



# EQUIPMENT NOZZLE LOADS SPECIFICATION

FOR THE

## CARTAGENA REFINERY EXPANSION PROJECT

**CB&I CONTRACT NO. 166000**

Document No: 000-SP-MU10-0015

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## INTRODUCTION

### 1.1 Scope

- 1.1.1 This standard defines the minimum requirements for forces and moments resulting from external pipe-work during normal operating conditions, to be allowed in the design of pressure equipment process nozzles.
- 1.1.2 Unless otherwise indicated during the execution of the Offer, the Purchaser will use these forces and moments as the basis for the design and pipe routing.
- 1.1.3 The Supplier is to note that the forces and moments used in the design of the equipment shall be equal to or greater than those referenced in this standard.
- 1.1.4 General guidelines are shown below.

### 1.2 Codes and Industry Standards

The following documents are referenced herein and form part of the Offer. Current editions of the industry standards including all mandatory addenda in effect at the time of the order shall apply unless otherwise indicated.

#### AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Boiler and Pressure Vessel Code, current edition, including all mandatory addenda in effect on the date of the Order and referenced standards according to year of acceptable edition listed in the appropriate sections of the ASME Code.

Section VIII, "Pressure Vessels" Division 1

Division 2 - Alternative Rules

#### WELDING RESEARCH COUNCIL (WRC)

Bulletin Number 107, "Local Stresses in Spherical and Cylindrical Shells Due to External Loadings"

Bulletin Number 297, "Local Stresses in Cylindrical Shells Due to External Loadings on Nozzles"

### 1.3 Vessels

The Supplier shall design the nozzles for the loads tabulated in Table 1.

|                                                                                                                                                                                                                      |                                                |                                                 |
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#### 1.4 Shell and Tube Exchangers

The Supplier shall design the nozzles for the loads tabulated in Table 2.

#### 1.5 Air Cooled Exchangers

The Supplier shall design the nozzles for 2 times the API 661 allowables.

#### 1.6 Heaters

The Supplier shall design the nozzles for the loads and movements per API 560 unless specified on the data sheet or Material Requisition.

#### 1.7 Tanks

The Supplier shall design the nozzles for the loads tabulated in Table 1.

#### 1.8 Plate and Frame Heat Exchangers

The Supplier shall design the nozzles for the loads tabulated in API 662 Part 1, Table 1.

#### 1.9 Rotating Equipment

The supplier shall design the nozzle per API requirements.

#### 2.0 COMPLIANCE

The Supplier shall confirm his compliance, in acceptance of the Purchase Offer, with the forces and moments stated in this standard.

#### 3.0 GENERAL

3.1 The indicated requirements are applicable for nozzle sizes 2" NPS and larger for columns, drums, and shell-and-tube heat exchangers. Manways, inspection openings and instrument connections are exempted.

3.2 The forces and moments shown in Table 1 are assumed to be generated by the connected piping system and are imposed on the applicable equipment nozzle at the outside wall of the equipment. If not indicated otherwise, the calculated forces and moments shall be guaranteed by the Supplier as minimum allowable loadings, working simultaneously per nozzle, per coordinate (x, y, z) in + or - direction.

|                                                                                                                                                                        |                                            |                                                 |
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- 3.3** Supplier will be advised in writing about the actual nozzle loadings if they exceed the values referenced in this specification.
- 3.4** The nozzle loadings are at design conditions and operate on the nozzle shell or head area in the corroded condition.
- 3.5** WRC 107/297 shall not be extrapolated. Connections outside the range of WRC 107/297 shall be evaluated by finite element analysis (FEA).
- 4.0 NOZZLE LOADINGS**
- 4.1** The stress evaluation shall be determined for the equipment design condition in accordance with WRC 107/297.
- 4.2** The allowable loads acting on nozzles shall be in accordance with Table 1.
- 4.3** The forces and moments orientation direction is in accordance with Figure 1 (except Shell & Tube Heat Exchangers, See Table 2 and TEMA RGP-RCB-10 for force and moment directions).
- 4.4** Combination of nozzle loadings and internal pressure:
- It shall be investigated if the nozzle is adequately designed for the combined loading of internal or external pressure and external nozzle loading(s). The local stresses (membrane, membrane plus bending) shall be determined in accordance with WRC Bulletin 107/297. The stresses resulting from the internal or external pressure shall be added.
- 4.5** Over-stress checking can be analyzed by finite element analysis (FEA). Software for FEA analysis shall be subject to approval of Purchaser.
- 5.0 ADDITIONAL REINFORCEMENT**
- 5.1** Use of Reinforcing pads due to exceeded stress values caused by external loadings shall be avoided if possible. If reinforcing pads are necessary, the following restrictions and requirements shall be considered:
- The material or the reinforcement shall have the same mechanical and chemical properties as the material of the equipment shell and head.
  - The pad diameter shall not be greater than two times the corroded ID of the nozzle. The pad thickness shall not exceed 1.25 times the thickness of the shell to which it is attached.

|                                                                                                                                                                        |                                                |                                                 |
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- c. The stresses in the shell at the pad OD shall be evaluated in accordance with this specification.

**5.2 Supplier shall notify the Purchaser and seek agreement in case the following matters need to be changed due to the values in Table 1.**

- a. Material requirements
- b. PWHT requirements due to thickness increasing
- c. Nozzle type changing due to shell thickness increase
- d. NDE requirements

|                                                                                                                                                                                                       |                                            |                                                 |
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**TABLE 1: ALLOWABLE LOADS ACTING ON NOZZLES ON TOWERS, DRUMS, AND OTHER PRESSURE VESSELS**

| NOZZLE<br>SIZE<br>(NPS) | FORCE/ MOMENT                         | FLANGE RATING, CLASS |               |
|-------------------------|---------------------------------------|----------------------|---------------|
|                         |                                       | 150# - 300#          | 600# - 2500#  |
| 2                       | FX, FZ, FA, FL, FO (lb / kN)          | 600 / 2.7            | 1,104 / 4.9   |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 246 / 0.3            | 453 / 0.6     |
| 3                       | FX, FZ, FA, FL, FO (lb / kN)          | 900 / 4.0            | 1,656 / 7.4   |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 538 / 0.7            | 990 / 1.3     |
| 4                       | FX, FZ, FA, FL, FO (lb / kN)          | 1,200 / 5.3          | 2,208 / 9.8   |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 945 / 1.3            | 1,739 / 2.4   |
| 6                       | FX, FZ, FA, FL, FO (lb / kN)          | 1,800 / 8.0          | 3,312 / 14.7  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 2,106 / 2.9          | 3,875 / 5.3   |
| 8                       | FX, FZ, FA, FL, FO (lb / kN)          | 2,400 / 10.7         | 4,416 / 19.6  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 3,730 / 5.1          | 6,863 / 9.3   |
| 10                      | FX, FZ, FA, FL, FO (lb / kN)          | 3,000 / 13.3         | 5,520 / 24.6  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 5,816 / 7.9          | 10,701 / 14.5 |
| 12                      | FX, FZ, FA, FL, FO (lb / kN)          | 3,600 / 16.0         | 6,624 / 29.5  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 8,364 / 11.3         | 15,390 / 20.9 |
| 14                      | FX, FZ, FA, FL, FO (lb / kN)          | 4,200 / 18.7         | 7,728 / 34.4  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 11,375 / 15.4        | 20,930 / 28.4 |
| 16                      | FX, FZ, FA, FL, FO (lb / kN)          | 4,800 / 21.4         | 8,832 / 39.3  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 14,848 / 20.1        | 27,321 / 37.0 |
| 18                      | FX, FZ, FA, FL, FO (lb / kN)          | 5,400 / 24.0         | 9,936 / 44.2  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 18,784 / 25.5        | 34,562 / 46.9 |
| 20                      | FX, FZ, FA, FL, FO (lb / kN)          | 6,000 / 26.7         | 11,040 / 49.1 |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 23,182 / 31.4        | 42,655 / 57.8 |
| 24                      | FX, FZ, FA, FL, FO (lb / kN)          | 7,200 / 32.0         | 13,248 / 58.9 |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | 33,365 / 45.2        | 61,392 / 83.2 |
| >24                     | FX, FZ, FA, FL, FO (lb / kN)          | SEE EQ. 1            | 1.84*(EQ. 1)  |
|                         | MX, MY, MZ, MT, ML, MO (ft-lb / kN-m) | SEE EQ. 2            | 1.84*(EQ. 2)  |

**EQ. 1** FORCE = 300\*D (LB)

**EQ. 2** MOMENT = 57.8\*D<sup>2</sup>+2.6D+9.8 (FT-LB)

**UNIT CONVERSION**

1 lb = 4.448E-3 kN

1 ft-lb = 1.356E-3 kN-m

|                                                                                                                                                                        |                                            |                                       |
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**TABLE 2: MAXIMUM ALLOWABLE NOZZLE LOADINGS ON EXCHANGERS**

Main nozzles in corroded conditions shall be capable to withstand the forces and moments listed in the following tabulation:

| Nozzle Size<br>Inch | Forces- Pounds |       |       | Moments Pound-Feet |        |        |
|---------------------|----------------|-------|-------|--------------------|--------|--------|
|                     | P              | VI    | Vc    | Mr                 | MI     | Mc     |
| 2" and 3"           | 600            | 600   | 600   | 600                | 600    | 600    |
| 4"                  | 1,000          | 1,000 | 1,000 | 1,200              | 1,200  | 1,000  |
| 6"                  | 1,800          | 1,500 | 1,500 | 3,000              | 3,150  | 2,700  |
| 8"                  | 3,000          | 2,400 | 2,400 | 6,000              | 4,500  | 4,500  |
| 10"                 | 4,000          | 3,000 | 3,000 | 6,000              | 6,000  | 5,000  |
| 12"                 | 4,500          | 4,000 | 4,000 | 6,000              | 7,500  | 6,200  |
| 14"                 | 5,000          | 5,000 | 5,000 | 7,000              | 9,000  | 7,500  |
| 16"                 | 5,800          | 5,800 | 5,800 | 7,500              | 9,000  | 8,500  |
| 18"                 | 6,500          | 6,500 | 6,500 | 8,300              | 9,800  | 9,300  |
| 20"                 | 7,000          | 7,000 | 7,000 | 9,200              | 10,500 | 10,200 |
| 24"                 | 7,700          | 7,700 | 7,700 | 10,500             | 12,500 | 11,900 |
| 26"                 | 9,240          | 9,240 | 9,240 | 12,600             | 15,000 | 14,200 |

**Notes:**

1. All the loadings are acting simultaneously on nozzles.
2. The maximum combined stresses, including the pressure stress, shall not exceed 0.8 x Yield strength at the design temperature or the specified temperatures for the special cases.
3. If reinforcement pads are required, vendor shall also include the calculations at the OD of the pads but the combined stresses shall not exceed 3 x Tensile stresses.
4. Vendor to submit their nozzle loading calculation of WRC 107 for review and approval.
5. Vendor to submit their nozzle loading calculations of WRC-107 for the special cases requested with the specified pressures and temperatures.
6. The designations and directions of forces and moments are referred to TEMA paragraph RGP-RCB-10 Nozzles in section 10 - RECOMMENDED GOOD PRACTICE.



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**FIGURE 1: DIRECTION OF FORCES AND MOMENTS**

