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Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals

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Item 10 (c) of the provisional agenda

Issues related to the Globally Harmonized System of Classification and Labelling of Chemicals: Classification criteria for flammable gases

Sub-Committee of Experts on the Globally Harmonized System of Classification and Labelling of Chemicals

Twenty-ninth session

Geneva, 29 June – 1 July 2015

Item 2 (b) of the provisional agenda

Classification criteria and related hazard communication: Classification criteria for flammable gases

Report of the Joint TDG-GHS informal working group dealing with categorization of flammable gases

Transmitted by the experts from Belgium and Japan

First day: Monday 9 March 2015

1. The Joint TDG-GHS informal working group (IWG) dealing with the categorization of flammable gases was organized in Brussels from 9 to 11 March 2015 by the Belgian and the Japanese delegations to the TDG and GHS sub-committees. Mr. Michaël Bogaert was appointed as chairman. Both delegations welcomed the participants. The participants (physically/by phone) list can be found in Annex 1of this report.

2. The purpose of this IWG was to review the current criteria and discuss possible modifications to the GHS Flammable Gas Category 1 (extremely flammable gases). The participants were reminded of the mandate given to this IWG during the plenary sessions of the GHS and TDG sub-committees (1-12 December 2014,Geneva). The mandate can be found in Annex 2 of this report.

Mandate item 1(a): Analysis of the necessity to create GHS subcategories, within Category 1, for flammable gases

3. Different presentations were given by governmental organizations and experts from industry and research institutes in order to give some background on the present situation and some recent evolutions:

(a) Introduction and objectives of IWG by Mr. Michaël Bogaert

The current criteria for flammable gases are based on the lower flammability limit and the flammability range. Transport only considers Flammable Gases Category 1, the others are considered by TDG as non-flammable. There is varying data regarding the flammable range of ammonia. In any case, ammonia and methyl bromide are considered as exceptions for some regulatory purposes because of historical reasons but arguably also fall under

Category 1. Currently most flammable gases except some very specific mixtures, are classified as Category 1. Belgium and Japan identified a need to subdivide Category 1, rather than lump all flammable gases into one category for the reasons explained in informal document - INF.10/Rev.1 (TDG, 46th session) – INF.05/Rev.1 (GHS 28th session).

(b) Description of the matter by Mr. Edward Lampert

From an industrial point of view, there is currently only one practical category of flammable gases. There is currently a practical inability to distinguish different levels of hazard within flammable gases. It would be useful for safety and knowledge reasons to have a distinction between higher and lower flammability gases. Even if such a distinction is made, all flammable gases should be labelled with a flame symbol and warning.

(c) Safety and Environmental requirements for additional categories by Mr. Denis Clodic

The Montreal Protocol of 1989 for the Protection of the Ozone Layer has led to the phasing out of ozone depleting substances (e.g. CFC, HCFC, etc.) in a short period of time. Linked with the Climate Convention this caused the change from non-flammable high "global-warming potential" (GWP) gases to low GWP gases which are considered as mildly flammable. This has also led to the introduction of hydrocarbons, hydro-fluor-olefines and others, as solvents, refrigerants, blowing agents, etc. There is a tradeoff between positive environmental impact and flammability of these compounds. We need a new flammability index, similar to the GWP-index, ranking the flammability of the gases.

(d) BAM's view on the desirability for other classification by Mrs. Cordula Wilrich

The current Flammable Gases Category 2 is virtually empty. With more subcategories there can be a better consideration of hazard. Maybe we should also think about revisiting Category 2, although it is not in the mandate.

(e) Review of standards in related fields [ISO, ASHRAE (the American Society of Heating, Refrigeration, and Air Conditioning Engineers)] by Mr. Osami Kataoka

Existing standards, such as ISO 5149, use a criterion based on the low flammability limit (LFL) 3.5 vol%, and ISO 5149-2014 and ISO 817 (2014) also use burning velocity of 10cm/s as a criterion: as well as heat of combustion of 19 MJ/kg. ASHRAE 34 makes also a subcategory based on the LFL_w 100g/m³ and heat of combustion (HoC) 19 MJ/kg, with a Subcategory 2L based on burning velocity, according to the measuring method described in ISO 817. Those categorizations show that there was a need for subdivisions.

CONCLUSION on Item 1 of mandate subject (a)

4. The IWG came to a principle agreement that there is a necessity to create an additional GHS subdivision within Category 1. This decision was based on:

- **Safety considerations including the necessity to mark off reliable hazard areas for flammable gases and the necessity to provide hazard guidance for users of, for instance, blowing agents, solvents, cleaners and other process gases in hot and humid climates and high temperature factory working environments,**

- **The reality of widespread adoption and further desirability of adoption of low GWP (but mildly flammable) gases to deal with climate change issues (Montreal Protocol/Kyoto Protocol) which arise with the currently used non-flammable gases**

5. The IWG further noted that:

- **Additional data or testing should not be mandatory, any sub-categorization of gases should be optional to the producer/user, and the sub-categorization scheme should not be unnecessarily complicated.**
- **Specific cases, such as Ammonia and Methyl Bromide, which now attract a special treatment within GHS and TDG and are now held outside the standard category 1 framework should continue to be held outside.**
- **The necessity to create an additional sub-category is independent of any decision as to the specifics of that sub-category.**
- **De-regulation in transport and unwanted downstream consequences must be avoided.**

Mandate Item 2 (a): Evaluation of the most appropriate additional parameters for modified classification criteria

(a) An overview was given by the expert Mr. Filip Verplaetsen about different flammability characteristics, prevention techniques, explosion/fire protection, sensitivity properties and severity characteristics.

The following parameters were retained as possible useful or relevant parameters as a basis for subcategorization: the flammability limits LFL/UFL and flammability range (UFL-LFL), the burning velocity, the minimum ignition energy (MIE)/the minimum ignition current (MIC)/the maximum experimental safe gap (MESG), the auto-ignition temperature AIT, the heat of combustion (HoC), the maximum explosion pressure (Pmax), the maximum rate of pressure rise Kg.

(b) BAM presented a proposal, based on lower flammability limits. This was based on the idea that primary hazard identification should be a task of TDG-GHS sub-committees. Secondary and constructional flammability characteristics seem to be too detailed for use in a classification and labelling system.

The determination methods of the flammability limits are well established: tube method, bomb method or glass flask. The international determination methods are sufficiently accurate and there is also the ISO 10156:2010 method available. There is a calculation method available for determining the flammability of gas mixtures and it can be extended with the Le Chatelier's equation to calculate the LFL for gas mixtures (even though there are some issues in application for halogenated compounds). The LFL values of pure gases (see Table 2 in ISO 10156) and also LFL values of refrigerants are known (see ASHRAE 34-2013).

Proposal 1:

- subcategory 1A LFL $\leq$ 5%,
- subcategory 1B 5% < LFL $\leq$ 13% or flammable range $\geq$ 12%
- cat 2 : LFL > 13% and flammable range < 12%

Proposal 2:

- cat 1: LFL < 5%,
- cat 2: LFL > 5%,

In proposal 1, only LFL would be used for subdividing Category 1, and all typical fuel gases will be in subcategory 1A, and most halogenated gases will become 1B. Proposal 2 would make more use of Category 2, which is now nearly empty.

(c) The Chilworth study on "GHS Category of flammable gases: review and proposed modification" was presented. It was concluded that the fundamental burning velocity (BV) is an intrinsic property that takes into account both likelihood and consequence of the flammability hazard. This study proposes a subcategory for flammability based on BV as follows: hazard Subcategory 1bwould include gases in Subcategory 1a with a BV < 10 cm/s with a modification of the hazard statement to H221- ("flammable gas").

(d) Mr. Scott Davis gave a presentation on the laminar or fundamental burning velocity (FBV). FBV helps to evaluate the likelihood and the consequences of a burning reaction and is essentially the reaction speed of this burning reaction. The combustion of hydrocarbons consists of chain reactions and halogens will stop these reactions and decrease reactivity. The transient state (linked to the speed of the reaction) is important, therefore FBV is an important parameter. Burning velocity is an intrinsic fundamental parameter. There is a good ranking in FBV of different gases, such as ethylene, methane, refrigerants, ammonia. FBV is also an important parameter to assess the turbulent flame velocity. NFPA has adopted FBV as the metric to determine safety venting in flammable gas environments. Testing FBV is feasible across the world with demonstrated testing methods. The total risk is the product of the likelihood and the consequence, and FBV is directly linked to both.

CONCLUSION on Item 2 of mandate subject (a)

6. Approximately 10 different parameters were brought forward in the IWG. Among them there was widespread support for extension of the use of LFL and the Flammable Range (FR), and the use of FBV. There was also mention of using AIT as a parameter to assure that any pyrophoric gases are reverted to Subcategory 1a extremely flammable gases.

Second day: Tuesday 10 March 2015

7. Mr. Denis Clodic gave a presentation on the flammability parameters for classification criteria and their relation to risk. In the existing ASHRAE classification not all substances are considered equally dangerous. In ASHRAE 34-2013 the criteria are LFL expressed in g/m³ and burning velocity. H4F2 (R152a) is different than Ammonia (NH3) because of the different burning velocity. In order to classify a gas to the ASHRAE -34 Subclass 2L, the FBV has to be determined to be above 10 cm/s..

8. Mr. Filip Verplaetsen presented a table with the pros and cons of the shortlist of parameters that were retained from the previous discussion. The table is given below. The primary parameters are LFL and FBV. As secondary parameters AIT and MIE were considered. There were no objections leaving HoC and MESG out of the short list for further consideration.

Table 1: Pros and Cons of shortlisted parameters for the criteria of flammable gases

Flammability parameters of gases : pros and cons **JOINT GHS-TDG INFORMAL WORKING GROUP (IWG) ON CATEGORIES OF FLAMMABLE GASES** **Meeting: 09, 10, 11 March 2015 - Brussels**		
Flammability parameter of gases	+	-
Lower flammability limit with range (UFL-LFL)	• Intrinsic property • Simple in determination • Currently in use in regulation and some standards • Calculation method for mixed gases established • Many values already available in ISO10156 • Linked with hazardous distance (e.g. ATEX)	• Practical use demonstrates that classification based exclusively on LFL/UFL may lead to inconsistencies, also link with flammability range • Mixing rule not always applicable for halogenated compounds • There is no gap around Cut-off value 5% il list of flammable gases
Laminar or Fundamental Burning Velocity (BV)	• Has a large gap around 10 cm/s in order to classify easily • Can be used as additional criterium for categorization • Intrinsic property, related to other likelihood properties • Standardised measurement method • Takes into account entire combustion process • Currently in use in some hazard standards	• Challenging to measure low burning velocity (below 5cm/s • No simple mixing rules available, more advanced modelling needed
Auto-ignition temperature	• Intrinsic property • Standardised measurement method • Link with temperature classes of explosion safe equipment	• Strongly dependent on test volume and geometry • Not direct link with intrinsic flammability hazard
Heat of combustion	• Known property • Easy to estimate	• Only represents the "end state parameter" and does not capture the transient combustion process
Minimun ignition energy (MIE)	• Intrinsic property • Standardised measurement method • Indicator of likelihood of ignition • Linked with MESG and BV	• Very difficult to measure accurately, currently known values are inconsistent • Current standard methods of measurement are imprecise • Does not give an idea of propagation
Maximum experimental safety gap (MESG)	• Linked with MIE and BV • Easier to measure	• Only measures propagation, and only in a limited exposure scenario

9. Based on these primary parameters three compromise proposals were developed within the IWG and are presented below.

Compromised options

Option 1

Using the LFL and FBV for sub-dividing

Category 1		Category 2
Default : Sub-category 1a	Option : Sub-category 1b	
Gases, which at 20°C and a standard pressure of 101.3 kPa are ignitable when in a mixture of 13% or less by volume in air or UFL-LFL ≥12 %	Gases from 1a with : 1) LFL > 5% And 2) FBV < 10 cm/s	Gases with : LFL > 13% and UFL-LFL < 12 %
 Extremely flammable gas (H220) Danger	 [Flammable gas] [H221][Hxxx] [Danger]/[Warning]	Flammable gas (H221) Warning

Date : 11 March 2015

Option 1 for the sub-categorization of Category 1 of flammable gases

10. The first compromise proposal places the flammable gases of the previous Category 1 by default in Subcategory 1a. There is an OPTION to move flammable gases to Sub-category 1b if the lower flammability limit LFL > 5% AND the fundamental burning velocity FBV < 10 cm/s. There was consensus that Subcategory 1b would also attract the "flammable" pictogram There was still discussion about the hazard phrase of sub-category 1b, therefore [flammable gas] is placed between square brackets. The GHS hazard statement code could be H221 or a new one (Hxxxphrase) could be proposed. There was also discussion whether [Danger] or [Warning] should be used as the signal word for subcategory 1b.

Option 2

Category 1		Category 2
Default : Sub-category 1a	Option : Sub-category 1b	
Gases, which at 20°C and a standard pressure of 101.3 kPa are ignitable when in a mixture of 13% or less by volume in air or UFL-LFL ≥12 %	Gases from 1a with : 1) 4% < LFL ≤ [6%]/[8%] AND FBV < 10 cm/s OR 2) LFL > [6%]/[8%]	Gases with : LFL > 13% and UFL-LFL < 12 %
 Extremely flammable gas (H220) Danger	 [Flammable gas] [H221][Hxxx] [Warning]/[Danger]	Flammable gas (H221) Warning

Date : 11 March 2015

Option 2 for the sub-categorization of Category 1 of flammable gases

11. The second option is a compromise proposal between the first option and a criterion based purely on the LFL. If the LFL is higher than a certain value (6% or 8%), no data on FBV is needed to put the gas in sub-category 1b. If the LFL is between 4% and this value (6%/8%) the FBV should be less than 10 cm/s. This additional use of the FBV criterion was considered necessary to remedy some adverse effects of using only LFL (e.g. allowing methane in sub-category 1b). A remark was made that according to this option, carbon monoxide (CO with LFL 10,9% and UFL 74% and BV=43 cm/s) can be classified as Category 1b for flammability. The IWG did not consider it appropriate to link other hazards (such as toxicity) to this work.

Option 3

Using the LFL or FBV for sub-dividing

Category 1		Category 2
Default : Sub-category 1a	Option : Sub-category 1b	
Gases, which at 20°C and a standard pressure of 101.3 kPa are ignitable when in a mixture of 13% or less by volume in air or UFL-LFL ≥12 %	Gases from 1a with : 1) LFL > [5% ?] [6% ?] [8% ?] OR 2) LFL < 10 cm/s	Gases with : LFL > 13% and UFL-LFL < 12 %
 Extremely flammable gas (H220) Danger	 [Flammable gas] [H221][Hxxx] [Danger]/ [Warning]	Flammable gas (H221) Warning

Date : 11 March 2015

Option 3 for the sub-categorization of Category 1 of flammable gases

12. The third option uses an OR criterion instead of an AND criterion for FBV for the Subcategorization into 1b. In an initial version of Option 3 a third OR criterion was added, namely the MIE > 10 mJ (ASTME 582-07 2007). Because the MIE criterion corresponds well with the criterion FBV < 10 cm/s, it was agreed to remove this third OR criterion for MIE from this option.

13. There was a remark and discussion to exclude the pyrophoric gases from Sub-category 1b, for example by adding the additional criterion of AIT > 54 °C.

14. It was argued that this is superfluous, since there is a recently adopted new hazard category in the flammable gases hazard class of the GHS for pyrophoric gases. Flammable gases that ignite spontaneously in air at a temperature of 54 ºC or below (AIT ≤ 54°C) are classified as Pyrophoric gases, see below or the United Nations document ST/SG/AC.10/C.3/2014/54 − ST/SG/AC.10/C.4/2014/5:

Classification		**Labelling**				**Hazard statement codes**
Hazard class	**Hazard category**	**Pictogram**		**Signal word**	**Hazard statement**	
		GHS	**UN Model Regulations**[a]			
Flammable gases	**Pyrophoric gas**			**Danger**	May ignite spontaneously if exposed to air	H232

The remark was retained, because there was a concern that pyrophoric gases could be invented that are categorized as “flammable” but not “extremely flammable”, while they have an AIT ≤ 54 °C and a wide flammable range (such a gas would, in any case, still fall in the Pyrophoric Gas subcategory). In order to exclude pyrophoric gases from subcategory

1b, an additional criterion AIT > 54°C could be added, or it could be added in textual form (e.g. subcategory 1b: may include only gases from Subcategory 1a which do not meet the criteria for pyrophoric gases and chemically unstable gases). It was also remarked that pyrophoric gases can also be part of flammable gases Category 2 at the moment, and no special treatment for 1b in this respect. It should be investigated in more detail if it should be permitted for some flammable gases to be classified both as pyrophoric and subcategory 1b.

Third Day: Wednesday 11 March 2015

Mandate item (e): Impact analysis on the existing classifications of flammable gases (with feedback from other gases-sectors)

15. The consideration of mandate subject (e) led to the production of an impact analysis table for each of the three options for subcategorization A preliminary impact assessment was presented that included the categorization of different flammable gases, with data taken from ISO 10156:2010, ISO 817:2014 and the Chilworth study. These new categorizations were made according to the 3 options developed by this IWG (see below). These options are subdivided into multiple suboptions based on the different cut off values for LFL being considered (i.e. for options 2 and 3). These cut-off values are placed between square brackets, e.g. for option 3,LFL > 5%, 6% or 8%. This results in two columns for option 2 and three columns for option 3.

Table 2: Subcategories of different flammable gases according to three compromise options

Excerpt from ISO 10156:2010 and ISO 817:2014 and Chilworth study

Gas	LFL*1	UFL	Range	BV	AIT	OPTION 1 (5%)	OPTION 2 (8%)	OPTION 2 bis (6%	OPTION 3 (5%)	OPTION 3 (6%)	OPTION 3 (8%)
	in % (v/v)			cm/s	C						
Carbonyl disulfide	0,6	60	59,4		NIA	1A	1A	1A	1A	1A	1A
Diborane	0,9	98	97,1		40	1A	1A	1A	1A	1A	1A
Germane	1	12,3	11,3		54	1A	1A	1A	1A	1A	1A
Dimethylpropane	1,3	7,5	6,2		450	1A	1A	1A	1A	1A	1A
Ethylacetylene	1,3	11,7	10,4		NIA	1A	1A	1A	1A	1A	1A
Methyl silane	1,3	88,9	87,6		160	1A	1A	1A	1A	1A	1A
Trimethylsilane	1,3	51,3	50		235	1A	1A	1A	1A	1A	1A
1,2-Butadiene	1,4	18,3	16,9	68	340	1A	1A	1A	1A	1A	1A
1,3-Butadiene	1,4	12	10,6	64	340	1A	1A	1A	1A	1A	1A
n-Butane (R600)	1,4	8,4	7	45	355	1A	1A	1A	1A	1A	1A
Silane	1,4	96	94,6		21	1A	1A	1A	1A	1A	1A
1-Butene	1,5	10,6	9,1	51	385	1A	1A	1A	1A	1A	1A
cis-Butene	1,5	9	7,5		325	1A	1A	1A	1A	1A	1A
Methylbutene	1,5	9,1	7,6		275	1A	1A	1A	1A	1A	1A
trans-Butenes	1,5	9,7	8,2		325	1A	1A	1A	1A	1A	1A
Isobutene	1,6	10	8,4		465	1A	1A	1A	1A	1A	1A
Phosphine	1,6	98	96,4		38	1A	1A	1A	1A	1A	1A
Propane (R290)	1,7	9,5	7,8	46	480	1A	1A	1A	1A	1A	1A
Cyclobutane	1,8	11,1	9,3	62	NIA	1A	1A	1A	1A	1A	1A
Isobutane (R-600a)	1,8	8,4	6,6	41	460	1A	1A	1A	1A	1A	1A
Methylacetylene	1,8	16,8	15		454	1A	1A	1A	1A	1A	1A
Propene (R1270)	1,8	10,3	8,5	54	498	1A	1A	1A	1A	1A	1A
Diethyl ether (R-610)	1,9	4,8	2,9	47	160	1A	1A	1A	1A	1A	1A
Propadiene	1,9	11,7	9,8		NIA	1A	1A	1A	1A	1A	1A
Ethyl methyl ether	2	10,1	8,1	42	190	1A	1A	1A	1A	1A	1A
Trimethylamine	2	11	9		190	1A	1A	1A	1A	1A	1A
Vinyl methyl ether	2,2	39	36,8		549	1A	1A	1A	1A	1A	1A
Acetylene	2,3	100	97,7	166	335	1A	1A	1A	1A	1A	1A
Cyclopropane	2,4	10,4	8	56	500	1A	1A	1A	1A	1A	1A
Ethane (R170)	2,4	12,5	10,1	47	515	1A	1A	1A	1A	1A	1A
Ethylene (R1150)	2,4	10,3	7,9	80	450	1A	1A	1A	1A	1A	1A
Ethylene oxide	2,6	31	28,4	108	429	1A	1A	1A	1A	1A	1A
Dimethyl ether (RE170)	2,7	27	24,3	54	405	1A	1A	1A	1A	1A	1A
Dimethylamine	2,8	14,4	11,6		401	1A	1A	1A	1A	1A	1A
Vinyl fluoride	2,9	21,7	18,8		385	1A	1A	1A	1A	1A	1A
Ethyl amine (R-631)	3,5	14	10,5	27	383	1A	1A	1A	1A	1A	1A
Chloroethane	3,6	14,8	11,2		494	1A	1A	1A	1A	1A	1A
Fluoroethane (R161)	3,8			38,3	455	1A	1A	1A	1A	1A	1A
Vinyl chloride	3,8	33	29,2		472	1A	1A	1A	1A	1A	1A
Arsine	3,9	75	71,1		NIA	1A	1A	1A	1A	1A	1A
Cyanogen	3,9	36,6	32,7		850	1A	1A	1A	1A	1A	1A
Hydrogen sulfide	3,9	45	41,1		260	1A	1A	1A	1A	1A	1A
Difluoroethane (R152a)	4	18,5	14,5	23	455	1A	1A	1A	1A	1A	1A
Hydrogen (R702)	4	75	71	317	500	1A	1A	1A	1A	1A	1A
Hydrogen selenid	4				NIA	1A	1A	1A	1A	1A	1A
Methyl mercaptan	4,1	21,8	17,7		420	1A	1A (no BV)	1A (no BV)	1A	1A	1A
Methane (R50)	4,4	14	9,6	37	537	1A	1A	1A	1A	1A	1A
Chlorotrifluoroethylene (R1113)	4,6	34	29,4		540	1A	1A (no BV)	1A (no BV)	1A	1A	1A
Dichlorosilane	4,7	96	91,3	96	55	1A	1A	1A	1A	1A	1A
Methylamine(R630)	4,9			25	430	1A	1A	1A	1A	1A	1A
Methyl formate (R-611)	5	23	18		449	1A	1A (no BV)	1A (no BV)	1A	1A	1A
Methyl nitrite	5,3				523	1A (no BV)	1A (no BV)	1A (no BV)	1B	1A	1A
Difluoroethylene (R1132a)	5,5	21,3	15,8		380	1A	1A (no BV)	1A (no BV)	1A	1A	1A
Fluoromethane (R41)	5,6	s		28	NIA	1A	1A	1A	1B	1A	1A
Vinyl bromide	5,6	15	9,4		530	1A (no BV)	1A (no BV)	1A (no BV)	1B	1A	1A
R-1234yf	6,2	12,3	6,1	1,5	405	1B	1B	1B	1B	1B	1B
Chlorodifluoroethane (R142b)	6,3	17,9	11,6		632	1A (no BV)	1A (no BV)	1B	1B	1B	1A (no BV)
Carbonyl sulfide	6,5	29	22,5		NIA	1A (no BV)	1A (no BV)	1B	1B	1B	1A (no BV)
R-1234ze(E)	6,5	NA		1,2	368	NF	NF	NF	NF	NF	NF
Deuterium	6,7	75	68,3		585	1A (no BV)	1A (no BV)	1B	1B	1B	1A (no BV)
Formaldehyde	7	73	66		430	1A (no BV)	1A (no BV)	1B	1B	1B	1A (no BV)
Trifluoroethane (R143a)	7	18,8	11,8	7,2	750	1B	1B	1B	1B	1B	1B
Methyl chloride (R40)	7,6	19	11,4		640	1A (no BV)	1A (no BV)	1B	1B	1B	1A (no BV)
1,1-dichlrio i-fluoroethane (R-141b	7,6	15,5	7,9		550	1A (no BV)	1A (no BV)	1B	1B	1B	1A (no BV)
Trichloroethene	7,9	100	92,1			1A (no BV)	1A (no BV)	1B	1B	1B	1A
Methyl Bromide	8,6	20	11,4		535	Exception	Exception	Exception	Exception	Exception	Exception
Tetrafluoroethylene (R1114)	10,5	60	49,5		180	1A (no BV)	1B	1B	1B	1B	1B
Trifluoroethylene (R1123)	10,5	27	16,5		>750	1A (no BV)	1B	1B	1B	1B	1B
Carbon monoxide	10,9	74	63,1	43	651	1A	1B	1B	1B	1B	1B
Methylene chloride (R-30)	13	19	6		556	1A (no BV)	1B	1B	1B	1B	1B
Difluoromethane (R-32)	14,4	31	16,6	6,7	530	1B	1B	1B	1B	1B	1B
Ammonia (R717)	15,4	28	12,6	7,2	651	Exception	Exception	Exception	Exception	Exception	Exception

*1) LFL numbers in ISO 10156:2010. Numbers in ISO 817:2014 are not same for some gases.

NF: Non flammable, has no flammability range at 20°C and 101,3 kPa

Exception: under the current GHS classification, Ammonia and Methyl Bromide may be regarded as special cases for some regulatory purposes

16. The following conclusions can be made from this preliminary impact assessment:

- No difference in categorization between the 3 options, for gases with LFL < 4%
- For gases with LFL 4% - 5 %, no difference between the 3 options, if no BV data was available,
- For gases with LFL 5% -6% only option 3 with a cut-off of 5% allows three gases to change to Subcategory 1B
- For gases with LFL:6% -8%: 6 gases cannot be classified as Subcategory 1B because no BV data is available at this moment. For option 2 bis (with a cut-off of 6%) and option 3 with a cut-off of 5% or 6%, the BV is not necessary to classify them as Subcategory 1B.
- For gases with LFL greater than 8% all gases would be Subcategory 1B except with option 1, because no BV data was available, and CO is only also according to option 1 Subcategory 1A ,not Subcategory 1B.

17. Presentation by the expert Mr Osami Kataoka :

The LFL alone is not always a good parameter. For example carbon monoxide (CO) has a high LFL but has a wide flammable range and a high BV. The stoichiometric concentration divided by the lower flammability limit (Cst/LFL) is correlated with BV. There exist some problems with measuring for high or very low MIE values. The LFL and the BV are complementary and should be used in conjunction, as was done in ASHRAE..

18. A definition of Fundamental Burning Velocity was given by the expert Mr. Scott Davis:

The fundamental burning velocity FBV is the rate (expressed in cm/s) at which a planar, laminar flame propagates into a quiescent unburned mixture. Fundamental burning velocity is an intrinsic property of the fuel and air mixture, whereby it is a measure of its burning reaction rate. FBV should be measured in dry air, and the method should correct for flow field influences such as flame curvature and stretch.

Conclusions

19. The progress made with the mandate can be summarized as follows:

(a) In line with mandate item (a) and (b) an agreement was reached on the necessity to subcategorize category 1 of flammable gases;

(b) Different presentations were given by the experts and are available on a dedicated Google Docs Drive. The link to this Drive is integrated in Annex 3 to this document;

(c) According mandate item (c) the available test methods and their accuracy to define the candidate parameters were analysed for the short list of parameters. Extensive data and standard test methods for LFL of gases and mixtures exist already, but some points need additional clarifications;

(d) Review of different standards from ASHRAE and ISO (mandate item (d)), especially in the field of refrigerants, showed that additional subcategories already exist in some fields;

(e) There was consideration of the impact on the existing classifications of flammable gases, which led to the production of a preliminary impact

analysis table indicating the various classifications according to the different compromise options. This is a first overview for a number of gases, which can be further elaborated to include more gases;

(f) There was limited consideration of developing details of possible modifications for GHS/TDG Manual of Tests and Criteria (mandate item (f)), but three favored options for classification were proposed. Within those options some aspects (Signal Word and Hazard Statement) are in square brackets and subject to further discussion.. It was agreed that, in any case, a flame symbol should be included for any new Subcategory within Category 1;

(g) Reporting to both sub-committees (TDG and GHS) on progress at the following UNSCEGHS & UNSCETDG meetings will be done in June 2015, according mandate item (g).

20. It can be concluded that the majority of the IWG participants have shown support for the first two compromise options. Option three was kept in the shortlist of options by a minority of the participants. It was agreed that this list of options constitutes a good starting point to review the impact of the sub-categorization on the different flammable gases of the different sectors.

21. The TDG and GHS sub-committees are invited to consider and comment upon the results of the IWG to give guidance on appropriate ways forward, in particular concerning the different proposed options. It is the intention of the experts from Belgium and Japan to organize a second session of the IWG between the June and December sessions of both sub-committees to continue the work, taking into account the comments received.

Annex 1

List of participants

GHS TDG IWG meeting : Attendees List on 9 - 11 March 2015 in Brussels

Participants							
Title	Name	Organisation	E-mail	Country		Physical	Tel
Mr.	Michaël Bogaert	Bel Transport Ministry	michael.bogaert@mobilit.fgov.be	Belgium		✔	
Mr.	Patrick Van Lancker	Bel Transport Ministry	Patrick.VanLancker@mobilit.fgov.b	Belgium		✔	
Dr.	Marie-Noelle Blaude	Bel Health and Environment Ministry	Marie-Noelle.Blaude@wiv-isp.be	Belgium		✔	
Dr.	Hiroshi Jonai	Nihon University	jonai.hiroshi@nihon-u.ac.jp	Japan		✔	
Mr.	Takashi Hamada	Nippon Kaiji Kentei Kyokai	taka-hamada@nkkk.or.jp	Japan		✔	
Mrs.	Ruriko Nakamura	Nat. Institute for Tech and Evaluation	nakamura-ruriko@nite.go.jp	Japan		✔	
Mr.	Yasujiro Miyake	Ministry of Economy, Trade and Industry	miyake-yasujiro@meti.go.jp	Japan		✔	
Mr.	Tetsuro Fukunaga	Japan Machinery Center	fukunaga@jmceu.org	Belgium		✔	
Mr.	Frederik Norman	Rapporteur	Frederik.norman@adinex.be	Belgium		✔	
Mr.	Osami Kataoka	As Expert	osami.kataoka@daikin.co.jp	Japan		✔	
Dr.	Scott Davis	As Expert	sgdavis7@gmail.com	Norway		✔	
Dr.	Denis Clodic	As Expert	denis.clodic@ereie-sas.fr	France		✔	
Prof.	Filip Verplaetsen	As Expert	Filip.verplaetsen@adinex.be	Belgium		✔	
Mr.	Martin Dieryckx	Observer	dieryckx.m@daikineurope.com	Belgium		✔	
Mr.	Pierre Wolfs	EIGA	p.wolfs@eiga.eu	Belgium		✔	
Mr.	Edward Lampert	CEFIC	lampert@lampert-japan.com	Japan		✔	
Mr.	Gerd-Uwe Spiegel	CEFIC	gerd-uwe.spiegel@dupont.com	Germany		✔	
Mr.	Jack Wert	The Compressed Gas Association	jwert@cganet.com	USA		✔	
Ms.	Amy Park	The Compressed Gas Association	apark@cganet.com	Canada		✔	
Mr.	Nacer Achaichia	Honeywell	nacer.achaichia@honeywell.com	Belgium		✔	
Ms.	Debra Kennoy	Arkema Inc	debra.kennoy@arkema.com	USA		✔	
Mr.	Jorge Dieguez	DuPont Chemicals & Fluoroproducts	jorge.dieguez@dupont.com	Switzerland		✔	
Mr.	Joachim Gerstel	DuPont Chemicals & Fluoroproducts	joachim.gerstel@dupont.com	Gremany			
Dr.	Cordula Wilrich	BAM Federal Institute for Materials Res	cordula.wilrich@bam.de	Germany		✔	
Prof.	Volkmar Schröder	BAM Federal Institute for Materials Res	volkmar.schroeder@bam.de	Germany		✔	
Mr.	Soedesh Mahesh	RIVM	soedesh.mahesh@rivm.nl	The Netherlands		✔	
Mr.	John Anicello	Airgas Inc	john.anicello@airgas.com	USA		✔	
Mr.	Joseph Nicklous	USDOT/PHMSA	joseph.nicklous@dot.gov	USA		✔	
Mr.	Lionel Aufauvre	INERIS	lionel.aufauvre@ineris.fr	France		✔	
Mr.	Satoshi Komatsu	JFMA	jfmajp@ca.mbn.or.jp	Japan		✔	
Mrs.	Violeta Shutarova Sokoleska	Ministry of Transport & Communications	violeta.sutarova@mtc.gov.mk	FYROM		✔	
Mrs.	Sonja Kostovska	Ministry of Transport & Communications	sonja.kostovska@mtc.gov.mk	FYROM		✔	
Mr.	Stefaan Vanderstraeten	Secretary	ghstdg.iwg.cat.gas@gmail.com	Belgium		✔	
Ms.	Lauriane Giet	Assistant to secretary	ghstdg.iwg.cat.gas@gmail.com	Belgium		✔	
Mr.	Michaël Hauspie	Waran Translations		Belgium		✔	
Mrs.	Kathy Landkrohn	U.S. Department of Labor, OSHA	landkrohn.kathy@dol.gov	USA			✔
Ms.	Jennifer Lawless	U.S. Department of Labor, OSHA	lawless.jennifer@dol.gov	USA			✔
Mr.	James Lay	U.S. Department of Labor, OSHA	lay.jim@dol.gov	USA			✔
Ms.	Maureen Ruskin	US OSHA	Ruskin.maureen@dol.gov	USA			✔
Mr.	Patrick J Jnueau	Transport Canada	patrick.juneau@tc.gc.ca	Canada			✔
Mr.	Richard Craig	Compressed Gas Association	rcraig@cganet.com	USA			✔
Mr.	Guy Colonna	NFPA	gcolonna@nfpa.org	USA			✔
Mrs.	Tagemine Alladin	Transport Canada	tagenine.alladin@tc.gc.ca	Canada			✔
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Annex 2

Formally endorsed GHS-TDG IWG mandate during plenary session (1-12 December 2014, Geneva)

(a) Analysis of the necessity to create GHS subdivisions, within Category 1, for flammable gases including evaluation of the most appropriate additional parameters for modified classification criteria (based on a review of past studies);

(b) Technical analysis of the candidate parameters linked to these criteria and their importance related to risks in workplace, for the users, for emergency services and for the transport of dangerous goods;

(c) Evaluation of the available test methods and their accuracy to define the candidate parameters;

(d) A review of regulatory and industrial standards in related fields;

(e) Impact analysis on the existing classifications of flammable gases (with feedback from other gases – sectors);

(f) Developing details of possible modifications for GHS/TDG Manual of Tests and Criteria;

(g) Reporting to both sub-committees (TDG and GHS) on progress at the next sessions.

Annex 3

Link to the google docs drive

https://drive.google.com/folderview?id=0B39bxM4AXnl6fi1tajRRZ250MzVGUkRZdGYyVThWVX
VuaXdQU3dUbUx6SHM3dWM1SWp0UUk&usp=drive_web