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ORGANIZATION OF DANGEROUS GOODS TRANSPORTATION BY ROAD: A FRAMEWORK FOR SAFETY AND COMPLIANCE

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The transportation of dangerous goods by road is one of the most heavily regulated activities in the logistics sector—and for good reason. Every day, thousands of vehicles carry flammable liquids, corrosive chemicals, toxic substances, and radioactive materials across road networks that pass through cities, residential areas, and environmentally sensitive zones. A single incident involving a tanker of hazardous chemicals can have catastrophic consequences for human life, property, and the environment. The organization of dangerous goods transport therefore demands a systematic, multi-layered approach that integrates regulatory compliance, risk assessment, personnel competence, vehicle integrity, and emergency preparedness.

At the international level, the carriage of dangerous goods by road is governed principally by the Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), established under the United Nations Economic Commission for Europe in 1957 and regularly updated—most recently in the ADR 2025 edition, applicable from 1 January 2025 (UNECE, 2024). The ADR framework has become the global benchmark, adopted not only across Europe but increasingly referenced by

countries seeking to align their domestic regulations with international standards (UNECE, 2023). This article examines the key organizational elements required for compliant and safe dangerous goods road transport.

The Regulatory Foundation: ADR and Its Structure The ADR Agreement itself is concise. Its central provision, Article 2, stipulates that dangerous goods may be carried internationally in road vehicles subject to compliance with two comprehensive annexes: Annex A, covering provisions concerning dangerous articles and substances (including classification, packaging, labeling, and documentation), and Annex B, covering provisions concerning transport equipment and transport operations (including vehicle construction, equipment, crew requirements, and operational procedures) (UNECE, 2024).

The agreement is structured to align with the UN Model Regulations on the Transport of Dangerous Goods, the International Maritime Dangerous Goods (IMDG) Code, the ICAO Technical Instructions for air transport, and the regulations for international carriage by rail (RID). This harmonized architecture ensures consistency across transport modes, facilitating multimodal shipments and reducing duplication of compliance burdens (International Maritime Organization, 2022).

Annex A contains seven parts covering: general provisions (Part 1); classification of dangerous substances (Part 2); the dangerous goods list, special provisions, and exemptions for limited and excepted quantities (Part 3); packing and tank provisions (Part 4); consignment procedures including marking, labeling, and documentation (Part 5); requirements for packaging and tank construction and testing (Part 6); and provisions concerning carriage, loading, unloading, and handling (Part 7) (UNECE, 2024).

Annex B contains two parts: requirements for vehicle crews, equipment, operation, and documentation (Part 8), and requirements concerning the construction and approval of vehicles (Part 9). Together, these provisions create a comprehensive safety framework covering the entire transport chain (UNECE, 2024).

The 2025 edition incorporates amendments adopted in 2022, 2023, and 2024, including new provisions for sodium-ion batteries, updated requirements for waste

transport in inner packagings, and clarifications on documentation acceptability in electronic formats (UNECE, 2024).

Classification and Identification: The Foundation of Safe Organization The first and most critical step in organizing dangerous goods transport is accurate identification and classification of the substances to be moved. ADR Part 2 establishes the classification system, which divides dangerous goods into nine classes based on the type of hazard presented: explosives (Class 1), gases (Class 2), flammable liquids (Class 3), flammable solids (Class 4), oxidizing substances and organic peroxides (Class 5), toxic and infectious substances (Class 6), radioactive material (Class 7), corrosive substances (Class 8), and miscellaneous dangerous goods and articles including environmentally hazardous substances (Class 9) (UNECE, 2024).

Each class has subdivisions that further specify the nature of the hazard. The classification determines every subsequent aspect of the transport organization—packaging requirements, vehicle specifications, crew training needs, and emergency response procedures. Research on dangerous goods logistics emphasizes that misclassification is a root cause of many transport incidents, as it leads to inappropriate packaging, inadequate vehicle selection, and incorrect emergency response (Glickman and Erkut, 2007).

A common organizational failure occurs at this initial stage. Many companies accept transport orders without sufficient information about the dangerous goods involved, or fail to verify whether the transport can be legally and safely executed with available resources (Health and Safety Executive, 2023). Before accepting any dangerous goods consignment, the transport organizer must establish: the UN number and proper shipping name; the class and packing group; the type and specification of required packaging; any special provisions or exemptions that may apply; and whether the intended route, vehicle, and crew are authorized for the consignment.

The Role of the Dangerous Goods Safety Adviser A cornerstone of the organizational framework is the mandatory appointment of a Dangerous Goods Safety Adviser (DGSA). Under the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (CDG) and equivalent legislation in other

jurisdictions, organizations that handle, process, or transport dangerous goods regularly—unless operating solely under limited quantity exemptions—must employ a qualified DGSA (Department for Transport, 2024).

The DGSA functions as the organization's internal expert and compliance watchdog. Their responsibilities encompass advising on the safe and correct transportation of dangerous goods; monitoring compliance with legal requirements governing packing, shipping, marking, labeling, and documentation; investigating accidents and infringements of regulations and maintaining records through reports; monitoring the provision of training and advice to other staff; and completing annual audit reports on the performance of the business (Department for Transport, 2024).

The DGSA also plays a critical role in incident reporting. When accidents involving dangerous goods occur during carriage, the DGSA is responsible for reporting to the relevant competent authority—in the United Kingdom, the Department for Transport (Health and Safety Executive, 2023).

The importance of the DGSA role has led to growing calls within industry to raise its profile. A 2025 call for evidence conducted by the UK Department for Transport found strong consensus among respondents on the need to strengthen enforcement against non-compliance with DGSA requirements and to ensure that organizations not only appoint a DGSA but follow their advice (Department for Transport, 2025).

Driver Competence: Training, Certification, and Continuous Development The driver is the final and arguably most critical link in the dangerous goods transport chain. ADR Chapter 8.2 requires that drivers of vehicles carrying dangerous goods (above threshold quantities) hold a valid ADR vocational training certificate. This certification is obtained through approved training courses and examinations covering core knowledge and, where relevant, specialization modules for specific classes (tankers, explosives, radioactive materials) (UNECE, 2024).

ADR training encompasses the safe handling, loading, and unloading of hazardous materials; the use of personal protective equipment; firefighting and emergency response procedures; and understanding of transport documentation and

vehicle marking requirements (International Road Transport Union, 2024). The training is not a one-time obligation; certificates are valid for five years and must be renewed through refresher training and re-examination. Research on driver competence in hazardous materials transport confirms that ongoing training and assessment significantly reduce incident rates compared to initial certification alone (Cantor et al., 2010).

Industry initiatives are expanding training beyond minimum regulatory requirements. The IRU Academy, in partnership with national training institutes, has developed programs combining ADR compliance with defensive driving techniques. Recent training sessions in India included hands-on firefighting exercises simulating tank vehicle fires, practical experience with personal protective equipment, transloading procedures, and vehicle inspections (International Road Transport Union, 2024). Trainees reported feeling more confident in handling dangerous goods and gaining deeper understanding of ADR rules, safety precautions, and emergency response techniques (International Road Transport Union, 2024).

Before departure, the driver must verify that all required documentation is present and valid: the ADR vocational training certificate; photo identification (valid driving license or passport); instructions in writing in a language the crew understands; a safety plan for high-consequence dangerous goods; and certificates of approval for vehicles (EX, FL, AT for tanks or BK for bulk goods) (UNECE, 2024).

Vehicle Requirements and Equipment Vehicles used for dangerous goods transport must meet construction and equipment standards specified in ADR Part 9. Requirements vary according to the class and quantity of goods carried. Tank vehicles carrying flammable liquids must meet specific design standards for the tank shell, pressure relief systems, and electrical installations. Vehicles carrying explosives require additional fire protection and electrical safety features (UNECE, 2024).

Pre-departure inspection is mandatory and must cover the proper condition and cleanliness of the vehicle and equipment (including cleaning certificates for tanks where required); validity of tank inspections (periodic and intermediate); vehicle marking including orange plates and ADR placards where required; fire extinguishers (for

vehicles over 7.5 tonnes maximum permissible gross weight, a minimum 12 kg total capacity including at least one 6 kg extinguisher and one 2 kg extinguisher for cabin fires); wheel chocks appropriate for wheel size; two self-standing warning signs; and first aid equipment compliant with road traffic regulations (UNECE, 2024).

Driver personal protective equipment must include high-visibility clothing, protective gloves, portable lighting apparatus (ATEX standard), respiratory protection mask (for toxic substances), a shovel, drain seal and collection container (for certain solid and liquid classes), eyewash liquid, and safety glasses (International Road Transport Union, 2024).

Orange-coloured plates are a distinctive requirement of ADR. These rectangular plates, displayed at the front and rear of the vehicle (and on the sides for tank vehicles), display the hazard identification number and the UN number of the substance being carried, enabling emergency responders to quickly identify the hazard and determine appropriate response actions (UNECE, 2024). Research on hazardous materials incident response emphasizes that rapid and accurate hazard identification is critical to effective emergency intervention and minimization of harm (Erkut, Tjandra and Verter, 2007).

Consignment Procedures: Documentation, Marking, and Labeling The consignment process is where the organizational framework translates into operational reality. ADR Part 5 establishes requirements for marking and labeling packages, placarding vehicles and containers, and preparing transport documentation (UNECE, 2024).

The transport document (dangerous goods declaration) must include the UN number preceded by the letters "UN"; the proper shipping name; the class and any subsidiary risks; the packing group where applicable; the number and description of packages; the total quantity of dangerous goods; and the name and address of the consignor and consignee. Special provisions may require additional information, such as the flashpoint for flammable liquids or the end of the holding time for refrigerated liquefied gases (UNECE, 2024).

The ADR 2025 amendments include several documentation clarifications.

Electronic documentation is now explicitly permissible, provided the required information is available during transport in a manner that allows identification of the goods and the vehicle. New provisions address the documentation requirements for sodium-ion batteries (new UN numbers 3551 and 3552) and battery-powered vehicles (UN numbers 3556, 3557, and 3558) (UNECE, 2024).

Marking and labeling requirements extend to all levels of the consignment—individual packages, overpacks, containers, and vehicles. Labels must conform to the standardized diamond-shaped hazard warning symbols prescribed by the UN Model Regulations. Placards (enlarged labels) must be affixed to transport units carrying dangerous goods above threshold quantities (UNECE, 2024).

Emergency Preparedness and Incident Response No organizational framework for dangerous goods transport is complete without robust emergency response planning. Companies must have plans in place to respond to incidents involving hazardous materials, including spills, fires, and accidents. These plans should include procedures for notifying authorities, containing and cleaning up spills, providing medical assistance if necessary, and protecting the surrounding population and environment (Health and Safety Executive, 2023).

Written instructions in the language of the vehicle crew must be carried in the cab and be readily accessible. These instructions provide guidance on the nature of the hazards, appropriate personal protective measures, and the actions to be taken in the event of an accident or emergency. Regular training and drills help ensure that both drivers and management are prepared to execute emergency plans effectively (International Road Transport Union, 2024).

For high-consequence dangerous goods—those with the potential for mass casualties or severe environmental damage—a detailed safety plan must be prepared addressing the specific risks of the operation and the measures in place to mitigate them. Research on hazardous materials transportation risk management emphasizes that emergency preparedness is most effective when integrated with route planning that minimizes exposure to populated and environmentally sensitive areas (Verter and Kara, 2001).

Conclusion: A Systematic Organizational Imperative The organization of dangerous goods transport by road is not a task to be improvised or delegated without oversight. It requires a systematic, documented, and regularly reviewed framework that integrates regulatory knowledge, personnel competence, vehicle integrity, and emergency preparedness. The ADR provides the international legal architecture; the DGSA provides the internal expertise; trained drivers and properly equipped vehicles provide the operational capability.

Gaps in any element of this framework can have severe consequences—legal penalties, civil liability, reputational damage, and, in the worst case, harm to human life and the environment. Organizations that invest in building robust dangerous goods transport systems do not merely comply with regulatory obligations; they protect their workforce, the public, and the integrity of the supply chains upon which modern society depends.

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