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TECHNICAL SPECIFICATION

HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

CIVIL DESIGN LOADS

JUNE 2021

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REFERENCES 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]

- ΦΕΚ 2184Α/20-12-1999, Αριθμ.Δ 17α/141/3/ΦΝ275 “Εγκριση Ελληνικου Αντισεισμικου Κανονισμού Ε.Α.Κ.-2000”

- ΦΕΚ 781Β/18-6-2003, “Τροποποίηση και Συμπλήρωση της απόφασης έγκρισης του Ε.Α.Κ. – 2000” (Διευκρινήσεις σχετικά με τα πρόσθετα σχόλια για τοιχώματα)

- Απόφαση αριθμ.Δ17α/115/9/ΦΝ275, ΦΕΚ 1154Β/12-8-2003) “Τροποποίηση της απόφασης έγκρισης του Ε.Α.Κ. – 2000” (αναθεώρησης του Χάρτη Σεισμικής Επικινδυνότητας)

- ΦΕΚ 270Β/16-03-2010 “Τροποποίηση των διατάξεων του Ε.Α.Κ. – 2000”

1. SCOPE AND OBJECTIVES

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. APPLICABLE STANDARDS AND LEGISLATION CODES

Structural design shall follow the Hellenic and European Legislation Codes. For subjects 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. DEFINITIONS

3.1 General Requirements

All structures shall be designed to encounter loading conditions occurring during:
- Realization (construction, transportation, installation).
-Expected structure lifetime (tests, normal operation, environmental impacts).
- All Civil structures shall be designed for a Design Working Life of 50 years.

3.2 Limit States

Each structure shall be designed for Ultimate Limit States (ULS) and Serviceability Limit States (SLS). Verification of one of the two categories of limit states may be omitted only if sufficient information is provided to demonstrate that it is satisfied by the other.

3.3 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, Live weight, Wind, Snow, Earthquake-Seismic, etc.

3.4 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 - seismic etc.

4. LOAD CASES

4.1 Dead Loads

- Dead weight of main and secondary structures including cladding, floors, foundations, framing, suspended ceiling, the partition walls, handrails, protection nets, fire proofing coating.
- Dead weight of all items permanently attached to the structure, (equipment, instrumentation, accessories, 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^2
- Floors supporting a lesser amount of piping: 0,5 KN/m^2
- 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.The weight of all equipment installations shall be derived from the manufacturer's data sheets and shall include any auxiliary piping and instrumentation.

Soil overburden load, as well as earth pressures, shall also be considered as dead load. Soil unit weight and soil properties for the calculation of earth pressure coefficients shall be obtained from the relevant Geotechnical Investigation Report. Geotechnical report furnished by the Contractor. In all other aspects dead loads shall be calculated according to the codes and standards.

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. Live loads shall be based on the provisions of Eurocode 1 (EN1991).

The following loads can be used for normal operating conditions:

• Platform floor plate only:	5 KN/m^2
• Platform framing or floor framing:	2,5 KN/m^2
• Platform framing subject to temporary storage of heavy equipment components:	actual load

- Roofs used as platforms around apparatus: 2,5 KN/m^2
- Stairs and landings: 3,5 KN/m2 or moving concentrated load of 5 KN
- Ladders: moving concentrated load of 2,5 KN
- Columns supporting platforms: 1,25 KN/m^2 of platform area
- Horizontal projection of roof: 1,0 KN/m^2
- 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 Teflon: 0,10
- steel on steel: 0,40
- steel on concrete: 0,50

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.
Traffic loads and loading patterns due to heavy vehicles circulation around (earth pressures) or above structures shall be obtained from EN1991.02.

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.
- 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**.

Therefore wind loads on structures shall be calculated by considering the appropriate basic wind velocity as follows:
• For Sites located in the mainland and at a distance >10km from shore the basic wind velocity shall be vb = 27 m/s
• For Sites located in the mainland and at a distance <10km from shore the basic wind velocity shall be vb = 33 m/s
All other design parameters relevant to wind pressure or wind load determination (e.g. terrain category, reference height, etc), shall be derived from **EN1991.01.04** and the relevant National application documents.
Where relevant, local amplification of wind speed due to terrain orography shall be considered according to **EN1991.01.04 §A.3**.

4.5 Snow Loads

Snow loads shall be calculated according the provisions of **ELOT EN 1991 (Eurocode 1) - Part 2-3** and the relevant National application standars.
For each structure under consideration roof snow loads shall be determined according to **EN1991.01.03**, taking into consideration the local terrain altitude where each structure is located.
The snow load case shall be combined with the other load cases as per the requirements of **ELOT EN 1992 (Eurocode 2), ELOT EN 1993 (Eurocode 3)** and the Greek regulations.

4.6 Seismic Loads

Seismic loads will be determined based on seismic response spectrum parameters, such as seismic zone, peak ground acceleration, soil class, importance factor, behavior factor, damping and spectral amplification factor, defined in **EN1998** and the relevant National Application Document.
Specifically, seismic forces shall be computed according to the **Hellenic Seismic Code (EAK-2003 ΦΕΚ 781Β/18.06.2003)**, with the following clarifications and adjustments.

The seismic base shear shall be taken as:
V_O = M . Rd (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.

Rd(T) = the design base acceleration.
The Rd(T) value shall be taken as:
Rd(T)= Ay_1 . (Θ / q) . βo . α (T), where:

A = the maximum horizontal ground acceleration **(EAK 2003)**
y_1 = the importance factor which shall be also as per **EAK 2003**
Θ = the foundation coefficient as per **EAK 2003**
βo = the coefficient of spectral amplification taken as β_o = 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

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. 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)

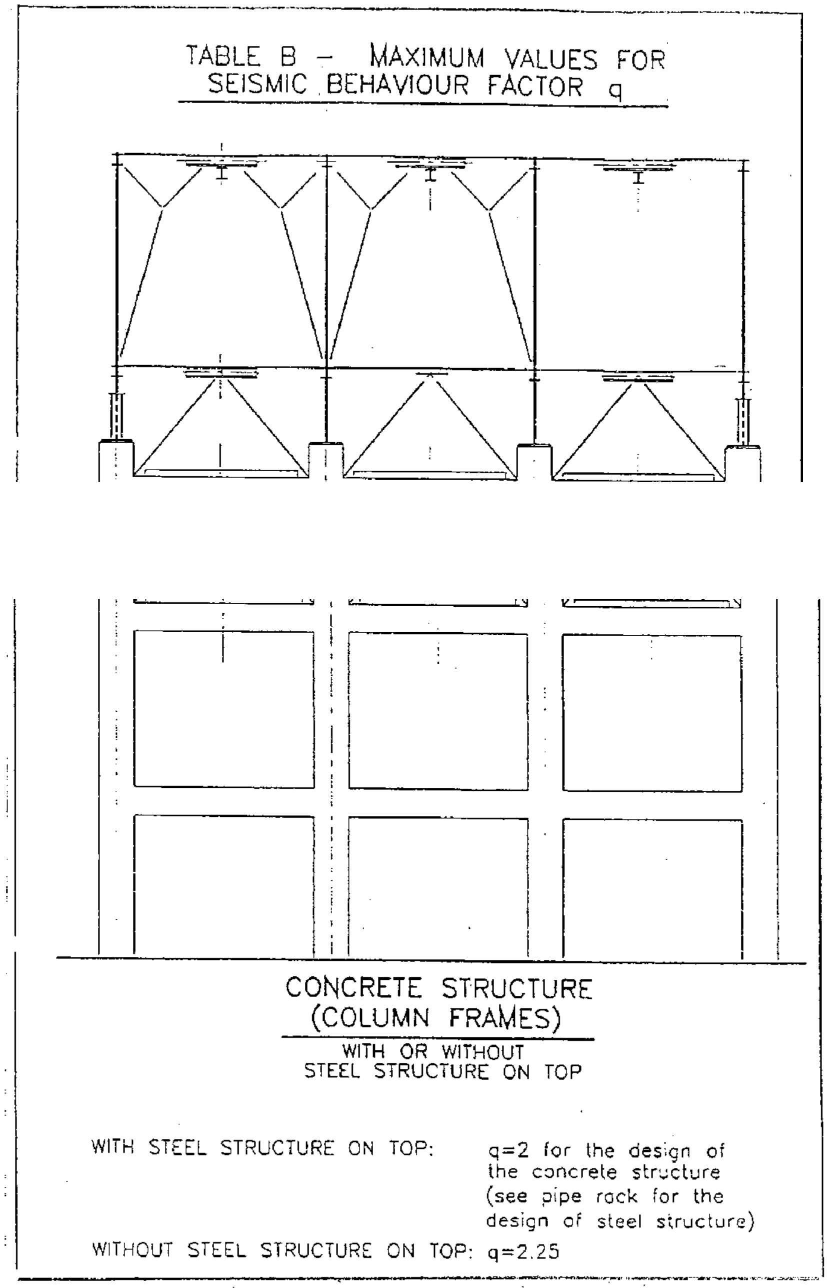
LOADING	ERECTION	TEST	NORMAL OPERATION	MIS-OPERATION	EMPTY OR SHUTDOWN
DEAD					
Structures	Include	Include	Include	Include	Include
Equipment	Include	Include	Include	Include	Include
Internals	Include **(7)**	Include **(3)**	Include	Include	Include
Internal lining (refractory)	Include **(6)**	Include **(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)**	-	-	-
LIVE					
Platforms	-	Modified **(4)**	Include	Include	-
Excess Misoperation fluid	-	-	-	Include **(1)**	-
OTHER					
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	-

NOTES

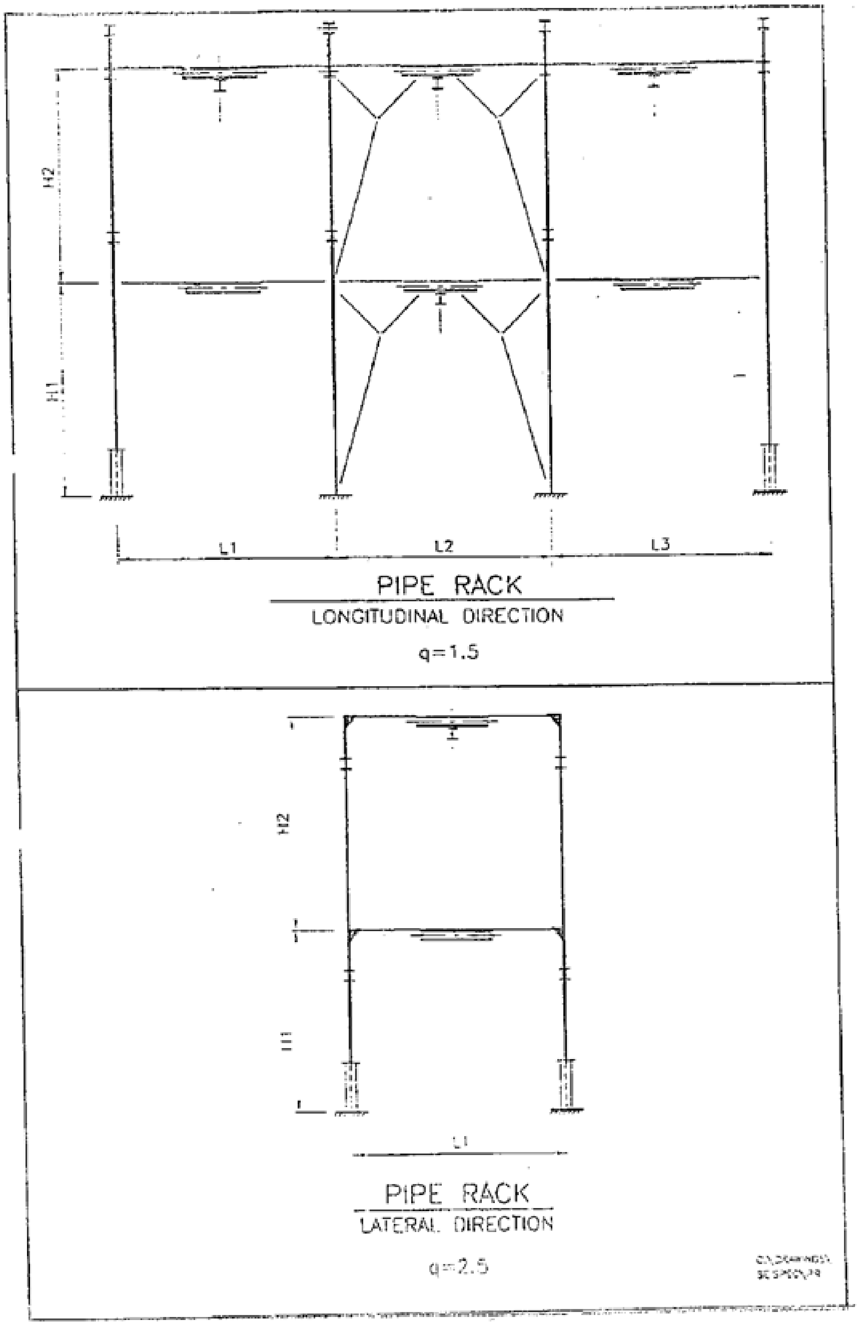
1. This load shall be computed due to faulty unit operation from items such as catalyst or liquid back-up.
2. Modified wind shall be 25% of the basic wind pressure.
3. These loads shall be included only if in place during the future test condition.
4. 50% of the platform live load included only for the 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

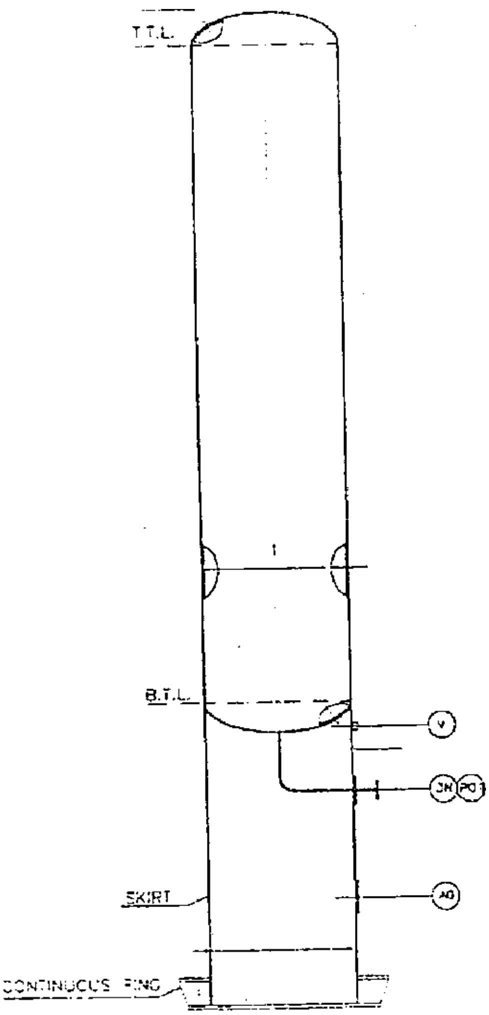
MAXIMUM VALUES FOR SEISMIC BEHAVIOR FACTOR



PIPE RACK

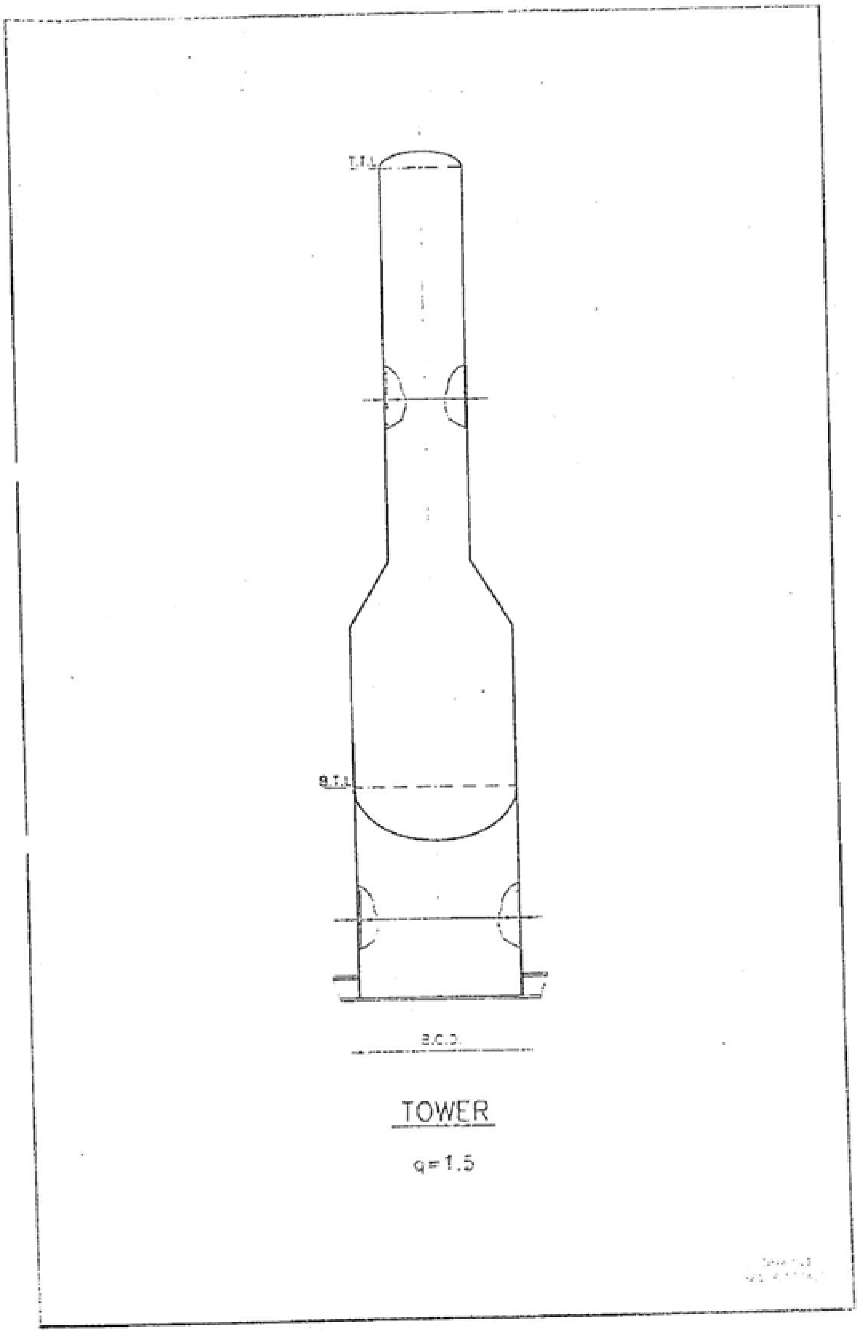

H2
H1
L1
L2
L3
PIPE RACK
LONGITUDINAL DIRECTION
q=1.5
H2
H1
L1
PIPE RACK
LATERAL DIRECTION
q=2.5

REACTOR

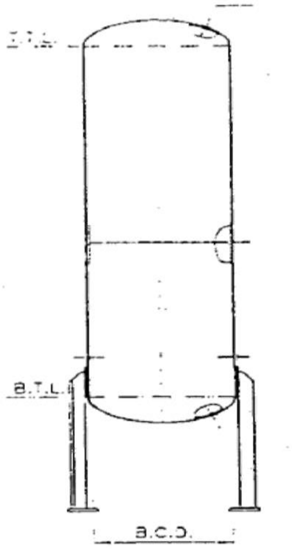


REACTOR

TOWER



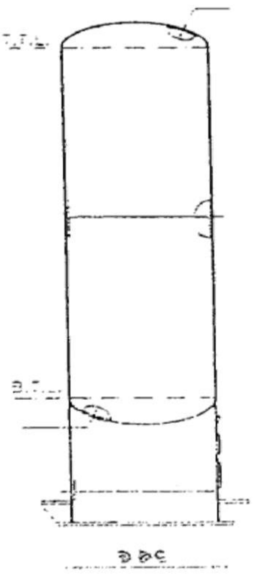
VERTICAL DRUM



VERTICAL DRUM

WITH LEGS

q=1.5

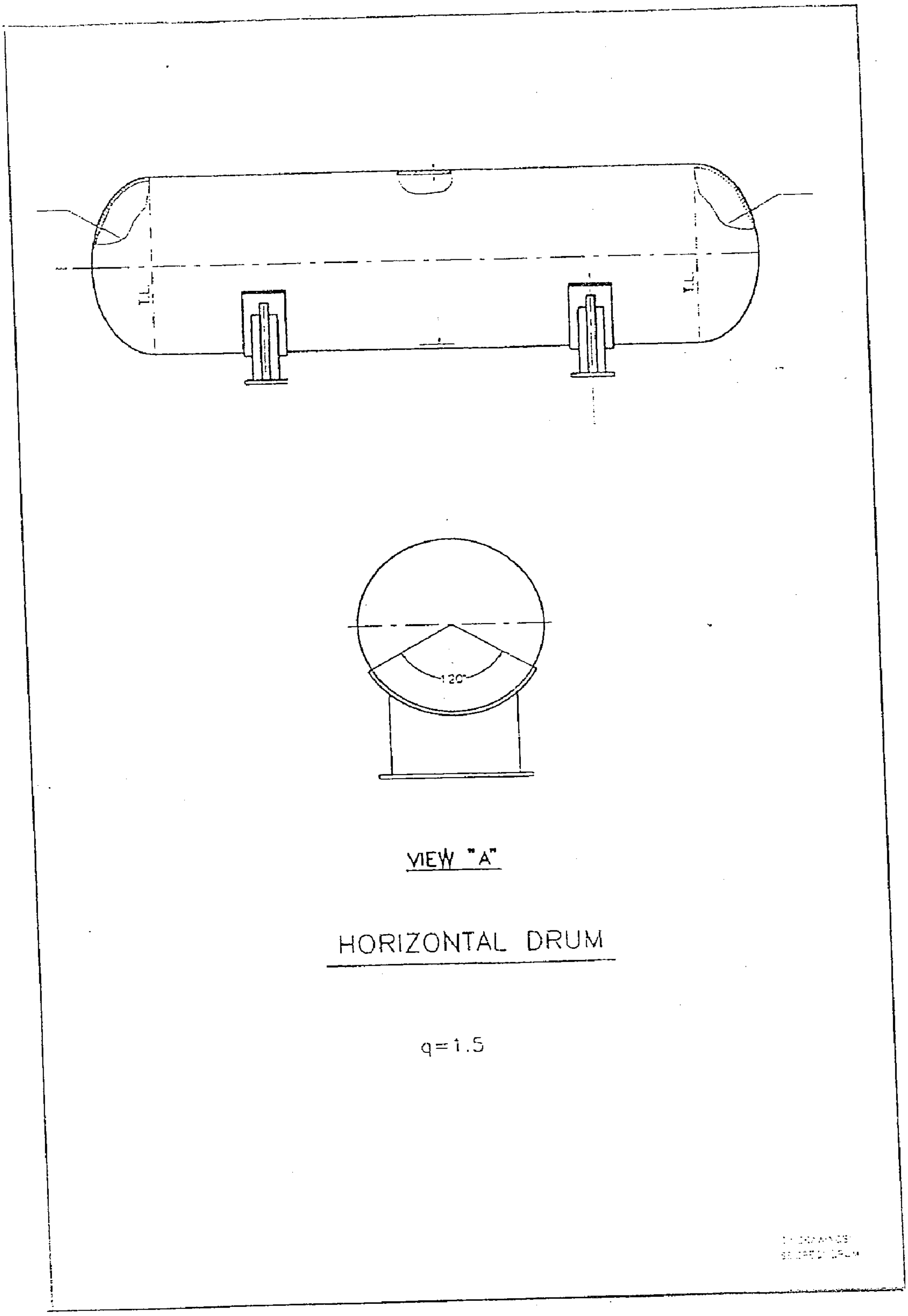


VERTICAL DRUM

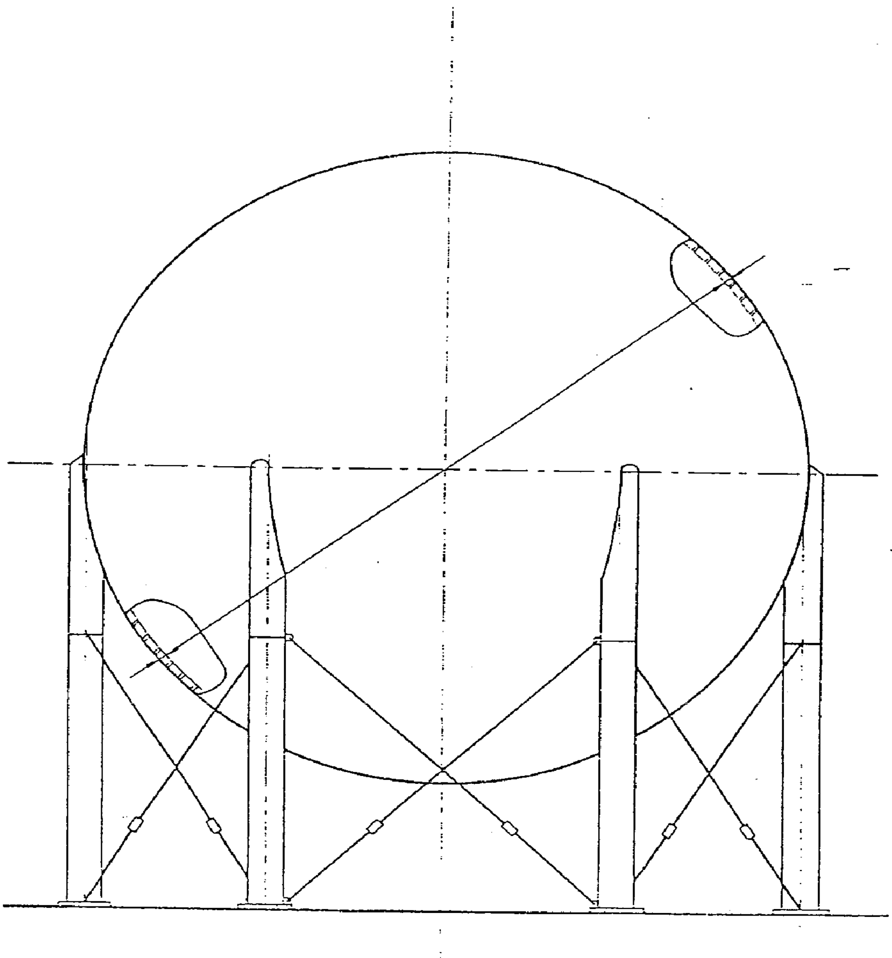
WITH SKIRT

q=1.5

HORIZONTAL DRUM



STORAGE SPHERE



STORAGE SPHERE

q=1.5