ASD-EUROSPACE
The Space group in ASD

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SPACE INDUSTRY COMMENTS ON NEW SPECIAL PACKING PROVISION "PP5" TO UN 2029 FOR HYDRAZINE ANHYDROUS

***Reference*:**

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

Sub-Committee of Experts on the Transport of Dangerous Goods (SCETDG)

SCETDG agreement at its 63rd session in Geneva on 27 November – 6 December 2023 to add a special packing provision "PP5" to the entry UN 2029 for hydrazine anhydrous

Possible next discussion at the 64th session of the SECTDG in Geneva on 24 June – 3 July 2024

1. INTRODUCTION

This is a joint paper of the European Space Industry, represented by ASD-EUROSPACE – with the support of European Space Agency (ESA), Deutsches Zentrum für Luft- und Raumfahrt (DLR), Centre National d'Etudes Spatiales (CNES) and the European Defence Agency (EDA) as observer with regards to an agreement of the UN Sub-Committee of Experts on the Transport of Dangerous Goods (SCETDG) at its 63rd session on 27 November – 6 December 2023.

This paper is also supported by the Aerospace, Security and Defence Industries Association of Europe (ASD). This paper is also strongly supported by the Defense Logistics Agency Aerospace Energy of US and the Aerospace Industries Association of America, Inc. (AIA).

More specifically, we refer to the agreement[1] of the SCETDG at its sixty-third session in Geneva on 27 November – 6 December 2023 to add a special packing provision "PP5" to the

[1] Report of the Sub-Committee of Experts in the Transport of Dangerous Goods on its sixty-third session, ref. ST/SG/AC.10/C.3/126, published on 22/12/2023, page 10 under *"M. New special provision and special packing provision of UN 2029"*; available at https://unece.org/transport/documents/2023/12/reports/report-sub-committee-experts-transport-dangerous-goods-its.

entry UN 2029 for hydrazine anhydrous (CAS No. 302-01-2),[2] as was proposed by China on 16 November 2023.[3] We understand that this change is due to come into force in January 2027 in the 24th Revision of the UN Model Regulations – unless a specific longer transition time is granted.

This paper has been prepared by the participants of the *ad hoc* PP5 Sub-Group of the Space Energetic Materials Working Group (EMWG);[4] the sub-group has been created specifically to address this rule change for hydrazine anhydrous after the mentioned agreement by the SCETDG, about which we obtained knowledge through online media earlier this year. The EMWG and the PP5 Sub-Group are operating under the umbrella of the Materials and Processes Technology Board of the European Space Components Coordination (ESCC MPTB).[5]

The effects of the addition of PP5 to the entry for UN 2029 hydrazine on producers and suppliers to the European space industry have been assessed within the PP5 Sub-Group. A dedicated discussion on the topic took place at an *ad hoc* EMWG meeting on 15 April 2024 with an invited expert from the European Chemical Industry Council (Cefic) attending the SCETDG, Dr. Dieter HEITKAMP. Subsequently the Sub-Group engaged in the preparation of the present paper, and elaboration of the impact assessment hereafter in Section 2 as well as the conclusions in Section 3.

Neither ASD-Eurospace nor the organisations participating in the EMWG PP5 Sub-Group or supporting it are eligible to submit formal proposals or requests to the UN SCETDG.

We are therefore seeking the urgent support of authorities participating in the SCETDG with a view to further decision-making on the change of UN 2029, based on the impact assessment and points raised in the following sections 2 and 3.

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[2] The current version of UN number 2029 for hydrazine anhydrous in the Dangerous Goods List foresees hazard Class 8 (corrosive) and subsidiary hazard Class 3 (flammable liquid) and/or Class 6.1 (toxic); see UN Model Regulations Rev. 23 (2023), Volume I), available at https://unece.org/transport/dangerous-goods/un-model-regulations-rev-23.

[3] Informal document ref. UN/SCETDG/63/INF.27 titled "New special provision and special packing provision of UN 2029, transmitted by the expert from China; available at https://unece.org/sites/default/files/2023-11/UN-SCETDG-63-INF27e.pdf.

[4] A list of PP5 Sub-Group participants can be found in Section 4. The EMWG was initiated by the ESCC MPTB in order to establish a broader regulatory monitoring and response frame and take the required actions to determine and mitigate possible regulatory obsolescence risks and other detrimental impacts (mainly but not limited to EU REACH) for space propellants and explosives (Energetic Materials). For hydrazine and other liquid propellants, the EMWG was preceded by the Space Hydrazine Task Force (HTF) on REACH Authorisation, established in 2011 (see the Annex for more information).

[5] The ESCC MPTB is a partnership between the European Space Agency (ESA), national space agencies, and space industry represented by ASD-EUROSPACE; it is chaired at present by ESA. Further information about the MPTB is available on the ESCIES website.

2. IMPACT ASSESSMENT OF ADDITION OF PP5 TO UN 2029

According to the special packing provision PP5 *"packaging shall be so constructed that explosion is not possible by reason of increased internal pressure. Gas cylinders and gas receptacles shall not be used for these substances."*

Currently, companies use **stainless-steel pressure receptacles** for packaging and transportation of hydrazine, which would be affected by PP5. Consequently, the addition of **PP5 would mean that companies could no longer use their current pressure vessels**.

We strongly believe that the current packing is the best available, safest solution, and has a long heritage. It has not led to any accidents in the EU over the course of the several decades of using and transporting hydrazine for EU space applications.

Given the well-established hazards of hydrazine[6] producers and suppliers to the space industry package it in stainless-steel pressure vessels for transportation purposes. These receptacles are rated with a test pressure of 35 bar. This makes them extremely durable in long-term condition and also ensures safety during transportation. It should also be noted that the pressure of the padding gas in these tanks is typically lowered for transport to around 2.5 bar.

Packing hydrazine into a less stable receptacle would greatly increase the risk of the receptacle being damaged while being loaded or in vehicle crashes during transportation. This risk would be further increased when such receptacle was used in places where the hot climate (e.g. Guiana Space Centre Launch Base) can make the internal pressure rise with a risk of rupture.

The addition of venting or overpressure devices further increases the risk of damage or inadvertent or undesired operation.

In an event leading to release, the substance could run into a roadside ditch or storm drain and enter the groundwater. This would have unforeseeable consequences for the environment and be accompanied with expensive fines and difficult cleanup processes. A meta-analysis by NASA has demonstrated that in 40% of the instances that there is a hydrazine leak there is an accompanying fire. This has shown to have severe consequences to equipment, facilities, and personnel.

We believe the **risk of an unstable receptacle being damaged during transportation** is much higher than the risk of a fire heating up a pressure drum long enough to lead to an explosion. Even if said event would occur, in case of an explosion most of the hydrazine would burn and the resulting products would be not as problematic for the environment or emergency responders as hydrazine in its liquid form.

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[6] See footnote 2.

Hydrazine tends to be very stable in a static configuration, assuming that compatibility characteristics have been addressed. Most incidents happen during some sort of dynamic operation. The installation and potential opening of a relief valve may appear to be beneficial but the historical evidence proves otherwise. It is strongly advised and counselled to not install venting or overpressure devices on hydrazine non-bulk transportation tanks.

In conclusion, we believe that the safest way – until an alternative solution is found – is to keep the current approach and continue to transport UN2029 in pressure receptacles with high mechanical stability to minimize the risk of exposure to the environment and population.

Identifying and implementing suitable alternative receptacles will take time and incur huge costs. If and when a suitable alternative is identified, companies would need to buy new receptacles and convert their production sites. In addition, storage facilities, transportation means and associated procedures would also require review and modifications.

Also, an **alteration of their filling system** would be necessary to be compatible with new receptacles. In fact, during hydrazine filling into propulsion systems, the tank is slightly pressurized. If the tank's ability to sustain pressure is modified therefore the whole process will be affected. It will either alter the duration of the fuelling (due to lower pressure) or, in the worst case, additional handling of hydrazine would be needed (such as transferring hydrazine into a drum able to endure more pressure). In both cases, it increases the risk during these critical operations, without talking about the fact that the actual receptacles made out of steel are bulky enough against moderate shocks, drops, etc. As an example, plastic is not as impact resistant as stainless steel (see Section 2.1. below with more details on alternative receptacles).

2.1. DETAILS ON ALTERNATIVES ASSESSMENT FOR RECEPTACLES

Industry participants have provided more details on possible alternative receptacles:

Various space propellants (hydrazine, MON[7], MMH[8]) are currently procured in pressurisable type tanks. These thick-walled stainless steel tanks are considered to have a significantly higher degree of safety and robustness across a number of processes versus the **thin-walled stainless steel or plastic UN drums**. Transport, offloading, storage, handling on site, and propellant transfer operations are all considered safer using these pressurisable tanks.

In line with this, it was reported that the use of UN drums was actually phased out many years ago due to concerns over safety.

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[7] Mixed Oxides of Nitrogen.

[8] MonoMethyl Hydrazine (CAS 60-34-4).

Similar issues would be experienced in terms of propellant transfer operations on site. The propellant is transferred from transfer tanks to the test cell run tanks by application of pressure. The UN drums typically have a very low pressure rating, and are not nominally considered pressurisable vessels, companies would therefore not consider application of pressure to UN drums as a viable process for transfer. Therefore any transfer process would need to be completely reconsidered. Transfer to an intermediate vessel is problematic in itself as this is still a transfer process potentially requiring application of pressure to the UN drums. Gravity draining, or filling under vacuum could be considered, however they have their limitations due to limited delta pressures applied across a system. There would be an inevitable and significant increase to the duration of any activity due to slower fill rates, and significantly greater quantity of UN drums required due to their smaller capacity. Pumping of hydrazine would be a highly risky, complex and technically challenging process with huge cost to implement. All of these options add risk as the number and duration of handling processes is increased, along with the intrinsic hazards of handling less robust drums. Filling systems, test cell propellant and pressurant feed systems, storage facilities, spill containment systems, site handling processes, etc. would all need to be physically modified and/or completely new systems designed, built, commissioned and tested to adapt to different receptacles.

There is also another issue: Hydrazine is susceptible to reaction with air (highly hygroscopic for example), and therefore there are diligent controls applied to ensure hydrazine is used in closed systems[9] (as well as of course the highly toxic nature and exposure risk). UN drums do not typically allow for this unlike pressure receptacles. UN drums are normally supplied with screwed caps only with no valves for isolation as on pressure receptacles. It is therefore not possible to uncap and connect UN drums without exposing the hydrazine contents to air (or other impurities which may destabilise the hydrazine), unless a completely enclosed temporary inert atmosphere around the drum can be applied (such as a bagging system with nitrogen). This again adds complexity, additional handling risk, and cost.

Specifically with regard to **plastics**, their compatibility with hydrazine is indeed a serious problem. There are not many plastics compatible with hydrazine available, especially for long-term applications (e.g. Teflon, although this may be subject to upcoming PFAS restrictions under EU REACH[10]). The problems that arise are mainly leaching effects, in which chemical elements in the plastic composition are leached and dissolved in hydrazine.

Thrusters for space applications generate thrust through the catalytic decomposition of hydrazine. In the case of contaminated hydrazine (with elements leached from plastics), the dissolved elements remain as a residue in the catalyst bed and thus clog the active surface of the catalyst, which leads to reduced catalytic reactivity and thus to thrust degradation.

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[9] See also in the Annex.

[10] See https://echa.europa.eu/hot-topics/perfluoroalkyl-chemicals-pfas.

Mentioned effects occurred in propulsion systems with by far less contact area (plastic surface wetted with hydrazine) compared to the surface of transport receptacles in use.

In addition, the (plastic) vessels would require metallic armatures for connecting the hydrazine storage tank with the fuelling equipment. For this, plastic tanks are not considered appropriate, especially taking known particle generations due to abrasion into account.

3. CONCLUSIONS

The current use of stainless-steel pressure receptacles for packaging and transportation of hydrazine anhydrous is the **best available, safest solution**, and has a long heritage. As shown, an alternative packing solution is not available today.

We are therefore much concerned about the addition of PP5 to UN 2029 given the mentioned substitution challenges and expected economic impacts for our industry. We also understand that the rule would apply regardless of the volumes stored and transported, which further adds to the impact.

Therefore, our industry **would not be able to comply with this new rule** if it were to come into force in a standard timeframe.

As a result, we believe that the special packing provision PP5 should be **removed** from UN 2029 for the transport of hydrazine anhydrous as a space propellant.

If this is not possible, it will be necessary – at the very least – to have a **long transition time** (such as 10 years after entry into force of the rule change) in order to see whether an alternative packing solution for our industry can be found and implemented.

We are therefore seeking the urgent support of authorities participating in the SCETDG with a view to further decision-making on the change of UN 2029, in order to allow us to ensure continued compliance with the applicable transport regulations.

We look forward to discussing this matter with you and are available for any further questions that you may have.

Kind regards,

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4. LIST OF PP5 SUB-GROUP PARTICIPANTS

This paper has been prepared by REACHLaw Ltd. In the frame of the *ad hoc* PP5 Sub-Group of the Energetic Materials Working Group (EMWG), following the collection of relevant information from the sub-group participants. It reflects the best knowledge available from experts in their field, thanks in particular to the support of

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The PP5 Sub-Group is supported by

ASD-EUROSPACE as Secretariat and

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Further information about the EMWG is available on the ASD-EUROSPACE website, including latest news alert with further references at https://eurospace.org/the-space-energetic-materials-working-group-expands-its-membership-and-scope.

ANNEX: ABOUT THE CURRENT USE AND TRANSPORT OF HYDRAZINE ANHYDROUS IN THE EUROPEAN SPACE SECTOR

This Annex is provided as background information only, to shed light on the history of the European Space Sector's recent work on hydrazine with regard to the EU REACH Regulation[11]. It was initially driven by the inclusion of the substance in the European Chemicals Agency (ECHA) Candidate List of Substances of Very High Concern (SVHC) for EU REACH Authorisation on 20 June 2011. We are aware that transport requirements based on UN Model Regulations and safe use requirements (here: based on EU REACH) are to be treated separately.

ESSENTIALITY OF HYDRAZINE ANHYDROUS FOR EU SPACE APPLICATIONS

Hydrazine anhydrous is a **strategic component** for satellite and launcher programmes in the EU. Due to its high purity quality required for space applications it is not comparable to other industrial uses and grades. In total, less than 20 tonnes per year of this "space-specified" hydrazine are currently being used within the European Union.

Most space vehicles including telecommunication, Earth observation, navigation and scientific satellites as well as space launchers rely on hydrazine and/or hydrazine derivative propellants. More specifically, major European programmes such as launchers (Vega), Galileo, GMES and other satellites produced for public agencies or for private operators use hydrazine.

Therefore, hydrazine remains a fundamental component for European space programmes to assure access to space as well as to accomplish its space missions.

CLOSED SYSTEM ASSESSMENT (REACH POSITION OF 2012, AS UPDATED IN 2020)

The different handling steps and conditions of use of hydrazine anhydrous for satellite, launcher and ground testing applications have been mapped and documented comprehensively as part of an assessment in the frame of the Space Hydrazine Task Force (HTF)[12] on REACH Authorisation in 2011; this assessment was subsequently updated in 2020.

The initial assessment was triggered by the inclusion of the substance in the REACH Candidate List of Substances of Very High Concern (SVHC) for Authorisation on 20 June 2011.[13] Candidate listing implies the substance's eligibility to be prioritized for inclusion in Annex XIV of REACH

[11] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency.

[12] After the discontinuation of the HTF at the end of 2022 the EMWG continues to jointly address all relevant regulatory issues for hydrazine anhydrous, among many other energetic materials.

[13] See https://echa.europa.eu/candidate-list-table/-/dislist/details/0b0236e1807da31d.

(Authorisation List), with a Sunset Date for final phase-out from use in the EU unless an authorisation is granted by the European Commission or an exemption clause applies.

Based on the assessments carried out, the European Space Industry had concluded on its position (hereafter also "REACH Position") that all propellant-related use of hydrazine for space applications could be exempted from an assumed REACH authorisation requirement, chiefly based on REACH Art. 56(4)(d) 2nd alt. "use as fuels in closed systems".[14] Figure 1 below from the REACH Position illustrates the exemption position, showing the various handling steps in the hydrazine supply chain prior to its target application as propellant.

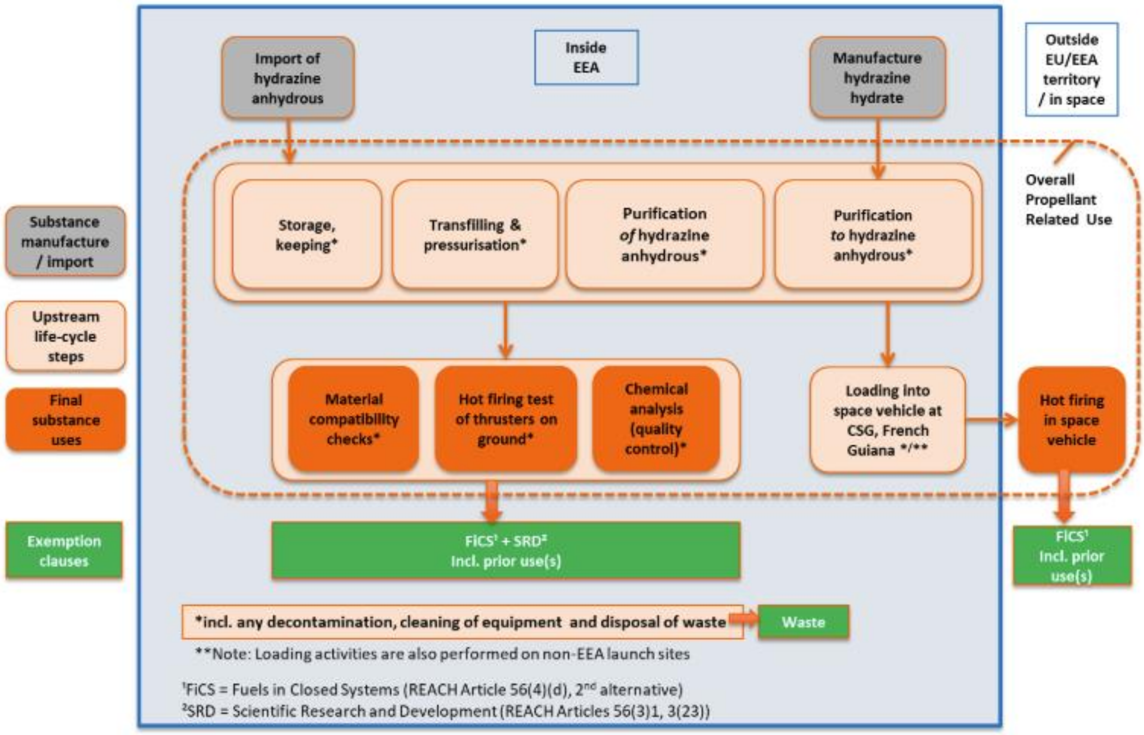

Figure 1 Exemption of propellant-related use in the European Space Industry from REACH authorisation

According to the abovementioned REACH Position the hydrazine supply system is **designed as a closed system.**[15] Hydrazine is stored in receptacles (pressure drums, transfer tanks, etc.) in dedicated areas under controlled conditions, with no likelihood of exposure. **Receptacles are designed and certified in accordance with transport regulations (IMDG, RID, ADR)** or applicable pressure system safety regulations. Periodic inspections of the receptacles as well as pressure & leak tightness check are carried out regularly.

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[14] The REACH Position (updated version of 8 April 2020) is available at https://eurospace.org//wp-content/uploads/2020/04/hydrazine-revised-reach-position-2020-final.pdf. It contains further information about the closed system assessment for hydrazine anhydrous reference, including in relation to transfilling, pressurisation and storage on page 20 under points 6.-8. of the REACH Position.

[15] Dedicated flowcharts illustrating the closed supply system have been developed for European satellite suppliers, launchers and ground test activities for thruster hot firing. They can be provided upon request.

Approximately 50-60 workers in total are involved in the handling of hydrazine anhydrous within the EU; they are specially trained and protected through adequate measures preventing exposure to the substance.

SEARCH FOR ALTERNATIVES TO HYDRAZINE

Hydrazine propulsion technology is based on more than 60 years of experience, resulting in a very well understood technology with a very high degree of heritage and reliability.

Nevertheless – given the hazardous properties of hydrazine and the regulatory push to phase out its use (not least because of the EU REACH candidate listing) – the European Space Industry, ESA and European national space agencies have been working on alternatives to hydrazine for spacecraft and launcher applications for over 20 years by now. As part of the ESA Clean Space initiative, alternative 'green'[16] propulsion technologies are also being investigated.[17]

Yet, replacement of hydrazine and associated hardware, reaching an equivalent system with the same performance for all classes of space vehicles, is not considered feasible within a decade, at least. This presupposes that all funding is readily available and no significant engineering or programmatic challenges are encountered. Therefore, an economically viable technology replacement must be seen in the context of an extended long-term strategy.

Thus a secured supply of hydrazine remains vital for the current and future success of European space programmes.

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[16] Viable alternatives should be of at least equal performance and safer (less toxic), but also sustainable from a life-cycle point of view, in order to avoid burden shifting. This assessment also includes the transport stage.

[17] See e.g. https://www.esa.int/Space_Safety/Clean_Space/Considering_hydrazine-free_satellite_propulsion.