

COMAH 2015: Practical classification of mixtures on COMAH establishments

Susan Fraser[1], Maria Mallafrè Garcia[2*], Howard Mason[2] and Jill Wilday[2]

[1]Health and Safety Laboratory (HSL), currently at TSGE Consulting Ltd., Concordia House, St James Business Park, Knaresborough, UK.
[2]Health and Safety Laboratory (HSL), Harpur Hill, Buxton, UK.
*Corresponding author: maria.garcia@hsl.gsi.gov.uk

The hazards classification for human health, physical properties and environmental endpoints as established by the Seveso III Directive [EC, 2012] determines whether a substance or a mixture is in scope of the Control of Major Accident Hazards (COMAH 2015) Regulations [HSE, 2015]. Since the EU Classification, Labelling and Packaging (CLP) Regulations [EC, 2008] introduced a new hazards classification system, the COMAH regulations in the UK and the Seveso III Directive in the EU are also required to implement these changes. In order to know if a substance or a mixture is within scope of Seveso III or COMAH 2015, an establishment must determine the hazards classification according to CLP for those aspects which are relevant to the legislation.

Operators can use the hazards classification stated in Safety Data Sheets (SDSs) obtained from their suppliers to classify the raw materials stored on site. However, if the substance was purchased before CLP came into force (i.e. it is still classified according to the Chemicals (Hazard Information and Packaging for Supply) Regulations 2009 CHIP [HSE, 2009], commonly known as CHIP, which predates CLP) or if mixtures are created within the establishment (including dilutions of raw materials in water and wastewater treatments), the hazards classification stated in the SDS may no longer apply. Finding suitable data for classification according to CLP can be complex, especially if there are multiple components involved (e.g. complex mixtures). In addition, the guidance on CLP produced by the European Chemicals Agency (ECHA) is comprehensive and interpretation often requires expert judgement. However, this information is required as operators must complete a COMAH notification process with the UK Competent Authority, which comprises the Health and Safety Executive (HSE) or the Office for Nuclear Regulation (ONR), and the relevant environmental agency, within the period specified in the COMAH 2015 guidance, i.e. by 1st June 2016.

This paper describes a practical approach to the hazards classification process for mixtures created on site for the hazards that are in scope of COMAH 2015, bringing together the key aspects of the CLP guidance issued by ECHA [ECHA, 2013]. This will provide a clear strategy for classification according to CLP for effective alignment to COMAH 2015.

KEYWORDS: COMAH 2015, Seveso III, hazard, classification, CLP

Introduction

The United Nations (UN) introduced the Global Harmonisation System (GHS) in order to ensure that the classification and labelling of chemicals are consistent between countries. This new classification system has been incorporated into the European Union (EU) legislation through the Classification, Labelling and Packaging (CLP) Regulations [EC, 2008], referred to as 'CLP'. The European Chemicals Agency (ECHA) has produced some guidance to help companies with the details of this legislation [ECHA, 2013]. Whilst the guidance is very useful, it is also highly detailed and contains a great deal of information and possibilities for the user. Application of some of the possible techniques and interpretation of the information could require the help of an expert in the field.

Before the implementation of CLP, there were several pieces of legislation that referred to the previous classification system which was based on the Dangerous Substances Directive (67/546/EEC) [EEC, 1967] and the Dangerous Preparations Directive (1999/45/EC) [EC, 1999] as amended, transposed into UK legislation as the Chemicals (Hazard Information and Packaging for Supply) Regulations 2009 [HSE, 2009], commonly known as CHIP. Since CLP came into force, these directives have been repealed. The Seveso III Directive [EC, 2012] deals with the control of on-shore major accident hazards involving dangerous substances, according to the CLP system. Seveso III is implemented in the UK as the Control of Major Accident Hazards (COMAH 2015) Regulations [HSE, 2015]. Since COMAH is concerned with major accidents, only those hazard classes in CLP that could become a major accident initiator are in scope of the regulations.

Annex VI of CLP contains the harmonised substances catalogue; this is a list of substances for which a harmonised classification is available, i.e. a classification that has been agreed by the EU. This classification represents the minimum hazard category that a company must use, although operators can classify under a more restrictive category if supporting data are available. The harmonised substances catalogue is also available through the ECHA classification and labelling

database (via the ECHA website[1]). If a substance has a harmonised classification but does not have a hazard category for a specific hazard class, it can be assumed that the hazard class is not applicable or relevant to the substance, based on the available knowledge [Mallafrè Garcia et al., 2015].

If a substance does not have a harmonised classification, but the supplier has provided a Safety Data Sheet (SDS) containing the hazards classification for the substance according to CLP, the classification provided in the SDS can be used. In this case, if a categorisation for a certain hazard class is not specified, it can be assumed that the substance does not qualify for that hazard class. Ultimately, responsibility for correct CLP classification lies with the supplier, but it should be noted that information from SDSs can sometimes be inconsistent.

As explained for the classification of substances, if a mixture is obtained directly from a supplier, the classification detailed in the SDS provided can be used, as long as the mixture is not modified on site. CLP describes how substances and mixtures should be classified and labelled in the EU.

The classification of a mixture that has been produced on site can require a very complex process. Test data on mixtures are not generally available, but where available, the data on the mixture should be used to determine its classification. Where there are no test data on the mixture itself, but there are sufficient test data on similar mixtures, CLP allows the use of bridging principles to determine the classification of the mixture. These principles are explained in Annex I, 1.1.3 of the CLP regulations. Although the bridging principles could be very useful as part of the classification process, expert judgement should be sought when applying these principles.

If none of the resources mentioned above are applicable to the mixture of concern, classification must be determined through calculation processes using data on all the hazardous ingredients that are present in the mixture. To do this, different types of information on all the ingredients would be required, depending on the hazard classes of concern for the mixture.

This paper aims to provide a practical and clear way forward for the classification of substances and mixtures according to the CLP criteria for those hazard classes that are in scope of COMAH 2015. The paper also provides additional advice to the CLP guidance and some updates from [Wilday et al. 2012].

Health hazards

The health hazards that are relevant to COMAH 2015 are acute toxicity and Specific Target Organ Toxicity, Single Exposure (STOT-SE). These correspond with COMAH 2015 health hazards: H1 (acute toxicity category 1), H2 (acute toxicity category 2 and category 3 for inhalation exposure) and H3 (STOT-SE category 1).

Acute toxicity (H1 and H2)

Acute toxicity is defined as the adverse effects occurring following the administration of a single dose of a substance or a mixture, multiple doses given within 24 hours or an inhalation exposure of 4 hours. Evidence for acute toxicity is usually obtained from animal testing and it is described by the route of exposure to the animal, namely: oral, dermal or inhalation.

Classification of acute toxicity is generally assigned on the basis of lethality, measured as LD_{50} or LC_{50} values. LD_{50} defines the dose of a substance that causes death in 50% of the population (LD – lethal dose); LC_{50} defines the concentration that would cause death in 50% of the population over a defined period of time (LC – lethal concentration). The lethal dose or concentration can depend on many factors including: exposure route and duration, animal species, and the experimental design, protocol and conditions. This can lead to a large variety in values even for the same substance. These issues were discussed in depth in [Wilday et al. 2012]. Although there are only a few OECD (The Organisation for Economic Co-operation and Development) Test Guidelines now, historically acute toxicity data was obtained using a variety of methods which led to a great deal of variation in LD_{50} and LC_{50} values. [ECHA, 2013] contains many options of how to deal with these data, interpretation of some of which would require an expert in the field.

Pure substances

When a CLP category is not available, relevant data must be obtained in order to determine the acute toxicity classification of a substance. A strategy for finding reliable data would be to firstly look at studies conducted according to Good Laboratory Practice (GLP) and OECD Test Guidelines where available (e.g. propriety chemical industry studies). Due to the Registration, Evaluation and Authorisation of Chemicals Regulations (REACH) [EC, 2006], a great deal of data is compiled on the ECHA website and is rated for quality using the Klimisch[2] scoring system. Toxicological databases and other published literature could also be useful, but may be unreliable. Several databases are described in [Wilday et al. 2012]. Data

[1] http://echa.europa.eu/information-on-chemicals/cl-inventory-database
[2] The Klimish score is a methodology for assessing the reliability of toxicology studies

found should be converted into the preferred format where possible, as described in [Wilday et al. 2012]. This is summarised with some updates below:

Animal model
In the majority of cases, the preferred animal models would be rat for oral and inhalation data and either rat or rabbit for dermal exposure. If good quality human data are available, these should be used in preference to the animal model; however, this will not be the case for the majority of substances. It should also be considered whether the standard animal models are appropriate for the particular substance to be classified. This should also be considered if data cannot be found in the preferred animals.

Units
Oral and dermal exposure routes should have data in units of mg/kg of body weight (bw). For the inhalation exposure route, the units required will depend upon the physical state of substance in the relevant acute inhalation toxicity study: mg/l for aerosols and vapours and ppmV for gases. It may be necessary to convert between mg/l and ppmV to obtain the correct units for the particular physical state. Formulae were provided in [Wilday et al. 2012] in order to convert between the two sets of inhalation units.

Duration
For acute inhalation toxicity, the 4 hour LC_{50} value is required for classification purposes. If the available study has been performed over a different duration (e.g. 1 hour), the derived LC_{50} should be converted to a 4 hour LC_{50}. CLP [EC, 2008] state that when converting from 1 hour duration, the LC_{50} must be divided by 4 for solids and liquids and divided by 2 for gases and vapours. However, CLP does not have a method for other time periods. The CLP guidance [ECHA, 2013] states that the method by [ten Berge et al. 1986] can be used, as long as it is performed with expertise. This method is described in full in [Wilday et al. 2012].

Physical state
For the inhalation exposure route, information on the physical state of the substance when tested is required in order to classify the substance according to CLP; however, this information is often not provided. In these cases, it is possible to estimate the likely physical state. Whether the substance was likely to be tested as a solid or as a gas can be determined from the melting and boiling point. It is more difficult to differentiate between substances that were likely to be tested as vapours and those that were tested as mists/droplets (aerosol of liquid). The CLP guidance [ECHA, 2013] recommends that the saturated vapour concentration (SVC) is calculated for the substance using Equation 1:

$$\mathrm{SVC\ (mg/l)} = 0.0412 \cdot \mathrm{MW} \cdot \mathrm{VP} \qquad (1)$$

Where:
MW = molecular weight of the substance in g/mol;
VP = vapour pressure of the substance in hPa at 20°C.

The SVC in mg/l should then be compared to the LC_{50} (in mg/l). If the LC_{50} is well below the SVC, it is considered most likely that the substance was tested as a vapour, whereas if the LC_{50} is close to or above the SVC it is likely that it was tested as an aerosol (mist) [ECHA, 2013]. It should always be considered as to whether the predicted physical state is appropriate and an expert should be consulted, if necessary.

Selecting data to use for classification
In many cases, there will be several pieces of data available for the substance in question. Some points to consider when selecting appropriate data are outlined below.

The best quality data to use are from studies conducted according to GLP and OECD Test Guidelines (e.g. propriety chemical industry studies). The REACH regulations have vastly improved the amount and quality of data available. These data are compiled on the ECHA website and Klimisch scoring criteria have been used to show whether the study was of good quality. Toxicological databases and published literature may also be useful but could be unreliable, so if these are being used the details of the study should be checked to establish whether it was of good quality. This could include checking the reference of the data, the amount of peer review it has undergone or whether the study has been performed according to approved testing guidelines e.g. OECD and to GLP. Data should be found from an appropriate animal model.

Trends within the data should be taken into account to ensure that an anomaly is not used. Within the trend, the worst case is generally the data point to use.

Some test data may be reported as "greater than" a particular figure, instead of giving a point value. These data can be used to establish a general trend but should not be used for classification in itself. If no other data are available, the details of the study should be checked and expert judgement used to decide whether it can be used. If the "greater than" figure demonstrates that the LD_{50} or LC_{50} is greater than the range for category 4, it can be used to demonstrate that the substance does not meet the criteria for classification for acute toxicity.

Acute toxicity data may also be reported as ranges of values. In these cases, the lower end of the range should be used as a worst case representative value unless any of the following statements are true:

- The substance has a harmonised classification and the value does not fit with the harmonised category.
- The value does not fit the general trend of the data.
- It is not from a reliable data source.

If any of these statements are true, the mid-point of the range should be considered.

Options if data are unavailable

If data are not available, several options may be considered. These require some expert judgement and so should be used with care and expertise:

- If the substance has a category, the point estimate defined by CLP can be used.
- If data are available that are provided as a "greater than" value, the details of the study can be examined to determine if that data are appropriate.
- If data are available for one of the exposure routes only, route to route extrapolation may be appropriate to determine values for other routes [IGHRC, 2006].
- If tests in an alternative animal model are appropriate, these data could be used.
- If a similar substance or structural analogue is appropriate, data for this substance may be used instead.

Mixtures

Firstly, the CLP general procedure for mixtures and the bridging principles should be checked. If none of these can be applied, an estimate of the acute toxicity of the mixture should be calculated. This is called an Acute Toxicity Estimate (ATE). In order to calculate this, information is required about each of the ingredients.

Ingredients that can be discounted from the calculation

If acute toxicity categories are known for the ingredients in a mixture, some substances or exposure routes may be eligible to be discounted from the calculations:

- Substances that are known to be completely harmless e.g. water.
- If a substance has been classified according to CLP and does not have a category for a particular exposure route, it can be assumed that it is not acutely toxic for that route.
- If a substance is classified under category 1, 2 or 3 for a particular exposure route and is contained in the mixture at a concentration below the acute toxicity cut-off value for these categories, i.e. < 0.1% [EC, 2008].
- If a substance is classified under category 4 for a particular exposure route and is contained in the mixture at a concentration below the acute toxicity category 4 cut-off value, i.e. < 1% [EC, 2008].
- If the LD_{50} or LC_{50} is greater than the range of category 4 for a particular exposure route for unclassified substances.

Substances that have a CLP category but do not fit these criteria or substances that have not been classified will require LD_{50} and LC_{50} data.

Obtaining data for ATE calculations

Substances that cannot be discounted from the calculations are referred to as "relevant" ingredients in the CLP guidance. Data should be obtained for the oral, dermal and inhalation routes for all relevant ingredients; the approach described in the section above for pure substances should be followed initially for each relevant ingredient prior to classifying the mixture as a whole.

Substances classified under CLP

If a substance has a CLP classification and the available toxicity data align with the category it has been assigned, these data should be used for the ATE calculation. If data cannot be found, or if the data do not fit with the assigned category, the point estimate for that category should be used instead. Point estimates are data points for each category for those instances where a category is available, but good quality data that fit with the category cannot be found [EC, 2008].

Substances not classified under CLP
If a substance has not been classified under CLP but acute toxicity data are available, these data should be used for calculation of the ATE (data should be obtained according to the method described earlier). If no data are available and all other options have been exhausted, the data should be declared as unavailable and treated as such in the calculation.

Physical state
Information on the physical state is required for all of the relevant ingredients. If the physical state has not been provided in the available studies or data, the method described above can be used to determine the most likely physical states that the ingredients were tested in.

For substances where a point estimate is being used, and the substance is either a vapour or an aerosol (as determined by melting and boiling points), the two potential point estimates should be compared to the SVC of the substance in mg/l as described above. If both point estimates compared to the SVC give the same outcome for the physical state, this is the correct physical state to use. Where this is not the case, expert opinion should be used, or if it cannot be determined, both should be considered possible and the ATE should be calculated using both physical states. In this case, the mixture would be classified at least twice and the worst case category applied.

Calculating the ATE for mixtures

An ATE is an estimate of the toxicity of a mixture, based on the toxicity and concentration of the individual ingredients. The appropriate equation should be used to calculate the ATE for each exposure route.

Where data are available for ≥90% of the composition
The following formula should be used to calculate the ATE when data has been found for ≥ 90% of the composition [EC, 2008]:

$$\frac{100}{ATE_{mixture}} = \sum \frac{C_{ingredient}}{ATE_{ingredient}} \quad (2)$$

Where:
$C_{ingredient}$ = concentration (%) for each ingredient;
$ATE_{ingredient}$ = ATE for each ingredient;
$ATE_{mixture}$ = ATE for the whole mixture.

Substances that have been discounted, for example if they are harmless (e.g. water) or are below a cut-off value, are not included in the calculations. A note should always be made of the percentage composition of the mixture that does not have data available.

Where data are available for <90% of the composition
The following formula should be used to calculate the ATE when data has been found for <90% of the composition [EC, 2008]:

$$\frac{100 - \sum C_{unknown}}{ATE_{mixture}} = \sum \frac{C_{ingredient}}{ATE_{ingredient}} \quad (3)$$

Where:
$C_{ingredient}$ = concentration (%) for each ingredient;
$C_{unknown}$ = concentration (%) of all substances for which data are not available;
$ATE_{ingredient}$ = ATE for each ingredient;
$ATE_{mixture}$ = ATE for the whole mixture.

In Equation 3, the percentage is adjusted to account for the percentage concentration of the mixture for which data are unavailable. This adjustment means that the ATE is calculated on the basis of the toxicity and concentration of the known ingredients. Again, a note should be made of the percentage composition for which there is no data available.

If the percentage content of the ingredients has been provided within a range, the worst case should be calculated for the ATE. To do this, the ingredients with the lowest LD_{50}/LC_{50} should be considered at the top of their concentration range, while the ingredients that are less toxic should be considered to be at the bottom of their concentration range. The total content should always equal 100%.

Where ingredients have been tested in different physical states
If the ingredients of a mixture have been tested in several different physical states, the mixture must be analysed in each of those physical states. For example, if Mixture A contains Substance 1 tested as a vapour and Substance 2 tested as an aerosol, Mixture A would need to be aligned to CLP both as a vapour and as an aerosol. If another ingredient had also been tested as a gas, it would need to also be classified this way. The mixture should therefore be analysed as many times as there are physical states and the worst case classification would be taken.

The same ATE value cannot be used for different physical states. The ATE should be calculated separately for as many physical states as there are in the mixture. The result would be an ATE for each physical state that is present in the mixture. In the example above, Mixture A would need to be classified to CLP twice, therefore two ATEs would be calculated; once with the substances tested as vapours and again with substances tested as aerosols.

The data that have been obtained for each substance should be used for the physical state that it was tested in. However, to obtain the other ATE values for the other physical states that are present in the mixture, point estimates should be used. To do this: the individual ingredient should be classified according to CLP based on the physical state in which it was tested. The same category of the desired physical state should be used to find the point estimate to use in the ATE calculation. For example, in Mixture A above, Substance 1 was tested as a vapour and has an LC_{50} of 0.3 mg/l. Substance 2 was tested as an aerosol and has an LC_{50} of 0.2 mg/l. So, Mixture A therefore requires classification as both a vapour and an aerosol:

As a vapour:
Substance 1 has LC_{50} 0.3 mg/l (vapour) → use this value in ATE calculation

Substance 2 has LC_{50} 0.2 mg/l (aerosol) → convert to vapour:
0.2 mg/l (aerosol) is a category 2 substance. Use the point estimate from category 2 vapours in the ATE calculation = 0.5 mg/l.

As an aerosol:
Substance 1 has LC_{50} 0.3 mg/l (vapour) → convert to aerosol:
0.3 mg/l (vapour) is a category 1 substance. Use the point estimate from category 1 aerosols in the ATE calculation = 0.005 mg/l.

Substance 2 has LC_{50} 0.2 mg/l (aerosol) → use this value in ATE calculation

Mixture A would therefore have two ATEs and subsequently two CLP classifications, one for vapour and one for aerosol. In this way, mixtures are classified for each of the physical states that the ingredients were tested in. The worst case is taken as the final classification for the mixture.

Classification for acute toxicity

Once either the LD_{50}/LC_{50} values have been obtained for a pure substance, or the ATEs have been calculated for a mixture, the substance or mixture can be classified according to CLP. This should be done for each exposure route. For mixtures with several ATEs for inhalation, these should all be classified according to CLP and the worst case used as the final classification. The substance or mixture should be classified according to the CLP criteria (LD_{50}/LC_{50} for the boundaries of each category). For mixtures with missing data, if ≥ 1% of the composition has unknown toxicity, a statement should be included with the classification to this effect, i.e. "X % of ingredients are of unknown acute toxicity".

STOT-SE (H3)

Single Target Organ Toxicity (STOT) is an endpoint that covers specific toxic effects that are not covered by other human health endpoints. STOT is defined as specific, non-lethal target organ toxicity arising from a single exposure to a substance or a mixture. All significant health effects that can impair function, reversible and irreversible, immediate and/or delayed that are not specifically addressed by other toxicity endpoints are included in the STOT category [ECHA, 2013]. STOT can be further divided into single exposure (SE), and repeated exposure (RE). These definitions are fairly self-explanatory, the single exposure (STOT-SE) effects are for those effects which occur after a single, acute exposure; whereas repeated exposure (STOT-RE) describes effects which occur after several exposures over time. In this paper, the classification approach for single exposures (STOT-SE) is considered.

In order to meet the criteria for classification for STOT-SE, there should be clear evidence of toxicity to a specific organ, especially when this is observed in the absence of lethality. It should also be ensured that STOT-SE is not used for any effects that are covered by other classification categories [ECHA, 2013]. STOT-SE has 3 hazard categories, 1, 2 and 3. Categories 1 and 2 are used for non-lethal but significant and/or severe toxic effects. Category 3 should be considered

separately from categories 1 and 2 and covers transient effects for either respiratory tract irritation (RTI) or narcosis only [ECHA, 2013]. The STOT-SE category 1 is discussed in this paper as this is the only STOT-SE category within scope of COMAH 2015.

Where CLP categories are available

Mixtures

For each ingredient with a STOT-SE 1 classification, the percentage content should be compared to the Specific Concentration Limit (SCL) or if not available, the generic concentration limit (GCL) for that category. If the substance is present at the threshold or above the limit, the mixture as a whole will require classification as category 1 for STOT-SE. SCLs are only available for some substances and are specific to that particular substance. The GCLs for STOT-SE category 1 are shown in the CLP guidance. It should be noted that category 1 effects are not additive since the underlying toxicity may differ.

As a general rule, if several STOT-SE categories apply, the worst case category would be used for the mixture. However, some consideration should be given as to whether any of the ingredients or their effects could interact.

Where CLP categories are not available

If a substance has not been classified, consideration should be given as to whether the substance meets the criteria for classification for STOT-SE. Sources of data for acute toxicity were described earlier; these data sources are also relevant for information about STOT-SE effects. As with acute toxicity, the priority should be placed on finding good quality data. When investigating STOT-SE effects, evidence should be sought rather than finding a specific figure for a category; case studies, case reports and abstracts are very helpful. STOT-SE categories are given on the basis that there is enough evidence to support the category. If data cannot be found for the substance at all, it should be considered whether data for a similar substance or structural analogue would be suitable for read-across purposes. If evidence cannot be found then the substance does not qualify for STOT-SE.

For potential category 1 substances, the effects could be for any acute effect but excluding the following: acute toxicity/ lethality, skin effects, reproductive effects, eye damage/irritation, respiratory/skin sensitisation, germ cell mutagenicity or carcinogenicity. It should be ensured that the effect does not cause death and is not for repeated exposure. These effects would be classified according to different criteria. Data and effects can be included from humans and any animal studies. If good quality data are found showing significant effects in humans this provides evidence supporting category 1 classification.

An effective dose (ED) is the dose at which the particular STOT-SE effect occurs. This is not available in many cases. Where available, the ED can be used as part of a weight of evidence approach to assign a category to the substance [ECHA, 2013]. These guidance values should be used as part of the whole approach, not as specific demarcation values and it should always be checked that the category is appropriate for the substance. As with acute toxicity, the substance is classified differently for inhalation depending on the physical state that the substance was tested in. If the physical state has not been provided with the study, the most likely physical state can be evaluated, as described for acute toxicity using the melting point, boiling point and SVC. It should always be considered as to whether this physical state is appropriate and an expert should be consulted if necessary.

If an appropriate ED has been identified and the category is suitable for the substance, it should also be used to set SCLs for the substance. The approach for setting the SCLs is described in detail in the CLP guidance. Essentially, the ED should be divided by the guidance value for that category and this is expressed as a percentage:

$$\text{SCL for Category} = \left(\frac{ED}{Guidance\ Value}\right) \cdot 100 \quad (4)$$

The percentage obtained in Equation 4 should be rounded down to the nearest preferred number. The preferred values are 1, 2 or 5 and their multiples of 10. More often than not, EDs are not available; studies and literature will need to be reviewed and expert opinion and a weight of evidence approach used as necessary.

Environmental hazards

Aquatic environment hazard categories under CLP are acute (category 1) and chronic (categories 1, 2, 3 and 4). The hazard categories in scope of COMAH 2015 are E1 (acute 1 and chronic 1) and E2 (chronic 2).

The hazard categories for both acute and chronic hazard classes can be directly translated from CHIP. It should be noted that environmental toxicity data from reliable sources may not indicate the classification category previously assigned in CHIP. It is therefore strongly recommended to check that peer reviewed data match the category allocated to the substance or mixture of concern.

Data gathering for substances

For acute toxicity, toxicity data for the three aquatic trophic levels (fish, crustacean and algae or aquatic plants) are required. For chronic toxicity, toxicity data for the three trophic levels are also required, as well as information on biodegradation. Chronic toxicity category thresholds vary depending on whether a substance is rapidly biodegradable or not (aquatic toxicity classification thresholds are available in [ECHA, 2013]). Data required for acute and chronic toxicity depending on the trophic level are described in the ECHA specific guidance [ECHA, 2014].

To determine the acute toxicity classification, the lowest of the acute toxicity values apply. To determine the chronic toxicity classification, a three step process should be followed (and stopped once a condition has been met). Firstly, if chronic toxicity data on the three trophic levels are available, the lowest of the values applies. Secondly, if only data on one or two trophic levels are available, the chronic data for the available trophic levels must be compared against the acute toxicity data for the remaining trophic levels and the worst case is used. Finally, if chronic data are not available for any of the trophic levels, acute toxicity data must be used for the chronic toxicity classification.

For chronic toxicity, if a substance is not classified under categories 1, 2 or 3, the safety net classification must be considered. This procedure takes into account different properties of the substance (such as water solubility, biodegradation, and bioaccumulation) to decide whether a classification under category 4 should be applied.

For those substances classified under category 1, either for acute or for chronic toxicity, multiplying factors (M-factor) must be assigned. The M-factor values depending on the toxicity are provided in the CLP regulations. The M-factor is a tool used in order that the more toxic substances have a higher contribution to the classification of a mixture; hence, the higher the toxicity of a substance, the greater the M-factor value representing that substance.

Classification of mixtures

This section provides guidance for classification of mixtures when data are not available and bridging principles cannot be applied. When hazard data for all the ingredients in a mixture are known, the summation method can be applied to determine the classification of a mixture. This methodology requires the composition of the mixture and the hazard category for each hazardous ingredient; the M-factor for those substances classified under category 1 for acute or chronic toxicity is also needed.

For acute toxicity classification (category 1), if the sum of the concentrations (in %) of the substances classified under this category multiplied by their corresponding M-factors is equal to or greater than 25%, the mixture would be classified as acute toxicity category 1.

This principle is also used for the classification of chronic toxicity category 1 (using substances classified as chronic category 1 and the chronic toxicity M-factor values). For chronic toxicity, when a mixture is not classified under category 1, it is necessary to check whether it is classified under other categories, starting with category 2. A mixture will be classified under this category if 10 times the value obtained in the category 1 summation, plus the sum of concentrations (in %) of all components classified as chronic 2 is equal to or greater than 25%.

If this is not the case, chronic toxicity category 3 summation must be applied, where 10 times the summation result for category 2 plus the summation of all the ingredients classified under category 3 (in %) is equal to or greater than 25%. Category 4 for a mixture would apply if the sum of all ingredients classified under categories 1, 2, 3 and 4 is equal to or greater than 25%.

In those circumstances when the hazard categories for the ingredients in a mixture are not known, the additivity formula should be used to determine the classification of a mixture. The additivity formula obtains an estimation of the toxicity of a mixture from the toxicity of its ingredients and their concentration in the mixture. Additivity formulae should be applied separately for the three trophic levels and select the lowest of the added toxicities as the estimate toxicity for the mixture (the estimate toxicity should be compared against the thresholds in the CLP regulations). The additivity formulae for acute and chronic environmental toxicity are presented in Equation 5 and Equation 6, respectively:

$$\frac{\sum C_i}{L(E)C_{50m}} = \sum_n \frac{C_i}{L(E)C_{50i}} \tag{5}$$

Where:
C_i = concentration of component i (in %);
$L(E)C_{50i}$ = LC_{50} or EC_{50} for component i;
n = number of components (i is running from 1 to n);
$L(E)C_{50m}$ = $L(E)C_{50}$ of the part of the mixture with test data.

$$\frac{\sum C_i + \sum C_j}{EqNOEC_m} = \sum_n \frac{C_i}{NOEC_i} + \sum_n \frac{C_j}{0.1xNOEC_j} \quad (6)$$

Where:
C_i = concentration of component i (in % - rapidly biodegradable components);
C_j = concentration of component j (in % - non-rapidly biodegradable components);
$NOEC_i$ = NOEC (rapidly biodegradable components);
$NOEC_j$ = NOEC (non-rapidly biodegradable components);
n = number of components (is is running from 1 to n);
$EqNOEC_m$ = Equivalent NOEC of the part of the mixture with test data.

Environmental hazards have cut-off values that indicate if a substance must be considered for the classification of a mixture containing that hazardous substance. For acute toxicity category 1 and chronic toxicity category 1, the cut-off value is 0.1%, although a lower value might be applicable depending on the toxicity of the ingredients classified under category 1 (in that case, the concentration would be (0.1/M)%), where M is the M-factor. For the rest of chronic toxicity categories, the cut-off value to use is 1%.

Physical hazards

Physical properties of purchased substances and mixtures are available in the SDSs provided by the supplier. There are eight physical hazard classes in scope of COMAH 2015: explosives (P1), flammable gases (P2), flammable aerosols (P3), oxidising gases (P4), flammable liquids (P5), self-reactive substances and mixtures and organic peroxides (P6), pyrophoric liquids and solids (P7) and oxidising liquids and solids (P8).

Classification of mixtures

For most of the physical hazard classes, the physical properties do not have a simple correlation with the composition of the mixture itself, so there are no calculations that can be done to determine the properties of the mixture. For this reason, the best way to determine the physical-chemical properties of a substance or a mixture is to test against the hazards of concern. Annex I (Part 2) of the CLP regulations mentions standard testing procedures for each hazard class. For some hazard classes, classifications can be derived through calculation, although testing would still be the preferred option. Details on how to classify for the physical hazard classes are detailed below:

Explosives (P1)

Many substances that were classified as explosives under CHIP are classified as explosive under CLP; however, many other substances are now classified as self-reactive substances, oxidising solids, organic peroxides or flammable solids (this latter hazard class is not in scope of COMAH 2015). For safety reasons, once a substance or a mixture has been classified as explosive, it should not be considered for classification in other physical hazard classes.

Those substances and mixtures that have been produced for practical explosive or pyrotechnic effects must be classified as explosives. The classification of substances or mixtures under the explosives hazard class is a very complex procedure. Related expertise is key to determine the explosive hazards of a substance or a mixture.

Flammable gases (P2)

Under CHIP, flammability classes were defined as flammable, highly flammable and extremely flammable, although there was no difference referring to the physical state of a substance or a mixture. For this reason, a direct translation from CHIP is not possible in this case.

There is a calculation method described in ISO 10156:2010 [BSI, 2010] to determine if a mixture is flammable or not (it does not assign a hazard category). This method can be applied when data for all flammable components (T_{ci}, maximum content of flammable gas *i* which, when mixed with nitrogen, is not flammable in air, in %) and for all inert components (K_k, coefficient of equivalency of the inert gas *k* relative to nitrogen) are available. If T_{ci} is not available, the LFL (lower flammability level) can be used. If K_k is not available, the value of 1.5 can be used. In this case, a gas mixture would not be flammable if:

$$\sum_{i=1}^{n} \frac{A'_i}{T_{ci}} \leq 1 \tag{7}$$

Where:

$$A'_i = \frac{A_i}{\sum_{i=1}^{n} A_i + \sum_{k=1}^{p} K_k B_k} \tag{8}$$

Where:
A'_i = equivalent content of the *i* flammable gas in the mixture, in%;
A_i = molar fraction of the *i* flammable gas in the mixture, in %;
K_k = coefficient of equivalency of inert gas *k* relative to nitrogen;
B_k = molar fraction of the *k* inert gas in the mixture, in %;
n = number of flammable gases in the mixture;
p = number of inert gases in the mixture.

Flammable aerosols (P3)

Flammable aerosols constitute a new hazard class under CLP; therefore, it is a new hazard category in scope of COMAH 2015. Classification of flammable aerosols depends upon the concentration of flammable components and the results of ignition tests. Most of the aerosols that contain 1% or more of flammable components are classified under one of the flammable aerosols categories. All aerosols that contain LPG as propellant should be classified under flammable aerosols under COMAH 2015 (category P3A). In the COMAH aggregation process to determine the scope of an establishment, the quantity to aggregate corresponds to the amount of the whole aerosol contents, not only the flammable components and excluding the weight of the aerosol can.

Oxidising gases (P4)

Gases that were classified as oxidisers under CHIP can be classified as oxidising gases under CLP. Most of the oxidising gases are identified in ISO 10156:2010 [BSI, 2010], which presents a calculation to be used for the classification of oxidising gas mixtures. The calculation can only be applied when C_i is available for all oxidising ingredients and K_k is available for all inert ingredients in the mixture. The calculation is presented in Equation 9:

$$OP = \frac{\sum_{i=1}^{n} x_i C_i}{\sum_{i=1}^{n} x_i + \sum_{k=1}^{p} K_k B_k} > 23.5\% \tag{9}$$

Where:
OP = oxidising power;
x_i = molar fraction of the *i* oxidising gas in the mixture, in %;
C_i = coefficient of oxygen equivalency of the i oxidising gas in the mixture;
K_k = coefficient of equivalency of inert gas k relative to nitrogen;
B_k = molar fraction of the k inert gas in the mixture, in %;
n = number of flammable gases in the mixture;
p = number of inert gases in the mixture.

Flammable liquids (P5)

The flash point limits for the classification of flammable liquids have changed. Under CHIP, extremely flammable liquid substances and mixtures were those with flash point lower than 0°C and a boiling point lower than or equal to 35°C, highly

flammable liquids had a flash point below 21°C and flammable liquids had a flash point not lower than 21°C and less than or equal to 55°C.

Under CLP, flammable liquids classified under category 1 have a flash point below 23°C and an initial boiling point not higher than 35°C, flammable liquids classified as category 2 had the same flash point limit but the initial boiling point above 35°C and flammable liquids category 3 are those with a flash point higher than 23°C and not higher than 60°C.

One of the consequences of the changes in the flash point thresholds is that all liquids that were classified as extremely flammable liquids under CHIP are now classified as flammable liquids category 1. Also, liquids with a flash point between 55°C and 60°C were not classified as flammables before and are now classified under category 3 (gas oils, diesel and heating oils with flash points between 55°C and 75°C are classified as category 3). The rest of substances and mixtures need to be re-evaluated to determine the correct classification.

For the classification of mixtures, the flash point of the mixture itself needs to be determined; although CLP recommends a methodology to calculate the flash point of a mixture using the UNIFAC group-contribution method [Gmehling, Rasmussen, 1982], it is not always a reliable method and it is then preferred to use data derived from testing or from recognised literature instead.

Self-reactive substances and mixtures and organic peroxides (P6)

Self-reactive substances and mixtures are those that can release decomposition energy and that may be thermally unstable. These were not defined under CHIP. Substances and mixtures that were classified as “other hazards” under COMAH 1999 may now be classified as self-reactive substances or mixtures; this means that a direct translation from CHIP is not possible for this category. Expert advice should be sought for the correct classification under any of the categories for this hazard class, which can be determined through detonation and deflagration properties of the material once it is packaged.

Organic peroxides were classified as oxidisers under CHIP, whereas they constitute a new hazard class under CLP; therefore, a direct translation from CHIP is not possible in this case. The singularity of organic peroxides is that hazardous materials are assigned under this hazard class on the basis of their chemical structure, although a hazard category is assigned by testing the organic peroxides in its packaging.

Pyrophoric liquids and solids (P7)

Pyrophoricity of liquids and solids can be determined via ignition tests. Because the classification criteria for pyrophoric liquids remain the same as it was under CHIP, those liquids that were classified as pyrophoric before are still classified as such. For pyrophoric solids, changes on the test methods referring to the environmental conditions could lead to a slightly different classification; however, if a substance or a mixture was classified as pyrophoric solid under CHIP can still be classified as pyrophoric solid under CLP.

Oxidising liquids and solids (P8)

The testing procedures for oxidising substances and mixtures are based on their capability to enhance the combustion of a combustible material. In general, and except organic peroxides, solids and liquids that were classified as oxidisers under CHIP can still be classified as oxidising solids and liquids under CLP, although the set-up and the criteria of the test method used under CHIP for oxidising solids was slightly different, so the classification might also differ for some solids.

Conclusions

Classification of substances and mixtures under CLP is required to determine if an establishment falls in scope of COMAH 2015. ECHA issued the CLP guidance to help operators in the classification process; clarification on the contents in both CLP and the CLP guidance is provided in this paper.

1. When a classification for a substance or a mixture is available, because either it is harmonised or a classification has been provided via a supplier’s SDS, this classification can be used.
2. When the classification for a mixture is not available, but the classification for a similar mixture is, bridging principles can be used to determine the classification of the mixture.
3. When there are no data for the mixture of concern, or for similar mixtures, information on all the hazardous ingredients in the mixture (or for those ingredients of unknown classification) must be gathered.
4. For acute toxicity and environmental toxicity, an estimate of the toxicity for the whole mixture can be determined based on the toxicity data of the ingredients.

5. When toxicity data are not available for ≥1% of the composition of a mixture, final classification for the mixture cannot be given. In this case, the mixture should be classified on the available data and a note should be made on percentage composition for which data are not available.
6. To classify a mixture under STOT-SE, the categories of the ingredients must be compared against their SCLs or GCLs.
7. To determine the environmental classification of mixtures using the summation method, the M-factor for those ingredients that are classified under category 1 would be required. The M-factor for the acute toxicity of a substance may be different from the M-factor for chronic toxicity.
8. For physical hazards classification, testing the properties of the whole mixture would be the preferred option, although for some categories a classification may be determined through calculations.

Disclaimer

The contents of this paper, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

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