DP-01-SEISMIC DESIGN OF EQUIPMENT, EQUIPMENT SUPPORTS AND TANKS

Ver.1 Date: October 2014

1. SCOPE

This Specification covers the requirements for seismic resistance of tanks, equipment and equipment supports. Its purpose is to amplify the requirements of the various applicable standards and provide additional relevant information to assist designers. It does not override any statutory requirements or particular requirements covered by the Particular Clauses of the Technical Specifications.

2 GENERAL

All structural aspects of design shall be verified by a New Zealand Chartered Professional Engineer experienced in the seismic design of industrial structures and tanks. A producer statement shall be submitted to this effect by the Supplier/Contractor/Designer.

All equipment and equipment supports shall comply with the applicable requirements of the NZ Building Act 2004, the New Zealand Building Code and the applicable approved documents including the New Zealand Loadings code AS/NZS 1170 and the appropriate materials codes. Pressure vessels shall, in addition, comply with the specific seismic requirements of the New Zealand Ministry of Transport, Marine Division.

If alternative methods to those stated in the approved documents are used, it is necessary for these to be approved by the relevant Territorial Authority and by the Engineer. The Supplier/Contractor shall be responsible for obtaining such approvals.

It is recommended that the seismic design of tanks should comply with either:

- Seismic Design of Storage Tanks (Ref 4), or
- API 650 -Appendix E (Ref 8),

except that the earthquake loading coefficients should be derived from the seismic loading spectra specified in NZS 1170.5:2004 (Ref 3) with corrections for damping levels appropriate to storage tanks as follows:

$C_d(T_i) = C_h(T_i,).Z.R.N(T_i,D).S_p..DF/k_\mu$

where $C_d(T_i)$ = horizontal design action co-efficient for response mode i
$C_h(T_i,)..$ = spectral shape factor for structural period T_i
Z = hazard factor
R = return period factor (either R_s of R_u for the appropriate limit state under consideration. (See below)
$N(T_i,D)$ = Near fault factor (assume = 1)
T_i, = period of vibration for response mode i
S_p = structural performance factor (assume = 1)
k_μ = inelastic spectrum scaling factor
μ = displacement ductility factor (assume = 2)
DF = Damping Correction Factor (see below)

Risk Factor R

When selecting which state applies to each part of the Works, refer to Schedule 1 – Equipment/Tanks Designated as Post Disaster or Essential for Operational Continuity.

Serviceability Limit State SLS1

$R_s = 0.25$

Serviceability Limit State SLS2

a) Equipment/tanks essential to operational continuity after SLS2 earthquake (Schedule 1): $R_s = 0.75$

b) Other equipment: SLS2 not required to be considered

Ultimate Limit State

a) Equipment/tanks designated as post disaster (Schedule 1): $R_u = 1.8$

b) Equipment/tanks containing hazardous materials capable of hazardous conditions beyond the boundary: $R_u = 1.8$

c) Equipment/tanks part of the water treatment process (Schedule 1): $R_u = 1.3$

d) Equipment/tanks containing hazardous materials not capable of hazardous conditions beyond the boundary: $R_u = 1.3$

e) Other equipment/tanks: $R_u = 1.0$

Damping Correction Factor DF

The NZS 1170.5:2004 spectra are based on 5% viscous damping . For other damping values, the following correction factors shall be used (Ref 9)

% Critical Viscous Damping	Correction Factor DF
0.5%	1.75
2%	1.33
5%	1.00
10%	0.80
15%	0.71
20%	0.67

For the convective mode, the appropriate value of damping is 0.5%. For the impulsive mode, refer to Ref 4 and/or Ref 8. For determining the applicable level of damping, the soil classification on any site under consideration should be determined. (See Ref 4, Section C2.8)

Tanks should also satisfy the provisions of an appropriate material code, to be agreed with the Engineer except where these conflict with the requirements above. For concrete tanks, the material code shall be NZS 3106:1986 (Ref 6).

The seismic design should consider the structural system as a whole comprising both the equipment and its supporting system. Agreement on seismic design parameters to be adopted should, therefore, be obtained at the preliminary design state.

The Supplier/Contractor shall submit with his design the following information:

- Weight and geometry of the equipment including positions of the centre of gravity and support points for maximum weight and normal operating weight.
- Ductility Capability
- Structural type and methods of achieving ductility (if applicable)
- The equipment horizontal design action co-efficient.
- Displacements of equipment for the serviceability and ultimate limit states.
- Foundation Loadings (dead, basic live, earthquake and wind load, where applicable)

3. SPECIFIC EARTHQUAKE ANALYSIS

For all structures exceeding 10m in height, or, T1 > 0.4sec or, T1 > 2sec and regular in accordance with NZS 1170.5 , a dynamic analysis should be carried out to determine the following:

- The degree of ductility demand on the yielding elements.
- The acceleration of equipment attached to the vessel.
- The structural separations required for connection bridges etc. and appurtenances.

4. COMMENTARY

4.1 SEISMIC LOADING CO-EFFICIENT

Seismic loading shall be determined using NZS 1170.5:2004. The relevant loading spectrum for the WWTP site is that for Site Subsoil Class D. However, if this is critical for design, this class should be checked. For any other Watercare site the geotechnical classification shall be determined.

4.2 EQUIPMENT SUPPORTED BY BUILDING STRUCTURES

These will generally be fixed to the building structures with connections having little or no ductility capability. The equipment seismic design loading is specified in Section 8 “Requirements for Parts and Components” of NZS 1170.5:2004 and depends on the following:

- Basic seismic co-efficient for the structure.
- Height of the centre of mass of the structure relative to the equipment.
- Whether the structure has been designed to be ductile.

Watercare will advise design values for these parameters when requested in writing to do so. In general, equipment seismic loadings will be larger the higher in the building the equipment is located, because earthquake induced accelerations in a structure increase with height.

If the equipment mounting is ductile, the seismic co-efficient shall be modified accordingly, in accordance with NSZ 1170.5.

4.3 FREE STANDING EQUIPMENT

The majority of items will have no provision for ductility. These shall be designed to remain elastic under the earthquake loading and will have seismic coefficients depending on the natural period of vibration. Items with ductility capability may be designed with the lower seismic forces with consequent saving in structure and foundations.

4.4 PRESSURE VESSELS

The design seismic co-efficient for pressure vessels should not, in general, be less than 0.5 to satisfy Ministry of Transport requirements.

5. REFERENCES

1. New Zealand Building Act, 2004
2. New Zealand Building Code,
3. NZS 1170.5:2004 Australian/New Zealand Standard, Structural Design Actions – Part 5: Earthquake Actions – New Zealand
4. Seismic Design of Storage Tanks - New Zealand National Society for Earthquake Engineering 2008.
5. Recommendations of a study group of the New Zealand National Society for Earthquake Engineering 1986.
6. NZS 3106: 1986 “Code of Practice for Concrete Structures for the Storage of Liquids”.
7. Standards Association of New Zealand

8. API 650 Appendix E, American Petroleum Institute
9. Kawashima, K and Aizawa, K (1984) “Modification of earthquake response spectra with respect to damping”. Proc Japan Society of Civil Engineering, Structural Engineering/Earthquake, pp 351-355.

6. SCHEDULE 1 – EQUIPMENT/TANKS DESIGNATED AS POST DISASTER ESSENTIAL FOR OPERATIONAL CONTINUITY

[to be completed prior to issue of specification]

EQUIPMENT/TANKS DESIGNATED AS POST DISASTER

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EQUIPMENT/TANKS ESSENTIAL FOR OPERATIONAL CONTINUITY AFTER SLS2 EARTHQUAKE

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EQUIPMENT/TANKS NOT PART OF THE PARTICULAR PROCESS

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Revised: January 2010