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

15 June 2016

Sub-Committee of Experts on the Transport of Dangerous Goods

Forty-ninth session

Geneva, 27 June – 6 July 2016

Item 10 (c) of the provisional agenda

Issues relating 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

Thirty-first session

Geneva, 5– 8 July 2016

Item 2 of the provisional agenda

Joint work with the Sub-Committee of Experts on the Transport of Dangerous Goods (TDG Sub-Committee)

Background information regarding hazard communication for flammable gases

Transmitted by the experts from Belgium and Japan

1. This document is submitted as background to the formal Proposal for modification of the classification criteria and hazard communication for flammable gases (ST/SG/AC.10/C.3/2016/17 − ST/SG/AC.10/C.4/2016/4), transmitted by the experts from Belgium and Japan.

2. During the December 2015 sessions of the Sub-Committee of Experts on the Transport of Dangerous Goods (TDG Sub-Committee) and the Sub-Committee of Experts on the Globally Harmonized System of Classification and Labelling of Chemicals, (GHS Sub-Committee), the joint TDG-GHS informal working group on classification criteria for flammable gases presented the results of its work consisting of new classification criteria to be used for dividing flammable gases. As noted in the report[1], there was full support for the criteria in option 3 in informal documents INF.15 (TDG Sub-Committee, 48th session) - INF.4 (GHS Sub-Committee, 30th session) i.e., allowing for sub-categorization of current category 1 into category 1A and 1B, with category 1B addressing gases with a lower flammability limit greater than 6% or a fundamental burning velocity of less than 10 cm/s.

3. It was noted that the new sub-category 1B would allow the classification of gases and gas mixtures with a lower burning velocity developed by the refrigeration and foam plastics industries following the phasing down of high global warming potential substances. It was also noted that the criteria in option 3 would not entail any change in classification for transport purposes.

4. This recommendation was based on factors such as:

- safety considerations including the necessity to mark off reliable hazard areas for flammable gases and the necessity to provide the right hazard guidance for users of, for instance, blowing agents, solvents, cleaners and other process gases,

[1] Refer to the report of the GHS Sub-Committee on its 30th session (ST/SG/AC.10/C.4/60, paras. 4 to 8)

- the need of a wider adoption of gases with low global warming potential (flammable) to deal with climate change issues (Montreal Protocol and Kyoto Protocol)

4. In the consensus recommendation from the IWG on flammable gases categories, led by the Belgian and Japanese GHS Delegations, gases which meet the criteria of category 1 or 1A[2] and which have a lower flammability limit (LFL) of more than 6% by volume in air; and/or a fundamental burning velocity (FBV) less than 10 cm/s may be categorised as Category 1B gases.

5. There has been discussion regarding the appropriate hazard statements for the revised categories. Belgium and Japan agreed to bring forward further information regarding the appropriateness of the signal word and hazard statement (warning/flammable gas) for the proposed category 1B. This document contains three pieces of information in this regard:

- The first is a set of tests which have been undertaken in response to the request for better understanding of the differences in escape time and consequences of ignition between the proposed 1A and 1B flammable gases categories. Gases in the testing are both pure gases in commercial use and mixtures created to illustrate these parameters for distinguishing between 1A and 1B gases. (See Annex 1).
- These tests results have been analysed by Dr. Denis Clodic, Expert on Global Warming and Gas Flammability, (See Annex 2)
- The third is an Expert Opinion from Professor M. J. Kalsher, Rensselaer Polytech Institute, regarding Hazard Communication Elements for a Proposed Modification of the Categories of Flammable Gases within the GHS Framework. (See Annex 3)

[2] 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 have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit are considered Category 1A gases.

Annex 1

Tests undertaken to better understand the differences in escape time and consequences of ignition between the proposed 1A and 1B flammable gases categories

TESTING THE RELATIVE HUMAN ESCAPE TIME FOR FLAMMABLE GASES

This test was designed to confirm, for various gases in the proposed 1A and 1B categories, the relative time between a) the start of a leak, b) a standard warning from a leakage tester at ¼ LFL and c) the creation of flammable conditions at 1/1 LFL; in other words, the time, after an alarm sounds, during which it is possible for a person to avoid and escape a warehouse or workshop before the conditions for a flammable environment are reached.

ESCAPE TIME TEST SET UP

- The test gas was leaked in a $1.5m^3$ container (1,800x900x900mm), at a rate of 3.5L/min, equivalent to either a severed 3cm pipe in a $18,000m^3$ warehouse (L 100m, W 30m, H 6m) or a severed 1.5cm pipe in a standard workshop (L 5m, W 6m, H 5m).
- The gas concentration was measured by oxygen replacement.
- Leakage testers were placed at 6 locations in the test apparatus. Escape time is the time from the ¼ LFL alarm to the 1/1 LFL (flammable atmosphere). To obtain conservative (shortest) escape time values, the ¼ LFL alarm times are recorded when all six testers signal the ¼ LFL and flammable atmosphere (1/1 LFL) is recorded when the first tester signals the flammable concentration.

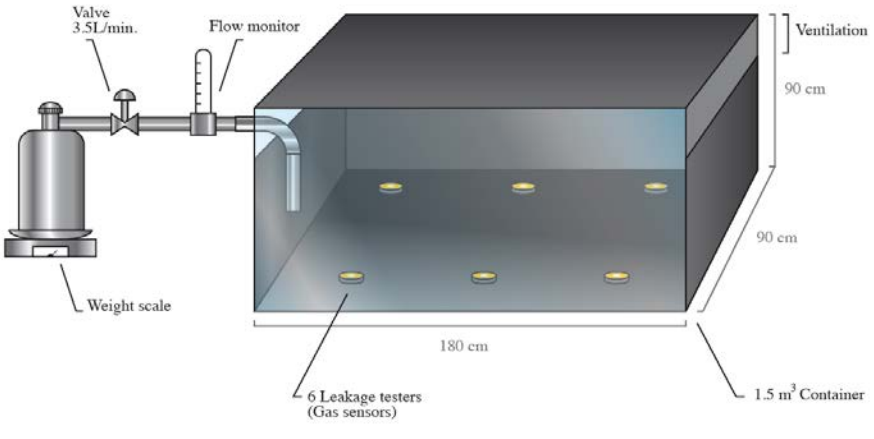


Figure 1: Escape time test set-up

DIFFERENCES IN RELATIVE ESCAPE TIMES FOR THE TESTED FLAMMABLE GASES

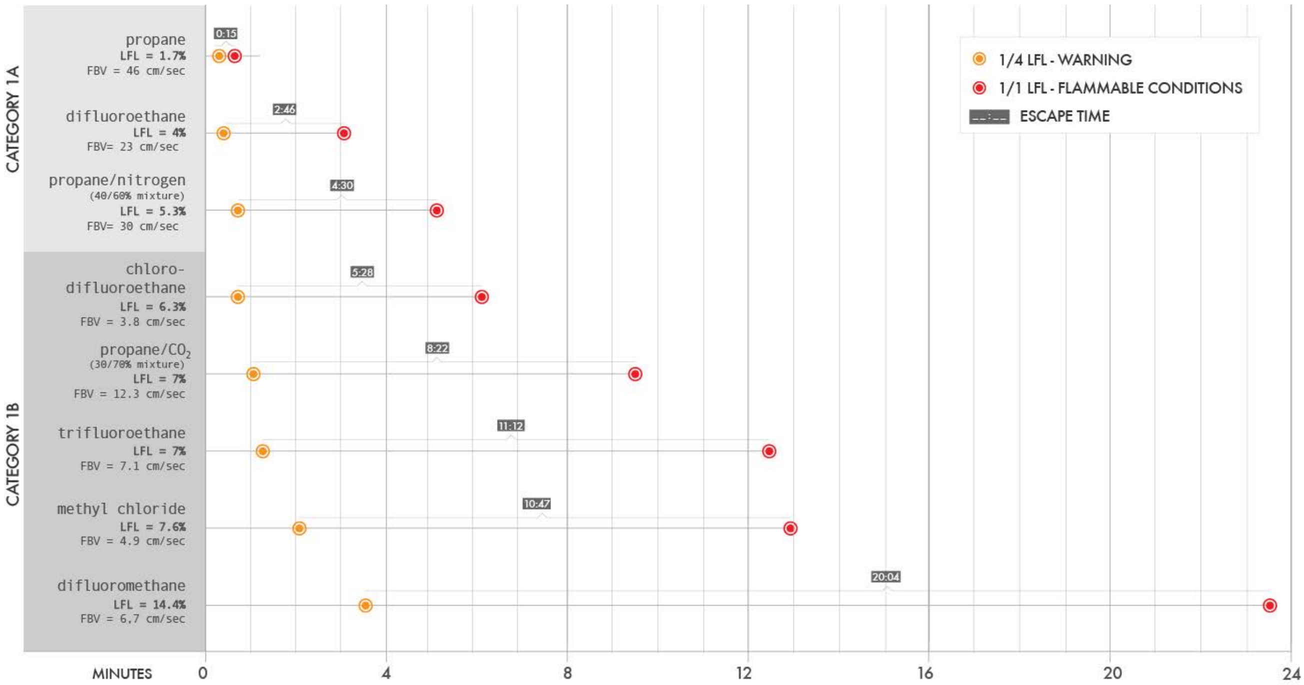


Figure 2: Differences in Relative Escape Times for the Tested Flammable Gases
An enlarged version of this graph is available on the last page of this document

ESCAPE TIME TEST RESULTS

- The test results are consistent, although not identical, to theoretical results and as expected, gases with higher LFL provide more escape time.
- Although escape times just above and below the LFL threshold are within one minute of each other, there are significant differences between the two categories of gases as a whole. Two gases with the same LFL but different FBV's would, if ignited, have different consequences.
- Gases in the 1B group uniformly allowed for reasonable exit after an alarm. P. Hughes and E. Ferrett[3] indicate that occupational structures should provide 2 to 3 minutes escape time. The results here indicate that in realistic situations category 1B gases allow an escape time of 5 minutes and more. The time would vary depending on structure size, geometry and leak rate but the observation of relative escape time remains valid.

[3] P. Hughes and E. Ferrett, International Health and Safety at Work: for the NEBOSH International General Certificate in Occupational Health and Safety, 2015, page 362

TESTING THE CONSEQUENCES OF AN IGNITION

Two tests were designed for examining the consequences of an ignition in a real life situation for gases categorised as 1A or 1B:

1. One test simulates a slow long term leak into a sealed, unvented, equipment room. In this case, there is sufficient time for the flammable gas to form a homogenous fuel/air mixture and the equipment in such room act as obstacles, potentially causing flame turbulence increasing the severity of the flame (worst case scenario).

2. The other is an accelerated test simulating a leak into a workshop or warehouse. The test was accelerated to make it practical to test multiple substances on multiple runs in a reasonable time. Consequently, a worst case scenario is recreated. Concrete block obstacles were included in the test apparatus, representing worktables and shelving, potentially causing flame turbulence.

For each test, an ignition source energetic enough to ensure ignition was used.

1. For four of the homogenous fuel/air mixture test, the ignition source was instantaneous (milliseconds). For the fifth one a longer duration ignition source was required to ensure ignition.

2. For the accelerated leak test, the ignition source was maintained until the end of the tests, so combustion continues even without self-propagation.

CONSEQUENCES TEST 1 (homogenous cloud) - SET UP

- A homogenous fuel/air mixture was created in a sealed space (1.5m^3) with obstacles.
- The right side of the test box is a vinyl sheet which fully separates from the box in the case of a sudden high pressure or flaps open to release over-pressure in the case of a slow pressure rise (required for laboratory safety).
- The fuel concentration was raised in steps until ignition occurred (additional gas added, pressure equalised, mixed and homogenised). Concentration is noted for each test as a percentage of Φ. Φ is a 1:1 air/gas equivalence ratio.
- Results were video-taped.

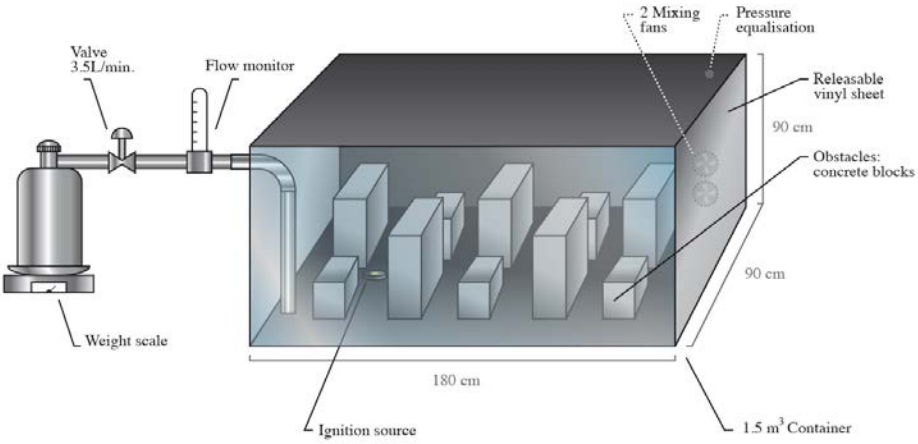


Figure 3: Consequences test (homogenous cloud) - set up

CONSEQUENCES TEST 2 (accelerated leak) - SET UP

The gas was introduced at a constant rate (15 L/min) in a vented space with obstacles sized and positioned to simulate work tables and stocking shelves.

- A high energy ignition source (5kV, 10mA, AC 60Hz) was positioned among the obstacles.
- The gas was leaked until ignition occurred.
- Results were video-taped. For the sake of demonstrating the results, the time (up to 20 minutes) during which the gas builds to a flammable concentration without any visible change has been edited out of the videos.

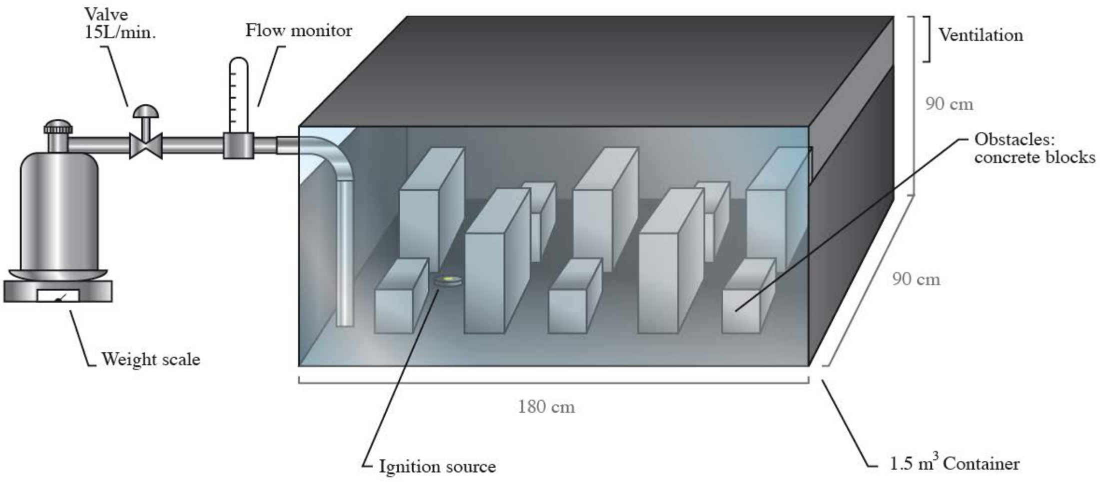


Figure 4: Consequences test (accelerated leak) - set up

CONSEQUENCES TEST 1 (homogenous cloud) – RESULTS

The videos of the test results exhibit a significant difference in the consequences of the combustion between the two categories of gases (see video links below).

As expected, the test results show a significant combustion with high overpressure for the 1A gases. For the tested 1B gases the flame propagation is noticeably milder and the over pressures vent and equalise immediately.

CONSEQUENCES TEST 2 (accelerated leak) – RESULTS

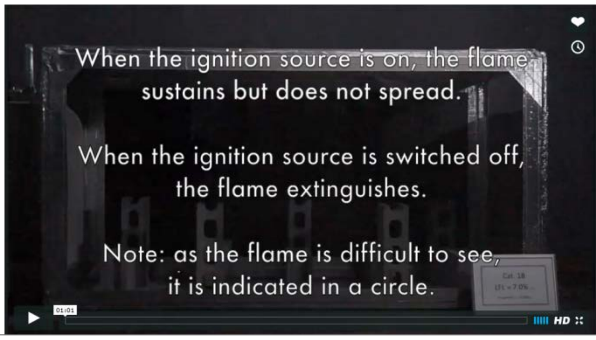
The videos of the test results exhibit a significant difference in the consequences of the combustion between the two categories of gases (see video links below). The test results for 1A gases show fire with a sustained and significant flame occurring. For the tested 1B gases, the flame remains small and sustains only with a continuous ignition source. When the ignition source is stopped, the flame extinguishes despite the continuing gas supply.

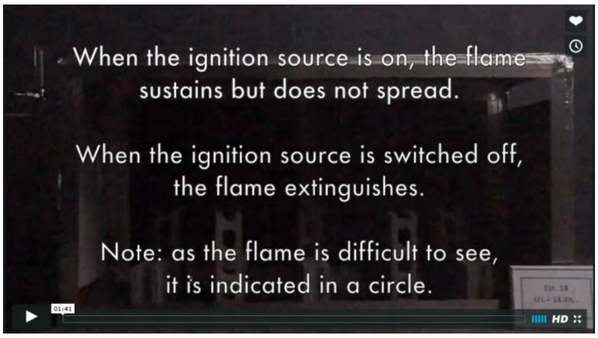
<table>
<tr><th></th><th>TEST GAS</th><th>OBSERVATIONS</th></tr>
<tr><td rowspan="2">CATEGORY 1A</td><td>Propane
FBV = 46 cm/sec

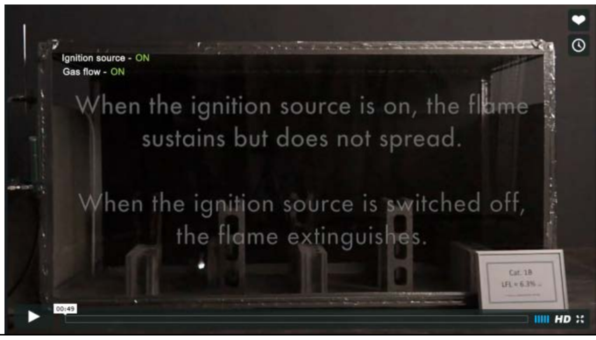
LFL = 1.7%v/v</td><td>Propane was used because it is the standard flammability gas.
Homogenous cloud
Having a high FBV (46 cm/sec), the results for propane demonstrate the severe consequences of a category 1A gas ignition. The gas concentration at ignition time was 0.65 Φ.
Accelerated leak
Once ignited, the propane flame spreads quickly and in all directions. As it exhausts the supply of pooled gas the flame burns selectively upstream towards the leak. This burning upstream introduces the extreme danger that the source of the gas might also ignite. In this video the flame sustains, even away from the ignition source, until the gas leak is terminated.
To view video please click on the image below:
Note the password is TDG-GHS
</td></tr>
<tr><td>Difluoroethane
FBV = 23 cm/sec

LFL = 4%v/v</td><td>Difluoroethane demonstrates a gas with approximately 50% of the FBV of propane but still with extreme flammability.
Homogenous cloud
The combustion of the homogenous cloud is noticeably less severe than the propane cloud although quite dangerous. The gas concentration was at ignition time 0.65 Φ.
Accelerated leak
The leak test for difluoroethane shows slightly less severe consequences than propane but is fairly dangerous in itself and burns upstream to the leak source. In this video the flame is extinguished by terminating the gas leak.
To view video please click on the image below:
Note the password is TDG-GHS
</td></tr>
</table>

<table>
<tr><th></th><th>TEST GAS</th><th>OBSERVATIONS</th></tr>
<tr><td rowspan="2">CATEGORY 1B</td><td>Propane/CO_2 mixture (30 / 70%)
FBV = 12.3 cm/sec

LFL = 7%v/v</td><td>This is not a commercially available or useful gas mixture. It was mixed specifically for this test to show a borderline gas with a high LFL and a fundamental burning velocity slightly above the threshold.
Homogenous cloud
The combustion of the homogenous cloud is relatively mild compared to the 1A gases. Moreover, the flame quenches against the obstacles. The gas concentration at ignition time was 0.55 Φ.
Accelerated leak
The flame, although difficult to see, occurs at 40 seconds. It quickly depletes the gas from the leak, drops again below LFL, and auto-extinguishes It ignites again, burns locally at the ignition source without propagating until the ignition source is turned off. It does not propagate upstream towards the source of the leak.
To view video please click on the image below:
Note the password is TDG-GHS

</td></tr>
<tr><td>Difluoromethane
FBV = 6.7 cm/sec

LFL = 14.4%v/v</td><td>Difluoromethane, which is a commercial gas, is eligible for category 1B because of both its very high LFL and its low FBV.
Homogenous cloud
The test results show a mild flame that rises because of the buoyancy of the warm gas and remains above the obstacles. Over-pressure generation is gradual and the vinyl sheet flaps open and remains intact. The gas concentration at ignition time was 0.85 Φ.
Accelerated leak
The flame, although difficult to see, burns locally at the ignition source without propagating until the ignition source is turned off. It does not propagate upstream towards the source of the leak.
To view video please click on the image below:
Note the password is TDG-GHS

</td></tr>
</table>

	TEST GAS	OBSERVATIONS
CATEGORY 1B	**Chlorodifluoroethane** **FBV = 3.8 cm/sec** LFL = 6.3%v/v	Chlorodifluoroethane sits firmly in the 1B category because of both its high LFL and its very low FBV. **Homogenous cloud** In this test, the flame does not propagate through the cloud; it auto-extinguishes within 15cm of the source. A real time and a slow motion video are provided. In the real time video, although the flame is within the circle indicated, it is difficult or impossible to discern. The gas concentration at ignition time was 1.0 Φ. **Accelerated leak** In this test, the flame although not self-propagating, continues to burn at the ignition source as long as the ignition source is energised. While burning, it creates an updraft which pulls gas which has pooled in the bottom of the box back to the ignition source. The flame does not however propagate upstream to the source of the leak. When the ignition source is extinguished the combustion ceases. To view video please click on the image below: Note the password is TDG-GHS 

Annex 2

Analysis of test results and conclusions for Hazard Communication by Dr. Denis Clodic, Expert on Global Warming and Gas Flammability

The videos of the 2 series of tests on *consequences of an ignition* for 5 different gases show significant differences between “1A” and “1B” substances.

Among those 5 gases, 2 are representative of category “1A” and 3 of category “1B”.

Table 1 summarizes the properties related to the thresholds between the two categories i.e: the lower flammability limit (LFL) and the fundamental burning velocity (FBV).

Table 1 - Category 1A and 1B substances being tested

Category	Substance	LFL (%)	FBV (cm/s)
1A	propane	1.7	46
1A	Difluoroethane (R-152a)	4	23
1B	Propane / CO2 (30/70%)	7	12.3
1B	Difluromethane (R-32)	14.4	6.7
1B	Chlorodifluoroethane (R-142b)	6.3	3.8

The 1st series is called “homogeneous cloud” the second is called “accelerated leak”.

Homogeneous cloud test

The 1st series of tests simulate long term slow leak leading to a flammable concentration within the occupied space.

Momentum

One obvious difference between the two “1A” substances and the three 3 “1B” substances is the ignited gas flow momentum on the weak wall (vinyl sheet), the rupture is much quicker for “1A” substances. This difference can be referenced qualitatively to the FBV, the higher the FBV the quicker the rupture. Moreover, Chlorodifluoroethane (R-142b) with a FBV of 3.8 cm/s does not generate any rupture.

Energy release

In order to quantify those differences, the time during which the flame is sustained is significantly different: the higher the FBV the shorter the time of energy release.

For a given amount of energy a shorter time of release results in a higher energy concentration and a higher possible severity of damages. The FBV is a consistent measure of the consequences of ignition.

Table 2 - Energy release time

Category	substance	Energy release time (s)	FBV (cm/s)
1A	propane	1.2	46
1A	Difluoroethane (R-152a)	4	23
1B	Propane / CO2 (30/70%)	6.4	12.3
1B	Diflurometh ane (R-32)	8.9	6.7
1B	Chlorodifluoroethane (R-142b)	No propagation	3.8

Accelerated leak test

The analysis of the test "*leak near an ignition source*" shows:

- A strong propagation for 1A substances, the higher the FBV the larger the propagation volume
- No propagation for any of the 3 "1B" substances, the flame is confined in a small volume and as stated in the video if the ignition source is switched off the flame stops even when the leak goes on.

Table 3 summarizes the main difference between "1A" and "1B" substances for the accelerated leak test.

Table 3 – accelerated leak test

Category	substance	Flame propagation	FBV (cm/s)
1A	propane	Yes	46
1A	Difluoroethane (R-152a)	Yes	23
1B	Propane / CO2 (30/70%)	No	12.3
1B	Diflurometh ane (R-32)	No	6.7
1B	Chlorodifluoroethane (R-142b)	No	3.8

Consequences on hazard communication

In the light of those two series of tests my conclusions are as follows:

- "1A" and "1B" substances are flammable and so their pictogram should be identical
- The flammability intensity or reactivity is significantly different between "1A" and "1B" substances with the chosen thresholds of LFL > 6% or FBV < 10 cm/s
- The difference of flammability is well covered by naming "1A" by the current hazard statement "extremely flammable gas" and "1B" substances by a new hazard statement "flammable gas".

Annex 3

Expert opinion from Professor M. J. Kalsher, Rensselaer Polytech Institute, regarding hazard communication elements for a proposed modification of the categories of flammable gases within the GHS framework

To:
The Committee of Experts on the Transport of Dangerous Goods
The Committee of Experts on the Globally Harmonized System of Classification and Labeling of Chemicals
The Experts from Belgium and Japan

Expert Opinion Regarding Hazard Communication Elements
For a Proposed Modification of the
Categories for Flammable Gases within the GHS Framework.

I have been asked to give my expert opinion regarding the design of hazard communications for a proposed modification of categories within the GHS framework for flammable gases. I attach more extensive references to support my competence to render this opinion but, briefly, I am an Associate Professor in the Department of Cognitive Science and Associate Dean for Academic Affairs for the School of Humanities, Arts, and Social Sciences at Rensselaer Polytechnic Institute in Troy, New York, the United States of America. I have published extensively in the related areas of risk communication and warnings. I have served as a member of the American National Standards Institute (ANSI) Z535 committee since 2003 and as chair for the ANSI Z535.3 sub-committee since 2012. ANSI Z535 provides guidelines for presenting safety and accident prevention information. Z535.3 is the part of the standard that provides criteria for the design, evaluation and use of safety symbols and pictograms to identify and warn against hazards and help people avoid injury. In this role, I am able to communicate the latest empirical findings concerning the use of safety symbols for the purpose of risk communication before ANSI policy decisions are made.

Background

This opinion is based on materials in the record of the second Informal Working Group (IWG2) dealing with categorization of flammable gases including the "Report of the Joint TDG-GHS Informal Working Group (IWG) dealing with categorization of flammable gases" transmitted by the experts from Belgium and Japan on behalf of the informal working group. I have not conducted independent research into the flammability of gases. Further, I must mention that, in research unrelated to this project, I have studied the hazard communication of the GHS in some depth [12; 16]; based on this research, I believe that the entire framework for hazard communications, especially the collection of pictograms that are used, would benefit from additional testing of the relationship between the hazard meant to be communicated vs. the hazard that is comprehended by the recipient. I believe that such study may lead to recognition of a need to re-design much of the hazard communication regime. For the purposes of this project, however, I have been urged to consider only hazard communication elements that are currently present within the GHS materials.

Definition of the Task

The task that I have undertaken is to evaluate the hazard communications elements: *Hazard Statement*, *Signal Word*, *Hazard Statement Code*, and *Pictogram* and recommend a set that would be appropriate to a new category of flammable gases within the GHS framework. That category is defined within the following description as Category 1B:

Category 1A	Category 1B	Category 2
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 > 6% OR 2) FBV < 10 cm/s	Gases with: LFL > 13% and UFL-LFL < 12 %

Furthermore, it is my understanding that the hazard communication elements that I may consider are limited to words, phrases, and pictograms that are currently used within the GHS framework. I assume that the experts from the various countries recognize that this is a formidable limitation.

Consensus Understanding from the Science of Human Factors

The effectiveness of all of the hazard communication elements, as a package, and of each element with respect to its most relevant audience, should be considered [9; 20; 24].

Variants of the same element meant to communicate significantly different hazard levels should be readily perceived, as intended, by members of the target audience [15; 20].

The message transmitted by the communication should accord with a realistic, practical understanding of the hazard to members of the target audience [16; 34].

Evaluation of the Hazard Communication Elements

Hazard Statement

The current Hazard Statements that look to be possible are Extremely Flammable Gas, Highly Flammable Gas, Flammable Gas, and Combustible Gas, by reference to the GHS Flammable Liquids framework.

At the outset, it should be recognized that the Hazard Statement is intrinsically a nuanced statement that is directed primarily to regulators, employers, standard writers, and others who are dealing with long-term understanding (as opposed to, for instance a pictogram, which is designed for immediate, gross understanding of a current situation [6; 17; 21]). Because the proposed new category is bracketed by "Extremely Flammable Gas" and "Flammable Gas," it would be easy to assign the Hazard Statement "Extremely Flammable Gas" to this new category. However, a look at the videos of the Gexcon presentation to the IWG2, and a review of the Schroeder report to the same group, show that the term "Extremely Flammable Gas" simply does not comport with reality, in the severity of the flame for gases under the Fundamental Burning Velocity category, or the probability of ignition for gases under the LFL category.

It is noted in other materials that consensus standard groups such as ISO and ASHRAE are using "Mildly Flammable" as the safety classification for this category [4; 14; 25]. However, that option would not work for GHS because, in English, the term "Mildly Flammable" would denote a group with less severe consequences than one labeled "Flammable." Here, where the 1B group is between 1A and 2, "Mildly" does not seem appropriate.

"Combustible" is a word of communication used in the Flammable Liquids framework. However, the word "Combustible" also is positioned below "Flammable" [3; 18; 27]. Accordingly, that term would not be accurate or applicable with respect to this group.

It is mentioned a number of times that there do not seem to be any current members of the Category 2 Flammable Gases Group. In addition, because the criteria for Category 2 are based only in LFL and not in FBV, any theoretical Category 2 gases are defined by the probability of ignition, and not the consequences of a flame. So, although not ideal, I propose that the Hazard Statement "Flammable" be used for both Category 1B and Category 2. Within the options set forth in the GHS, the Hazard Statement "Flammable" will best avoid confusion and provide some differentiation in hazard level between Category 1B and Category 1A, which will retain the Hazard Statement "Extremely Flammable." While it is, indeed, necessary to draw some distinction between Category 1B and Category 2, I would propose that, in the context of the total communications package, with the aforementioned restraints, this is accomplished much more effectively, especially for workers in occupational and storage sites, by inclusion of a pictogram, which I will discuss below.

Consequently, I recommend "Flammable" as the Hazard Statement for Category 1B.

Signal Word

For Signal Word, GHS seems to be limited here to a choice between "Danger" and "Warning." This is not necessarily a bad thing because – while "Caution" is used in the U.S. ANSI Z535 standard to signal hazards that, if not avoided, could result in minor or moderate injury [2] – testing has found that the word "Caution" often has substantial overlap with "Warning" in terms of perceived level of hazardousness [5; 11; 15; 23; 32; 33].

Given many years of testing for these signal words, the choice is fairly easy. "Danger" should be reserved for hazards that, if not avoided, will result in death or serious injury [2; 5; 7; 13]. Hazards that could, if not avoided, result in death or serious injury, and hazards that present a highly mediated hazard of death, should be signaled with "Warning" [2]. Doing otherwise weakens the meaning of the Danger signal word, and leads to habituation to that word that is unacceptable for a total framework [33]. Of course, new terms not currently in use in any formalized system (*e.g.*, "Deadly" [22; 31]) could be included in testing to determine whether this provides the desired separation in connoted hazard among the proposed categories.

Applying that standard to the current situation, it seems clear from the videos that gases that are included in the new Category 1B by reason of Fundamental Burning Velocity less than 10 cm/sec most likely represents a potential source of injury, but not death. This is seen from the pressure data in the Gexcon presentation, and by visual observation of the flames in the videos. Unlike the hazard of fires of solids or liquids, the combustion events here are of shorter duration. In the 50 m3 chamber, these are 5 to 7 second events at the most. The maximum duration that an individual would be directly exposed to a flame is even less. And the flames are notably less intense that those of the "Extremely Flammable" Category 1A group. This is true not only at the extreme of the group (propane)—a difference can be readily recognized between the combustion of the 15 cm/sec gas and that of the 10 cm/sec gas.

Consequently, I recommend "Warning" as the Signal Word for Category 1B.

Hazard Statement Code

The Hazard Statement Codes that are currently possible under the GHS construct look to be H220 and H221. These Hazard Statement Codes seem to go as a set with the Hazard Statements. It should be well noted that the hazard prevention prescriptions for these two codes are identical: there is no distinction made in the prevention prescription between H220 and H221. In this case, I can recommend that the Hazard Statement Code currently assigned to the Hazard Statement "Flammable" continue in that function.

Consequently, H221 is the proper Hazard Statement Code for this package of communication elements.

Pictogram

The pictogram options available here seem to be either the presence or absence of the standard GHS "Flammability Pictogram" if alternative pictogram options are not to be considered.

It is desirable to include a pictogram for Category 1A and 1B, but not Category 2, as part of the overall "package" of hazard communication elements, for several reasons:

The pictogram alerts users to the possibility of an ignition and combustion hazard [26; 33]. The current category 2, however, is said to have no cohorts, and therefore no actual risk of combustion. The pictogram thus can be used to delineate what is currently a real risk (Category 1A and 1B) from a theoretical one.

The pictogram raises the degree of overall hazard communication above the package of hazard communication elements of Category 2, and puts the entire package into a range between Proposed Category 1A and Category 2. The presence of the pictogram provides conspicuity above and beyond the signal word and textual components, and it is not subject to literacy or language requirements [10; 29; 35].

Although there are data to indicate that the GHS pictograms are not universally understood, and there is debate as to whether different degrees of hazard may be better communicated by varying the urgency connoted pictorially [1; 8; 30], the flammability pictogram has relatively high levels of comprehension for communicating a flammability hazard for the material or package labeled with it [19; 28].

Consequently, I recommend inclusion of the current GHS flammability pictogram, or a newly developed and validated alternative configuration, for Category 1A and Category 1B.

Total Package of Hazard Communication Elements

In summary, the package of hazard communication represents a reasonable compromise, maybe the only reasonable compromise using current communications elements, for the new Category 1B.

- The inclusion of the current GHS flammability pictogram for Category 1B is likely to increase conspicuity and potentially raise the level of warning above the category 2, and it facilitates effectiveness via non-verbal communication. Through use of the pictogram, an immediate risk of combustion can be communicated to workers and bystanders in advance of a potential combustion event.
- The differentiation of the written communication elements, "Flammable" and "Warning," or other similar alternatives, gives regulators, employers, and others who make decisions based on written evidence sufficient information that there is a difference between Category 1A and Category 1B that should be accounted for when regulating or adjusting risk profiles.
- Avoiding the words "Extremely Flammable" or "Highly Flammable," which could introduce unnecessary and potentially dangerous confusion and/or ambiguity, maintains the unity of the warning phrase with the observable fact for Category 1B, which is important for this category and for the integrity of the GHS system of hazard classification.

Proposed Label Elements for Flammable Gases:

	Flammable gases		
	Category 1A	Category 1B	Category 2
Symbol			*No Symbol*
Signal word	Danger	Warning	Warning
Hazard statement	Extremely flammable gas	Flammable gas	Flammable Gas
Hazard statement codes	H220	H221	H221

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Respectfully submitted,

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FIGURE 2 : ENLARGEMENT - DIFFERENCES IN RELATIVE ESCAPE TIMES FOR THE TESTED FLAMMABLE GASE