2013 International Nuclear Atlantic Conference - INAC 2013
Recife, PE, Brazil, November 24-29, 2013
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: **978-85-99141-05-2**

SEISMIC ANALYSIS OF THE SADDLE SUPPORTS FROM A HORIZONTAL VESSEL

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ABSTRACT

The design of horizontal cylindrical vessels and their supports are often conducted using the standards and design codes exist, that in general the resulting cylindrical shells have a thickness determined by the maximum circumferential stress. As the maximum circumferential stress governs the design of these vessels, we can adopt it as a mathematical model of a horizontal beam on supports so that such simplification does not compromise the validity of the results.

This work will discuss the behavior of vessels supported by saddles. Through the design of supports by saddles, get some possible configurations, such that we will opt to study the supports by saddles with reinforcement rings, where one of the constraints imposed by the standard and the design codes is that the contact angle between the vessel and the saddles have a minimum value determined.

This analysis focuses on the behavior of the multiple saddles supports which are anchored to a rigid foundation. With the aim to study the seismic saddle supports, which are an essential part of the pressure vessel installed in horizontal, under seismic loading conditions (with one of the saddles is constrained in three directions and the other three saddles with restrictions in two directions and free only in axial direction of pressure vessel), will hold a study that addresses the issue through analytical calculations and numerical method such that it is possible to compare the results.

1. INTRODUCTION

In general horizontal cylindrical vessels resistant to temperature and internal pressure are designed according to standards and international codes design, which often result in pressure vessels with wall thicknesses uniforms, which are governed by the calculation of circumferential stress. But their supports do not always follow the same rules.

As the aim of this work is to study the mechanical behavior of the saddle supports for large horizontal cylindrical vessels, we can treat it mathematically as a horizontal beam on support without compromising the quality of the responses.

In our study we are considering a not conventional nuclear power plant (NPP) subject to the natural events in which the earthquake loading is the only natural events affecting all structures, where we must ensure, therefore, that the structures that connect the vessel horizontal to the floor, or their saddles continue to provide dimensional stability and supports so as to perform their safety function. This analysis focuses on the behavior of the multiple saddles supports which are anchored to a rigid foundation.
The seismic qualification is required due to earthquake loading is the only natural events that affect all structures, internally and externally, can be combined with other loads to check the active and inactive systems.
In this study are not considered the effects of the internal pressure and temperature on the mechanical behavior of the vessel horizontally, therefore the effects of stress concentration in the region of contact between the vessel and the saddles due to dilations caused by these loads will be ignored. Also not considered the behavior of individual equipment staying inside the vessel horizontally, only their masses added to the vessel however considered in the same central position, characterizing the CG vessel. Any effect due to radiation on materials will be considered.
The acceleration imposed on the set will be applied at the base of the saddles such that is possible to capture the behavior their component under the action of the earthquake and the weight of the vessel.

2. OBJECTIVE

In this work, we are proposing be possible to design seismic support for multiple saddles through consecrated methodology, applying what is most modern in seismic loading considerations.

3. CONSIDERATIONS

Local damage an earthquake can cause depend on factors such as the magnitude of the earthquake, the distance from the epicenter, local conditions and soil conditions and design of structures. How magnitude is a measure of the size of earthquake that can be directly associated to the energy released, there is a great difficulty in performing this measurement accurately. An earthquake has a unique magnitude, but has much intensity, depending on the distance from the epicenter.
How the intensity of an earthquake is a parameter that characterizes the effects on people, objects, structures built and environment at a specific location, with an intensity scale, where the Mercalli intensity scale evaluates the effects of the earthquake on each point territory, so that the values vary according to the distance to the epicenter area (which is more intense due to the proximity of the area of energy release) depending also geo-structural characteristics of the ground traversed by the seismic waves and of the type population and characteristics of buildings. This spatial variation effects allows trace the lines that delimit the territory areas where the earthquake was felt with equal intensity.
Similarly to the other scales of intensity, intensity scale Mercalli is qualitative and does not provide absolute information on the earthquakesince the effects observed depend on the characteristics of the absolute location will be evaluated. The evaluation is also subject to

high subjective, since it is based on human observation. To counter this subjectivity, observers are trained and the range includes a set of objective parameters that should be checked.
With this assumption, we can use a deterministic methodology which is the scale mModified Mercali Intensity (MMI), which is a qualitative scale used to determine the intensity of an earthquake from its effects on people and on the natural and built structures . The effects of an earthquake are classified in degrees, denoted by roman numerals from I to XII, with grade I representing a tremor not felt by people and the grade XII representing to calamitous change the topography of the region affected.
On this scale, Brazil is situated in a range between VI (where the earthquake causes the beginning of panic in the population) and VII (where the earthquake causes limited damage in buildings of good construction and triggered widespread panic in the population). However we can use also a probabilistic methodology which through the lifting of a Threat Curve, determine the probability of occurrence of a natural event ranging between 10^{-4} and 10^{-5}, which gives us acceleration close to 0,1 g.
There is also the Brazilian Standard NBR 15421, which divides Brazil into five seismic zones, where zone 0 is the area to accelerations in the minor value and zone 4 where we have the major value.

Table 1: Seismic zones in according to NBR 15421

Seismic Zone	a_g - Accelerations value
Zone 0	$a_g = 0{,}025g$
Zone 1	$0{,}025g \le a_g \le 0{,}05g$
Zone 2	$0{,}05g \le a_g \le 0{,}10g$
Zone 3	$0{,}10g \le a_g \le 0{,}15g$
Zone 4	$a_g = 0{,}15g$

Through the mapping given by this standard, a conservative consideration the values given for zone 2, or acceleration in the order of up to 0,10g.

4. ANALYSIS

Analyzes will be performed three different mathematical models and compared their results.
Initially be considered a static analysis with the equivalent static acceleration values. In the second model will perform a numerical analysis using the response spectrum acceleration (table 2) applied to the bases of the saddles horizontal vessel. And finally the third model will perform a numerical analysis of type Time History (accelerogram).
Spectrum Response is defined as the maximum plots of the responses (acceleration, velocity or displacement) over time for a system of one degree of freedom, in some data damping values over a range of natural frequencies.

Table 2: Response Spectrum in terms of acceleration

Frequency (Hz)	a_Y – vertical $\left(m/s^2\right)$	a_X – transversal $\left(m/s^2\right)$	a_Z – longitudinal $\left(m/s^2\right)$
1,0	1,26	1,78	1,77
2,4	2,87	4,15	3,83
4,6	4,92	4,98	6,72
7,0	6,61	4,73	7,14
8,0	6,29	4,65	5,98
10,0	6,29	4,65	4,94
12,0	6,29	4,65	4,94
15,0	5,42	2,99	3,18
18,0	3,75	2,17	2,50
22,0	2,61	1,88	2,14
25,0	2,49	1,86	2,04
28,0	2,35	1,84	2,03
31,0	2,29	1,82	2,01
34,0	2,24	1,80	1,99

These spectra in acceleration responses are determined from the accelerations on the floors of structures under the action of seismic excitations project. For a more precise analysis of the responses, we considered the response spectrum in terms of acceleration applied to the bases of the saddles horizontal vessel. However like the saddles vessel horizontal studied have a configuration such that one of these saddles Saddle Fixed call, since its movement is constrained in three directions, and the other three saddles denominate Furniture Saddles, where only the displacement in the direction of z-axis (longitudinal) is free and the other directions are restricted, why are not considering the loads these saddles toward the z-axis (longitudinal) in Table 3.

Table 3: Load weight in each of the bases of the horizontal vessel

	Saddle Fixed	Mobile Saddle 1	Mobile Saddle 2	Mobile Saddle 3	Total
F_X – transversal (N)	2.610.000	1.670.000	1.540.000	1.680.000	7.500.00
F_Y – vertical (N)	7.390.000	10.320.000	5.690.000	5.320.000	28.720.000
F_Z – longitudinal (N)	4.810.000	---	---	---	4.810.000

The figure 1 shows the horizontal vessel schematic view with their saddle supports.

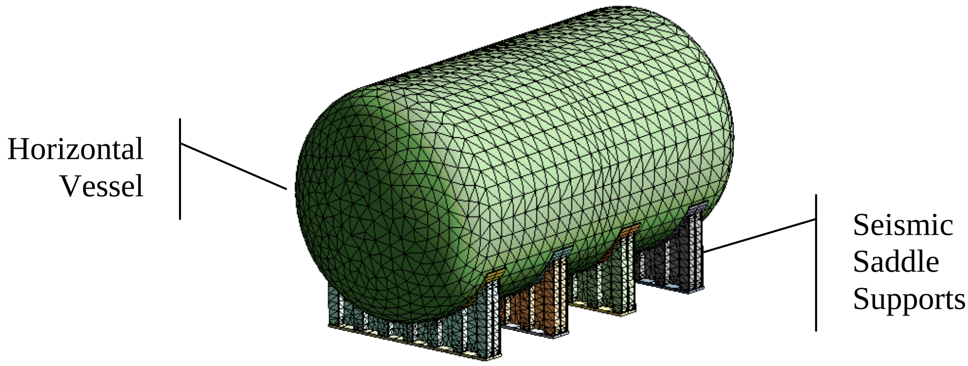

Figure 1. Seismic saddle supports for horizontal vessel.

Static analysis used with equivalent static acceleration values of maximum forces result obtained on the basis of the horizontal vessel and the static values expected for these strength (maximum force) considering the mass times the acceleration of the machine's maximum range. Considering the above, we applied an acceleration equal to the maximum static response spectrum acceleration in each direction, as shown in table 1. This equivalent static acceleration is covered by item II "Acceptance Criteria", 1B, page 3.7.2-7 of NUREG-0800, Standar Review Plan (SRP) 3.7.2 - Seismic System Analysis, which suggests the use of factor 1, 5 times the maximum spectral response acceleration for simple structures.

Maximum force:

$$F_{MAX} = \left(\frac{m}{g}\right) * (a) \tag{1}$$

Maximum force with earthquake:

$$F_{EMAX} = 1{,}5 * \left(\frac{m}{g}\right) * (a) \Rightarrow \tag{2}$$

Acceptance criteria:

$$F_{SIS} > F_{EMAX} \Rightarrow OK \tag{3}$$

5. CONCLUSIONS

In this paper we can see that the results for calculations and analysis carried out showed that the saddles are properly sized for the loads and conditions proposed.
For future work, we suggest the implementation of the effects of localized deformation of the vessel in the region of the saddle, thus capturing the effects of bending on the saddles.

ACKNOWLEDGMENTS

We would like to thank once this work would not be possible without the collaboration directly or indirectly from some people whose which I am very grateful.

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