

Proposed Change 2153

Code Reference(s):	NFC25 Div.B 4.1.2.2. (first printing)
Subject:	Flammable and Combustible Liquids
Title:	Classification of Additional Water Miscible Liquid Mixtures
Description:	This proposed change provides classification for four additional water-miscible liquid mixtures.
Related Proposed Change(s):	PCF 2145

This change could potentially affect the following topic areas:

- | | |
|--|--|
| ☐ Division A | ☒ Division B |
| ☐ Division C | ☐ Design and Construction |
| ☐ Building operations | ☐ Housing |
| ☐ Small Buildings | ☐ Large Buildings |
| ☒ Fire Protection | ☐ Occupant safety in use |
| ☐ Accessibility | ☐ Structural Requirements |
| ☐ Building Envelope | ☐ Energy Efficiency |
| ☐ Heating, Ventilating and Air Conditioning | ☐ Plumbing |
| | ☐ Construction and Demolition Sites |

Problem

To manage the risks of water-miscible liquid mixtures (WMLMs), the National Fire Code of Canada (NFC) classifies mixtures of methanol, ethanol, 2-propanol, acetone and acetic acid and water according to their flammability or combustibility.

For other WMLMs, the industry often faces stricter storage and handling requirements based on the hazards associated with the pure solvent. These include flammability and combustibility. While adding water to a hazardous solvent can lower these risks, it does not eliminate them. Therefore, stricter guidelines for the pure solvent are usually followed during storage. This means ensuring proper ventilation, using suitable containers, and implementing fire safety and spill containment measures.

These precautions can add costs that could be avoided if the risk posed by the WMLM were properly assessed and the WMLM classified accordingly.

Justification

WMLMs are often used in cosmetics (e.g., 1-propanol), cleaning products (e.g., 1,4-dioxane and tert-butanol), household items (e.g., 1,4-dioxane), and arts and crafts (e.g., morpholine).

Diluting pure solvents with water often reduces their hazard level. To enable Code users to assess their flammability or combustibility and regulate storage, this proposed change would add four WMLMs to the flammability and combustibility classifications in Table A-4.1.2.2. of the NFC: mixtures of 1,4-dioxane, 1-propanol, morpholine, and tert-butanol and water.

The four WMLMs proposed for inclusion in the NFC do not have boiling points below 37.8°C (see Table 1 below). This means none would be classified as Class IA flammable liquids. The most hazardous among them would be classified as Class IB flammable liquids [1].

Table 1. Boiling Point of Solvents Proposed for Inclusion in the NFC

Solvent	Boiling Point, °C
1,4-Dioxane	101.2 [1]
1-Propanol	97.2 [3]
Morpholine	128 [1]
tert-Butanol	82.3 [1]

This proposed change classifies the four additional WMLMs based on data from closed-cup flash point tests in the literature. The testing data for each WMLM are provided below.

1. 1,4-Dioxane

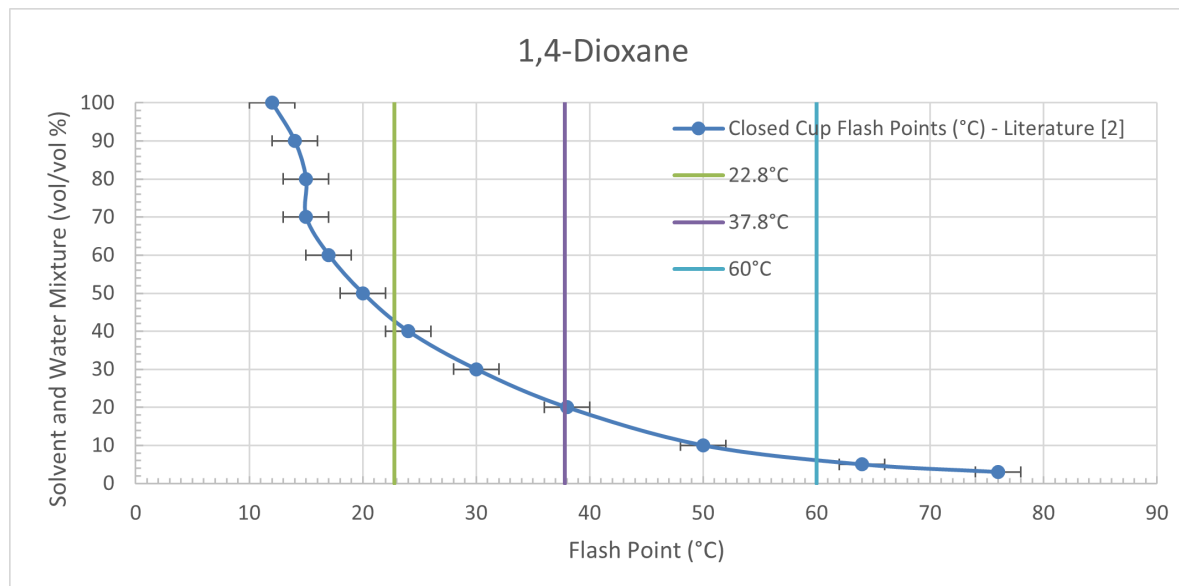
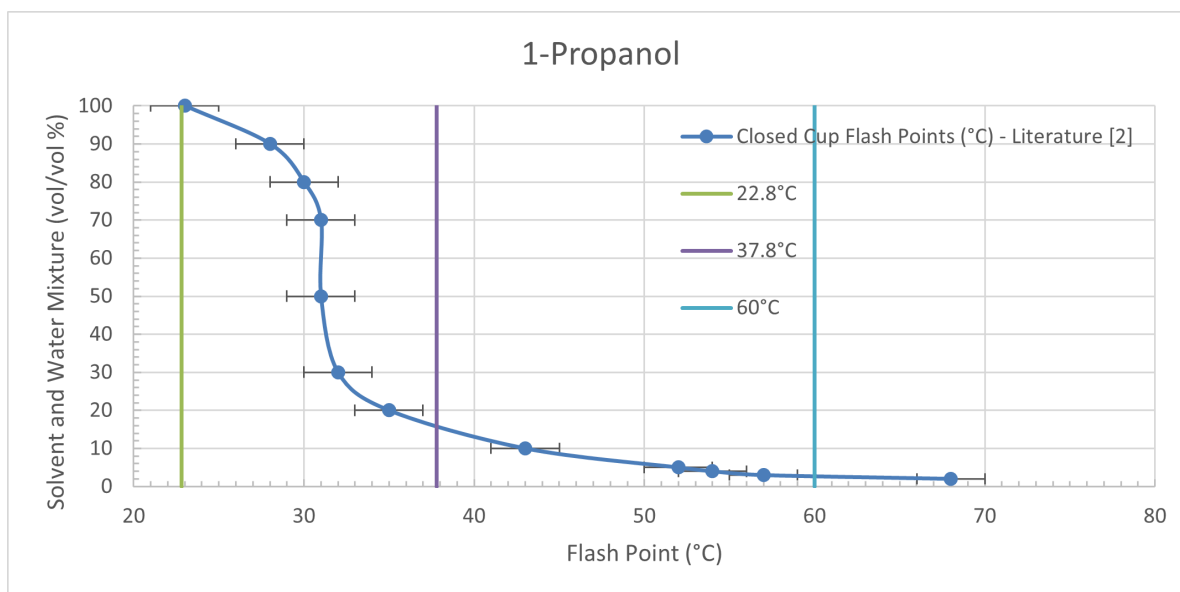


Figure 1. Closed-cup flash points of 1,4-dioxane–water mixture

Table 2. Closed-Cup Flash Points of 1,4-Dioxane–Water Mixture [2]

1,4-Dioxane, % v/v	Closed-Cup Flash Point, °C	Uncertainty, +/- °C
100	12	2
90	14	2
80	15	2
70	15	2
60	17	2
50	20	2
40	24	2
30	30	2
20	38	2
10	50	2
5	64	2
3	76	2

2. 1-Propanol**Figure 2. Closed-cup flash points of 1-propanol–water mixture****Table 3. Closed-Cup Flash Points of 1-Propanol–Water Mixture [2]**

1-Propanol, % v/v	Closed-Cup Flash Point, °C	Uncertainty, +/- °C
100	23	2

90	28	2
80	30	2
70	31	2
50	31	2
30	32	2
20	35	2
10	43	2
5	52	2
4	54	2
3	57	2
2	68	2

3. Morpholine

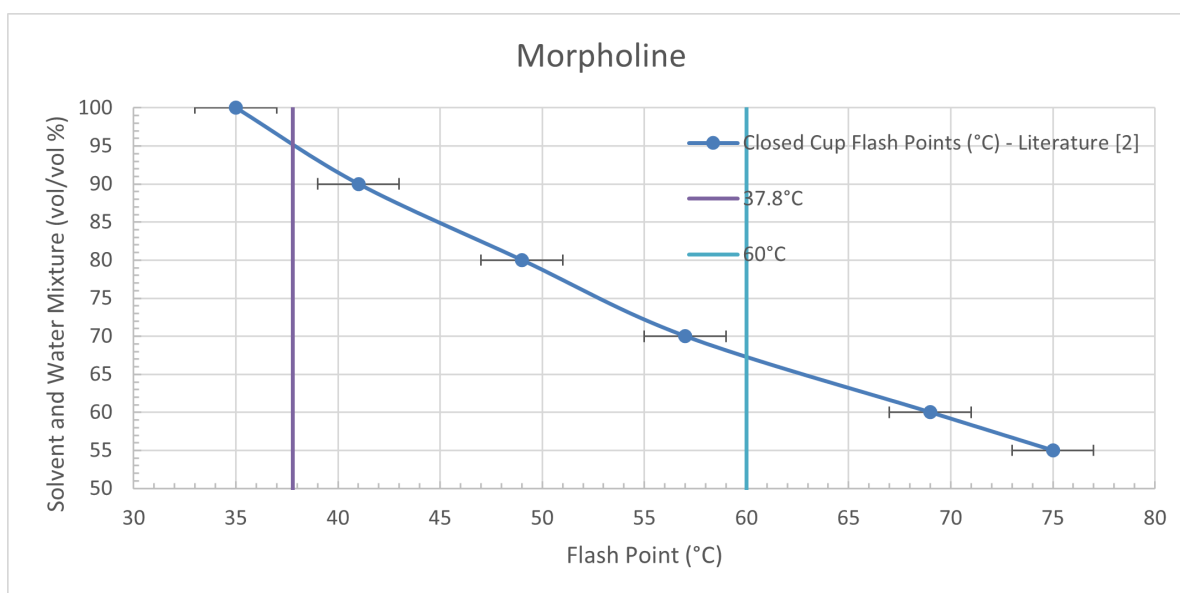


Figure 3. Closed-cup flash points of morpholine–water mixture

Table 4. Closed-Cup Flash Points of Morpholine–Water Mixture [2]

Morpholine, % v/v	Closed-Cup Flash Point, °C	Uncertainty, +/- °C
100	35	2
90	41	2
80	49	2

70	57	2
60	69	2
55	75	2

4. tert-Butanol

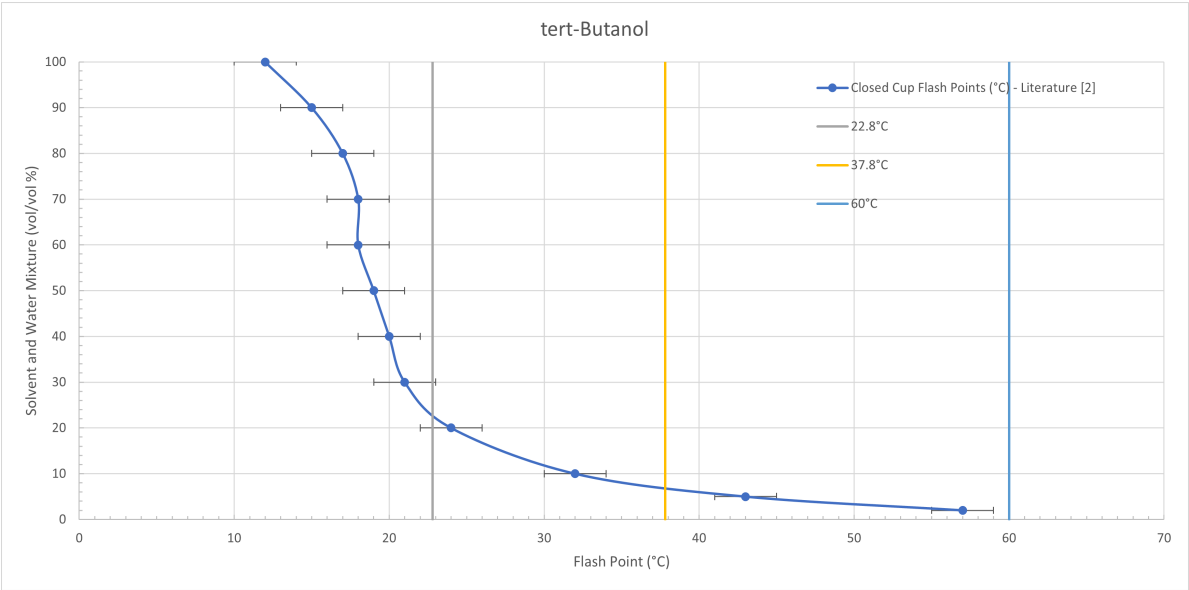


Figure 4. Closed-cup flash points of tert-butanol–water mixture

Table 5. Closed-Cup Flash Points of tert-Butanol–Water Mixture [2]

tert-Butanol, % v/v	Closed-Cup Flash Point, °C	Uncertainty, +/- °C
100	12	2
90	15	2
80	17	2
70	18	2
60	18	2
50	19	2
40	20	2
30	21	2
20	24	2
10	32	2
5	43	2
2	57	2

Based on NFC Subsection 4.1.2. and the data from closed-cup flash point tests in the literature, and by interpolating between the relevant data points, the classification of the four new WMLMs in the NFC should be as shown in the revised Table A-4.1.2.2.-2030.

References

- [1] Haynes, W. M., Lide, D. R., and Bruno, T. J., *CRC Handbook of Chemistry and Physics*, 97th Edition, Boca Raton, FL 33487-2742: Taylor & Francis Group, 2016–2017.
- [2] Astbury G., Bugand-Bugandet J., Grollet E., and Stell K., "Flash Points of Aqueous Solutions of Flammable Solvents," IChemE Symposium Series No. 150, pp. 1–18, 2004.
- [3] National Center for Biotechnology Information, *1-Propanol*. PubChem, National Institutes of Health. <https://pubchem.ncbi.nlm.nih.gov/compound/1-Propanol> (accessed November 20, 2025)

For more information on these WMLMs, visit the website of the US National Center for Biotechnology Information:

- 1,4-Dioxane: https://pubchem.ncbi.nlm.nih.gov/compound/1_4-Dioxane
- 1-Propanol: <https://pubchem.ncbi.nlm.nih.gov/compound/1-Propanol>
- Morpholine: <https://pubchem.ncbi.nlm.nih.gov/compound/Morpholine>
- tert-Butanol: <https://pubchem.ncbi.nlm.nih.gov/compound/tert-Butanol>

PROPOSED CHANGE

[4.1.2.2.] 4.1.2.2. Water-Miscible Liquid Mixtures

(See Note A-4.1.2.2.)

- [1] 1)** For the purposes of this Part, ~~mixtures of methanol, ethanol, 2-propanol, acetone or acetic acid~~ water-miscible liquid mixtures of the specified solvents and water shall be classified in conformance with Sentences (2) ~~to (6)~~ to (10).
- [2] 2)** A mixture of methanol and water shall be classified as
- [a] a) a Class IB liquid if the concentration of methanol is 90% or more by volume,
 - [b] b) a Class IC liquid if the concentration of methanol is 30% or more but less than 90% by volume, or
 - [c] c) a Class II liquid if the concentration of methanol is 20% or more but less than 30% by volume.
- [3] 3)** A mixture of ethanol and water shall be classified as
- [a] a) a Class IB liquid if the concentration of ethanol is 90% or more by volume,
 - [b] b) a Class IC liquid if the concentration of ethanol is 30% or more but less than 90% by volume, or
 - [c] c) a Class II liquid if the concentration of ethanol is 20% or more but less than 30% by volume.

- [4] --)** A mixture of 1-propanol and water shall be classified as
- [a] --) a Class IC liquid if the concentration of 1-propanol is 16% or more by volume, or
 - [b] --) a Class II liquid if the concentration of 1-propanol is 2% or more but less than 16% by volume.
- [5] 4)** A mixture of 2-propanol and water shall be classified as a Class IC liquid if the concentration of 2-propanol is 20% or more by volume.
- [6] --)** A mixture of 1,4-dioxane and water shall be classified as
- [a] --) a Class IB liquid if the concentration of 1,4-dioxane is 43% or more by volume,
 - [b] --) a Class IC liquid if the concentration of 1,4-dioxane is 20% or more but less than 43% by volume, or
 - [c] --) a Class II liquid if the concentration of 1,4-dioxane is 6% or more but less than 20% by volume.
- [7] 5)** A mixture of acetone and water shall be classified as a Class IB liquid if the concentration of acetone is 5% or more by volume.
- [8] 6)** A mixture of acetic acid and water shall be classified as a Class IB liquid if the concentration of acetic acid is 8% or more by volume.
- [9] --)** A mixture of morpholine and water shall be classified as
- [a] --) a Class IC liquid if the concentration of morpholine is 95% or more by volume, or
 - [b] --) a Class II liquid if the concentration of morpholine is 67% or more but less than 95% by volume.
- [10] --)** A mixture of tert-butanol and water shall be classified as
- [a] --) a Class IB liquid if the concentration of tert-butanol is 24% or more by volume,
 - [b] --) a Class IC liquid if the concentration of tert-butanol is 7% or more but less than 24% by volume, or
 - [c] --) a Class II liquid if the concentration of tert-butanol is 1% or more but less than 7% by volume.

Note A-4.1.2.2.

According to research and test results, mixtures containing less than 20% by volume methanol, ethanol or 2-propanol, less than 2% by volume 1-propanol, less than 5% by volume acetone, ~~or~~ less than 8% by volume acetic acid, less than 6% by volume 1,4-dioxane, less than 67% by volume morpholine, or less than 1% by volume tert-butanol in water are unlikely to present a fire hazard. While these water-miscible liquid mixtures still have flash points, they may not be able to develop sustained burning because of the presence of water in the mixtures. Therefore, these mixtures are not classified as flammable or combustible liquids. They may, however, be classified as dangerous goods to which the requirements of Part 3 would apply.

The flash points and fire points of water-miscible liquid mixtures depend on the concentration of the water-miscible liquid. The classifications noted in Article 4.1.2.2.

for mixtures of methanol, ethanol, 1- or 2-propanol, acetone, ~~or~~ acetic acid, 1,4-dioxane, morpholine or tert-butanol and water, which are summarized in Table A-4.1.2.2., take into account the flash points and fire points of the mixtures at various concentrations of the water-miscible liquid, as well as their unique fire and chemical properties.

Table [4.1.2.2.] A-4.1.2.2.
Classification of Mixtures of a Water-Miscible Liquid and Water
Forming Part of Note A-4.1.2.2.

~~Volume Concentration of the Water-Miscible Liquid, %~~ <u>Solvent</u>	Classification		
	Class IB	Class IC	Class II
	<u>Volume Concentration Range of the Solvent in Water, % v/v</u>		
Methanol	<u>≥ 63</u> (PCF 2145)	<u>≥ 30 and < 63</u> (PCF 2145)	<u>≥ 10 and < 30</u> (PCF 2145)
~~≥ 90~~	~~✓~~	~~—~~	~~—~~
~~≥ 30 and < 90~~	~~—~~	~~✓~~	~~—~~
~~≥ 20 and < 30~~	~~—~~	~~—~~	~~✓~~
Ethanol	<u>≥ 56</u> (PCF 2145)	<u>≥ 18 and < 56</u> (PCF 2145)	<u>≥ 5 and < 18</u> (PCF 2145)
~~≥ 90~~	~~✓~~	~~—~~	~~—~~
~~≥ 30 and < 90~~	~~—~~	~~✓~~	~~—~~
~~≥ 20 and < 30~~	~~—~~	~~—~~	~~✓~~
<u>1-Propanol</u>	<u>—</u>	<u>≥ 16</u>	<u>≥ 2 and < 16</u>
2-Propanol	<u>≥ 41</u> (PCF 2145)	<u>≥ 12 and < 41</u> (PCF 2145)	<u>≥ 3 and < 12</u> (PCF 2145)
~~≥ 20~~	~~—~~	~~✓~~	~~—~~
<u>1,4-Dioxane</u>	<u>≥ 43</u>	<u>≥ 20 and < 43</u>	<u>≥ 6 and < 20</u>
Acetone	<u>≥ 7 (PCF 2145)</u>	<u>< 7 (PCF 2145)</u>	<u>— (PCF 2145)</u>
~~≥ 5~~	~~✓~~	~~—~~	~~—~~
<u>Morpholine</u>	<u>—</u>	<u>≥ 95</u>	<u>≥ 67 and < 95</u>

~~Volume Concentration of the Water-Miscible Liquid, %~~ <u>Solvent</u>	Classification		
	Class IB	Class IC	Class II
	<u>Volume Concentration Range of the Solvent in Water, % v/v</u>		
<u>tert-Butanol</u>	≥ 24	≥ 7 and < 24	≥ 1 and < 7
~~Acetic acid~~ (<u>PCF 2145</u>)			
≥ 8	✗	—	—

It is impractical for every type and concentration of water-miscible liquid mixture to be classified in the Code. The classification of a mixture not covered in Article 4.1.2.2. can be determined by measuring its fire point using the open-cup test described in ASTM D92, "Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester", and then classifying it in accordance with Sentences 4.1.2.1.(2) and (3) by treating the measured fire point as the flash point of the mixture. This procedure should also be followed to determine the classification of a mixture containing multiple water-miscible liquids and water, as the flash point and fire point of the mixture are likely to differ from those of each water-miscible liquid in water. (Note that closed-cup tests are used to determine the flash points of pure liquids.)

Impact analysis

This proposed change may ease the compliance burden for Code users who store and handle these WMLMs. It would also save the one-time cost of flammability or combustibility testing to a classification standard.

Compliance cost savings

Based on their flammability or combustibility classification, flammable and combustible liquids are subject to different requirements regarding the maximum quantity allowed to be stored, clearance distances and location for storage, installation of fire suppression systems, and installation of storage tanks and ancillary equipment, as well as procedures for safe dispensing, loading and unloading. Thus, the cost of Code-compliant storage and handling could be quite different between a Class I and a Class II liquid.

Mixing a flammable or combustible solvent with water may reduce its fire risk such that the resulting mixture falls into a lower hazard classification than the pure solvent. Because the lower classification requires less stringent storage and handling protocols, proper classification of WMLMs could significantly reduce costs. Due to the variety of real-life situations, however, the exact or average compliance cost savings cannot be calculated.

For example, 1,4-dioxane—which is widely used as a substitute for methylene chloride in paint stripper formulations because of its lower volatility—is classified as a Class IB liquid in its pure form, but when it is diluted with water to less than 20% by volume, the resulting WMLM falls under Class II. According to NFC Sentence 4.2.5.2.(2), the maximum quantity of the diluted 1,4-dioxane and water mixture (Class II) that is allowed to be stored in mercantile occupancies that are not sprinklered is 8 L/m² of the total area of the suite, up to an absolute maximum 8 000 L, while the maximum quantity of pure 1,4-dioxane (Class IB) permitted to be stored is 0.3 L/m² of the total area of the suite, up to 300 L. The classification of the 1,4-dioxane and water mixture would therefore allow a greater quantity of less than 20% by volume 1,4-dioxane and water to be stored in a single mercantile suite, which would provide some relief for business owners with limited space who need to store large amounts of diluted 1,4-dioxane.

Classification testing cost savings

Currently, the classification of WMLMs not covered in Article 4.1.2.2. can be determined by measuring their closed-cup flash points in accordance with Subsection 4.1.3. and classifying them in accordance with Sentences 4.1.2.1.(2) and (3).

The cost to perform a standardized flash point test in accordance with Subsection 4.1.3. can vary significantly, starting at approximately \$150 with the final cost depending on the lab, raw material type, number of samples, and required turnaround time [1][2].

References

[1] Petro-Lubricant Testing Laboratories, Inc., ASTM D56: Flash Point by Tag Closed Cup, <https://www.petrolube.com/price-list-catalog/astm-d-56a-10927/>.

[2] MaTestLab, ASTM D56 Standard Test Method for Flash Point by Tag Closed Cup Tester, <https://matestlabs.com/test-standards/astm-d56/>.

Enforcement implications

This proposed change could be enforced by the infrastructure currently available.

Who is affected

Regulators, engineers, building owners, contractors, fire services and certain businesses using WMLM.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[4.1.2.2.] 4.1.2.2. ([1] 1) no attributions

[4.1.2.2.] 4.1.2.2. ([2] 2) no attributions

[4.1.2.2.] 4.1.2.2. ([3] 3) no attributions

[4.1.2.2.] -- ([4] --) no attributions

[4.1.2.2.] 4.1.2.2. ([5] 4) no attributions

[4.1.2.2.] -- ([6] --) no attributions

[4.1.2.2.] 4.1.2.2. ([7] 5) no attributions

[4.1.2.2.] 4.1.2.2. ([8] 6) no attributions

[4.1.2.2.] -- ([9] --) no attributions

[4.1.2.2.] -- ([10] --) no attributions