3. Types of Vessels

### 3.1 Storage Tanks (Non-Refrigerated)

#### 3.1.1 Types of Storage Tank

Vertical cylindrical steel storage tanks can be divided into two main groups: fixed roof tanks and floating roof tanks.

The main structural hazard associated with tank demolition concerns the roof and the roof supporting structure. It is therefore important to recognise the different designs that may be found in practice.

#### 3.1.2 Fixed Roof Tanks

Fixed roofs may be flat, conical or dome shaped (spherical). Generally, tanks less than 12m diameter have either:

- A self-supporting membrane type roof without framing
- A supported roof with a simple rafter type framing

Tanks over 12m diameter have either:

- A supported roof with a trussed type framing supported off the shell
- A supported roof with a column supported framing

Note: Fixed roof tanks used for the storage of motor spirit or other volatile products are often equipped with an internal floating cover.

#### 3.1.3 Floating Roof Tanks

The following types of floating roof are commonly used:

- Pontoon type floating roof
- Double deck floating roof
- Pontoon type roof with radial stiffeners
- Buoy type floating roof

### 3.2 Refrigerated Liquefied Gas Storage Tanks

First generation tanks, built prior to 1975 are frequently classified as "single containment tanks". The tanks may have a single or double wall. The tanks were usually designed to BS 4741<sup>(11)</sup>, BS 5387<sup>(12)</sup> or API 620, Appendices Q and R.

Single wall tanks, with external insulation, were normally used for the storage of butane, ammonia, propane and propylene. See Figure 11 and 12. Double wall tanks were normally used for the storage of ethane, ethylene and LNG. See Figure 13 and 14. The outer wall of a double wall tank is not designed to contain the refrigerated liquid, but provides the vapour barrier for the insulation around the inner tank. The outer wall is rather thin.

Double wall tanks without suspended deck were provided with an inner and outer roof so that the inner tank contained the refrigerated liquid and the product vapour. The space between inner and outer tank was filled with an inert gas (nitrogen) under a small positive pressure. Later double wall tanks were provided with a suspended deck, supporting the roof insulation, and an open-top inner tank. In double wall tanks with a suspended deck, the product vapour is contained within the outer tank.

Second generation refrigerated tanks were built after 1975. These tanks are classified as either double or full containment tanks. Double and full containment tanks often include a concrete wall with steel liner and concrete or steel roof, surrounding an open-top inner tank. Such tanks are designed to BS 7777.

Refrigerated storage tanks may be constructed on an elevated concrete structure to allow free ventilation under the tank foundation. They can also be placed directly on a foundation at ground level, in which case bottom-heating elements are used to prevent frost heave in the soil under the tank.

### 3.3 Column Supported Spheres

Column supported spheres are used for the storage of liquefied gases under pressure. The shell and the columns are designed to carry the dead weight, the weight of the product or test water and any additional forces resulting from wind or seismic loads. Column supported spheres are stable structures as long as all columns and the column bracing are functioning properly. As soon as one column fails the entire structure is likely to collapse and topple. See Section 11.

## 4. Methods of Demolition

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### 4.1 Demolition Alternatives

There are two demolition alternatives, on site (Figure 2) and off site demolition of which the former is more common.

On site demolition can be further divided into:

- a) Demolition on a decommissioned site
- b) Demolition on an operating site with reasonable access and working area
- c) Demolition on an operating site with restricted access

While this document deals mainly with on-site demolition, many of the principles apply also to off-site demolition. The latter assumes that the tank can be removed in one piece and the feasibility of this need to be checked.

Demolition work can be carried out either cold or hot.

Cold cutting employs some form of spark free cutting device such as water cutting, using a milling cutter, a hydraulic saw or hydraulic scissors (Figure 1).

Hot cutting uses various forms of thermal cutting. The choice of method depends on the tank design and location (Section 5.1), on environmental factors (Section 5.3), on the experience of the contractor (Section 6), and on the equipment available.

### 4.2 Factors Affecting the Choice of Demolition Method

#### 4.2.1 General

The risks to personnel working on the demolition of storage tanks should not be under estimated. Several accidents, some of them fatal, have occurred in the past. Safety awareness is an essential constituent of a satisfactory demolition and demolition options are influenced considerably by local conditions.

These guidelines are not intended to give a complete description of all possible demolition methods but describe the essential requirements of a satisfactory procedure.

#### 4.2.2 Tank Design

Storage tanks are designed to an appropriate Code or Standard. Individual tank components and structural members will be designed and constructed to be consistent with the Code requirements necessary to satisfy a range of imposed or assumed conditions defined at the design stage.

Different conditions arising as a result of damage, distortion or corrosion, or indeed from the demolition process itself, can clearly impose significant changes in loading on tank components and structural members. These can result in failure.