IPENZ PRACTICE NOTE 19 v4 CHANGES

Graeme Lindup

WorleyParsons New Zealand, 25 Gill Street, New Plymouth, New Zealand

Graeme.Lindup@worleyparsons.com

Keywords: *IPENZ, Practice Note 19.*

ABSTRACT

Version 4 of IPENZ Practice Note 19 (IPENZ 2016) has been released this April and this paper gives a refresher on the practice note with an emphasis on the changes incorporated into Version 4.

1. WHAT IS PRACTICE NOTE 19?

1.1 Background

The Practice Note 19 (PN19) is based on a paper presented to the New Zealand Society for Earthquake Engineering Technical Conference in 2006 and published in the Society's Bulletin (Lindup 2007).

That paper used the American Society of Civil Engineers (ASCE) Task Committee on Seismic Evaluation and Design of Petrochemical Facilities "Guidelines for Seismic Evaluation and Design of Petrochemical Plants" (ASCE 1997) and adapted these for the use with NZS 1170.5 (SNZ 2004). Although aimed at petrochemical plants, the ASCE guidelines were able to be used for other industrial plants that have nonbuilding structures not similar to buildings.

PN19 updates for New Zealand, the seismic guidelines for the design of pressure equipment and their supports. It was first issued in February 2013, it has been updated a number of times and last released in April 2016 as Version 4. PN19 does not replace the Approved Code of Practice for Pressure Equipment (ACPPE) (WorkSafe 2001) in its entirety; it only updates the ACPPE's seismic requirements. The remainder of the document outlines how pressure equipment can comply with the Pressure Equipment, Cranes and Passenger Ropeways Regulations (PECPR) of New Zealand.

1.2 Content

The majority of PN19 addresses how to determine seismic actions using the known behaviour of industrial structures and New Zealand's mapped seismic hazard. The Practice Note has 10 sections and 9 appendices.

The main body of the practice note addresses issues relating to how earthquakes affect industrial plant and how the seismic actions may be determined for the sizing of new pressure equipment and industrial structures or for the checking of existing or modified items.

The appendices provide additional information such as guidelines for specific equipment, worked examples and recommendations for the minimum seismic coefficients for pressure equipment in the locations covered by NZS 1170.5.

2. VERSION 4 MINOR CHANGES

2.1 The Changes

- Most references to NZS4203 (SNZ 1992), the superseded structural loading standard have been removed.
- Most references to AS/NZS1200 (SNZ 2000) Appendix I and Table I1 have been removed.
- References to OSH or the Department of Labour have been changed to WorkSafe.
- Corrected errors in the definition of Combination Structures with regards to the % weight of non-structural items.
- Section 5.18 Working Stress Methods has been split into 3 sub-parts with a new section on brittle fracture.
- Sections 7.3.1 and 7.3.4 have become redundant with the removal of references to NZS4203.

- Some clarifications to the assumptions listed in the example calculations in Appendix E.

3. VERSION 4 MAJOR CHANGES

3.1 The Changes

- Section 5.4.2 Strength Provisions for items coming under the PECPR Regulations has been re-written.

- The Royal Commission on the Canterbury Earthquakes recommendation regarding peak seismic displacements has been included in Section 5.19 Seismic Displacements and in the example calculations in Appendix E.

- Appendix D "Guidelines for Retrofitting or Modifying Existing Plant" has now been included.

3.2 Section 5.4.2 Items coming under PECPR Regulations

This section outlines the current practice of determining seismic coefficients for pressure equipment and their supports. A seismic coefficient is determined from NZS 1170.5 and PN19 and that is compared to the minimum value given in Table H1 of Appendix H, PN19 and the maximum value of these two is then used in the design. Further it is stated that:

"The intention is that all pressure equipment shall be designed to have adequate strength and stability during earthquakes to satisfy the:

- Pressure containment limit state so that in a design period earthquake leak tightness and position retention are maintained. Complying with recognised pressure equipment standards demonstrates this."

3.3 Section 5.19 Seismic Displacements

The poor performances of some inter-storey stairs in multi-storey buildings during the major Canterbury earthquakes lead to a Technical Report to the Royal Commission by Bull (2011). Bull outlined that this appeared to arise from structural engineer's being confused about the difference between design and peak seismic displacements. He and the Royal Commission (Recommendation 39) recommended that the peak displacements be determined from a seismic analysis where in the calculations for the seismic forces, the structural performance factor S_p was set to unity. Structural analyses undertaken to consider the sliding or toppling stability of the overall structure are already required to do this as per NZS 1170.5 clause 4.4.1.

Bull also recommended for structures containing escape routes, the stairs between levels should be designed to remain operable for deflections determined from at least a 2500 year return period earthquake. Thus for a normally manned plant, the main escape paths from elevated levels, need to consider the 2500 year return period earthquake deflections in their design especially their supports.

3.4 Appendix D "Guidelines for Retrofitting or Modifying Existing Plant"

This appendix is new for Version 4; it was left out of the earlier versions as consensus on how the topic could be outlined was difficult to achieve between plant owners, design engineers, design verifiers and the regulatory authorities.

The purpose of this appendix is to guide controllers, designers and design verifiers when existing pressure equipment is to be altered. Equipment that requires re-design may not necessarily need to meet the full seismic loading code requirements. This Practice Note recommends the designer follows and documents an engineering safety process for determining low, medium and high risk and then choose the appropriate earthquake design action.

The appendix is sub-divided into 7 sections: Introduction, Risk Evaluation, Unmodified Plant, Procedure for Alterations and Repairs, Alterations Affecting Seismic Strength, Reduced Seismic Loading and Design Guidelines for Alterations to Existing Pressure Equipment.

3.4.1 Risk Evaluation

The persons conducting a business or undertaking (PCBU) requirement to identify hazards may initially be complied with by a qualitative process. Figure D1 can be used to classify the equipment into low, medium or high risk categories. This is based on the Hazard Level for the item determined from AS 4343 but there are other considerations that can move the item from one risk group to another.

Some guidelines have been given on:

- What a significant effect from a loss of containment means.
- What an equipment item operating outside of its design parameters means.

3.4.2 Unmodified Plant

Section 3 considers "Unmodified Plant" and what the Act requires of employers. A procedure is set out for old unmodified plant on what "all practical steps to ensure the safety of employees at work" would involve with regards to seismic considerations.

- The "Do nothing" approach is only valid for the Low Risk Category items.
- Medium risk items require a walk down evaluation.
- High risk items require an engineering evaluation and a comparison with current codes.

3.4.3 Procedure for Alterations and Repairs

Section 4 outlines the procedure for alterations and repairs of existing plant. This procedure is intended to supplement Appendix A of the ACPPE to show the additional steps required to determine the extent of engineering analysis required.

A flow chart is given that covers:

- Fitness for service or remaining life assessments
- Proposed modifications
- Proposed repairs
- The Design Verification, fabrication inspection and certificates of inspection required to get the pressure equipment returned to service

3.4.4 Alterations Affecting Seismic Strength

Section 5 considers alterations that affect seismic strength. ACPPE Appendix A Clause 4.5 requires alterations to be treated as new design and to be design verified. For practical reasons it is necessary to define what level of alteration is significant in terms of seismic resistance.

This Appendix recommends the designer conducts an initial analysis to determine whether "trigger points" apply and consequently to define when a seismic design assessment is required.

The Trigger points for treating alterations as "new" plant are:

- A 10% change limit to:
    a. Increases in weight or over-turning actions
    b. Decreases in seismic strength
    c. Alterations to load paths
    d. Process design conditions
- Displacement-induced failure risk increasing
- Relocation
- An extension of the Design Life (for items post PECPR 1999)

3.4.5 Seismic Loading

This Practice Note acknowledges that an increased level of risk of failure of existing structures in an earthquake is considered acceptable in building regulations and society in general.

The intention of Appendix D is that existing pressure equipment should be required only to meet a loading requirement based on the risk classification and the designer's engineering judgement of the meaning of

"all practicable steps". Where the engineer is designing an alteration affecting seismic strength and a reduction of the seismic design load below the current code requirements appears necessary, the designer may decrease the design seismic load to the appropriate value from Table D2 provided that the resultant seismic strength is not lower than prior to the alteration.

Table D2: Seismic Reduction Factors

PRESSURE EQUIPMENT RISK CATEGORY	MINIMUM SEISMIC DESIGN LOADS FOR EXISTING PRESSURE EQUIPMENT
High	• 50% of current requirement • 100% of requirement at the time of installation (note i & ii) • 0.1g
Medium	Maximum of: • 34% of current requirement (note ii) • 100% of requirement at the time of installation (note i & ii) • 0.1g
Low	Maximum of: • 34% of current requirement (note iii) • 100% of requirement at the time of installation (note i & ii) • 0.1g

Notes for Table D2:
i. If 100% of current requirement is lower than the requirement at the time of installation, then the current requirement can be used provided it is not less than 0.1g.

If a site specific seismic assessment is carried out and results in 100% of the current required seismic load being lower than the original design load, then the current seismic load can be used. When conducting a seismic assessment on an existing item of pressure equipment to this appendix, a remaining design life of not less than 25 years shall be used, as recommended in Section 5.1.6 of the Practice Note.

Section 6 is not intended to apply to equipment that is relocated from another site or to a higher elevated location on the same site. Relocated equipment shall be assessed against 100% of current requirements and upgraded if necessary.

Should a need arise to use a value of less than 34% of current requirements, the designer may do so provided that an engineering justification is provided and formally accepted by the controller, design verifier and equipment inspector. The minimum requirement of 0.1g is based on the requirement of the old NZSS 95 "Model Building Bylaw", which is effectively the first seismic design load requirement in New Zealand following the 1931 Napier earthquake.

3.4.6 Design Guidelines for Alterations to Existing Pressure Equipment

Section 7 covers design guidelines for alterations to existing pressure equipment. When the seismic analysis of a pressure equipment system shows that certain components are overstressed, it is best to modify the design and/or support arrangements to reduce stresses to within the allowable limits.

Where this is not feasible e.g. due to a lack of accessibility and/or when the cost of modifications would be prohibitive, the engineer may consider more advanced, less conservative analytical techniques. Advanced analytical methods can have much lower factors of safety than the traditional code calculations and therefore the lower seismic design load from Section 6 cannot be justified without further work.

The New Zealand Society for Earthquake Engineering (NZSEE) has recommended however, that 66% of current standard is the minimum level of risk that would be acceptable in a societal sense, e.g. for Importance Level = 2, an increase from 10% to 20% chance of exceedance. This level therefore, can be justified regardless of the method used.

Guidelines have been given on the extent of seismic assessments for:

- Piping systems
- Vessels, Turbines and Boilers
- On the interface between new and existing pressure equipment
- Differential displacements between new and existing pressure equipment
- Extent of the analysis of foundations and supports
- Pressure equipment with no documentation

3. CONCLUSION

There have been a substantial amount of small editorial changes. These are all highlighted throughout the Version 4 document.

Seismic peak earthquake displacements are now calculated as per the Royal Commission's recommendations.

Appendix D "Guidelines for Retrofitting and Modifying Existing Plant" has now been included and has begun to be used for projects throughout New Zealand.

ACKNOWLEDGEMENTS

The Working Party who have been a significant part of the journey for this document since 2009 especially Cameron Smart who had the hard task of herding disparate voices and to Stephen Holm who kept at writing Appendix D.

REFERENCES

American Society of Civil Engineers: *Guidelines for Seismic Evaluation and Design of Petrochemical Plants – First Edition*. (1997).

Lindup, G.: *Adapting the Structural Design Actions Standard for the Seismic Design of New Industrial Plant*, Bulletin of the New Zealand Society for Earthquake Engineering 40(3): 81-141. (2007).

Standards Australia and Standards New Zealand: *AS/NZS 1200:2000 Pressure Equipment*. (2000)

Standards New Zealand: *Structural Design Actions – Part 5 Earthquake Actions – New Zealand*. NZS 1170.5. (2004).

Standards New Zealand: *NZS 4203:1992 Code of Practice for General Structural Design and Design Loadings for Buildings.* (1992).

WorkSafe New Zealand: *Approved Code of Practice for Pressure Equipment (Excluding Boilers)*. (2001).