



**HELLENIC GAS  
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**TECHNICAL JOB  
SPECIFICATION**

**400/1**

**REVISION 0**

**DATE 29/06/2011**

## **LNG PLANT**

## **CIVIL DESIGN LOADS**



Job Spec. No 400/1  
Revision 0  
Date 29-06-2011  
Page 2/17

QUALITY ASSURANCE PAGE

CHANGES LOG

REVISIONS LOG

Rev. No	Rev. Date	REASON FOR CHANGE	Made By	Approved By
0	29-06-2011	FIRST ISSUE	PQ DPT.	V.G.

Job Spec. No 400/1  
Revision 0  
Date 29-06-2011  
Page 3/17

## CONTENTS

### REFERENCE DOCUMENTS

- 1.0 SCOPE
- 2.0 APPLICABLE CODES
- 3.0 DEFINITIONS
- 4.0 LOAD CASES
- 5.0 LOADING COMBINATIONS

Job Spec. No 400/1  
Revision 0  
Date 29-06-2011  
Page 4/17

**REFERENCE DOCUMENTS**

ELOT EN 1991

[Eurocode 1: Actions on structures]

ELOT EN 1992

[Eurocode 2 - Design of concrete structures]

ELOT EN 1993

[Eurocode 3: Design of steel structures]

EAK-2003 ΦΕΚ 781Β/18.06.2003

«Τροποποίηση και συμπλήρωση Ελληνικού Αντισεισμικού Κανονισμού  
ΕΑΚ 2000»

[Hellenic Seismic Code]

## 1.0 SCOPE

This specification covers Load Cases and Load Combinations to be considered in the design of steel and concrete structures and foundations.

This specification is not applicable to the design of tanks, vessels or silos (i.e. for vessel wall thickness), but it is applicable for calculating minimum design loads for base plates, base rings, anchor bolts and foundations of the previous.

Blast Loads and Load Combinations are not included in this specification.

This specification is not intended to replace sound engineering judgment.

## 2.0 APPLICABLE STANDARDS AND LEGISLATION CODES

Structural design shall follow the Hellenic Legislation Codes. For subjects not covered by Hellenic Legislation Codes, European Standards i.e. Eurocodes or any relevant Code acceptable by Hellenic Authorities may be used. Loads shall follow the requirements of **ELOT EN 1991 (Eurocode 1)**.

In case of conflict between Standards, Codes and this specification the more stringent one will govern.

## 3.0 DEFINITIONS

### 3.1 GENERAL

All structures shall be designed to encounter loading conditions occurring during:

- Realization (construction, transportation, installation).
- Expected structure lifetime (tests, normal operation, environmental impacts).

### 3.2 LOAD CASES

Load Cases are sets of individual loads having the same origin, i.e. are caused by the same natural phenomenon. Examples are the Dead Weight, Wind, Earthquake, etc.

### 3.3 LOAD COMBINATIONS

Load Combinations are groups of Load Cases which may occur simultaneously for a certain time in the life of the structure.

Examples of Load Combinations are the groups of loads acting during erection, during tests (hydrotest), during normal operation, at the time of earthquake etc.

## 4.0 LOAD CASES

### 4.1 DEAD LOADS

- Dead weight of main and secondary structures including cladding, flooring, the partition walls, handrails, protection nets, fire proofing coating.
- Dead weight of all items permanently attached to the structure, (equipment, machines, tanks, cranes, piping, etc).

Piping loads may be estimated as follows:

- In areas of extensive piping, such as the lower two floors of tower structures:  
1,0 KN/m<sup>2</sup>

**Job Spec. No** 400/1  
**Revision** 0  
**Date** 29-06-2011  
**Page** 6/17

- Floors supporting a lesser amount of piping: 0,5 KN/m<sup>2</sup>
- All pipes larger than DN 300 diameter shall be considered as concentrated loads at their point of support.
- High pressure pipes and fittings of all sizes shall be adequately considered.

#### 4.2 LIVE LOADS

These are loads produced to the structure during its normal operation by personnel, equipment and piping with their normal weights, stored products, etc

The following loads can be used for normal operating conditions:

- Platform floor plate only 5 KN/m<sup>2</sup>
- Platform framing or floor framing 2,5 KN/m<sup>2</sup>
- Platform framing subject to temporary storage of heavy equipment components actual load
- Roofs used as platforms around apparatus 2,5 KN/m<sup>2</sup>
- Stairs and landings 3,5 KN/m<sup>2</sup> or moving concentrated load of 5 KN
- Ladders moving concentrated load of 2,5 KN
- Columns supporting platforms 1,25 KN/m<sup>2</sup> of platform area
- Horizontal projection of roof 1,0 KN/m<sup>2</sup>
- Railings for platforms and stairs, top railing 0,5 KN point load in any direction

In case of lifting equipment or machine induced dynamic load a minimum Dynamic Amplification Factor (DAF) of 2 will be considered on the lifting weight.

Loads produced by piping at their fixed points and on the sliding supports shall be taken into account.

The following coefficient of static friction shall be used to determine forces at sliding surfaces:

- teflon on teflon 0,10
- steel on steel 0,40
- steel on concrete 0,45

On pipe racks loaded with more than 4 pipes, a friction coefficient of 0,1 (applied to total pipe weight) shall be used in the design of support beams.

#### 4.3 TEST (OR EXCEPTIONAL) LOADS

These loads are due to operations which may occur during the life of the structure but one not combined with normal operation design conditions.

Some test loads are the following:

- 100% of capacity filled with process fluid, or if hydrostatically tested, the water weight in the equipment and piping, whichever is greater.
- Impact loads. These should be as per minimum requirement of **ELOT EN 1991 (Eurocode 1) - Part 5** or per Manufacturer's instructions, whichever is higher.

Job Spec. No 400/1  
Revision 0  
Date 29-06-2011  
Page 7/17

- Crane induced loads, as per **ELOT EN 1991 (Eurocode 1) - Part 5**. Loads caused by cranes working at their maximum working loads will be considered, but not combined with design wind loads.

- Tube bundle pulling force.

Exchanger bundle pulling force shall be considered to be equal to 100% of the bundle weight and applied to fixed shell support only.

#### 4.4 WIND LOADS

The wind loading shall be computed as per **ELOT EN 1991 (Eurocode 1) - Part 2-4**.

#### 4.5 SNOW LOADS

The snow load shall be computed as per **ELOT EN 1991 (Eurocode 1) - Part 2-3**.

The snow load case shall be combined with the other load cases as per the requirements of **ELOT EN 1992 (Eurocode 2)** and **ELOT EN 1993 (Eurocode 3)** and the Greek regulations.

#### 4.6 SEISMIC LOADS

Seismic forces shall be computed according to the **Hellenic Seismic Code (EAK-2003 ΦEK 781B/18.06.2003)**, with the following clarifications and adjustments.

The seismic base shear shall be taken as:

$V_0 = M \cdot R_d(T)$ , where:

**M** = the total mass of the structure which includes :

- The dead weight of the structure including all equipments with their operating weight.
- 30% of live loads.

**R<sub>d</sub>(T)** = the design base acceleration.

The **R<sub>d</sub>(T)** value shall be taken as:

$R_d(T) = A \gamma_1 \cdot (\Theta / q) \cdot \beta_0 \cdot \alpha(T)$ , where:

- A** = the maximum horizontal ground acceleration (**EAK 2003**)
- γ<sub>1</sub>** = the importance factor which shall be also as per **EAK 2003**
- Θ** = the foundation coefficient as per **EAK 2003**
- β<sub>0</sub>** = the coefficient of spectral amplification taken as **β<sub>0</sub> = 2,5**
- a(T)** = α coefficient depending upon structure's fundamental period in each direction. a(T) values smaller than unity shall be used only if detailed calculations provide accurate prediction of structure's fundamental period.
- q** = the structure's behaviour factor. This factor for the most important refinery structures is given in **Table B**.

A minimum factor of safety of 1.30 must be obtained against structure overturning due to the seismic loading.

Earthquake forces shall not be considered as acting simultaneously with wind loading or forces from infrequent surging fluids in equipment.

#### 4.7 LOADS FROM SURGING FLUIDS

Job Spec. No 400/1  
Revision 0  
Date 29-06-2011  
Page 8/17

The horizontal loads produced by vibration of fluidised solids contained in vessels and piping shall have a maximum value 15% of the fluidised solid weight, and they shall be distributed over the full vessel height in a triangular mode similar to the distribution of quasi-static seismic forces.

## 5.0 LOAD COMBINATIONS

All structures shall be designed to withstand all Loading Combinations in **Table A** of this specification.



**TABLE A**  
**Loading Combinations**  
(Note numbers in brackets)

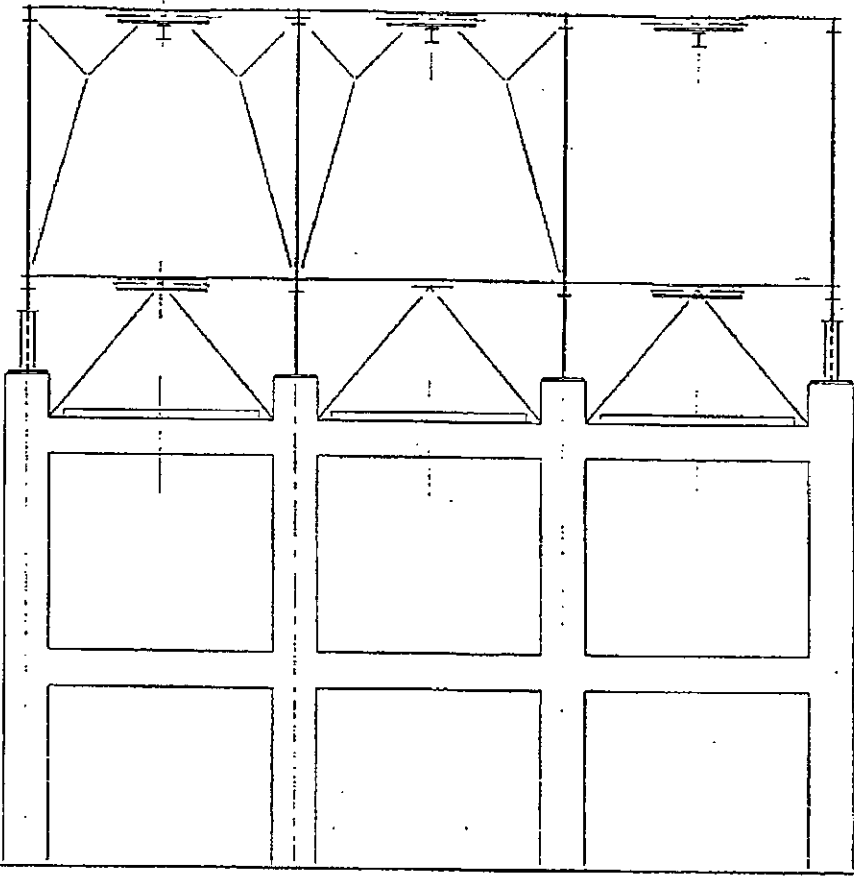
LOADING	ERECTION	TEST	NORMAL OPERATION	MIS-OPERATION	EMPTY OR SHUTDOWN
<b>DEAD</b>					
Structures	Include	Include	Include	Include	Include
Equipment	Include	Include	Include	Include	Include
Internals	Include (7)	Include (3)	Include	Include	Include
Internal lining (refractory)	Include (6)	Include (3)	Include	Include	Include
Piping	Include	Include (3)	Include	Include	Include
Platforms	Include	Include (3)	Include	Include	Include
Insulation	Include	Include (3)	Include	Include	Include
Fireproofing	-	Include (3)	Include	Include	-
Normal fluids	-	-	Include	Include	-
Test fluids	-	Include (5)	-	-	-
<b>LIVE</b>					
Platforms	-	Modified (4)	Include	Include	-
Excess Misoperation fluid	-	-	-	Include (1)	-
<b>OTHER</b>					
Surge (normal contents)	-	-	Include (9)	-	-
Thermal piping (10)	-	-	Include	Include	-
Wind or earthquake	Wind only	Modified Wind (2)	Greater of two	Modified Wind (2)	Greater of two
Construction equipment	Include	Include	-	-	-
Misc. special loads (8)	-	-	Include	Include	-

**Job Spec. No** 400/1  
**Revision** 0  
**Date** 29-06-2011  
**Page** 10/17

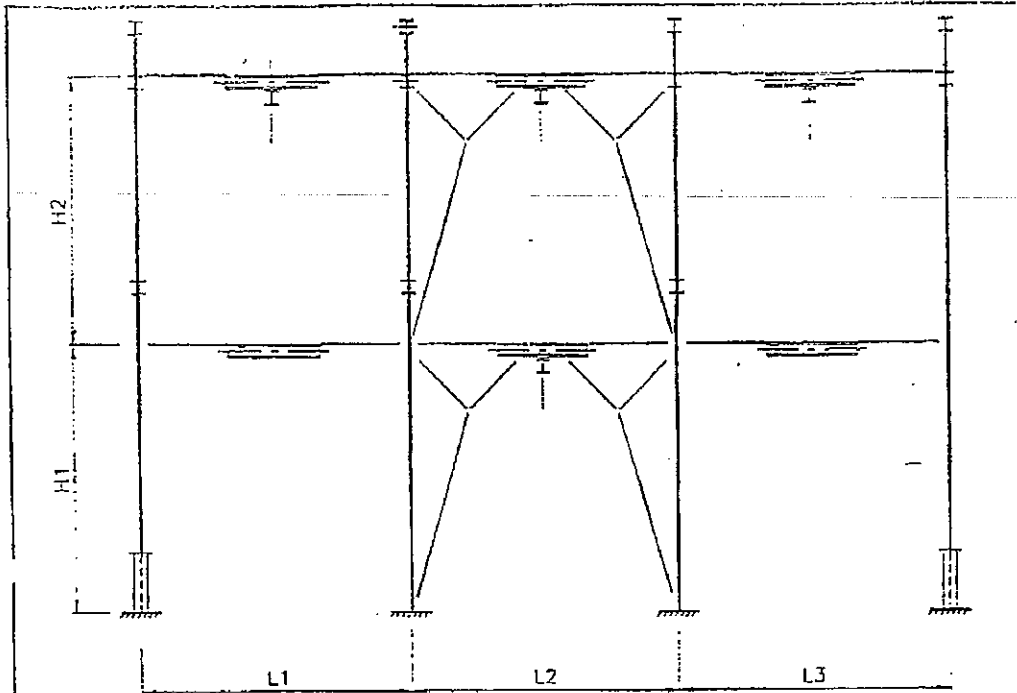
**NOTES**

1. This load shall be computed due to faulty unit operation from items such as catalyst or liquid back-up.
2. Modified wind shall be 25% of the basic wind pressure.
3. These loads shall be included only if in place during the future test condition.
4. 50% of the platform live load included only for the test condition.
5. This load for vertical vessels includes only the test fluid as permitted by the vessel design for the combination pneumatic and/or hydrostatic field test.
6. Include if not removable and installed in shop.
7. Exclude only if possibility exists for full projected wind area without internals.
8. Misc. special loads such as those due to vibration, thermal expansion/contraction, impact, lateral earth pressure, fluid pressure, etc.
9. Omit infrequent surge when combined with earthquake.
10. Thermal fixed loads only are to be combined with wind or earthquake.

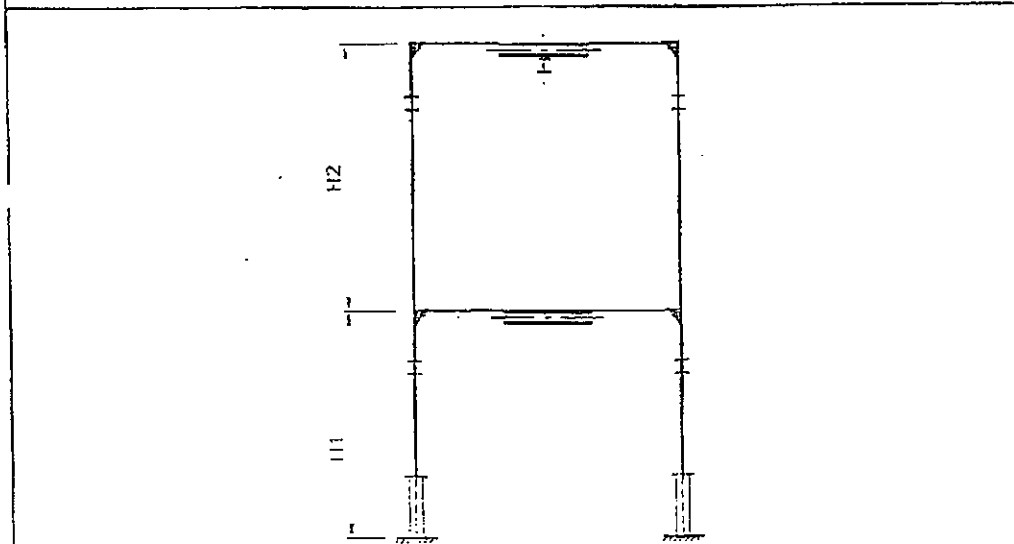
**TABLE B**  
**MAXIMUM VALUES FOR SEISMIC BEHAVIOR FACTOR  $q$**

<u>TABLE B – MAXIMUM VALUES FOR SEISMIC BEHAVIOUR FACTOR <math>q</math></u>	
	
<b>CONCRETE STRUCTURE (COLUMN FRAMES)</b>	
<b>WITH OR WITHOUT STEEL STRUCTURE ON TOP</b>	
WITH STEEL STRUCTURE ON TOP:	$q=2$ for the design of the concrete structure (see pipe rack for the design of steel structure)
WITHOUT STEEL STRUCTURE ON TOP:	$q=2.25$

**PIPE RACK**

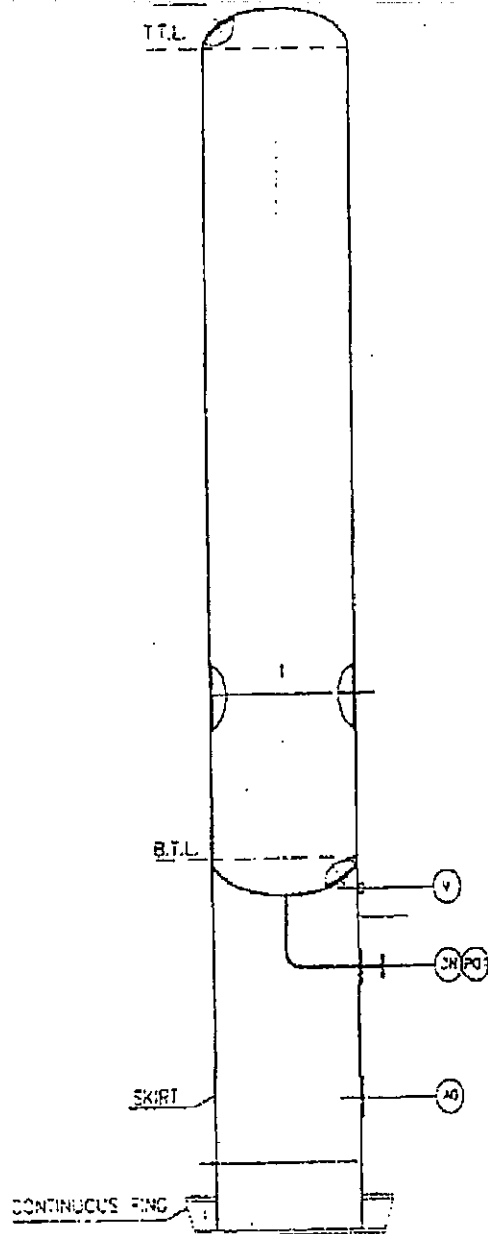


PIPE RACK  
LONGITUDINAL DIRECTION  
 $q=1.5$



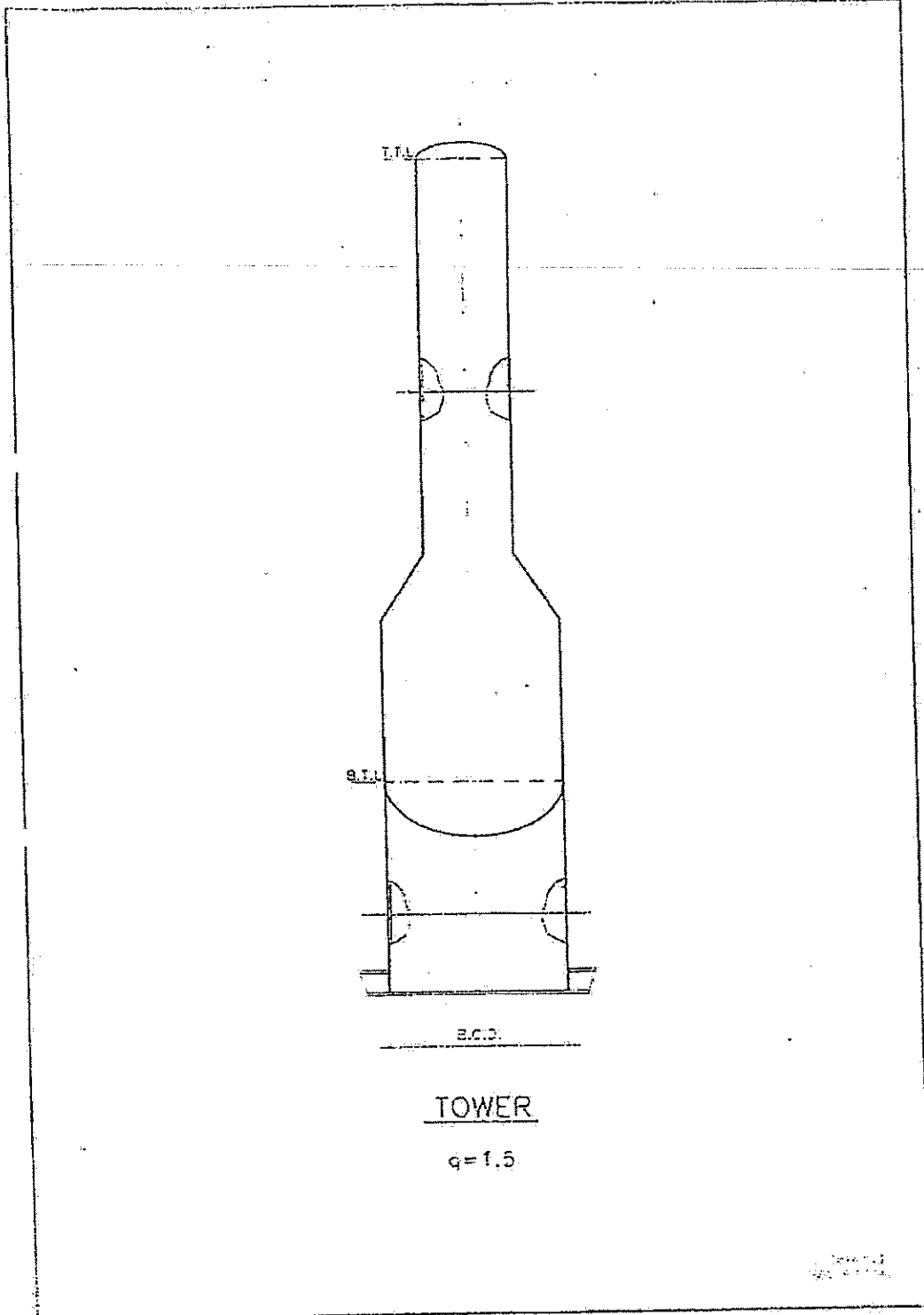
PIPE RACK  
LATERAL DIRECTION  
 $q=2.5$

REACTOR



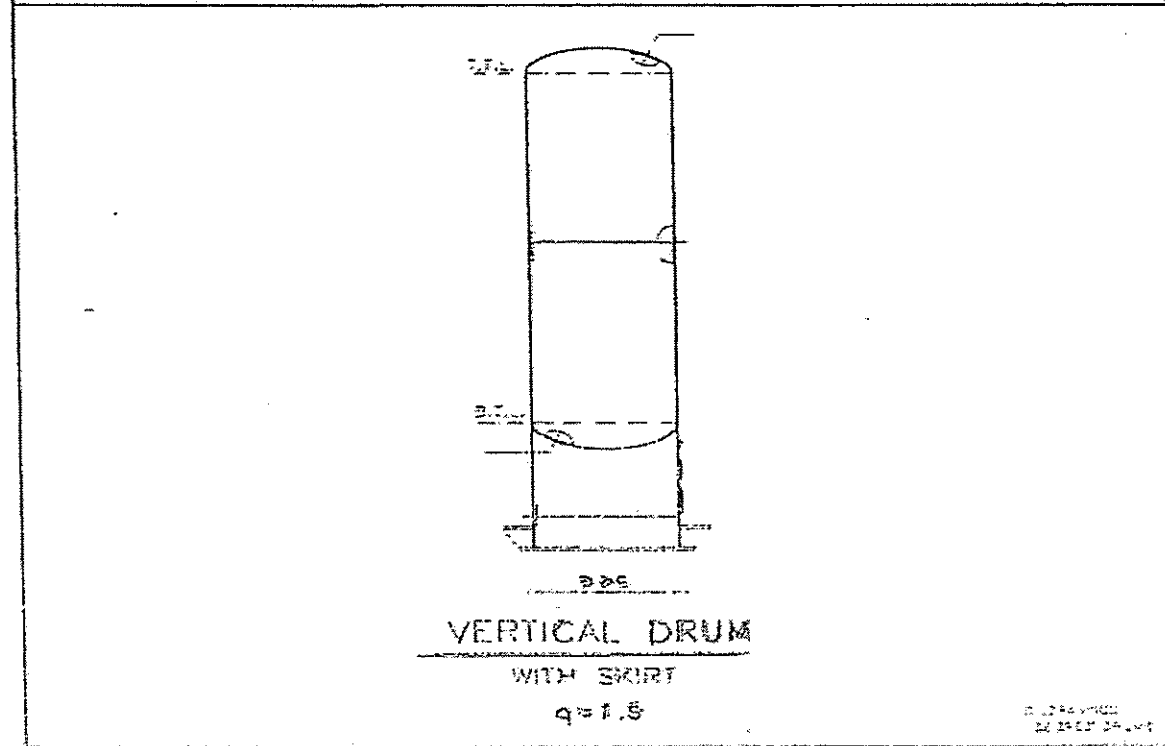
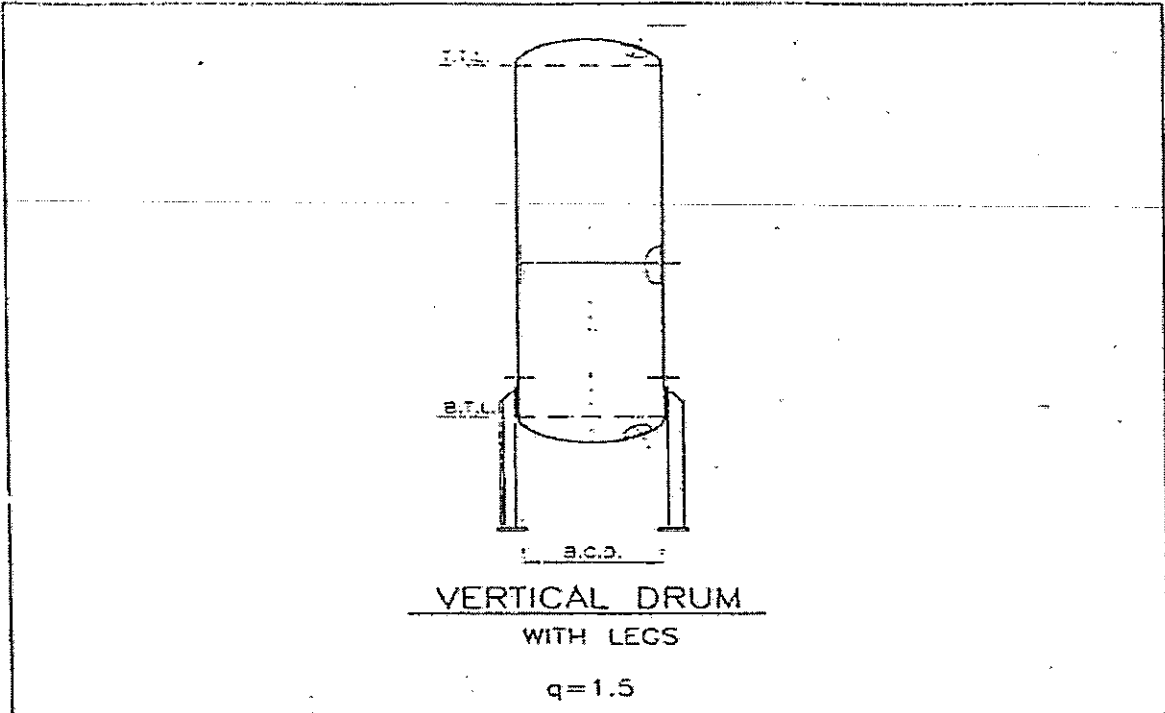
REACTOR

TOWER



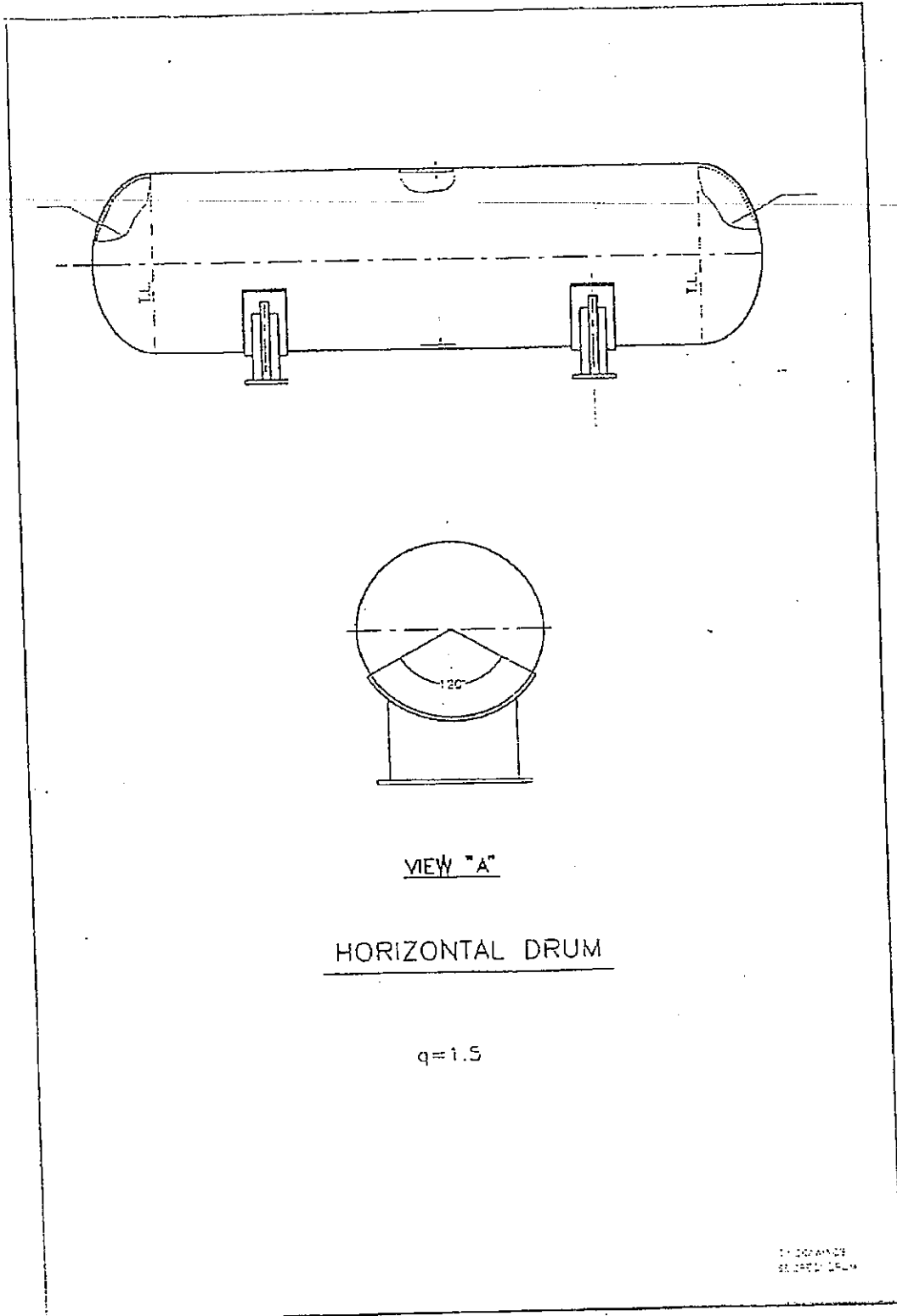
Job Spec. No 400/1  
Revision 0  
Date 29-06-2011  
Page 15/17

VERTICAL DRUM



Job Spec. No 400/1  
Revision 0  
Date 29-06-2011

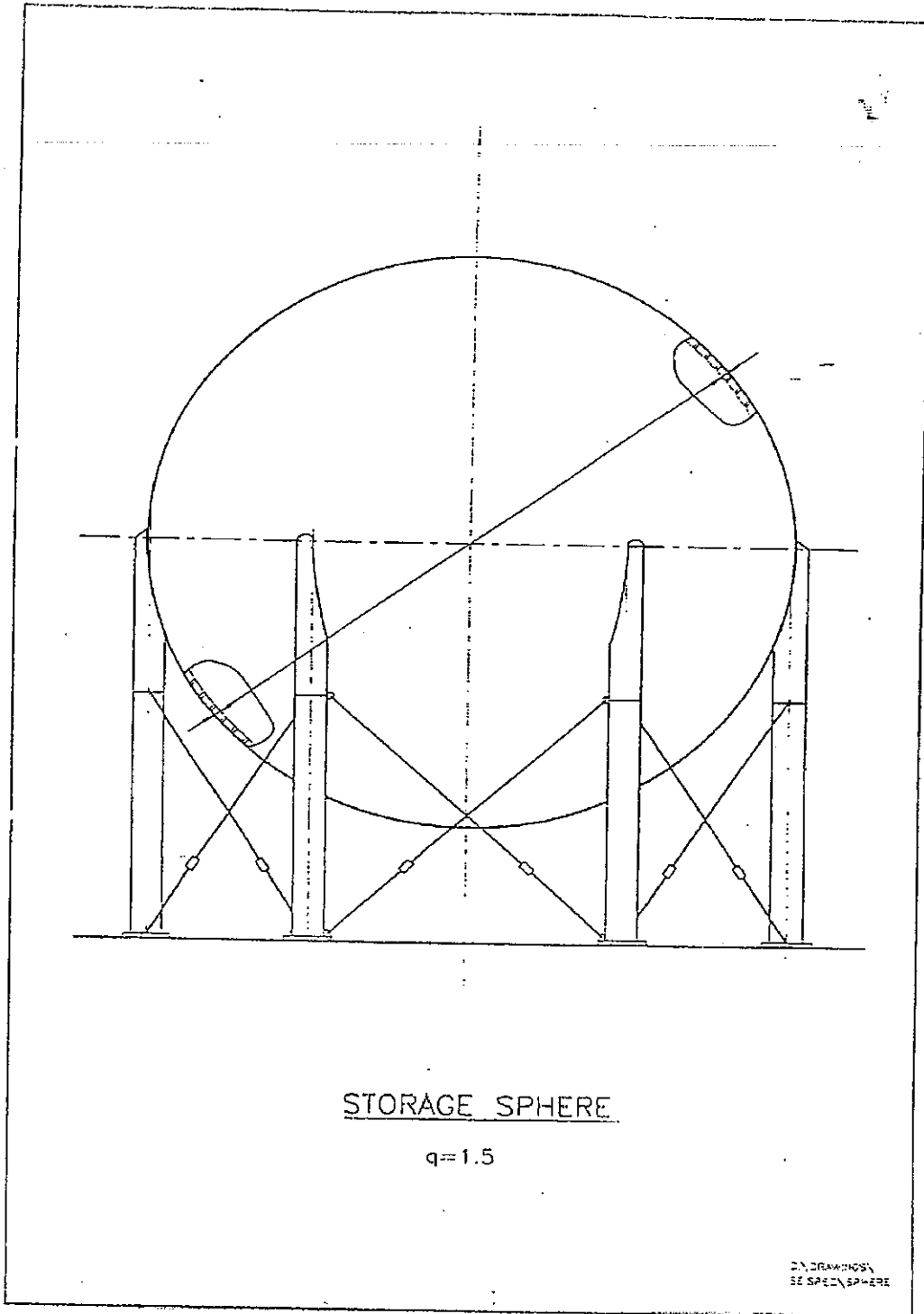
HORIZONTAL DRUM





Job Spec. No 400/1  
Revision 0  
Date 29-06-2011  
Page 17/17

STORAGE SPHERE



STORAGE SPHERE

q=1.5

FOR DRAWINGS,  
SEE SPECIFICATION