



GS 158-4 REFRIGERATED AMMONIA STORAGE TANKS FOR CHEMICAL PROCESSING PLANT

October 1996

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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SCOPE AND PURPOSE This practice covers BP Chemical's minimum requirements for design, materials, shop and field fabrication, inspection, testing, cleaning, insulation and painting of new ammonia storage tanks. This practice is to supplement: - CIA "Guidance for the large scale storage of fully refrigerated anhydrous ammonia in the UK". - EEMUA Publication 147 "Recommendations for the design and construction of refrigerated liquefied gas storage tanks".											
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FOREWORD

Introduction to BP Group Recommended Practice and Specifications for Engineering

The Introductory volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Guidance for Specification

This Guidance for Specification is a supplement to [EEMUA 147](#) and [CIA](#) "Guidance for the large scale storage of fully refrigerated anhydrous ammonia in the UK" is based on additional requirements developed from lessons learned within the specialist business.

Qualifications to Applicability

This Guidance for Specification although a Group document has been prepared and developed by BP Chemicals and is specifically designed for use in Chemical Plants.

Application

This Guidance for Specification is intended to guide the purchaser in the use or creation of a fit-for-purpose specification for enquiry or purchasing activity. It is to be used as a supplement to [EEMUA 147](#) and the [CIA](#) "Guidance for the large scale storage of fully refrigerated anhydrous ammonia in the UK".

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Engineering Practices Group, Engineering Shared Service or the Custodian. See Quarterly Status List for contacts.



1. SCOPE AND PURPOSE

This practice covers BP's minimum requirements for design, materials, shop and field fabrication, inspection, testing, cleaning, insulation and painting of new ammonia storage tanks.

1.1 Application of this Document

This practice is to supplement:

- [CIA](#) "Guidance for the large scale storage of fully refrigerated anhydrous ammonia in the UK".
- [EEMUA Publication 147](#) "Recommendations for the design and construction of refrigerated liquefied gas storage tanks".

1.2 Type of Tank

This practice supports the [CIA](#) recommendations that new installations are built with secondary containment achieved by either using a double containment or full containment design.

BP requires the secondary containment to be of a steel outer tank. Concrete walls can be used when specifically approved by BP and shown to be more economic.

2. QUALITY ASSURANCE

The following shall apply:

- The tank contractor shall operate a quality system based upon the principles of [ISO 9001](#) or an equivalent standard.
- The tank contractor shall submit his quality plan to the contractor with the bid. A quality plan prepared for a similar job, executed within the past two years may be sufficient at bid stage.
- After the award of the tank contract, the contractor shall prepare a detailed quality plan listing all construction and inspection on an item by item basis. The quality plan shall cover both shop and site activities.

As regards to traceability of materials, the following requirements shall govern:

- The tank contractor shall submit with his tender, his proposed traceability system. Such a system shall ensure that all tank materials and those materials



attached to tank, are able to have their origins traced before, during and after fabrication.

As regards material certification, the requirement is:

- Only steel manufacturer's certificates are acceptable to tank materials including any items welded to the tank. Stockist certificates are unacceptable.

3. MATERIALS

3.1 Inner and Outer Tanks

The inner and outer tanks shall be of all welded construction and fabricated from normalised carbon-manganese steel. The steel shall meet the requirements of type I material as defined in Section 5.0 of [EEMUA 147](#).

3.2 Insulation

- 3.2.1 The load bearing insulation system beneath the base of the inner tank shall be installed by the vendor. The load bearing insulation system shall include cellular glass blocks - Foamglass R by Pittsburgh Corning Inc. Grade HLB 115 or an equivalent. Each glass block layer shall be laid at 90° to the previous layer. An approved inorganic powder shall be used to fill the top and bottom surface of the glass blocks. PC85 by Pittsburgh Corning or equivalent may be considered. Each glass block layer shall be separated from the other by an interleaving material.

Annular rings of perlite concrete or wood suitably impregnated to prevent loss of strength due to ingress of moisture may be used directly below the inner tank shells. The moisture content in perlite concrete to be restricted to 10% maximum, unless approved by BP.

- 3.2.2 The insulation system used in the annular space of the tanks shall consist of three annular layers made up as follows:
- (a) A 'closed cell' foam structure type on the inside of the outer tank. The purpose of this insulation would be to prevent any thermal shock on the outer shell should any leakage occur in the inner tank.
 - (b) Insulation on the outer wall of the inner tank to minimise the compressive load exerted by insulation given in para. 3.2.2 (c) below.
 - (c) Perlite insulation between the above two annular layers.



- 3.2.3 Pipes and fittings which need to be insulated, whenever possible shall use preformed sections. Alternatively, foamed in-situ areas will be sectioned and surfaces prepared to permit future ease of removal. Cleating will be assembled with a soft compressible waterproof joining strip or compound.

3.3 Material Traceability and Certification

- 3.3.1 The tank contractor shall submit with his tender, his proposed traceability system. Such a system shall ensure that all tank materials and those materials attached to tank, are able to have their origins traced before, during and after fabrication.
- 3.3.2 Only steel manufacturer's certificates are acceptable to tank materials including any items welded to the tank. Stockist certificates are unacceptable.

3.4 Miscellaneous

- 3.4.1 The outer tank anchoring material (bolt or strap) shall be identifiable against mill certificates giving chemical analysis and mechanical properties.
- 3.4.2 Any components welded directly to the tanks shall be fabricated from material identical to that part of the tank to which the component is welded.

4. DESIGN

4.1 General

- 4.1.1 The tank shall be erected on an elevated piled concrete slab foundation. The top of the concrete shall be at an elevation of approximately 2.0 metres above the surrounding area. The foundation and tank shall be designed to withstand a full hydrostatic test of the tank.
- 4.1.2 Figure 1 provides the relative levels of normal max. level, HLA, HHLA etc.
- 4.1.3 The design of the inner tank shall be based on a product height to the maximum emergency level. However, it shall be noted that the hydrotest condition may govern the shell minimum thickness requirement. In which case, the design of inner tank shall be based on water fill to maximum emergency level, with the allowable stress not exceeding 85% of the yield or proof stress of the construction material.



- 4.1.4 For double containment the outer tank shall be designed for the equivalent height of product in the outer tank resulting from volume in the inner tank up to maximum emergency level, plus 0.5 m. A check shall be made for test conditions with the allowable stress limit given in Para. 4.1.3. However, during hydrotest conditions, only one half of the design wind load needs to be considered. For full containment the vapour pressure shall be taken in addition to the height mentioned above.
- 4.1.5 The anchorage to resist uplift, due to internal gas pressure, wind or seismic forces shall be provided if there is a possibility for the shell and the adjacent bottom plate of the outer tank to lift off its seating under any conditions of operation or testing. No anchorage shall be provided for the inner tank.
- 4.1.6 The internal and external tanks shall be regarded as completely independent structures in which neither contributes anything to the other in the resistance to uplift.
- 4.1.7 The anchorage shall be attached to the shell and not to the bottom plate of the tank.
- 4.1.8 Anchor bars or straps shall have a minimum cross sectional area of 500 mm². A corrosion allowance of 1 mm shall be added to all surfaces or alternatively they may be made from corrosion resistant material.
- 4.1.9 Anchorage points shall be spaced at a minimum of one metre and at a maximum of 3 metres.
- 4.1.10 The tank design shall accommodate movements of the tank due to thermal changes and minimise induced bending stress in the shell.
- 4.1.11 The final welds or tightening of the anchor bolts shall be carried out when the tank is with water up to its design level.
- 4.1.12 The contractor shall be responsible for providing a water deluge system fire protection for the tank. The system covering spray sizes and locations, automatic detection systems etc. shall be fully in accordance with [NFPA No. 15](#) - standard for water spray fixed system for fire protection. The main objective of the system shall be to keep the outer tank surfaces below 100°C under all environmental conditions.
- 4.1.13 The base insulation system described under para 3.2.1 shall be designed with a minimum safety factor of 3.0. The foamglass shall extend to the full diameter of the outer tank unless other measures are taken to protect the perimeter. In any case the foamglass shall extend beyond the inner tank annular plate by a minimum of 400 mm.



- 4.1.14 For installation in a region of seismic activity, a seismic analysis of the tanks and associated pipework shall be carried out. The inner tank shall be designed to avoid any anchoring. The method used for seismic analysis of the tanks shall be approved by BP at bid stage. For guidance the height/diameter ratio of the tank should not be greater than 0.4.

4.2 Bottom Plates Design

- 4.2.1 The shell/bottom plate corner joint on both tanks shall be of the full penetration type weld.
- 4.2.2 The welded joints of the bottom plates of the outer tank shall be double pass welds. After the first pass, vacuum box testing shall be carried out. Any leaks or faults in the joint shall be made good prior to completion of the second weld pass.
- 4.2.3 The annular plates shall not be wider than 1000 mm. All annular plates shall be ultrasonically inspected for laminations for a distance not less than 150 mm from the outer edge and along the whole length. After examination each plate shall be stamped on its upper surface in a manner that would enable identification to be made even after the completion of construction. For this purpose only round nosed stamps shall be used.

5. WELDING

5.1 General

- 5.1.1 The Contractor shall submit all welding procedure specifications for BP approval. Welding procedure qualification tests shall be carried out on the contract material. Pre-qualified welding procedures are not acceptable for this application.
- 5.1.2 Details of weld profiles for shell joints are given in Figure 3 of this Recommended Practice. Vertical joints in bottom shell courses shall be at least 300 mm away from any annular plate joint.
- 5.1.3 Butt welds between stiffening ring sections shall not be welded through to the shell. A mousehole shall be provided at each butt weld location and the weld between shell and stiffener continued through the mousehole. Butt welds joining ring stiffener sections shall be at least 150 mm away from any main shell seam.



- 5.1.4 Temporary attachments on the tanks shall be kept to an absolute minimum, and on removal the resultant scar shall be dressed smooth and subjected to a dye penetrant examination.

6. CONNECTIONS

Connections between the inner and outer tank shall be detailed in the vendors tender.

7. INSTRUMENTATION

- (a) The instrumentation of the tank shall meet relevant project specifications.
- (b) All instrumentation and level gauges provided shall be clearly identified in the P&ID of the tank.
- (c) For all instrumentation, the contractor shall provide technical details and corresponding vendor information.

8. ELECTRICAL

The outer tank shall be provided with at least 3 earthing connections in accordance with BP Group [RP 12-16](#) Figure 5. The inner tank shall be connected to the outer tank by at least three flexible earthing connections.

The spiral stairway to the top of the tank, the top platform and other areas where personnel need access for maintenance, shall be provided with adequate lighting.

9. STAIRWAY, PLATFORM AND HANDRAILS

9.1 General Requirements

In addition to the requirement given below, stairways, platforms and handrails shall comply with the structural requirements of project civil specifications. Stair treads shall meet project specifications.

9.2 Stairway

The stairway to the top of the tank shall be a spiral type with the access tower as its axis.

9.3 Platforms

Platforms with access from the main stairway shall be provided such that necessary maintenance facilities to all accessories at the top of the



tank can be provided. The design and coverage of this platform shall consider the safety of personnel working in the platform area.

10. SITE FABRICATION AND ERECTION

- (a) The method of construction shall be the erection of the outer tank and roof prior to installation of foundation insulation, followed by erection of the inner tank. Alternative procedures will be considered, but details of erection will be subject to BP approval.
- (b) No work shall be subcontracted out without the written approval from the contractor.

11. COMMISSIONING AND DECOMMISSIONING

- (a) A system shall be provided for purging the inner tank and outer annular space for both commissioning and subsequent in-service examination should the need arise.
- (b) Unless otherwise agreed with BP, an independent chill down system shall be provided for commissioning which will be separate from the normal operating fill system. Such a 'system' shall be removed from site after commissioning.
- (c) A low level pump-out provision shall be provided for emptying the tank prior to decommissioning.

12. ADDITIONAL INSPECTION

- (a) The inspection guidelines given under 7.1.5 of [EEMUA 147](#) shall be considered as mandatory. Ref. para. 7.1.5 (5) of [EEMUA 147](#), the following additional NDT tests shall be carried out:

- 100% Radiography on any welded joints in anchor straps.
- 100% Crack detection on anchor bolt attachments to shell.

All radiographic examination during fabrication shall be carried out with X-Ray equipment.

- (b) All plates for construction and test shall be surface inspected. Plates over 12mm thick shall be ultrasonically inspected by automatically recording equipment, transverse to the direction of rolling. The acceptance limits shall be as defined in [ASTM A578](#), acceptance level 1.
- (c) It shall be the responsibility of the contractor to maintain adequate inspection at tank vendor's works and erection site to ensure that the requirements of this



Code and related documents are met. As a minimum the contractor's inspection scope shall cover the following activities:

- All activities covered under Para 7.1.5 of [EEMUA 147](#) and para 12. (a) above.
- Laying of base insulation.
- Position and squareness of termination point flanges.
- Cleanliness of inner tank, piping and annular space.
- Hydrotesting of tanks.
- Surface preparation and painting.
- Cleanliness and installation and operation of all safety relief (including vacuum valves) devices.

It should be noted that either the inspection by independent inspection authority or tank vendor's inspection is not a substitute for contractor's inspection.

13. PAINTING

- (a) All external surfaces of the outer tank shall be suitably prepared and painted in accordance with project painting specification after the testing of the tank is completed.
- (b) Specifically external surfaces of the outer tank and connected piping shall be blast cleaned to [BS 4232](#) second quality to match the pictorial standards shown in Swedish standard [055900 Sa 2 1/2](#). The tank surfaces shall then be primed with 2 coats of zinc phosphate, 2 pack epoxy primer, 65 microns dft per coat and finished with 2 coats of micaceous iron oxide, 2 pack epoxy finish 75 microns dft per coat to give a total dry film thickness of 280 microns.
- (c) The paintwork shall be guaranteed for 5 years.

14. INDEPENDENT INSPECTION

BP shall nominate an Independent Inspection Authority (IIA) to carry out the inspection and testing of the tank together with necessary design approval. All cost incurred by IIA will be borne by BP. However, cost due to additional inspection resulting from tank vendor's/contractor's fault would be back-charged to the contractor. It shall be the tank vendors responsibility to submit necessary calculations, drawing, documents etc. to the IIA and receive the necessary approval. Also the tank vendor shall be responsible for arranging with the IIA to carry out the inspection at appropriate stages. It is to be noted by the tank vendor that BP shall be at liberty to carry out any inspection during the entire construction stage of the tanks.

As a minimum, the following inspection activities shall be carried out by IIA:



- (a) Before the start of any fabrication, all plates shall be examined and their certificates be checked against identification mark on materials. It is to be ensured that all materials are free from defects and that their thicknesses, other dimensions etc. are not less than those values in approved design calculations.
- (b) The detail of material properties listed in materials certificates shall be verified to ensure that they are not inferior to the requirements of the corresponding specifications of the material. Any additional requirements imposed by BP on material shall be taken into account.
- (c) All relevant weld procedures shall be approved.
- (d) Welder performance qualification certificates shall be reviewed. Welders shall be site qualified by the contractor's Site Welding Inspector. Acceptance will be on contract material based on X-ray examination.
- (e) All shell and roof plates shall be examined after forming.
- (f) The edges of all openings in shell and roof cut to incorporate nozzles shall be examined to ensure that they are free from any laminations.
- (g) Set up of weld seams shall be examined. The examination shall include edge preparation, alignment of plates, alignment of pipe welds etc.
- (h) All X-ray films shall be reviewed and unacceptable weld defects shall be reported.
- (i) 100% vacuum box testing and 100% crack detection shall be witnessed.
- (j) Installation of both shell insulation and bottom foam glass block insulation system shall be inspected.
- (k) Hydrostatic and leak testing per para. 8.0 of [EEMUA 147](#) shall be witnessed.
- (l) Details of nameplates shall be checked.
- (m). The contents of the construction dossier shall be reviewed for completeness and correctness.
- (n) A certificate of construction confirming that the design, construction etc. of the tank fully complies with the tank specification.

15. DRAWINGS AND SPECIFICATIONS

The contractor shall be responsible for supplying tank vendor's drawings and documents to BP. As a minimum the following documents need to be approved by BP:



- (a) Tank specification and quality plan.
- (b) Tank process/mechanical data sheet.
- (c) Enquiry requisition of the tank.
- (d) Purchase requisition of the tank.
- (e) Fabrication drawing to include procedure for foamglass block laying, inner and outer tank details, all connections, suspended deck and platforms together with stairway. All fabrication drawing where relevant shall include the thickness, specification and grade of all materials used including weld metal, design conditions, design code, weld procedures and their preparation, etc.
- (f) Detail mechanical calculation including seismic analysis and heat gain computation.
- (g) All welding procedures.
- (h) Repair procedures.
- (i) Test procedures.
- (j) Painting specification.

16. INFORMATION TO BE SUPPLIED BY THE CONTRACTOR WITH HIS TENDER

The contractor shall provide the following information with his tender:

- (a) Proposed tank vendor's list and their experience in the design and construction of similar type of tanks.
- (b) Contractor's standard technical specification for RLPG tanks.
- (c) Detail of quality system operated by tank vendor.
- (d) Preliminary diameter and height of both inner and outer tanks.
- (e) Design loadings (including internal and external pressure) of both tanks.
- (f) Type of safety valves and the names of suppliers.
- (g) Detail of materials and its source.
- (h) Scantling thicknesses.



- (i) Where relevant preliminary seismic analysis of the tank system.
- (j) Pump supplier's details, pump duty specification, number of pumps and arrangement.
- (k) Full technical specification of insulation (both foam glass blocks and shell insulation) their thicknesses.
- (l) P&ID and a schematic sketch of the tank system.
- (m) Process data sheet for tank with details of all connections.
- (n) All instrumentation data and the vendor list for instrumentation.
- (o) Proposals for the removal of liquid in the annular space of the tank resulting from entail spillage failure of the inner tank.
- (p) Synopsis of the deluge system provided.
- (q) Details of access opening on suspended deck.
- (r) Schedule for design, construction and commissioning of the tank.
- (s) Proposals for filling and removal of Perlite insulation.

17. TANK DOSSIER

Before the tank is handed over to BP, the contractor shall be responsible for providing BP with the required number of tank dossiers, as specified in the contract documents. As a minimum, the dossiers shall contain the following information:

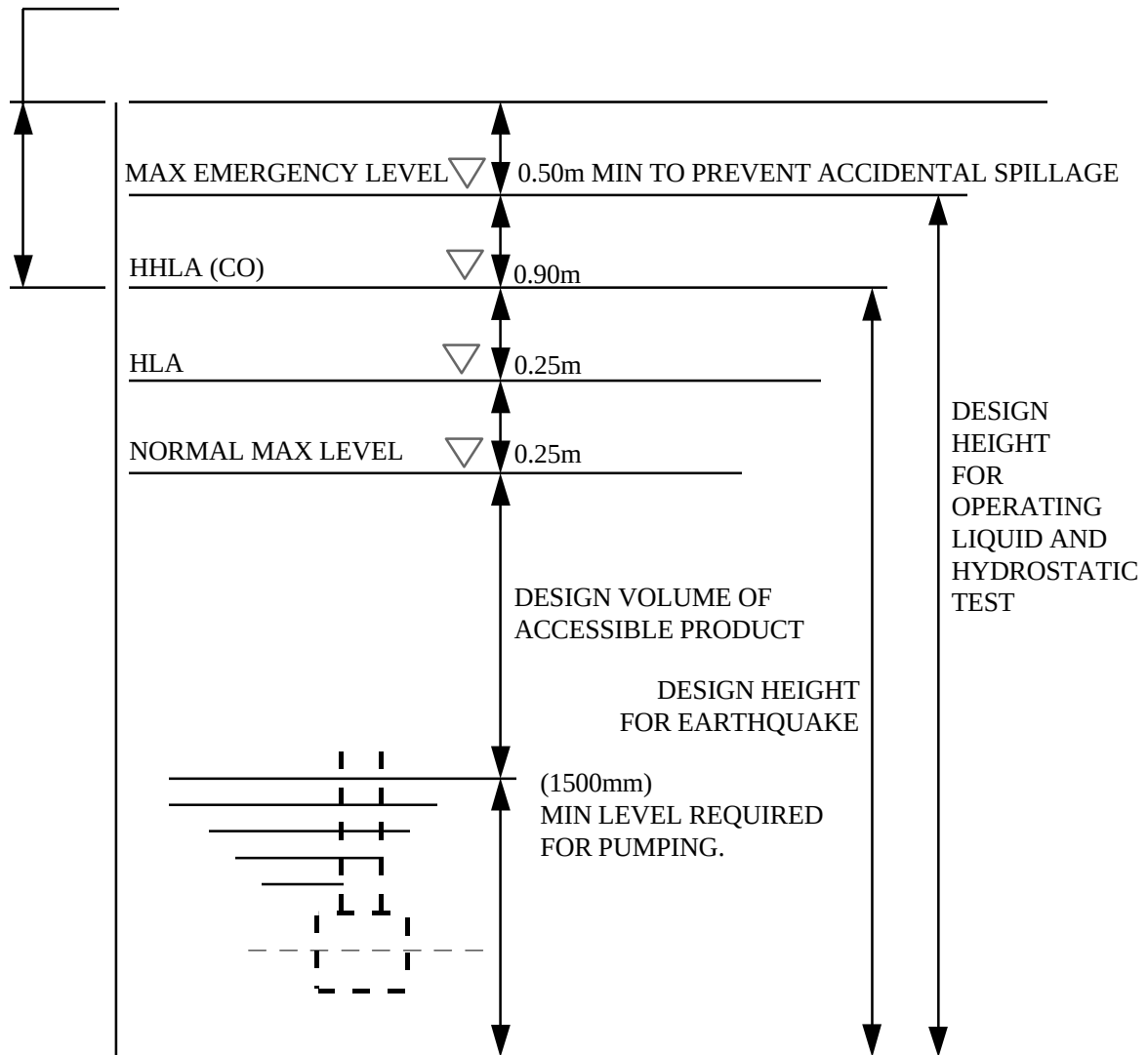
- (a) IIA design approval letter and certificate of acceptance of the tank.
- (b) Approved fabrication drawing.
- (c) Material identification chart.
- (d) Set of design calculations approved by IIA.
- (e) Radiograph identification chart.
- (f) Approved repair procedures.
- (g) Radiograph report.
- (h) Welder/seam identification chart.



- (i) Qualified welding procedure specifications.
- (j) Welder qualifications.
- (k) Weld crack detection report.
- (l) NDT personnel qualification.
- (m) Pressure test report and vendor's certificate.
- (o) Nameplate rubbing.



HEIGHT TO CONTAIN PRODUCT IN EARTHQUAKE. *



* NOT LESS THAN SLOSHING HEIGHT UNDER SEISMIC LOADING

FIGURE 1

INNER TANK LEVEL REQUIREMENTS



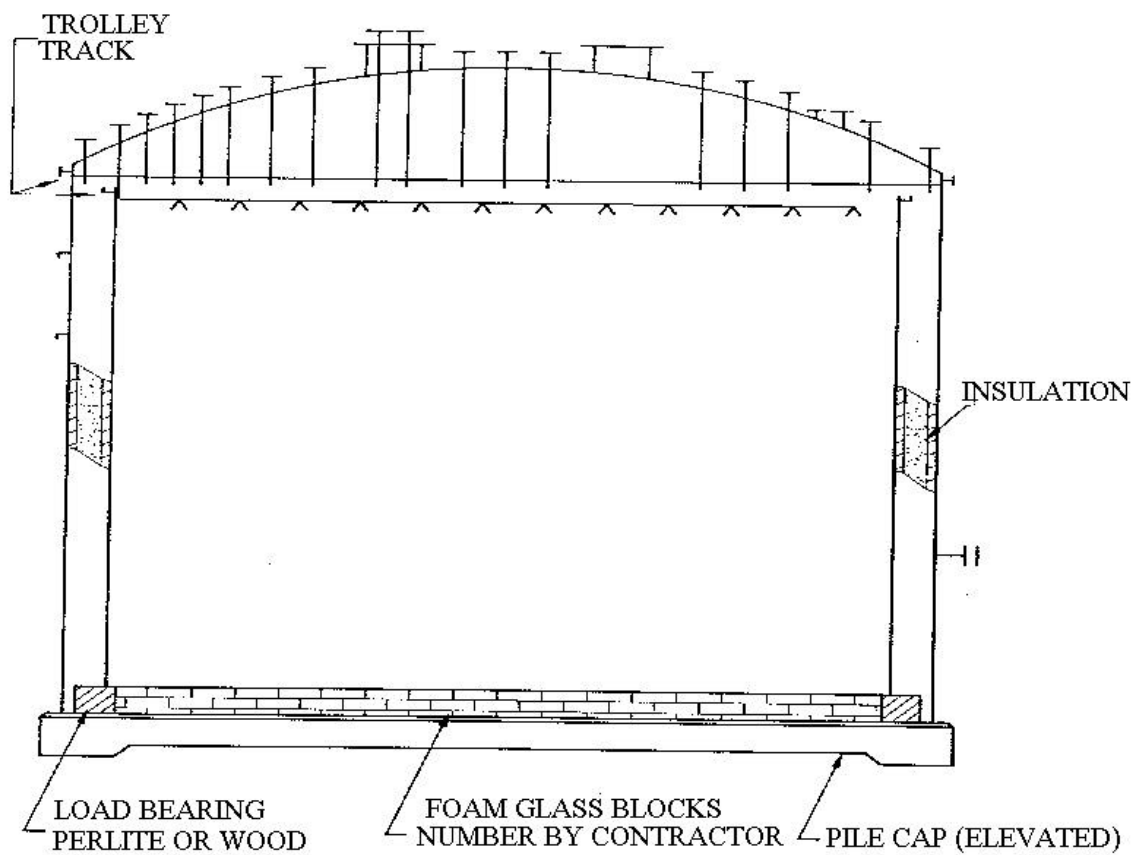


FIGURE 2
SCHEMATIC SKETCH OF TANK

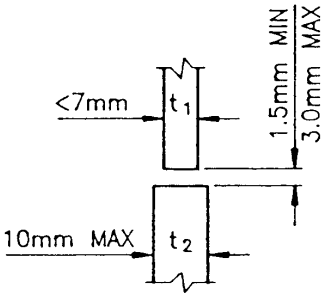
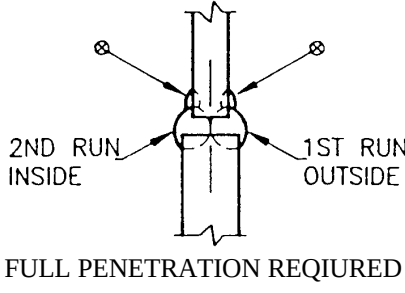
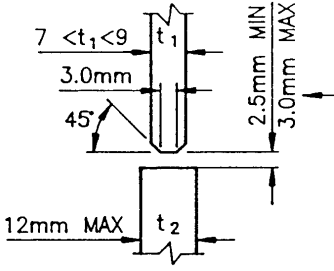
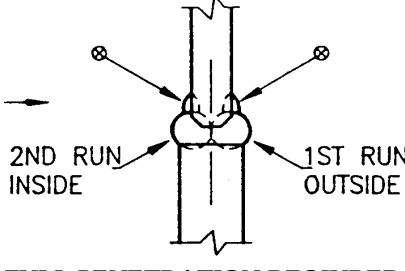
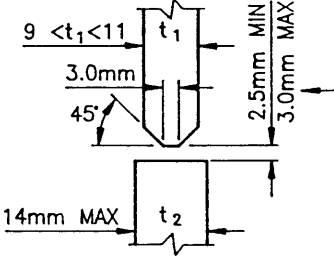
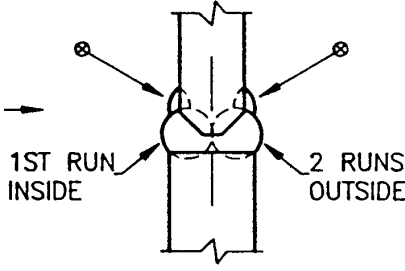
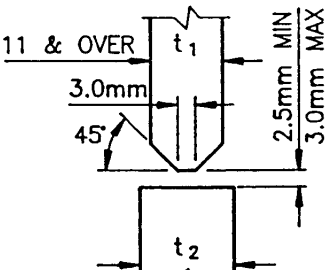
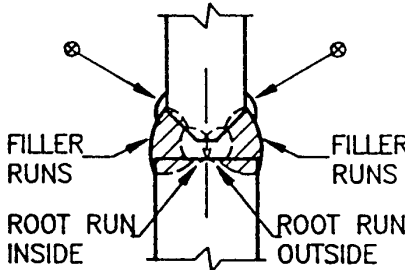
JOINT DETAIL	WELDING PROCEDURE	WELD DETAIL
	ONE RUN EACH SIDE WITH 4.0mm OR ONE RUN EACH SIDE WITH 3.25mm WHEN $t_2 < 6.25\text{mm}$ THE JOINT SHOULD BE BACK CHIPPED TO ENSURE SOUND ROOT PENETRATION IF THE GAP CONTRACTS SUFFICIENTLY TO REQUIRE THIS PRECAUTION.	
	← 1ST & 2ND RUNS WITH 4.0mm →	
	TWO RUNS OUTSIDE AND ONE RUN INSIDE WITH 4.0mm PREFERRED. ALTERNATIVELY 1ST RUN OUTSIDE WITH 5.0MM 2ND RUN OUTSIDE WITH 4.0MM 1ST RUN INSIDE WITH 5.0MM	
	ROOT RUNS WITH 4.0mm FILLER RUNS (SHADED AREAS) WITH 4 OR 5.0mm	
NOTE:- 't_1' = THICKNESS OF UPPER PLATE 't_2' = THICKNESS OF LOWER PLATE <u>UNDERCUT</u>: RUNS MARKED ⊗ TO FILL UNDERCUT WHERE NECESSARY MUST BE APPLIED WITH 3.25 OR 4.0mm		

FIGURE 3
APPROVED MANUAL WELDING PROCEDURES
(SHEET 1 OF 2)

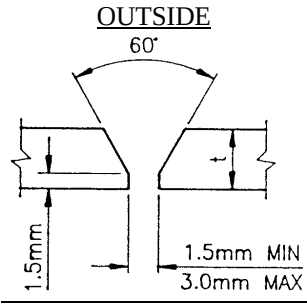
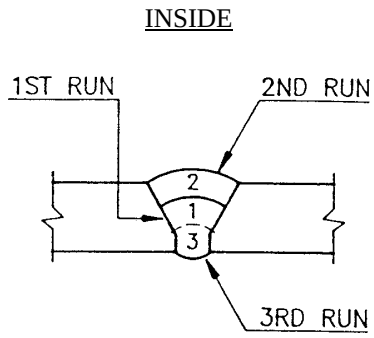
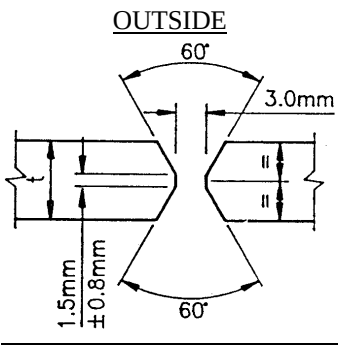
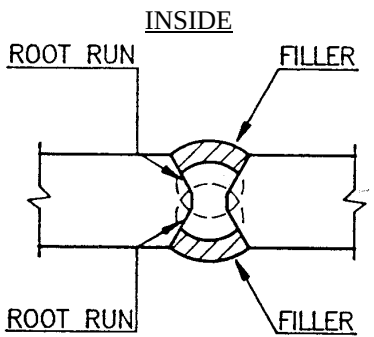
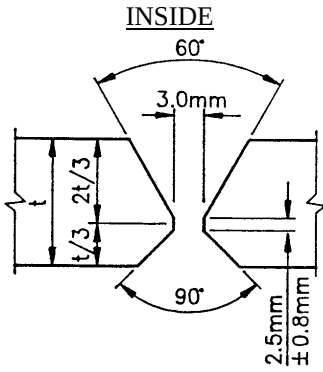
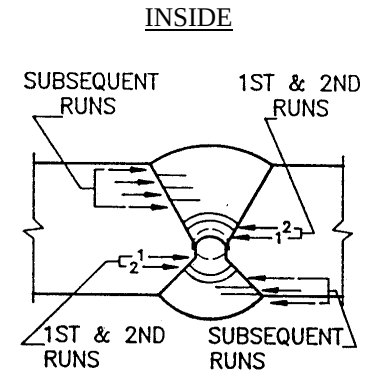
JOINT DETAIL	WELDING PROCEDURE	WELD DETAIL
5mm < t < 9mm THICK  OUTSIDE 60° 1.5mm 1.5mm MIN 3.0mm MAX INSIDE	2 RUNS OUTSIDE AND 1 RUN INSIDE WITH 3.25mm PREFERRED. ALTERNATIVELY 4.0mm PERMITTED. ALL RUNS APPLIED IN UPWARD DIRECTION.	 INSIDE 1ST RUN 2ND RUN 3RD RUN OUTSIDE
9mm < t ≤ 13mm THICK  OUTSIDE 60° 3.0mm 1.5mm ±0.8mm 60° INSIDE	ALL RUNS WITH 3.25mm ALTERNATIVELY ALL RUNS WITH 4.0mm. RUNS APPLIED IN UPWARD DIRECTION. FILLER RUNS (SHADED AREAS)	 INSIDE ROOT RUN FILLER OUTSIDE
t > 13mm THICK  INSIDE 60° 3.0mm 90° 2.5mm ±0.8mm OUTSIDE	TWO RUNS OUTSIDE AND ONE RUN INSIDE WITH 4.0mm PREFERRED. ALTERNATIVELY 1ST RUN OUTSIDE WITH 5.0MM 2ND RUN OUTSIDE WITH 4.0MM 1ST RUN INSIDE WITH 5.0MM	 INSIDE SUBSEQUENT RUNS 1ST & 2ND RUNS OUTSIDE
NOTE:- 't1' = THICKNESS OF PLATE		

FIGURE 3 (SHEET 2 OF 2)

APPROVED MANUAL WELDING PROCEDURES



DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSEs Introductory volume.

Tank Contractor	The organisation responsible for the complete design, fabrication, supply and installation of the Tank.
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Abbreviations

ASTM	American Society for Testing Material
CIA	Chemical Industries Association
EEMUA	Engineering Equipment and Material Users Association
HHLA	High High Level Alarm
HLA	High Level Alarm
IIA	Independent Inspection Authority
NFPA	National Fire Protection Agency
NDT	Non-Destructive Testing
P&ID	Piping and Instrument Diagram
RLPG	Refrigerated Liquid Petroleum Gas



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

International Standards

ISO 9001 Quality Systems - Specification for design/development, production, installation and servicing.

British Standards

BS 4232 Surface Preparation

RP Group Documents

RP 12-16 Electrical Systems and Installations - Earthing and Bonding

Industry Codes and Standards

CIA Guidance for the large scale storage of fully refrigerated anhydrous ammonia in the UK.

EEMUA 147 Recommendations for the Design and Construction of Refrigerated Liquefied Gas Storage Tanks.

NFPA 15 National Fire Protection Agency

ASTM A578 Specification for Ultrasonic Examination of Plain and Clad Steel Plates

