
**MEDITERRANEAN ACTION PLAN (MAP)
REGIONAL MARINE POLLUTION EMERGENCY RESPONSE CENTRE FOR THE
MEDITERRANEAN SEA (REMPEC)**

Fifteenth Meeting of the Focal Points of the Regional Marine
Pollution Emergency Response Centre for the
Mediterranean Sea (REMPEC)

REMPEC/WG.56/3/2
12 May 2023
Original: English

Kappara, Malta, 13-15 June 2023

Agenda Item 3: Illegal and accidental oil and HNS pollution from ships

Mediterranean Technical Working Group (MTWG) and related activities

For environmental and cost-saving reasons, this document will not be printed and is made available in electronic format only. Delegates are encouraged to consult the document in its electronic format and limit printing.

Note by the Secretariat

This document provides an update on the progress made by the Mediterranean Technical Working Group (MTWG) since the Fourteenth Meeting of the Focal Points of REMPEC and proposes future activities to be integrated into the Programme of Work of the MTWG for the biennium 2024-2025.

Background

1 The Meeting of the Focal Points of the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) (Malta, October 2000) agreed to establish the Mediterranean Technical Working Group (MTWG) aimed at facilitating the exchange of technical data and scientific information on the subject matter of preparedness for and response to marine pollution emergencies. That meeting adopted the Guidelines for the MTWG which were further reviewed and subsequently adopted by the 11th Meeting of the Focal Points of REMPEC (Malta, June 2015) (REMPEC/WG.37/14/1/Annex II). These Guidelines provided the method of work for the MTWG.

2 Based on the recommendations adopted by the 12th Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (“the Barcelona Convention”) and its Protocols (Monaco, November 2001), the need for such a regional forum (i.e. MTWG) was strengthened. It was agreed that REMPEC should develop and maintain close working relationships with other Regional Activity Centres (RACs) of the UNEP/MAP and with other “specialized regional organizations” which play a coordinating role, in particular, with those scientific institutions in the region.

3 The 22nd Ordinary Meeting of the Contracting Parties to the Barcelona Convention and its Protocols (COP 22) (Türkiye, December 2021) adopted the Mediterranean Strategy for the Prevention of, Preparedness, and Response to Marine Pollution from Ships (2022-2031), hereinafter referred to as “the Mediterranean Strategy (2022-2031)”. It addresses issues related to the activities carried out within the MTWG in its Common Strategic Objective 1 (CSO 1): Prevent, prepare for, and respond to operational, illegal and accidental oil and HNS pollution from ships.

4 To meet the CSO 1, the Contracting Parties to the Barcelona Convention and its Protocols (CPs) acknowledged the need to further develop policies to address current and new challenges in prevention, preparedness for and response to operational, illegal and accidental pollution from ships in the Mediterranean, and to facilitate and enhance existing or new services to foster monitoring and exchange of knowledge and data.

5 CPs also recognized the need for a stronger inter-sectoral cooperation between at-sea, shoreline, and wildlife responders, port authorities, oil and chemical industry and agree to aim for a holistic / integrated management of marine pollution incidents that enable a coordinated response operation at sea and onshore, including the response to wildlife.

Programme of Work (PoW) of the MTWG for the biennium 2022-2023

6 The 14th Meeting of the Focal Points of REMPEC (online, 31 May to 2 June 2021), considered document REMPEC/WG.51/10 providing an update on the progress made by the MTWG since the 13th Meeting of the Focal Points of REMPEC (Malta, June 2019), and the proposed activities to be integrated into the work programme of the MTWG for the present biennium 2022-2023.

7 Acknowledging the valuable work carried out by the MTWG, the 14th Meeting of the Focal Points of REMPEC agreed to maintain the OPRC-HNS Correspondence Group, established within the MTWG by the 13th Meeting of the Focal Points of REMPEC, encouraged the CPs, which had not yet done so, to nominate their national entities and/or officials as contact points for this Correspondence Group and considered the following tasks to be implemented through this Correspondence Group to:

- .1 continue supporting the process for the establishment of the Common Emergency Communication System in accordance with the outcome of the discussions on the related document REMPEC/WG.51/9/2;

- .2 contribute to the development of an operational guide on the response to spills of Hazardous and Noxious Substances (HNS), in the framework of the Sub-Committee on Pollution Prevention and Response (PPR) of the International Maritime Organization (IMO); and
- .3 extend the period of the mandate of the MTWG to allow for further progress and finalization of the task related to the Guide on condensate spills by end December 2021.

Implementation of the PoW of the MTWG for the biennium 2022-2023 and proposed activities for 2024-2025

OPRC-HNS Correspondence Group under the MTWG

8 Pursuant to the decision of the 14th Meeting of the Focal Points of REMPEC, to maintain the OPRC-HNS Correspondence Group under the MTWG to carry out its PoW for the present biennium, the Secretariat in its Circular Letters of February 2022 and January 2023 respectively on the Directory of Competent National Authorities requested CPs to designate and update, *inter alia*, the members of the MTWG. Noting that so far only fifteen (15) designations out of twenty-two (22) were confirmed, the Secretariat proposes to encourage the CPs, which has not yet been done, to nominate their national entities and/or officials as contact points for the OPRC-HNS Correspondence Group.

9 Considering that risks associated with the transport by ships of oil and HNS with possible harmful consequences on biota and ecosystems cannot be eliminated and that accidents can and still do occur, and referring to the above paragraphs 4 and 5 and the ongoing and expected future developments in terms of sharing data on monitoring of acute pollution, the Secretariat proposes to:

- .1 the MTWG to consider the following tasks:
 - .1 through the OPRC and HNS Correspondence Group to contribute with the Barcelona Convention Offshore Oil and Gas Group (OFOG) Sub-Groups: on Environmental Impact and on Health and Safety for the development of the Post 2016-2024 Mediterranean Offshore Action Plan.
 - .2 through the establishment of a new Correspondence Group on Data Sharing, Monitoring and Reporting to:
 - .1 improve the contribution of the CPs to activities related to Data Sharing, Monitoring and Reporting on Oil and HNS Spills in the Mediterranean; and
 - .2 contribute to the preparation of MEDEXPOL 2024 on Data Sharing, Monitoring and Reporting.
- .2 the CPs to designate through the REMPEC OPRC Focal Points, the appropriate national entities and/or officials as contact points for these Correspondence Groups.

Communication System

10 Pursuant to the decisions of the 13th Meeting of the Focal Points of REMPEC, which requested the Secretariat to envisage the use of the Common Emergency Communication and Information System for Marine Pollution Incidents (CECIS MP) of the European Commission (EC) to enhance coordination of requests and offers of international assistance in the Mediterranean in case of emergency, the 14th Meeting of the Focal Points of REMPEC stressed the importance of setting up a common communication system for the Mediterranean, through a unique Platform.

11 The Meeting also agreed upon the use of the CECIS MP by all the CPs, and, accordingly, on a set of operational matters to progress on the establishment of the common communication system (REMPEC/WG. 51/13).

12 Therefore, to the launch by the EC of the project for the renewal and upgrade of CECIS MP, to be completed end 2023, the progress on setting up the common communication system was suspended. In this context, the Secretariat proposes to maintain the task assigned to the OPRC-HNS Correspondence Group to test and enhance the Communication System, once developed, and to assist the Secretariat during the different phases of the development of the new system.

The Marine HNS Response Manual – Multi-Regional Bonn Agreement, HELCOM, REMPEC

13 It is recalled that the Marine HNS Response Manual was developed in cooperation with the Bonn Agreement and HELCOM. The 14th Meeting of the Focal Points of REMPEC adopted the Marine HNS Response Manual – Multi-Regional Bonn Agreement, HELCOM, REMPEC (the Manual). Recognizing the importance of the Manual, and upon request from IMO, REMPEC submitted the Manual to the 9th session of the IMO Sub Committee on Pollution Prevention and Response (PPR 9) to contribute to the development of an Operational Guide on the Response Spills of HNS (the Guide).

14 Following the outcome of discussions at PPR9 (London, UK, April 2019), further work was carried out by REMPEC in consultation with the HELCOM and Bonn Agreement Secretariats resulting in the proposal for the development of the Guide of the removal of regional specificities from the Manual and to divide its content in two parts: Part I – focusing on preparedness and Part II – focusing on response. The proposal was submitted to PPR 10 in January 2023 and was endorsed by the plenary (London, UK 24-28 April 2023). A Drafting Group was tasked to draft and submit the Draft Final Guide to the next MEPC Meeting.

15 The Secretariat recognizes the important contribution of the OPRC HNS Correspondence Group during the development of the Manual and, having been adopted by the 14th Meeting of the Focal Points of REMPEC, proposes to encourage the CPs to use the Manual.

Review of Guidelines for the use of dispersants for combating oil pollution at sea in the Mediterranean region

16 In 2011, the Centre developed a revised version of the Guidelines for the Use of Dispersants for Combating Oil Pollution at Sea in the Mediterranean, which was adopted by Decision IG.3/5 of the Eighth Ordinary Meeting of the Contracting Parties to the Barcelona Convention (Türkiye, October 1993).

17 More recently, the Sub regional Workshop on Dispersants and their Operational Use and Effectiveness, organized with the framework of the Sub-regional Marine Oil Pollution Contingency Plan between Cyprus, Greece and Israel (Greece, October 2021) recognized the value of these Guidelines and agreed upon additional specific information concerning the Mediterranean Sea within Part II of the Guidelines ‘Basic Information on Dispersants and their Application’ about the issues of Salinity, Nutrient level and Desalination plants.

18 In this context, the Secretariat proposes to include the above-mentioned review on Part II of the Guidelines in the PoW of the MTWG for the biennium 2024-2025 for submission by the Secretariat of the revised version to the 16th Meeting of the Focal Points of REMPEC for approval.

Condensates – Chemical Intervention Guide for the Mediterranean

19 Recognizing that traditional techniques and response methods to combat marine oil spills may not be fit for the purpose of handling incidents involving condensates, it is recalled that the 13th Meeting of the Focal Points of REMPEC requested the preparation of a study on the matter with the view of its approval by the 14th Meeting of the Focal Points of REMPEC.

20 Using Cedre's guidance entitled 'Condensates – Chemical Intervention Guide', as a basis and with inputs from the MTWG on condensates used in the Mediterranean, a Draft Guide was submitted to the 14th Meeting of the Focal Points of REMPEC (Annex I to document REMPEC/WG.51/10/1).

21 Recognizing that more work was required, the 14th Meeting of the Focal Points of REMPEC agreed to extend the period of the mandate of the MTWG to the end December 2021 to allow for further progress and finalization of the work. That meeting also requested the Secretariat to review the Draft Guide, taking into account the inputs received and to submit the Draft Guide for consideration and approval by the present Meeting.

22 During the intersessional period, REMPEC consulted the CPs and technically reviewed the Draft guide, adding further guidance on the level of exposure to condensate spills in liquid state, the compensation regimes. The draft version of the 'Condensates – Chemical Intervention Guide for the Mediterranean' is set out in the **Annex** to the present document for examination and approval by the present Meeting.

Actions requested by the Meeting

23 The Meeting is invited to:

- .1 **take note** of the information provided in the present document; and
- .2 **consider** the proposals put forward by the Secretariat to be integrated into the PoW of the MTWG for the biennium 2024-2025, as laid down in paragraphs 8, 9, 12, 15, 18, and 22 of the present document.

Annex

Condensates – Chemical Intervention Guide for the Mediterranean



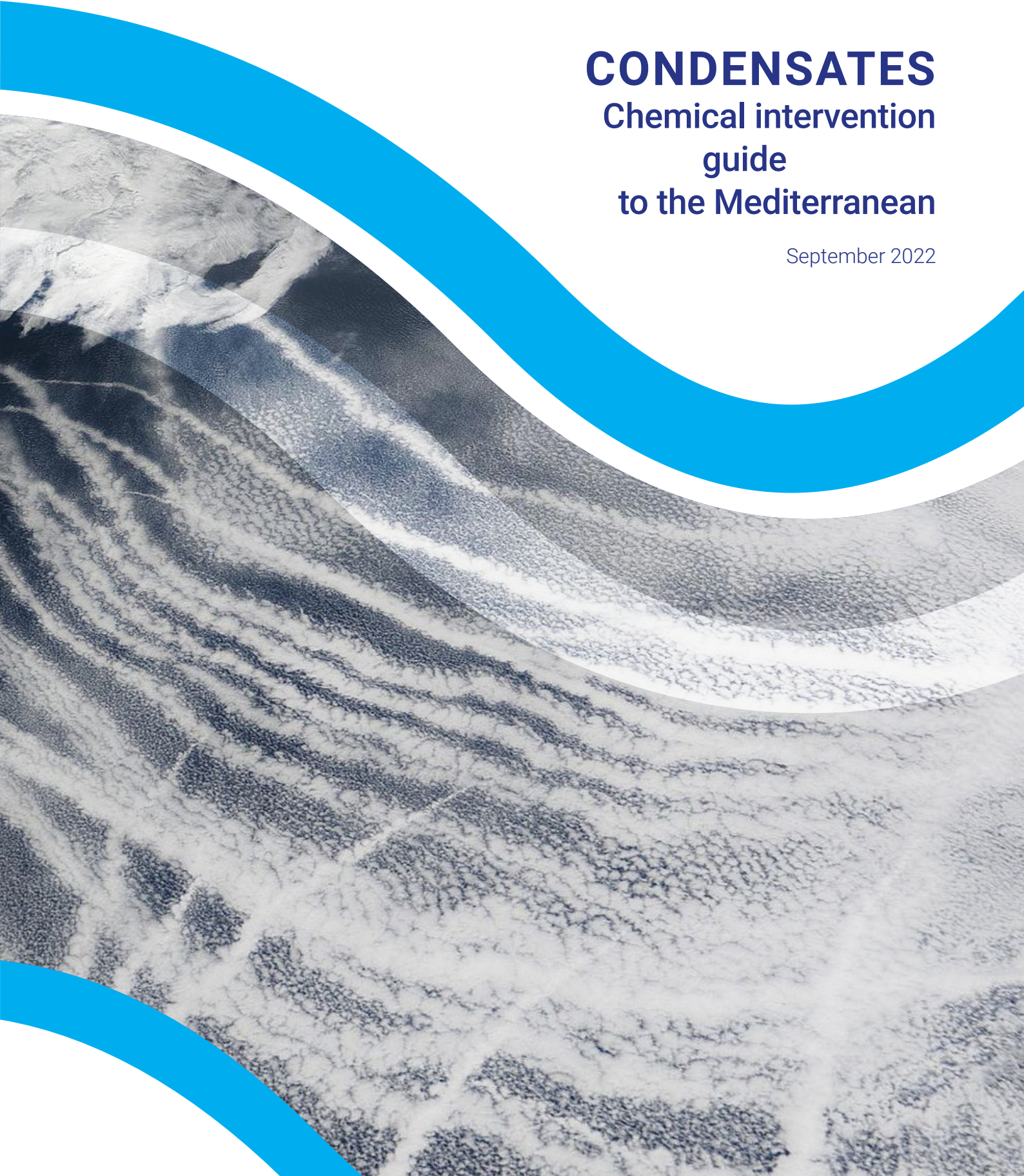
Mediterranean
Action Plan
Barcelona
Convention



CONDENSATES

Chemical intervention guide to the Mediterranean

September 2022



NOTE

This document is aimed at facilitating the implementation of the "Protocol concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency" of the Barcelona Convention (Emergency Protocol, 1976) and the "Protocol concerning Co-operation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea" (Prevention and Emergency Protocol, 2002) by the Contracting Parties of the Barcelona Convention.

This "Guide", which is advisory, does not affect in any way already existing or planned national laws and regulations related to matters covered by it. REMPEC assumes no liability whatsoever for any potentially damaging consequences which could result from the interpretation and use of information presented in this document.

This document has been prepared, in the framework of the Mediterranean Technical Working Group (MTWG) Programme, by the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC), with the technical support of the "Centre de documentation de recherche et d'expérimentations sur les pollutions accidentelles des eaux" (CEDRE). The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of UNEP Mediterranean Action Plan (UNEP/MAP), REMPEC or the International Maritime Organization (IMO), concerning the legal status of any country, territory, city, or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.



Purpose of the guide

Dissemination in the form of guides of study results, experimental research and feedback from accidents constitutes an important component of Cedre's activities, highlighted by its strategic committee.

This guide is intended for operational staff who may be confronted by an accidental spill of condensates in an aquatic environment. This document does not deal with soil pollution. It aims to provide operational staff with useful information in the fight against pollution or in the development of response plans to address such a spill.

The purpose of this guide is to provide quick access to essential information (see Chapter B, *Primary emergency data*), as well as to provide bibliographic sources relevant to the search for complementary data.

It contains experimental data, as well as the results of scenarios corresponding to accidents on the high seas for surface or deep-sea (blowout) discharges. These scenarios are meant solely to provide emergency guidance to decision makers. Each real accident case must be analysed specifically, and the decision maker cannot avoid measurements *in situ* (in air, water, sediment, aquatic fauna, etc.) in order to specify the exclusion zones.

This guide is intended for specialists who are familiar with the techniques to be implemented in the event of a disaster and who are able to judge the advisability of applying the recommended measures. While the fight to limit the consequences of spills is at the centre of our concerns, we cannot ignore the protection of workers and human toxicology.



REMPEC

Sa Maison Hill

Floriana, FRN 1613, Malta

Tel: +356 21 337 296/7/8

rempec@rempec.org - www.rempec.org

© 2022 REMPEC



Contents

Purpose of the Guide.....	3
---------------------------	---

A | What you need to know about condensates 6

B | Primary emergency data 8

B.1 - Chemicophysical characterisation of some condensates.....	8
B.2 - Typical chemicophysical data.....	11
B.3 - Identity sheet.....	12
B.4 - Flammability data.....	12
B.5 - First aid data.....	14
B.6 - Transport, handling, storage.....	14
B.7 - Toxicological data.....	15
B.8 - Ecotoxicological data.....	15
B.9 - Behaviour in the aquatic environment.....	16
B.10 - Persistence in the aquatic environment.....	18
B.11 - Environmental impacts following a spill.....	19
B.12 - Potential impacts on different environments.....	19
B.13 - Potential impacts on economic resources.....	21

C | Examples of real cases and modelling of different accident scenarios 22

C.1 - Examples of real cases.....	22
C.2 - Modelling of different accident scenarios.....	24

D | Combating spills 26

D.1 - Recommendations related to intervention....	26
D.2 - Techniques to combat pollution.....	27
D.3 - Choice of personal protective equipment (PPE).....	30
D.4 - Table of resistance of materials to condensates.....	30
D.5 - Waste treatment.....	31

E | Additional information 32

E.1 - Glossary.....	32
E.2 - Initialisms and acronyms.....	33
E.3 - Useful websites.....	34
E.4 - Bibliography.....	35
E.5 - Content of Figures.....	35

Appendix: Chemicals: classification, labelling and packaging.....	36
-------------------------------------------------------------------	----

A | WHAT YOU NEED TO KNOW ABOUT CONDENSATES

Definition

Condensates occupy an intermediate spot along the spectrum of unrefined hydrocarbons, which extends from natural gas to crude oils. Together with natural gas deposits and the gaseous portion of oil fields, they represent the share of hydrocarbons that, gaseous in the deposit, condense in liquid form during their expansion under atmospheric pressure. Condensates are generated by separation on site, at the wellhead or in more complex processes in natural gas processing plants and refineries. Generally, they are made of alkanes containing at least five carbon atoms, unlike liquefied petroleum gases (propane, butane), which contain fewer. In addition to aliphatic compounds, condensates also contain aromatic compounds such as benzene, toluene, ethylbenzene and xylene (BTEX compounds) and naphthalene in most abundance. Certain condensates may also contain hydrogen sulphide (H₂S). They are light products with a high content of volatile compounds, unstable and flammable products characterised by an API density of at least 45 (density less than 0.80 g/L at 15°C).

A great variability of chemico-physical composition and behaviour exists in condensates. Some are similar to kerosene, characterised by low asphaltene content and rapid evaporation. These condensates do not, *a priori*, form emulsions and appear to be poorly suited to chemical dispersion. By contrast, other, heavier condensates, richer in asphaltenes, are less prone to evaporation, emulsify and are potentially dispersible. These chemico-physical differences have important consequences in terms of behaviour in the environment and the control techniques to be implemented in the event of an accident. It is therefore necessary to be very careful and to determine, as a priority, the type of condensate that must be faced.

In this guide, we will discuss diverse examples of condensates studied in the laboratory and/or at the pilot stage, in order to observe the widest possible spectrum of behaviours and the responses to be provided in the event of an accident.

Condensates are in particular governed by the OPRC 1990 and HNS 2010 conventions, as well as the Marpol Annex I.

Use

Because of their almost immediate use (little processing in a refinery or gas treatment plant), condensates are of very high economic value. Their production is increasing sharply. They are mainly used for the production of naphtha, kerosene and diesel fuel.

Production, processing, transport

Condensate deposits are located on land or offshore and are distributed globally (North Sea, Africa, the Middle East, Southeast Asia, etc.). They are transported by pipelines to coastal refineries. Some refineries are specially designed to process them (the Ras Laffan refinery in Qatar, Skikda refinery in Algeria or Daesan refinery in South Korea). The countries with the longest condensate pipelines are Algeria, Indonesia and Libya. Processed condensates are discharged by sea into oil tankers.

Some countries like Italy may see their production decrease, as well as the production of gas, while that of crude oil is relatively stable (Figure 0).

Risks

Fire:

Highly flammable liquid and vapour. During use, a flammable/explosive vapour-air mixture may form. Vapour denser than air remains at ground level, with a very high risk of explosion. The friction caused by the flow of the product creates static electricity charges that can generate sparks, causing ignition or explosion.



Toxicity:

- Harmful by inhalation. May have anaesthetic effects if high vapour concentrations are inhaled.
- Harmful if swallowed. May give rise to inhalation pneumonia, developing within a few hours in the



event of aspiration into the lungs due to its low viscosity. Medical supervision is essential for 48 hours.



- Harmful to skin. May cause skin and eye irritation in the event of contact with the liquid or exposure to the vapours.

Behaviour in the aquatic environment

When discharged into water, condensates float (density < 0.8 at 15°C) and form a slick on the surface, of which some compounds dissolve. The evaporation of the slick can be rapid depending on the winds and the type of condensates (between 50 and 90% in three to four days). If the atmospheric turbulence is low, condensate vapours, heavier than air, move to the water's surface.

Condensates are toxic for aquatic organisms and can cause long-term adverse effects in the aquatic environment. They are weak but potentially bioaccumulative. The rates of condensate biodegradability are highly variable and depend on the content of polar compounds in aged chemicals.

Control strategy

This guide deals with condensates transported in liquid form. Because of their high content of volatile compounds, above all, they pose a safety hazard (fire, explosion, accumulation of vapour in areas of concentration). Their great variability implies different control strategies to be implemented according to the chemical. From an antipollution point of view, if the chemical has reached the water's surface, control may be limited to the lightest to allow the chemical to evaporate naturally.

In the case of the heaviest chemicals forming emulsions of low viscosity, chemical dispersion may be considered whatever the volumes involved, provided that the general recommendations specific to this technique are complied with (sufficient sea conditions, distances to the coast, consideration of particularly sensitive areas from an ecological perspective, etc.).

In the event of a small spill, after the evaporation of the light elements, the heaviest condensates can be trapped in absorbent materials.

In case of significant accidents, condensates can be recovered by pumping or concentrated skimming, or by diverting the slicks with floating dams.

In the latter case, for safety reasons, the recovery area can, if necessary, be covered with fire foam to reduce evaporation. These operations involve the ability to manage the risk of fire throughout the recovery chain (storage/transfer of recovered chemicals).

In terms of safety, in case of blowout, according with local regulations, having at hands data concerning the ecological characteristics of the benthic and pelagic ecosystems and after selection of an appropriate dispersant, chemical dispersion by submarine injection is an option to be explored. In the event of accidents in sensitive coastal areas (marshes, for example), in situ burning could be envisaged taking into account the occurrence of resulting persistent residuals on the sea bottom affecting the benthic biota and fauna. This technique is however generally not recommended in the Mediterranean area.

Compensation

The majority of condensates can be defined as "non-persistent" according to the IOPC Funds' definition ⁽¹⁾, with the exception of certain products which are close to light crude oils and which do not meet the 95% distillation criterion. While compensation for condensate spills will not generally be covered by the Civil Liability Convention, it will be covered by the Hazardous and Noxious Substances Convention once it enters into force.

Figure 0. Petroleum hydrocarbons produced in Italy.

	1990	2000	2005	2010	2015	2016	2017	2018	2019
Crude oil (t x 1,000)	4,641	4,555	6,084	5,047	5,455	3,746	4,138	4,673	4,268
Condensates (t x 1,000)	27	31	27	25	15	14	10	11	10
Natural gas (millions m ³)	17,296	16,633	12,071	8,302	6,877	6,021	5,657	5,553	4,983

Source: Unione Energie per la Mobilità (UNEM); Data Book 2021 – Energie per la mobilità

(1) A petroleum product is considered non-persistent if, at the time of transport, at least 50% of the hydrocarbon fractions, by volume, distill at a temperature of 340°C, and at least 95% of the hydrocarbon fractions, by volume, distill at a temperature of 370°C when tested in accordance with American Society for Testing and Materials (ASTM) Method D86/78 or any subsequent revision thereof.

B | PRIMARY EMERGENCY DATA

B.1 CHEMICOPHYSICAL CHARACTERISATION OF SOME CONDENSATES p. 8	B.9 BEHAVIOUR IN THE AQUATIC ENVIRONMENT p. 16
B.2 TYPICAL CHEMICOPHYSICAL DATA p. 11	B.10 PERSISTENCE IN THE AQUATIC ENVIRONMENT p. 18
B.3 IDENTITY SHEET p. 12	B.11 ENVIRONMENTAL IMPACTS FOLLOWING A SPILL p. 19
B.4 FLAMMABILITY DATA p. 12	B.12 POTENTIAL IMPACTS ON DIFFERENT ENVIRONMENTS p. 19
B.5 FIRST AID DATA p. 14	B.13 POTENTIAL IMPACTS ON ECONOMIC RESOURCES p. 21
B.6 TRANSPORT, HANDLING, STORAGE p. 14	
B.7 TOXICOLOGICAL DATA p. 15	
B.8 ECOTOXICOLOGICAL DATA p. 15	

B.1 Chemicophysical characterisation of some condensates

Condensates are a liquid mixture of hydrocarbons that are lighter than crude oils, generally containing more

than five carbon atoms. The majority of the compounds are linear or branched alkanes, various monoaromatic compounds (BTEX: benzene, toluene, ethylbenzene and xylene), polyaromatics (including naphthalene), as well as, potentially, sulphuric hydrogen. BTEXes are among the most toxic or harmful lightweight chemicals and are subject to numerous regulations.

Figure 1. Example of the main chemicophysical properties of condensates.

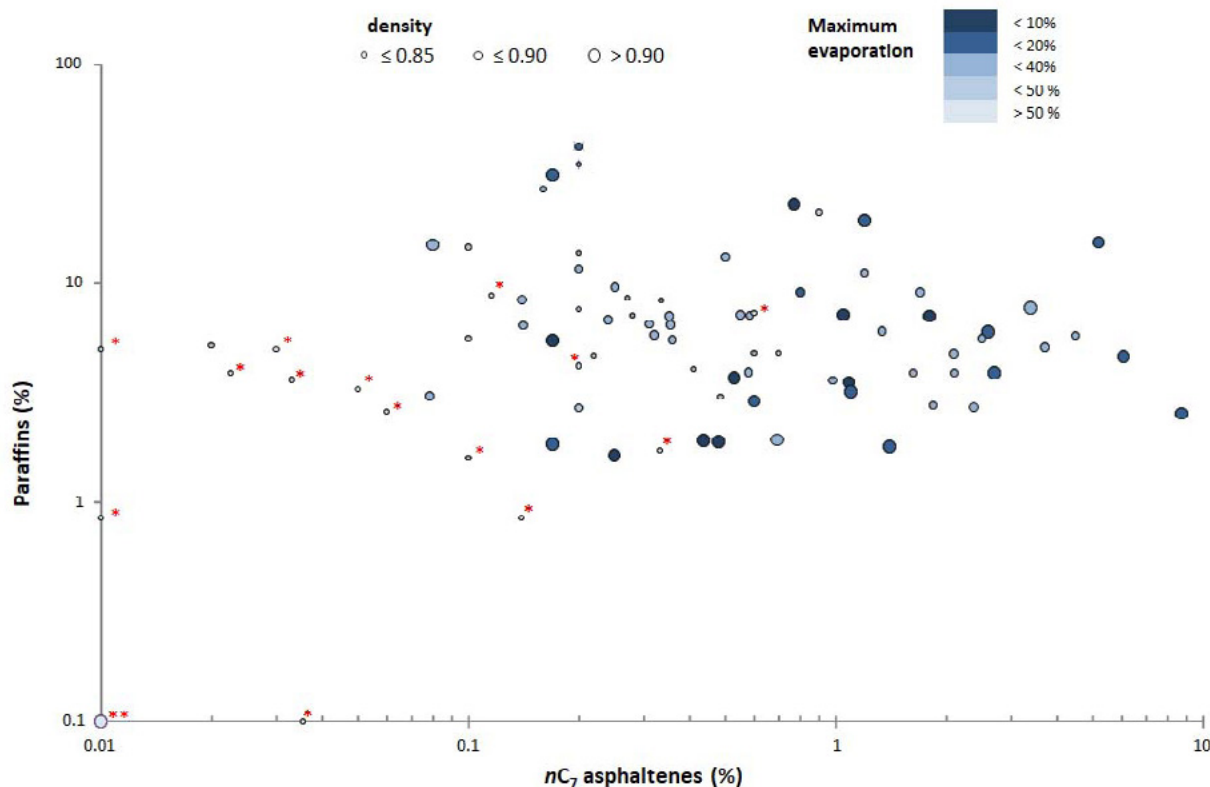
Name of the condensate	Country	nC ₇ Asphaltenes (% wt)	Paraffins (%)	Density at 20 °C	250 °C+ (% vol.) ⁽²⁾
Absheron *	Azerbaijan	0.12	8.8	0.808	50
Akpo *	Nigeria	0.2	4.2	0.796	53
Maharaja Lela *	Brunei	0.14	0.9	0.818	64
Gudrun/Sleipner mix **	Norway	0.03	3.6	0.779	67
Handil *	Indonesia	0.33	1.7	0.822	67
Vega **	Norway	0.02	3.90	0.770	72
Dolphin *	Qatar	0.04	<0.1	0.774	81
South Pars*	Iran	0.04	0.1	0.752	83
**	Myanmar	<0.01	<0.1	0.906	86
Alve ***	Norway	0.03	5.0	0.793	61
Snøhvit blend ***	Norway	0.10	1.6	0.767	76
Smørbukk ***	Norway	0.06	2.6	0.801	57
Sleipner ***	Norway	<0.1	0.9	0.742	86
Huldra ***	Norway	0.01	5.0	0.806	53
Kristin ***	Norway	0.60	7.3	0.795	60
Midgard ***	Norway	0.01	0.02	0.761	88

* Total condensate / Cedre data ** Statoil condensate / Cedre data *** Statoil condensate / SINTEF data

(2) The distillation residue at 250°C is used to define the maximum expected rate of evaporation at sea.



Figure 2. Positioning of condensates on the raw and refined petroleum product spectrum studied at Cedre (marked with a red star on the graph).



Nearly all condensates have a density of less than 0.85 at 20°C, a value which corresponds to light crude oils. For half of them, it is less than 0.80 and may be close to the specifications applied to petrols, of the order of 0.75.

Some condensates produced in Tunisia show even lower densities (at 15°C), 0.728 for the Miskar and Hasdrubal mixture, and 0.660 for the Gabes condensate.

The asphaltene levels, an indicator of the chemical's ability to emulsify, and paraffin levels are extremely variable. They are, however, for nearly all chemicals, less than 0.2% and 10%, respectively.

Figure 2 shows the condensates and crude or refined petroleum products studied at Cedre for the period 2009-2019, according to their asphaltene and paraffin levels.

The size of the circles is proportional to the density at 20°C, and their colour is related to the maximum expected rate of evaporation at sea (the darkest colours correspond to the chemicals that evaporate the least). The condensates are marked with a red star.

In the remainder of this guide, these condensates will often serve as an example for discussing the variability of behaviours and the control techniques to be implemented. Data from safety data sheets (SDSes) from different sources will also be integrated for aspects not treated

during the trials (flammability, for example) and to illustrate the diversity of values according to the sources of information.

Detailed chemical composition and distillation curves

Petroleum products consist of thousands of molecules that can be grouped into four chemical families:

- **Saturates:** They contain only hydrogen and carbon atoms. The simplest are gases (methane, ethane, propane, etc.) and the heavier are paraffins (usually between 20 and 30 carbon atoms).
- **Aromatics:** They contain only carbon and hydrogen atoms but in the form of aromatic rings. They are known for their toxicity, like benzene, the simplest in the family, or benzo[a]pyrene. There are also many branched derivatives that correspond to the base molecule with one or carbon atoms added (C₂-benzene, for example, benzene with two extra carbon atoms). The lightest compounds also have a relatively high solubility compared to the other constituent molecules of petroleum products.
- **Resins and asphaltenes:** These molecules are not volatile and contain, in addition to carbon and hydrogen, sulphur, oxygen or nitrogen. Asphaltenes are distinguished from resins by their insolubility in so-called

non-polar solvents (pentane, hexane, heptane), which explains how these two families are often grouped together. It should be noted that the metals present in petroleum products are associated with asphaltenes.

The detailed chemical composition of nine condensates was determined in accordance with the modelling software OSCAR. The main families of compounds presented in Figure 3 include light saturates in particular, having up to 10 carbon atoms (C_1 - C_{10} saturates), C_6 - C_{10} monoaromatics, aromatics grouped under the acronym BTEX (benzene and C_1 -benzene, toluene, ethylbenzene and

xylene) and C_2 -/ C_3 -/ C_4 benzenes, as well as the heaviest subset, greater than 25 carbon atoms ($>C_{25}$).

The distillation curves in Figure 4 illustrate the diversity of chemicals grouped in the condensate category. The lightest fraction of each chemical does not necessarily correspond to very volatile compounds. For example, South Pars distils from 25°C, while Myanmar only distils from approximately 150°C to have, ultimately, the highest evaporation rate at 250°C. This diversity is illustrated by the chromatograms shown in Figure 5, as well as by the range of flash points (see [B.4](#)).

Figure 3. Simplified chemical composition of the condensates studied.

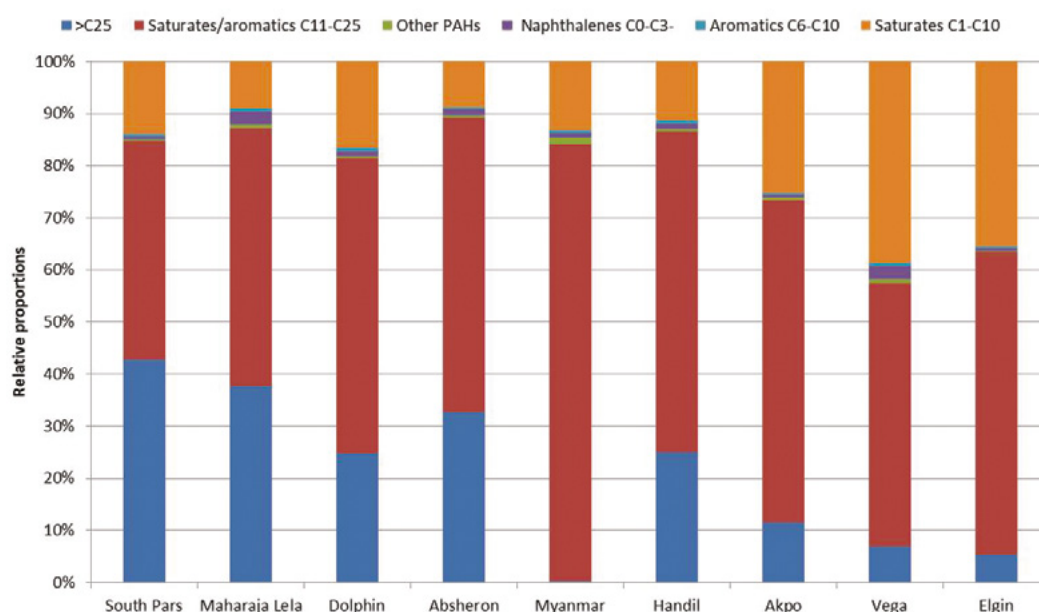


Figure 4. Distillation curves of the condensates studied.

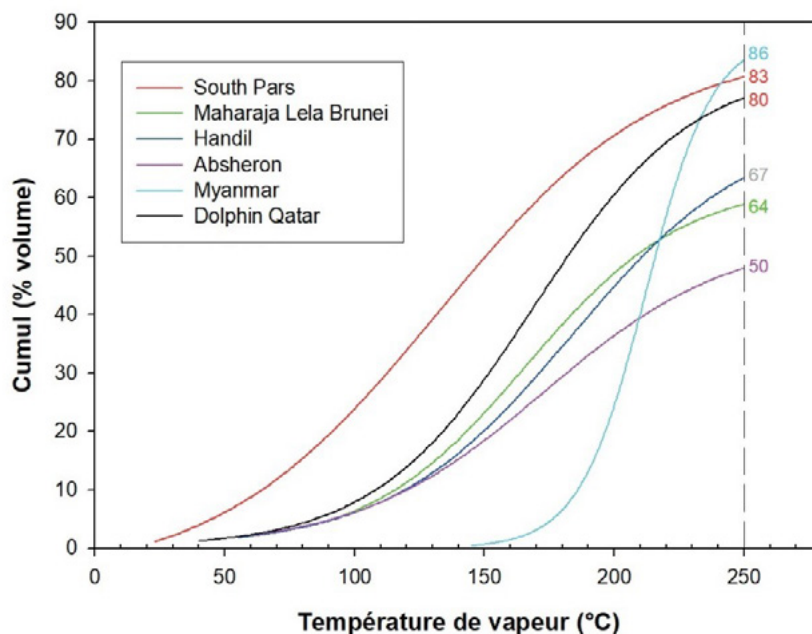
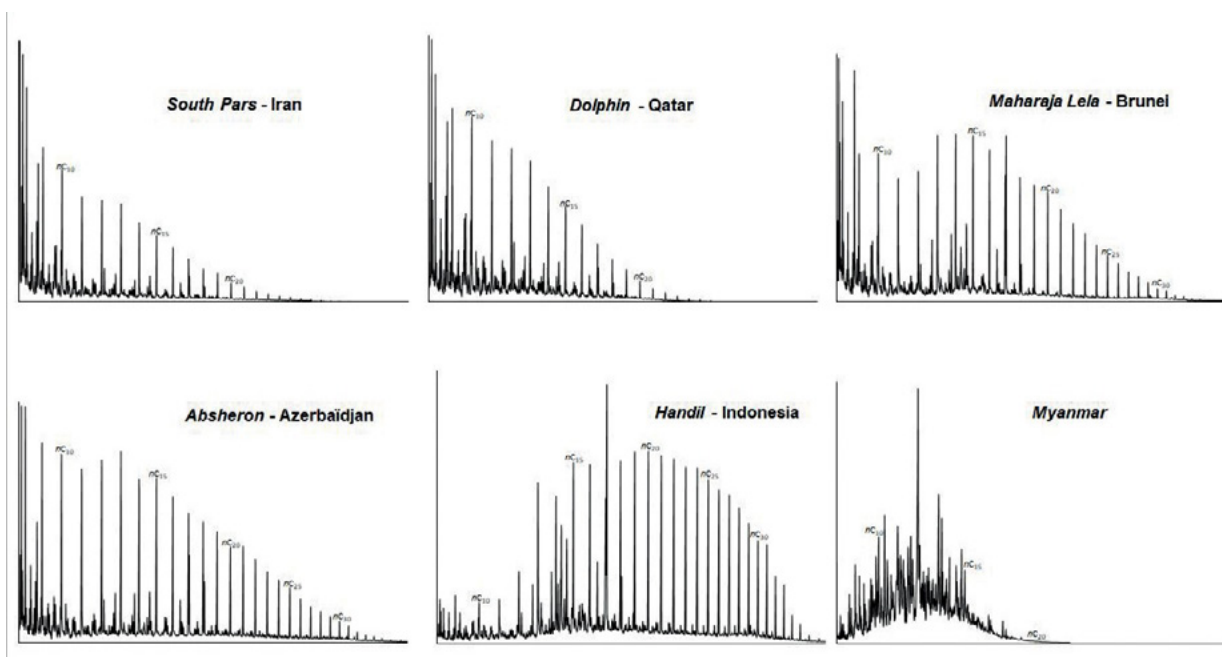




Figure 5. Illustration of the compositional diversity of some condensates studied at Cedre.



B.2 Typical chemicophysical data

Figure 6. Typical chemicophysical data on condensates.

Physical state / colour	Liquid ranging from colourless to dark brown*
Odour	Characteristic of petroleum, rotten eggs if hydrogen sulphide is present*
Density	<800 kg/m ³ at 20°C (API > 45) 810 kg/m ³ for the majority of the condensates studied (with an exception at 906) SDS Total: 750-900 kg/m ³ at 15°C SDS Akpo total: 903,1 kg/m ³ at 15°C All other SDSes: 600-800 kg/m ³ at 15°C
Viscosity	Very low: 0.8 to 1.8 mm ² /s at 40°C
Vapour pressure	21 to 500 hPa at 20°C** 1 to 18 mPa.s at 26°C, according to the Cedre/Total data
Boiling temperature	< 340°C**
Solubility	In water at 20°C: insoluble (<1,600 mg/L)** Soluble in organic solvents, greasy substances** Monoaromatics (BTEX) ⁽³⁾ dissolve mainly (<100 mg/L)***
Evaporation (in volume)	50- 90% (depending on the nature of the condensate), according to the Cedre/Total data

* Sources: SDS Total condensates, SDS Total Akpo condensate, SDS Statoil stabilised condensate, SDS Gudrun Statoil petroleum/condensate, SDS Phillips 66 natural gas condensate, SDS HESS and Concawe natural gas condensate ** SDS Total *** Concawe

(3) The solubility of monoaromatics is highly dependent on benzene content. As a guideline, from a Concawe source:
- for 1.5% benzene by weight: benzene concentration: 18-90 mg/L
- for 3% benzene by weight: benzene concentration: 60 mg/L

B.3 Identity sheet

Condensates occupy an intermediate spot between natural gas and crude oil and have variable chemico-physical compositions. They exist under different designations and are classified under different identification numbers.

Figure 7. Main condensate designations.

Synonyms	Liquid natural gas well, pentane plus, C5+, low boiling point naphtha. Anglophones also call it "lease" or "plant condensate"
Transport designation	Petroleum distillates (benzene, toluene, n-hexane, aromatic hydrocarbons), crude oil, liquid hydrocarbon, flammable liquid
Identification	UN number: 1268 (or 1267, 1993, 3295) CAS number: 64741-47-5 (68919-39-1) EC number: 265-047-3 (272-896-3)
Related petroleum products (composition and behaviour)	Petrol for the impacts and risks linked to the phases of evaporation and solubilisation, kerosene for the chemico-physical properties of the lightest chemicals

There is a specific entry for the Natural gas condensates (petroleum) substance (CAS n° 64741-47) on the European Chemicals Agency (ECHA) webpage (<https://echa.europa.eu/el/brief-profile/-/briefprofile/100.059.116>) and scientific data resulting from a unique REACH Registration (Bioaccumulation factors, acute and chronic toxicity aquatic data, etc.).

Information from the Registration dossier submitted by GAZPROM MARKETING AND TRADING FRANCE 24 are publicly available (<https://echa.europa.eu/el/registration-dossier/-/registered-dossier/13792/1>).

In addition to the above, if the condensates are imported from a third country to the European Economic Area, their registration obligations according to the REACH Regulation should be assessed and, if needed, a registration dossier should be submitted to ECHA along with all the required information, after data sharing with the already existing registrant.

Product labels.

			
GHS02 Flammable	GHS08 Sensitising, mutagenic, carcinogenic, reprotoxic	GHS07 Toxic, irritant, sensitising, narcotic	GHS09 Dangerous for the environment

B.4 Flammability data

Condensates are extremely flammable chemicals.

Figure 8. Flammability data.

Flashpoint (ASTM D 93)	< 35°C (Pensky/Martens) SDS Total 50°C for Myanmar
Auto-ignition point	> 400°C SDS Total (although this value may be lower for other SDSes: 250°C)
Flammability or explosivity limits (% in air)	Lower limit: 0.85% (Total Akpo), 1.4% (Phillips 66) Upper limit: 5.0% (Total Akpo), 7.6% (Phillips 66)
Chemicals with hazardous decomposition (SDS Total)	Complete combustion, in the presence of excess air, generates carbon dioxide (CO ₂) and water vapour. Incomplete combustion generates carbon monoxide (CO), soot and split chemicals: aldehydes, ketones
Stability and Reactivity (SDS Total)	Stability: stable given recommended handling and storage conditions Reactivity: combustible if it is brought to a temperature greater than its flashpoint Conditions to avoid: Avoid the proximity of hot surfaces, flames, static electricity or sparks Keep away from any source of ignition Do not smoke nearby

Laboratory tests done at Cedre on six condensates show initial flashpoint values, before any ageing phenomenon, spread over a wide range (from below -10°C up to 50°C). These data are consistent with the distillation curves and chromatographic profiles that have shown a very volatile and highly variable fraction ratio (Figure 5).

The flashpoint values measured on residues at 150°C are more homogeneous, in the range 40-55°C, which is explained by the effect of distillation. It is accepted that these residues at 150°C are representative of a time at sea in the order of two to three hours, which must nevertheless be qualified according to the circumstances of the spill at sea (continuous or discontinuous, low or high volumes, etc.), as well as oceanic weather conditions (high temperatures and winds accelerate the increase in the flashpoint). With the same nuances, the distillation residue at 200°C is close to a time at sea of six to seven hours. The corresponding flashpoints sit between 70 and 85°C.

It should be noted that the harmonised system of classification and labelling of chemicals (SGH) defines several categories of flammable chemicals by flashpoint value, as shown in Figure 9.

Condensates are therefore classified, on average, as flammable for up to two to three hours at sea and non-flammable after six to seven hours.



Figure 9. Definition of classes of flammability (source: Ineris). See the different categories and H grades in the appendix.




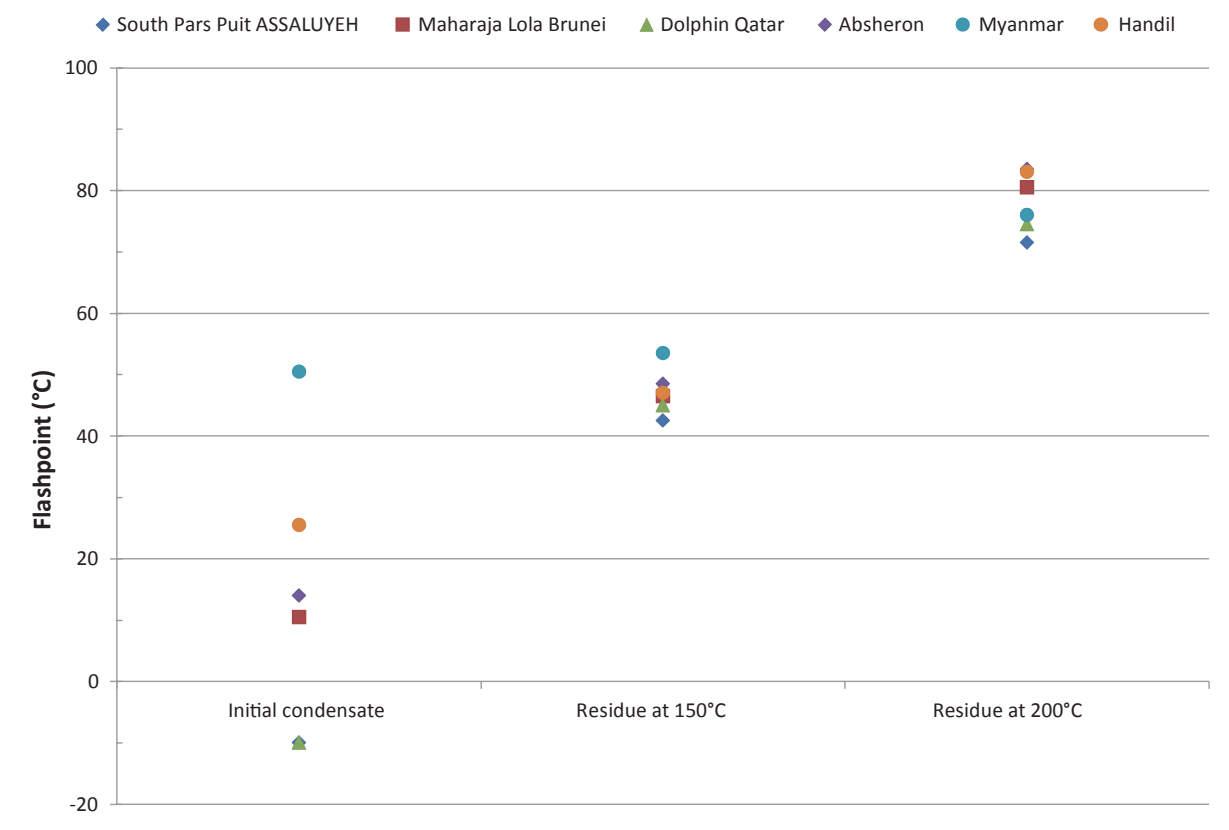
Classification	Labelling	Classification criteria
Flammable liquid Category 1 H224: highly flammable liquid and vapour	 Hazard H224	Flashpoint < 23°C Boiling point ≤ 35°C
Flammable liquid Category 2 H225: highly flammable liquid and vapour	 Hazard H225	Flashpoint < 23°C Boiling temperature > 35°C
Flammable liquid Category 3 H226: flammable liquid and vapour	 Caution H226	23°C ≤ flashpoint ≤ 60°C

Figure 10. Flashpoints of some condensates studied at Cedre and their distillation residues.



B.5 First aid data

In case of serious or persistent disorders, call a doctor or seek emergency medical assistance.

Inhalation

- Transport the victims to the outdoors and keep them at rest in a position where they can breathe comfortably.
- Call a doctor immediately.
- If necessary, provide oxygen.
- In case of respiratory arrest, apply artificial respiration.
- Place under medical supervision.

Skin contact

- Remove affected clothing.
- Perform immediate and prolonged washing with abundant soap and water. Hospitalise in case of serious contamination.

Eye contact

- Do not use contact lenses in work areas.
- Wash immediately with plenty of water for at least 15 minutes, keeping eyelids open wide.
- Consult an ophthalmologist.

Ingestion

- Do not drink any fluids or induce vomiting (risk of pulmonary aspiration).
- Risk of serious disorders if aspirated into the lungs (during vomiting, for example).
- Emergency transport to hospital.
- If swallowed, rinse mouth with water (only if the victim is conscious).

Protection of rescuers

In case exposure is likely to pass the occupational exposure limit:

- In a well-ventilated area, use a respiratory protection device.
- In a confined space, use an air-supply device.

B.6 Transport, handling, storage

Transport

UN number: 1268 (or 1267, 1993, 3295)

Official transport designation: petroleum distillates (benzene, toluene, n-hexane, aromatic hydrocarbons), crude oil, liquid hydrocarbon, flammable liquid.

Ground transport

- RID (rail) regulation/ADR agreement (road)
- Vapour pressure at 50°C (kPa): ≤110
- Hazard identification classification: 3
- Classification code: F1
- Hazard code: 33
- Packing group: I (or II for certain types of condensates)
- Dangerous for the environment: yes Tunnel code: D/E
- Label(s): 3 + N



Inland water transport

- ADN regulation
- Hazard identification classification: 3
- Classification code: F1
- Packing group: I
- Hazardous to the environment: yes Label(s): 3
- Hazards: (3+N2+CMR)

Maritime transport

- IMDG code
- Hazard identification classification: 3
- Packing group: I
- IMDG-marine pollution: marine pollutant
- IMDG-EmS: F-E, S-E
- IMDG label(s): 3

Air transport

- OACI/IATA regulations
- Hazard identification classification: 3
- Packing group: I
- Dangerous for the environment: yes
- Hazard label(s): class 3 – flammable liquid

Handling

- Handle in a well-ventilated environment.
- During use, a flammable/explosive vapour-air mixture may form.
- Avoid the formation or diffusion of vapours, fumes or aerosols into the atmosphere (especially during chemical loading or unloading).
- Vapours are denser than air and can spread at ground level.
- Maintain distance from all sources of ignition.
- Avoid proximity to hot surfaces, flames, static electricity or sparks.
- In case of possible exposure, use suitable protective clothing, including gloves and goggles.
- Use safety shoes and protective clothing that do not generate electrostatic charges.
- Install showers and eyewash fountains.
- Do not eat, drink or smoke during use.



Technical measures

Inspection, storage, cleaning and maintenance of storage tanks require strict procedures.

- Only work on cold, degassed and ventilated tanks (risk of explosive atmosphere).
- Take precautionary measures against static electricity discharges that can occur during mixing and transfer operations.
- Provide appropriate explosion-proof electrical equipment.
- Ground all conductive materials.

Tips for use

- Only use the chemical in a closed system.
- Ban air for transfers.
- Travel at low speeds (static electricity).
- Take special precautions in case the use or processing of the chemical leads to stable emulsions with water.

Storage

- Only use aromatic-hydrocarbon-resistant containers, seals, pipes, etc.
- The chemical can form an explosive mixture with air, particularly in empty, unclean containers.
- Store far from heat sources. Avoid the accumulation of static electricity by grounding equipment.
- Store in a well-ventilated area.
- Store preferably in the original packaging. Otherwise, if necessary, transfer all the indications on the regulatory label to the new packaging.
- Design the installations to prevent the spread of flaming slicks.
- Provide a retention tank.

Recommended packaging material

- Stainless steel.

Materials to avoid

- Strong oxidants.
- Acids and bases.

concentrations: neurological disorders, loss of consciousness, coma.

- **Ingestion:** harmful. Digestive disorders: diarrhoea, vomiting.
- **Skin contact:** harmful. In case of significant skin contact, cutaneous penetration may cause toxic effects: central nervous system, digestive system.

Local effects

Irritating to the skin.

Contact with the liquid or vapour exposure may cause eye irritation.

Specific effects

Condensates contain benzene, classified as carcinogenic and mutagenic.

- **Genotoxicity:** *In vivo* and *in vitro* tests indicate genotoxic potential.
- **Carcinogenesis:** Benzene is carcinogenic to humans.
- **Toxicity for reproduction:** fertility: toxic effects for the reproductive system. Foetal development: toxic effects for foetal development.
- **Aspiration hazard:** In case of accidental ingestion, the chemical may be aspirated into the lungs due to its low viscosity and give rise to pneumonia from inhalation, developing within a few hours. Medical supervision is essential for 48 hours.

Specific toxicity for certain target organs (STOT: Specific Target Organ Toxicity)

- **STOT single exposure:** may cause drowsiness and dizziness.
- **STOT repeated exposure:** risk of serious effects to organs following repeated or prolonged exposure. Prolonged and repeated exposure by inhalation of vapours and/or prolonged skin contact may cause benzene poisoning.
- **Target organ(s):** at high doses, central nervous system, digestive system, renal impairment, haematological system.

B.7 Toxicological data

The toxicity of condensates depends critically on their BTEX levels, benzene in particular. If the chemical contains hydrogen sulphide (H₂S), it may be particularly harmful by inhalation (very toxic gas).

Acute human toxicity

- **Inhalation:** harmful. Risk of headache, drowsiness, nausea. In case of inhalation of high vapour

B.8 Ecotoxicological data

SDS Total condensates

The ecotoxicological data mentioned in the safety data sheet written by Total on condensates are as follows:

Acute toxicity for the aquatic environment

CL₅₀ - 96 hours - fish: 1.1-4.4 mg/L

EC₅₀ - 48 hours - Daphnia magna: 1.2-2.7 mg/L

Chronic toxicity to the aquatic environment

No information available.

Effect on terrestrial organisms

No information available.

Cedre conducted ecotoxicological tests on the Akpo condensate in accordance with three OSPAR protocols. For tests on fish and algae, only dissolved fractions were evaluated.

The following results were obtained:

Figure 11. Ecotoxicological data for the Akpo condensate.

Fish (<i>Scophthalmus maximus</i>)	Maximum dissolved aromatic at 300 mg/L No effect on fish
Crustacean (amphipod <i>Corophium</i> sp.)	Sediment levels of 33 to 862 mg/kg EC ₅₀ = 161 mg/kg
Algae (<i>Skeletonema costatum</i>)	Maximum dissolved aromatic at 488 mg/L No effect on algae

It should be noted that the concentrations in dissolved aromatics correspond to the concentrations of 20 so-called parent polycyclic aromatic hydrocarbons (naphthalene, phenanthrene, benzo[a]pyrene, etc.), as well as 25 families of branched derivatives (C₁-naphthalenes, C₂-naphthalenes, etc.).

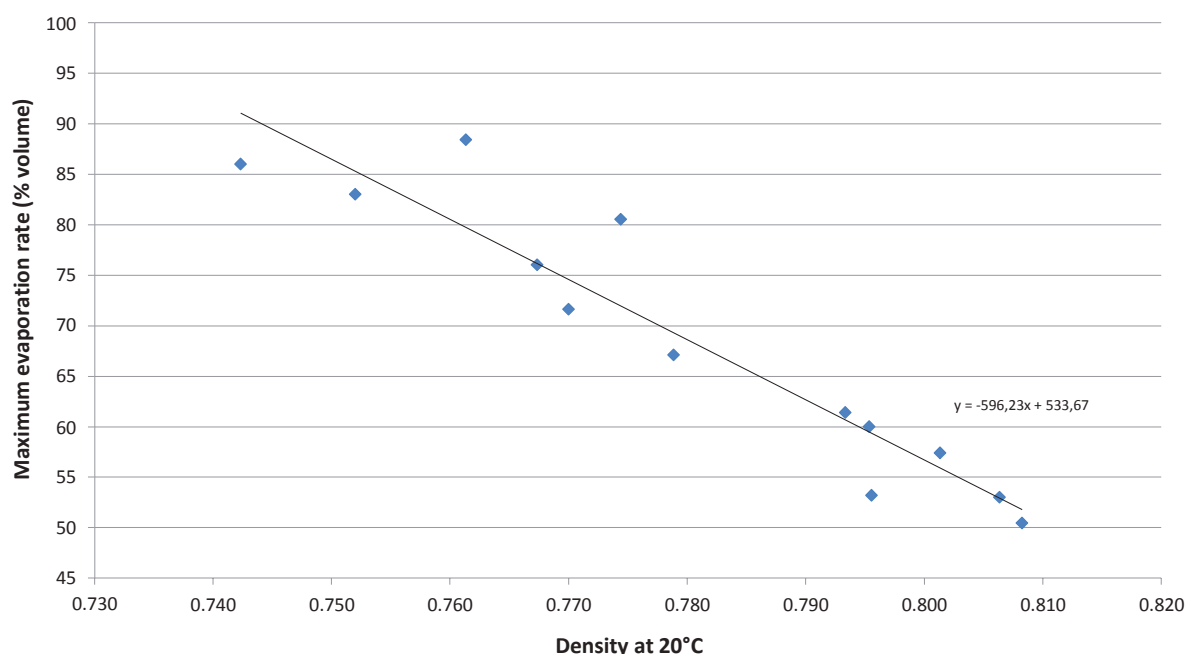
B.9 Behaviour in the aquatic environment

Given their compositions, characterised by low levels of asphaltenes and paraffins and associated with evaporable fractions generally greater than 50%, the predominant behaviours of condensates are spreading and evaporation. However, some types of condensates can emulsify, hence their behaviour is similar to that of light crude oil. The results presented below illustrate laboratory test results on six condensates provided by Total, as well as data obtained according to the same protocols provided by the company Equinor. In addition, experiments were conducted in the Polludrome® on the Vega and Akpo condensates, which are representative of the range of chemicals *a priori* capable of forming emulsions. These hydrocarbons have similar paraffin content (3.9% and 4.2%, respectively) but significantly different asphaltene content (0.02% and 0.2%, respectively).

Evaporation

Condensates have high vapour pressure. As a result, evaporation is an important process during a spill and can cause the near-total disappearance of the chemical within three or four days. The maximum evaporation rate can be estimated by the fraction distilling below 250°C. For chemicals with a density of less than 0.81 at 20°C, it is possible to establish a relationship between density and the maximum expected rate of evaporation at sea (Figure 12). This relationship makes it possible, therefore, to provide a first item of important operational data, namely the quantity of hydrocarbon that can persist at sea.

Figure 12. Relationship between condensate density at 20°C and their maximum rate of evaporation at sea.





Spreading

Condensates with a low viscosity and a density lower than the water's spread very quickly on its surface in the absence of barriers (dam, bank, coast, etc.). Depending on the nature of the chemical, the film can quickly transform into iridescence, which then disappears as an effect of evaporation.

Solubilisation

In the family of petroleum products, condensates are the most likely to cause contamination of the water column through solubilisation. Monoaromatic hydrocarbons (BTEXes) are relatively abundant there and are the most soluble (but equally toxic) hydrocarbons. The most soluble (and toxic) is benzene, with a solubility in the order of 1.8 g/L.

Some polycyclic aromatic hydrocarbons (PAHs) of low molecular weight, like naphthalene or benzothiophene, which are abundant in some condensates such as Akpo, may also solubilise rapidly in the aqueous phase. Studies conducted at Cedre on Akpo have shown that dissolved naphthalene contributes 60% of the total PAHs analysed.

In the longer term, because of their low vapour pressure, compounds solubilised in water can gradually return to the atmosphere in the form of steam.

Dispersion

Dispersion (suspension in the water column) only appears in the event of violent agitation (surf, waterfall, torrential speed). Furthermore, due to the low density of condensates relative to water, dispersion is fairly unstable and

a surface coalescence is rapidly observable, as soon as the agitation conditions subside sufficiently.

Emulsification

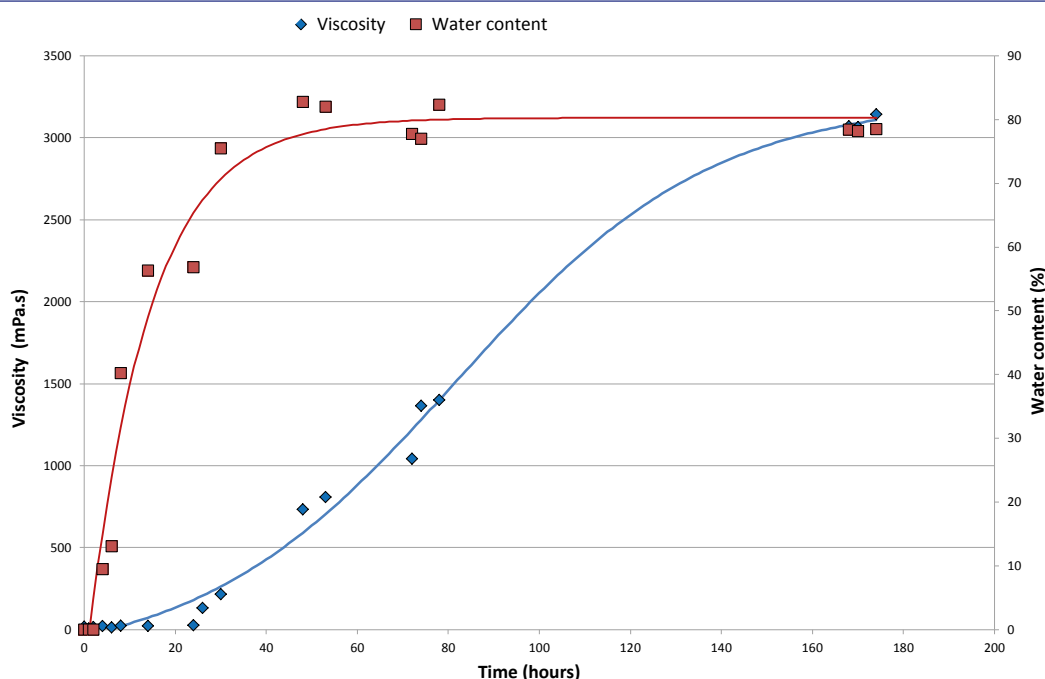
The condensates studied all exhibit initial asphaltene content lower than the generally accepted threshold for emulsion formation (around 0.2 to 0.3%). However, the expected evaporation at sea is very significant, from 50% to 80%, which has the effect of concentrating the asphaltenes. Also, for the condensates studied at Cedre, this maximum value was calculated as shown in Figure 13. It appears that the levels are very often beyond the threshold of 0.2 to 0.3% and that emulsions formed, the viscosity of which is proportional to these same levels.

Figure 13. Maximum asphaltene levels in condensates after ageing at sea and viscosity of emulsions formed in the laboratory.

Name	Maximum level of asphaltenes (%)	Viscosity of the emulsion at 250°C +/75% water (MPa.s at 26°C)
<i>South Pars Puit ASSALUYEH</i>	0.21	-
<i>Maharaja Lela Brunei</i>	0.39	49
<i>Dolphin Qatar</i>	0.18	-
<i>Absheron</i>	0.23	38
<i>Myanmar</i>	0.07	-
<i>Handil</i>	1.02	493
<i>Akpo</i>	0.43	125

Source: Cedre

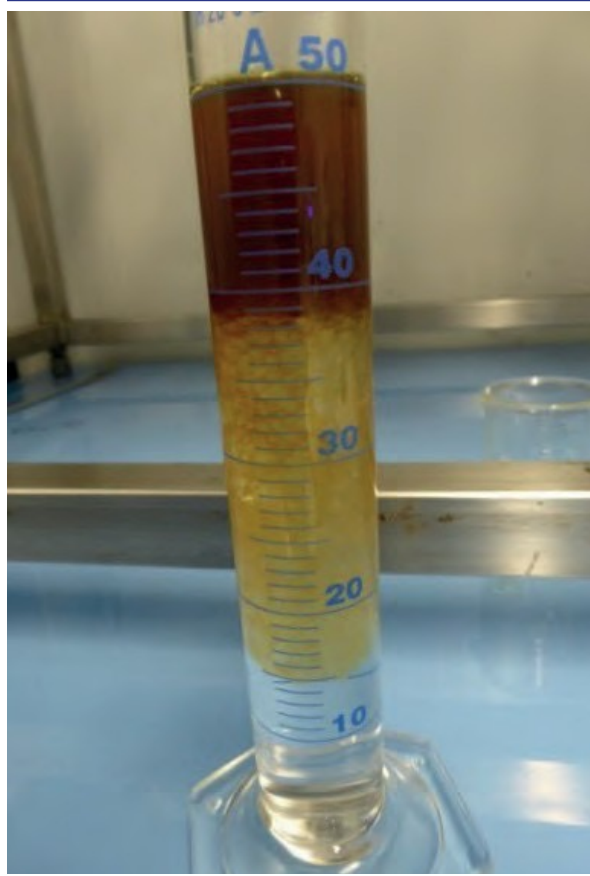
Figure 14. Change in density and viscosity of the Akpo condensate during the Polludrome® test.



These laboratory data were confirmed for the condensate Akpo during the Polludrome® test. The viscosity and density values in Figure 14 show that emulsification only starts after four hours of ageing, which is consistent with the initial low value for asphaltenes, which gradually increases with the evaporation of the light fractions. ⁽⁴⁾

The Vega condensate was also tested at the Polludrome®, but at lower temperatures (5°C and 13°C). Despite its low level of asphaltenes (0.02%), the chemical emulsified with water levels in the order of 80% to 90%. The viscosities were low, however, up to a maximum of 1,000 mPa.s and the emulsions were not very stable, as evidenced by rapid settling in the absence of stirring (photo).

Rapid settling of the Vega condensate in the absence of agitation.



Biodegradation

The constituent molecules of condensates are light hydrocarbons which are partly biodegradable in the absence of inhibitory effects (very cold temperature, presence of chemicals having a biocidal effect, etc.).

Tests carried out on several condensates in the Cedre laboratory showed that their theoretical biodegradation amounts to about 60% ⁽⁵⁾. So, for an evaporation rate of 50% to 75%, the amount of chemical remaining in the

⁽⁴⁾ Note: The higher viscosity obtained in these Polludrome® tests compared to laboratory tests is a testament to the limit of small-scale (beaker) tests for chemicals with very low viscosity.

⁽⁵⁾ Value calculated by quantifying the levels of saturates, aromatics, resins and asphaltenes (SARA compounds) at the end of the Polludrome® ageing study. These levels are affected by a rate of biodegradability depending on their chemical family and defined by the IMO (*Guidance Document for Decision Making and Implementation of Bioremediation in Marine Oil Spills*. London: International Maritime Organization, 2004).

environment at the end of the biodegradation process is in the order of 10% to 20% of the initial volume.

Adsorption

The hydrocarbons in condensates are liable to adsorb onto sediments, as well as suspended mineral and organic particles. This fixation phenomenon is favoured when the pollutant is dispersed in the water column, the pollutant-particle contact then being facilitated (e.g., plume at the estuary exit). This phenomenon is amplified for heavy condensates.

Hydrocarbons may be trapped on clay particles, resulting in significant slowing down of their biodegradability. When concentrations are high, the mechanism for fixing hydrocarbons on the suspended particles can lead to a gradual transfer of the pollutant to the drop areas.

B.10 Persistence in the aquatic environment

The persistence of condensates in the aquatic environment is low, since most of the chemical evaporates (from 50% to 90% by volume). If a part emulsifies, it can be manually or mechanically recovered or chemically dispersed.

Pollution by condensates can persist if circumstances lead them to infiltrate sediments (bank, shoreline) where evaporation can no longer occur. In very particular conditions, cold climates and in anoxic zones, condensates can remain permanently.

Persistence in the environment mainly consists in compounds with little or no degradability, which represent a small proportion of the chemical and the hydrocarbons "trapped" on the particles in suspension. When these charged particles settle on the bottom, they can, in some specific cases, lead to accumulations. Groundwater can be contaminated when, in land-based facilities, the chemical enters the soil.

Example of persistence

The Vega condensate, after evaporation at 72% of its initial volume, is biodegradable at a rate of 60%. The persistent fraction, given these two phenomena, is in the order of 10% of the initial volume.

Potential bioaccumulation data (SDS Total)

The potential for bioaccumulation in the environment is low; the bioconcentration factor (BCF) is such that $\log BCF = 0.7-4.15$.



B.11 Environmental impacts following a spill

Firstly, condensate pollution creates safety problems for people. These issues, not addressed in this part specifically dedicated to the environmental aspects in aquatic settings, must be addressed as a priority (see [D.1](#)).

Condensates, chemicals in the aquatic environment that are not highly persistent, can lead to a significant environmental impact through direct contact or exposure to their soluble compounds.

Direct contact

Since condensates are low density, floating chemicals, the impact is primarily on the fauna and flora living on the surface of the water or on the shores. Bottom-dwelling (benthic) organisms can be exposed to the pollutant at shallow depths or when the pollutant trapped on suspended matter settles. When there is agitation (waves, surf, etc.) of fine sediments on the shores, there may be mixing or even surface burial. This contact can harm organisms living in the sediment (burrowing organisms).

Dissolution of toxic compounds

The compounds in the condensates are very significantly dissolved and readily volatilised after having experienced an aqueous phase. The contamination of the water column is therefore transitory but not to be ruled out in shallow depths (from a few metres to a few tens of metres, depending on the importance of the pollution). When water renewal is low and/or the environment is confined, all aquatic organisms can be locally impacted.

Light aromatics

The light aromatic compounds are degradable and not highly bioaccumulative but present a significant toxicity. The most toxic of these compounds is benzene, with a CL_{50} of five to a few tens of ppm depending on the aquatic species (3.7 ppm for the leopard frog to 31.2 ppm for the *Daphnia magna* freshwater species).

Benzene and its derivatives are relatively abundant in the different condensates studied. This is evidenced by the levels measured in comparison with a light crude from the Middle East, the Al Khalij crude oil produced by Total E&P Qatar.

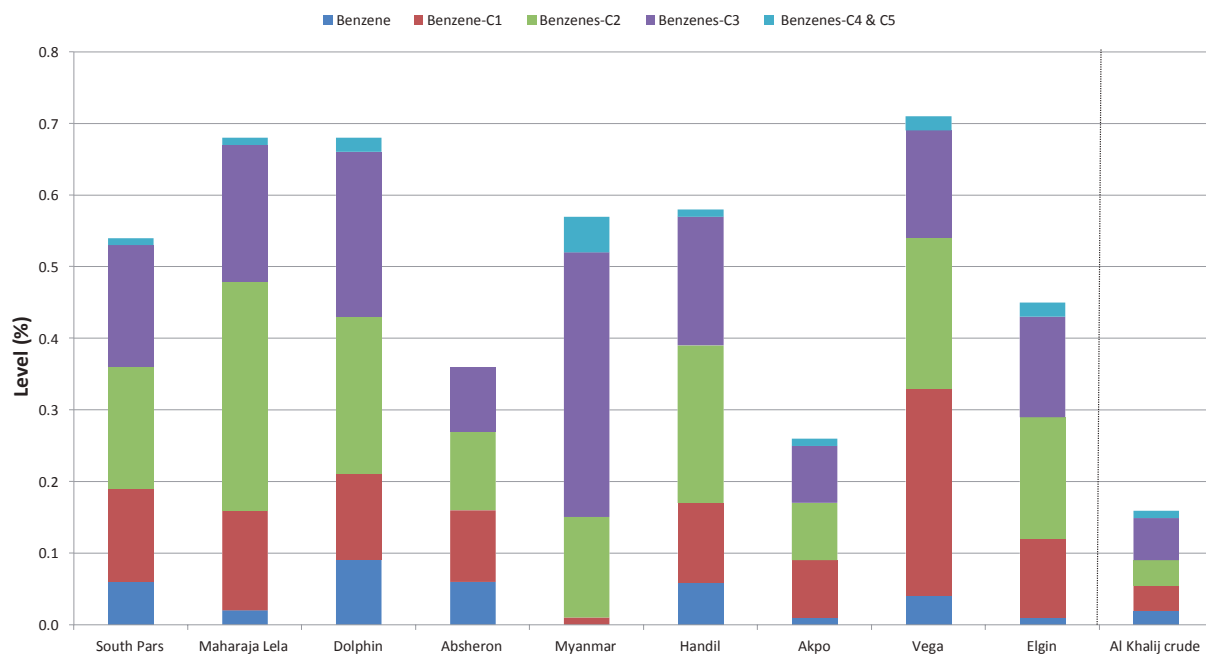
The ecotoxicological data obtained from condensates on marine species are presented in [B.8](#).

B.12 Potential impacts on different environments

Spills at sea

Evaporation will affect the majority of the spilled chemical, which, depending on its composition, can then be emulsified. The lightest condensates will not persist in the environment and will not have a significant impact on it. The heaviest condensates have similar impacts as light crude oils, mainly on avifauna. Condensates can affect seabirds coming in contact with surface slicks. Like all greasy chemicals, they alter the plumage of birds, which then die from hypothermia or ingestion of the pollutant from cleaning themselves.

Figure 15. Monoaromatic compound levels in the condensates studied compared to a light Arabic crude oil, Al Khalij crude.



Cold or frozen water

In cold environments, evaporation may be slowed, which involves wider contact with the pollutant and increases the risk of infiltration into the substrate or ice layer. In this case, the pollutant may eventually remain trapped until thawing.

Studies conducted by Cedre in arctic conditions on a very light chemical of the condensate type have shown that a chemical spill in a body of water that is ready to freeze leads, after ice formation, to migration through the entire thickness of the dissolved compounds.

Coastal spill

Spawning grounds and nurseries

A spill can have serious repercussions if it occurs during the spawning or nursery season of a species. Reproduction may be affected or larval growth or fry compromised. As in areas of seagrass, these phenomena are only observed in the event of significant pollution in shallow and/or fairly stagnant water.

Benthic commercial species (including crustaceans)

In shallow areas of coastal waters, a spill can affect the various species exploited commercially in a more or less visible sense. Possible effects include the alteration of the flesh of these species, which may become unfit for consumption.

Mudflats, lake and sea marshes

For marshes, damage through direct contact of the pollutant with the affected vegetation is foreseeable. It is possible that condensate will pollute the sediment for both mudflats and marshes, especially if the body of water is agitated or if the tide causes the pollutant to settle on the substrate. In this case, the contamination that affects the surface layer can extend deeper due to the effect of burrowing organisms (bioturbation for mudflats) or by transfer along the root networks for marshes. The buried pollutant can constitute a lasting contamination, because evaporation is no longer possible. In addition, muddy and marshy substrates are most often anaerobic, which limits the pollutant's biodegradation.

Mangroves

Condensates can affect the mangrove cover by simple contact with the adventitious roots of the mangroves and also damage the associated fauna (crustaceans, etc.).

In addition, as in the case of marshes and mudflats, if there is direct and prolonged contact with the sediment, there may be a risk of substrate contamination.

Seagrasses

Only dissolved toxic compounds can affect seagrasses during a condensate spill. This is possible only for a massive spill into narrow, shallow, coastal waters.

Rocky foreshores

A condensate spill, *a priori*, has only limited repercussions if the condensate is barely or not at all aged when it arrives at the coast. The mixing of water that is favourable for the continual remobilisation of the pollutant thus allows its evaporation and dispersion. However, a direct impact on the fixed organisms is possible (e.g., limpets). Aged and emulsified, the condensates would not be highly persistent and would have a very limited impact over time.

Sandy foreshores

Wave agitation and tides can lead to penetration into the sediment of substantial amounts of condensates. In this case, the impact of pollution depends on the ecological richness of the site, which, with exceptions, is generally low (e.g., turtles' egg-laying sites). If the chemical tends to emulsify, a deposit can form on the surface of the foreshore, requiring a clean-up operation.

Coral reefs

Since mostly submerged, exposure to the pollutant is due mainly to the dissolving of the toxic condensate compounds. This impact is all the more important because the corals are close to the surface in still waters. Corals remain fragile and vulnerable animals whose mucus can attach to toxic organic compounds.

Spill on an industrial site or in a river

For industrial sites on land, condensates will spread rapidly due to their low viscosity and will penetrate sediments rapidly. Well-sealed structures will create areas of accumulation that will limit evaporation, creating a risk of ignition of vapours.

If the spill reaches a river, the impact will be on the banks and deep in the sediments at once, as well as throughout the entire water column, due to the abundance of light and soluble elements.

1: Mudflat - 2: Seagrass habitat - 3: Mangrove.





B.13 Potential impacts on economic resources

Aquaculture

With pollution, the presence of dissolved compounds (BTEX) or the presence of condensates dispersed in the subsurface by agitation can provoke various effects on cultivated species ranging from lethal effects to changes in the flesh, making the product unsuitable for consumption.

Salt marshes

The polycyclic aromatic hydrocarbons (PAHs) of condensates, in particular naphthalenes, can contaminate the salt produced in these marshes in the event of a petroleum spill. Yet the risk remains low to the extent that a salt marsh is a partitioned space that can be closed to prevent the entry of a floating pollutant.

Tourist beaches

Beyond the issue of health safety during the emergency response (see [D.1](#)), condensate pollution on a beach can cause a momentary interruption of tourism activity. If a condensate seeps into the sand, evaporation can become difficult and require aeration of the sediment (e.g., through the harrowing technique) to accelerate the process. If the chemical emulsifies at sea and settles on beaches, they may be closed for cleaning.

Industrial water intake

- Cooling water intake: Condensates have *a priori* little risk of entering en masse into circuits, the inlets of which are generally deep. However, water quality can be quite significantly affected by the presence of dissolved aromatic compounds.
- Catchment (in particular for desalination plants), intake from tanks: In case of significant pollution, there is a risk of contamination of the water intake by soluble compounds, which may require closure (as a preventive measure).

Muddy-sandy foreshore.



C | EXAMPLES OF REAL CASES AND MODELLING OF DIFFERENT ACCIDENT SCENARIOS

C.1 EXAMPLES OF REAL CASES p. 22

C.2 MODELLING OF DIFFERENT ACCIDENT SCENARIOS p. 24

C.1 Examples of real cases

Three major accidents have occurred on offshore oil platforms (Uniacke G-72 and Elgin) and more recently on board an oil tanker carrying a condensate (the *MT Sanchi*). There have been several notable accidents in sensitive coastal areas (marshes, etc.).

Renewed experience with condensate accidents shows their principal characteristics:

- Condensate leaks are primarily a safety issue in terms of fire and explosion.
- Evaporation of the released condensates seems very fast, in that an estimate gives an evaporation rate of 75% within 24 hours of the leak.
- The impact of spills on aquatic wildlife is small. However, some birds may be affected.

Uniacke G-72 oil drilling, Nova Scotia, 1984

On this platform situated on the continental shelf, an uncontrolled eruption of gas and condensate took place below the water's surface. It ran for 10 days at a maximum rate of 48 m³/day (the flow decreasing with time). The operator, Shell, triggered its emergency plan, organised aerial monitoring of the slicks to track their drift and evaluate their thickness and breadth, proceeded to air sampling of condensate in the slick and in fish and checked for possible deposits and the impact on nearby Sable Island. Thanks to the numerous storms at the time of the leak, the condensate slick was rapidly dispersed. The evaporation of the condensate was estimated at 75% after 24 hours. The rest formed a surface slick or was driven into the water column. The slick persisted for several days and was observed up to 10 km from the drilling. The part dissolved in the water column

undoubtedly persisted for longer because of its reduced evaporation.

Yet hydrocarbon concentrations detected up to a depth of 21 m were low and no effect was observed for marine wildlife.

Montara offshore oil field, Timor Sea, 2009

On 21 August 2009, approximately 230 km off the coast of northwest Australia on the *Montara* offshore oil field in the Timor Sea, an uncontrolled eruption of hydrocarbons occurred from a well head drilled by the West Atlas mobile platform.

The hydrocarbon increase consists of:

- light crude oil (but with a paraffin level of 11% and pour point rising to 27°C) immediately forming surface slicks;
- a mixture of condensates and gas released into the atmosphere, posing a risk of explosion near the platform.

The spill into the sea was estimated at 4,800 tonnes. The leak continued until 3 November 2009. The slick generated reached 40 km wide by 136 km long. Aerial reconnaissance was initiated from the beginning of the crisis to follow the slick drift and guide the nautical resources in the area (recovery vessels, aircraft for spreading dispersants, etc.).

From the second day after the spill, hydrocarbon slicks were treated by spreading dispersants by aircraft and ships. The large paraffinic component of crude tends to solidify the slicks as the temperature decreases and affected the time window for using the most efficient dispersants in the afternoon. Even so, chemical dispersion proved effective.



Oceanic weather conditions (at low agitation) are not conducive to the natural dispersion of crude oil but favourable to containment and recovery operations. As with dispersion operations, a particular constraint appeared in connection with the high paraffin content of the spilled crude, which solidified overnight. Overall, 844 m³ of emulsion was recovered, the proportion of crude oil of which AMSA (the Australian Maritime Safety Authority) estimated at 58% (493 m³).

At the same time, a group of experts mobilised to develop a strategy to halt the leak. The option chosen was to drill a bypass well joining the main well, at a depth of 2,600 m. The interception of the main well, a true technical challenge, was carried out on 3 November, stopping the leak with the injection of 540 m³ of heavy sludge.

The antipollution reaction was considered a success. No appearance on the coast, with its ecologically sensitive sectors, was observed.

Elgin production platform, North Sea, 2012

A gas and condensate leak occurred on a closed well that had been shut down and isolated for a year. The leak was due to the unpredictable corrosion of a well casing. Facing risks of fire and explosion, all personnel were evacuated and a safety perimeter was established. A nearby platform was also evacuated. The condensate spreads to the surface of the water, forming a very large, very thin, iridescent slick, the majority of which evaporated in a few hours. The maximum evaporation rate at sea could be estimated at about 75%. The operator, Total, used satellite, air and naval resources to observe the situation and establish, with international experts, the most suitable intervention strategies to control the leak. Heavy mud was injected at the well head from a semi-submersible drilling rig. After 12 hours of injection, the methane leak was halted. The well was carefully monitored in the following days to ensure the success of the intervention. In two months the leak released up to 200,000 m³ of natural gas per day. The British authorities put the platform back into service almost 12 months after the accident. There were no victims to mourn, but the cost of this accident amounted to several hundred million euros.

MT Sanchi, East China Sea, 2018

Following a collision with the Hong Kong bulk carrier *CF Crystal*, sailing towards China, the Iranian oil tanker *MT Sanchi*, en route to South Korea, caught fire on 6 January 2018 about 300 km off Shanghai. On 10 January, part of the oil tanker exploded, and the Chinese government's fire-fighting operations were interrupted. On the 13th, further attempts to stop the fire were made, but on the 14th, the oil tanker exploded entirely and sank to a depth of 115 m off Japan's Ryukyu archipelago.

After the shipwreck, some of the 136,000 tonnes of leaching condensate burns rapidly at the surface, causing impressive air pollution. On 15 January, the fire ceased and, given its low viscosity, the condensate evaporated and/or spread on the surface of the sea, forming a thin, iridescent film, the size of which was estimated to be as high as 300 km² by the Chinese authorities. Despite strong water agitation in the area, which favours natural dispersion, on 16 January, fragmented slicks were observed by the Japanese coast guard 27 km north of the collision site. On 21 January, the polluted surface was judged to be about 330 km² by the national Chinese ocean authority. On 2 February, the first oil pellets, which could have come from residues from the burning of condensate or heavy fuel oil, hit the coast of the islands of southern Japan. On 23 February, at least 16 islands were affected and 90 tonnes of waste collected.

The Chinese government very quickly launched rescue operations in collaboration with South Korea and Japan to find the crew of the oil tanker, who unfortunately did not survive. About 15 vessels present in the area participated in the aid effort, hydrocarbon recovery and firefighting. On the basis of information from the national maritime rescue centre, some 60 control operations were carried out by boats of all kinds, for a result, as of 21 January, of 27 tonnes of dispersants used, 440 tonnes of absorbents used and 800 metres of dams deployed.

If it was above all a human catastrophe, it was also the largest condensate release into the environment observed to date, highly volatile crude oil having burned for about 10 days and causing major air pollution. Though the respective amounts of condensate that contaminated the atmosphere and the sea are difficult to estimate, the air pollution was likely more significant than the aquatic pollution.

Other cases

In addition to these four major accidents, several cases of pipeline or well-head leaks in coastal wetlands should be noted, notably in Louisiana (United States). The areas contaminated by these accidents are, however, very small (< 0.5 km²). Examples include the accidents at the Rockefeller Wildlife Refuge in 1995, the Atchafalaya Basin in 1996 or in Mosquito Bay in 2001. In these ecologically fragile areas, manual or mechanical recovery of the pollutant is difficult and has led to further deterioration of the sites. In two of the cases cited, Rockefeller Wildlife Refuge and Mosquito Bay, burning *in situ* was chosen as the control technique. This proved effective, the burned areas having returned to the same vegetation levels relatively quickly (from a few months to two to three years) as areas not affected by the pollution.

C.2 Modelling of different accident scenarios

The accident scenarios presented here, simulated by the software OSCAR (SINTEF, Norway), are only indicative. In a real accident, the extent and fate of the pollution may be different because of the surrounding conditions, but also because of the very nature of the condensate.

The following examples were obtained from the test data from the Maharaja Lala condensate in Brunei.

Two scenarios with constant currents and winds were simulated:

- **Scenario 1:** A deep (1,000 m) spill, continuing for 30 days at a rate of 4,770 m³ of oil per day. The GOR (gas-oil ratio) was set at 2,000.
- **Scenario 2:** An instantaneous surface spill (one hour for the software) of 10,000 m³. The behaviour over time was simulated over a period of 20 days.

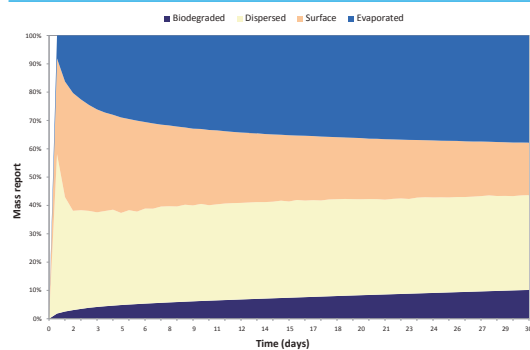
Figure 16. Modelling parameters.

Parameters	Simulation characteristics
Constant current	0.07 m/s – northwest direction
Constant wind	10 knots – southeast to northwest
Surface sea temperature	22°C
Sea temperature at a depth of 1,000 m	4°C
Salinity	35 ppt
Air temperature	21°C
Dissolved oxygen content	10 mg/L
Suspended material	0 mg/L

Scenario 1: Deep spill (blowout)

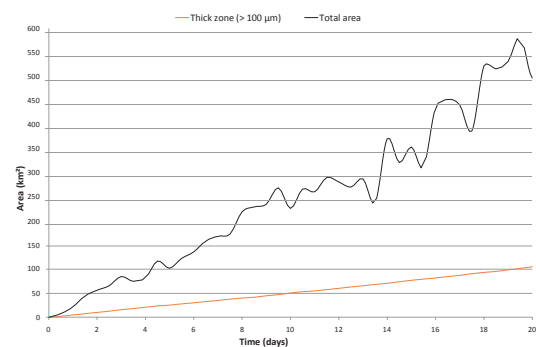
Some of the condensate is dispersed in the water column at the beginning of the event and this proportion remains roughly constant throughout the 30-day simulation. The quantities arriving at the surface are therefore similar over time, but then reduced in part by evaporation and biodegradation phenomena (about 10%), though the magnitude of this process is difficult to anticipate.

Figure 17. Material report of the "deep spill" scenario.



The surface slick therefore extends progressively, fed by the regular arrival of pollutant, but the area of high thickness, greater than 100 µm, remains modest given the volumes involved (4,770 m³ per day). After 30 days of blowout, the slick is approximately 100 km² in size, which from an operational point of view allows for containment/recovery or dispersal operations.

Figure 18. Changes in the size of the surface of the condensate slick for the "deep spill" scenario.

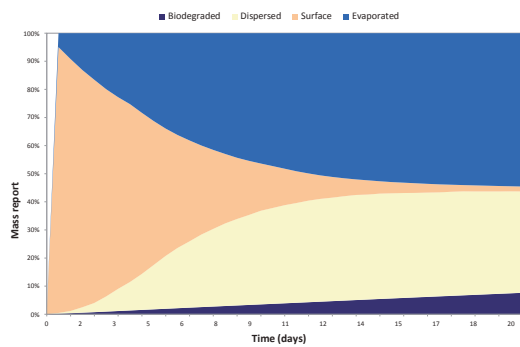




Scenario 2: Surface spill

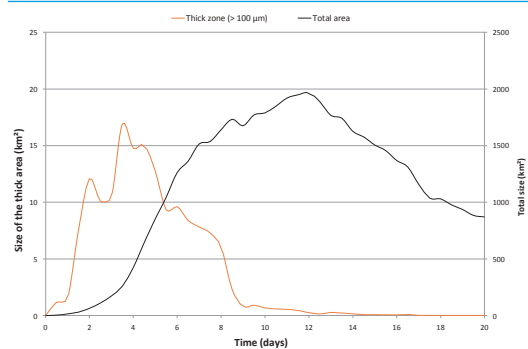
Most of the condensate will gradually disperse in the water column or evaporate, or even biodegrade (though this process is difficult to model). In the end, only about 150 m³ of the pollutant will remain of the 10,000 m³ initially spilled. (Taking into account the emulsification phenomenon, this volume could reach 750 m³, for a level in water of 80%).

Figure 19. Material report of the "surface condensate spill" scenario.



For the thick part of the surface slick (greater than 100 µm), it spreads rapidly after a spill and almost disappears after two weeks. The maximum area is approximately 15 km² after four days, allowing for containment/recovery or dispersion. This could limit the thinner area, which would otherwise extend over 1,000 to 2,000 km² for several days and could result in very diffuse arrivals on a long coastline, depending on the spill area.

Figure 20. Changes in the size of the slick surface for the "surface condensate spill" scenario.



D | COMBATING SPILLS

D.1 RECOMMENDATIONS RELATED TO INTERVENTION..... p. 26	D.4 TABLE OF RESISTANCE OF MATERIALS TO CONDENSATES..... p. 30
D.2 TECHNIQUES TO COMBAT POLLUTION... p. 27	D.5 WASTE TREATMENT..... p. 31
D.3 CHOICE OF PERSONAL PROTECTIVE EQUIPMENT (PPE)..... p. 30	

D.1 Recommendations related to intervention

Any control action must be preceded by in-depth reflection on people's safety (workers and third parties) in order to secure the area and protect people. The following paragraphs recall the basic elements of this reflection, which should be pursued throughout the operations. Condensates can be almost colourless chemicals, which makes operations tricky, because it is sometimes difficult to discern the contours and extent of a slick.

First instructions

- Halt the spill, if possible.
- Establish a security perimeter (this can be achieved using atmospheric models run by specialized institutes).
- Secure the premises by prohibiting access to the polluted area and evacuating the people there.
- Eliminate any possible cause of ignition (use of explosion-proof equipment, bronze tools, etc.).
- Open and ventilate any more or less enclosed places in the area.
- Be sure to block any outlets in contact with the polluted body of water in order to prevent the chemical from rising and to minimise the risk of explosion in the pipes.

In all cases, seek the help of firefighting professionals.

In the event of a spill in a river, care will be taken to suspend the use of water downstream from the spill point (closure of water intakes, stall entrances, etc.).

Vapour, explosiveness monitoring measures

When responding to a condensate spill, the first safety measure will be to control the percentage of vapours in the air (see **B.4**) using an explosimeter. A safety must be taken into account, and the intervention will continue

for a threshold below 10% of the minimum threshold (1.4%) of flammability in air.

In the event of strong evaporation, the measurement of the VOC rate in the air (some are very toxic) using detection devices allows the safety of workers to be assured (e.g., HNU photoionisation detector or Draeger tube for BTEX aromatic vapours).

Remotely controlled tools such as drones, equipped with real-time continuous monitoring micro-sensors, can be used for the measurements of VOC and flammability.

The risks of ignition of condensate vapours and poisoning of operators are all the higher if the premises are poorly ventilated (closed area and pipes, absence of wind, etc.) or enclosed, allowing the vapours to accumulate.

Vapour measurement with an explosimeter.





Burning spills

If the fire is declared and too advanced, it is necessary to evacuate people within a sufficient radius. Firefighting will take precedence over pollution-control.

Any action taken will be:

- by approaching upwind of the spill and/or upstream of the current;
- by equipping workers with explosimeters and personal protective equipment (see **D.3**).

The recommended extinguishing agents are chemical foam, dry ice or dry powder. Water may be ineffective in extinguishing the fire, but it can be used to cool walls and surfaces exposed to it. It is also possible to knock down the vapours by spraying water. Do not use a solid jet of water, as it will cause the flames to spread. The fuel source must be isolated: Allow it to burn under control until the fuel is exhausted or use the appropriate extinguishing agents.

In all cases, secure the area and ensure the safety of workers and residents. For more safety/fire information, refer to the specialised literature.

Anti-fire dam.



D.2 Techniques to combat pollution

Main strategies for responding to a condensate spill

The first steps, before any intervention with highly flammable condensates, should be dedicated to defining a safety perimeter and controlling the atmospheric explosivity while protecting the hot spots. These measures must be accompanied by monitoring pollution and its spread (marking of slick, drifting buoys), as well as its movements using modelling (see Cedre's operational

guide "Aerial observation of oil pollution at sea" and "Guide for combating accidental marine pollution in the Mediterranean" (REMPEC 2000)).

Do nothing, let it be

In most cases, the natural evaporation of condensates reduces pollution in the aquatic environment. This is probably the most common control option to adopt if security allows. This option does not preclude the use of floating dams or, under certain conditions, tailored dams to protect particular areas that may be contaminated with the slick. The presence or absence of soluble condensate compounds in the water column should also be assessed (in turbid waters, these molecules attach to the suspended matter and may settle).

Mechanical containment/recovery

This is the second control option when pollution cannot be allowed to evaporate on its own. When the situation permits, confinement of the slick by a floating dam towed at very low speed or placed in the current (< 0.7 knots) in order to contain and thicken the slick will greatly increase the efficiency of the recovery. This option therefore involves handling highly flammable chemicals, and draconian safety measures must be taken throughout the treatment chain (explosive atmosphere, fire or poisoning, use of explosion-proof equipment). However, by virtue of ageing, the flashpoint of condensates increases, passing above 60°C in a few hours (one hour for Akpo, the heaviest condensate type, six hours for Vega, the lightest type at low temperature, or 5°C), making the product less dangerous. These same dams can also be used to divert the path of the slick to an area that is more favourable in terms of safety (avoidance of hotspots), calmer or more accessible for condensate recovery, or to prevent the condensate from migrating to an ecologically or socioeconomically sensitive area.

Light chemicals are characterised by low viscosity. So they do not pose particular problems for pumping, but tend on the other hand to spread rapidly into extremely thin slicks. The main difficulty then consists of making a good selection between the hydrocarbon and the water at the time of recovery, even if emulsions are generally not highly stable in the case of condensates and the water drawn with the hydrocarbons can, *a priori*, be easily separated through settling. As such, self-adjusting threshold scrubbers, as well as oleophiles will be suitable tools. The latter are characterised by high selectivity but a significantly lower recovery rate.

Use of absorbents

When the quantities of pollutant to be recovered are small (in the order of a few tens of litres maximum), which can nevertheless represent large polluted areas, recourse to absorbents will often be the most suitable solution for a fine cleaning after the lighter parts have evaporated, in order to avoid any risk of explosion at the

storage point. They may also be recommended in the case of heavier condensates, which may emulsify, but the viscosity of which remains limited.

Surface chemical dispersion

Chemical dispersion must be considered in the light of what is recommended generally for crude and refined petroleum products, except that there is no limitation, *a priori*, due to high viscosities. One of the criteria for choosing this strategy will be the evaporation rate.

The lightest condensates, comparable to a cut kerosene (e.g., Elgin, Myanmar, South Pars or Dolphin Qatar), have expected evaporation rates at sea in the range of 80% to 85% (most evaporation takes place in 24 to 48 hours). Although they were found to be dispersible in tests conducted at Cedre, chemical dispersion is not recommended for chemicals with low persistence at the surface of the sea, for evaporation rates greater than 70%.

In general, chemical dispersion can be recommended for condensates the evaporation of which is less than 70% and asphaltene content greater than 0.1% (e.g., Maharaja Lela, Absheron, Handil, Akpo). These products can emulsify at rates of 70 to 80%, which implies that the amount of pollutant remaining on the sea surface is similar to the volume initially spilled. As with light crude oils, time and precautions are necessary prior to any Intervention, due to their flammability. Though their maximum viscosity is low, laboratory tests and tests aged samples at the Polludrome® showed a decrease in the effectiveness of treatment with ageing. This can thus be uncertain for Absheron for a simulated time of 36 hours, even very reduced for Handil or Akpo. ⁽⁶⁾ Conversely, dispersibility may increase in the first few hours due to a small increase in viscosity associated with an increase in density. Given the risks associated with the application of dispersants by boat within the first few hours of a spill, it may be necessary to delay the use of this technique by a few hours.

Finally, notable differences in effectiveness have been identified for several dispersants. As much as possible, it is therefore necessary to conduct comparative studies of the efficiency of upstream dispersants in order to optimise the response strategy.

Underwater dispersion

The advantage of underwater injection of dispersant is to limit the arrival of hydrocarbons, usually highly flammable, at the surface vertical to the leak, where most

of the anti-pollution control is concentrated. This option can reduce the risks linked to the nature of the chemical. As with surface dispersion, the relevance of this technique is to be considered and put in perspective with respect to surface evaporation and chemical persistence.

Burning *in situ*

This technique is generally not recommended in the Mediterranean area. It can, *a priori*, be applied to condensates, mostly highly flammable, in very particular situations, notably in deserted places, because of the associated risks (fire and smoke). The possible consequences must be studied beforehand on a case-by-case basis, incorporating any beneficial or harmful effects on the environment. For example, in some special cases, burning *in situ* may be recommended in ecologically sensitive areas (marshes, seagrass habitats) where trampling and the passage of mechanical recovery tools may further degrade ecosystems. The fate of the burning residue, however small, must also be incorporated into the decision process.

Studies conducted at Cedre have shown that 85 to 90% of a light chemical of the condensate type can be burned, but these values are to be seen relative to the evaporation rate, which can reach 80% in some cases. As with dispersants, it is possible to define a window of opportunity upstream knowing that the effectiveness of burning decreases over time. A study conducted in the Cedre burn bench showed the possibility of setting fire to a condensate slick, regardless of the degree of simulated evaporation (residues at 150°C, 200°C and 250°C). It was also possible to set various emulsified residues on fire at 50% water.

Spill context and response decision

In open sea

In the context of low-volume spills, and given condensates' evaporation rate, one of the most appropriate solutions is to let the condensate spread and evaporate naturally. The definition of these small volumes, in the order of a few m³, is a function in particular of the endangered area, national regulations, the possibility of deviations and the potential environmental and socio-economic consequences.

For medium to major pollution, the lightest condensates, which demonstrate an evaporation of more than 70%, close to petrol and kerosene, have a low persistence, while the risk for workers is high. The "do nothing, let it

⁽⁶⁾ The Handil condensate dispersibility study shows that, according to the IFPEN test, the dispersion efficiency becomes uncertain for a viscosity of 300-400 mPa.s and reduced according to the MNS test from 100 mPa.s.



be" option is therefore also recommended in this case. For lower evaporation rates, the intervention strategies described above are possible, with recovery being prioritised.

In a coastal area

Pollution control operations should be carried out when the pollutant's drift points to the coast or ecologically or socio-economically sensitive areas, whatever the volume spilled (in general, a slick moves with the current and under the influence of the wind – 100% from the current and 3% from the wind). Protecting these areas with dams may be considered, fireproof if possible. It is important to note that these measures involve the use of nautical resources which are not easily compatible with ATEX certifications and which must therefore be used well before the arrival of the pollutant. The use of dispersants is necessarily more delicate than recovery, which must be prioritised. Geographical limits apply generally to the use of dispersants in proximity to coasts, sometimes nuanced according to the volume spilled. In the case of burning, the first question is regulatory, since this technique is banned in many countries. The next question then arises regarding smoke and its harmfulness.

In the case of a spill in the order of a few m³ very close to the coast or at the coast, if the slick is confined naturally, recovering the pollutant after covering it with a low- or medium-swell emulsifier foam mat can be considered, to limit the formation of flammable vapours. The recovery will then take place with a floating intake head

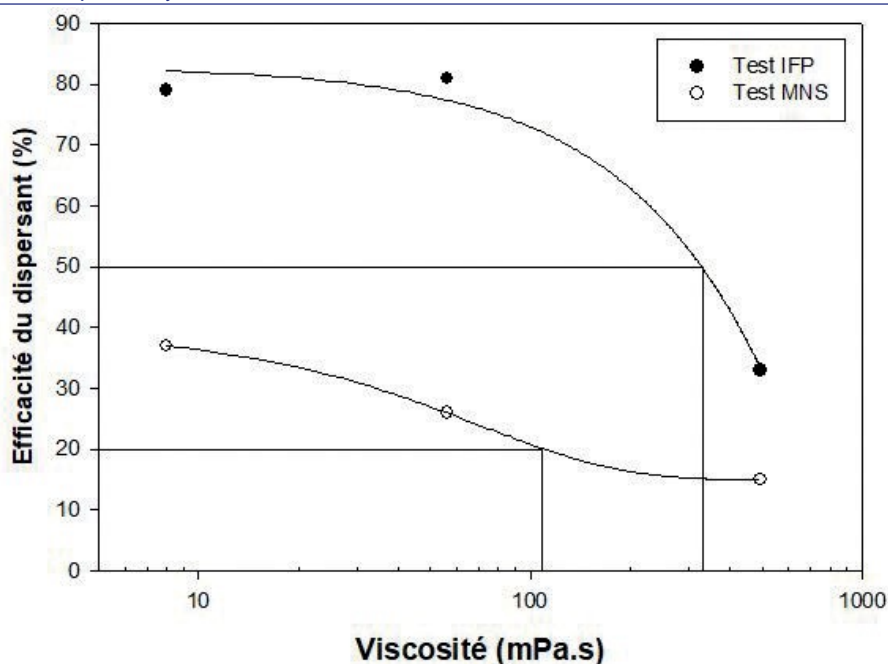
adapted to recover the pollutant under the foam mat. Care should be taken to secure the storage tank by rendering it inert, and to ensure that there are no hotspots in the area. In this case, it is recommended that a "carp tail" or "manta" suction head be used with a sanitation truck or water sewage truck (which both allow vacuum pumping), provided that the combination is ATEX certified and follows the ADR regulations for storage and road transport. These operations must be performed by trained professionals equipped with suitable personal protection (respiratory and skin protection – see **D.3**). For larger volumes, self-adjusting threshold collectors, as well as oleophiles are recommended, but their use may be limited by the flammability of the chemical.

On land and in inland waters

In the case of a spill on land, taking into account the risk of ignition of the vapours, it is appropriate, first and foremost, to assess the extent of the pollution and to define a safety perimeter. The outlets (sewers, drains, collectors) must then be protected as a priority to avoid the spread of pollution in the aquatic environment and networks, while limiting, as far as possible, the spread of the pollutant by the creation of merlons (sand, earth, etc.).

If the spill reaches a river, it is appropriate, in the short term, to ensure the protection of downstream water intakes while controlling the risk of ignition. In the medium term, it will be necessary to clean the impacted banks after the evaporation process has been completed.

Figure 21. Evolution of dispersibility of the Handil condensate.



D.3

Choice of personal protective equipment (PPE)

Choice of protective clothing

- Wear protective clothing covering, as much as possible, the whole body.
- **Face and eye protection:** Wear chemical protective goggles (do not use contact lenses in work areas). It may be necessary to wear a face mask. For handling low-concentration chemicals for a short time, a respirator with a type A filter is recommended. For higher concentrations or long-term exposure, use a self-contained breathing apparatus.
- **Skin protection:** Wear protective gloves resistant to aromatic hydrocarbons: nitrile rubber (contact by spraying), fluoropolymer (contact by immersion), boots, overalls and/or other hydrocarbon-resistant protective clothing.
- Promptly remove all contaminated clothing that would no longer provide complete skin protection.

Choice of respiratory protection

- Mandatory use of a self-contained breathing apparatus in a confined atmosphere due to the abundance of gases released.
- Personal respiratory protection equipment must be worn as soon as there is a risk of inhalation of toxic vapours when concentrations are close to the mean exposure value (MEV = 200 mg/m³).

Full breathing mask with cartridges.



D.4

Table of resistance of materials to condensates

The constituent elements of protective equipment and the materials used must be resistant to condensates.

The table below lists the compatibility of various plasters and elastomers with respect to condensates.

		Unleaded petrol	Ethanol
Acrylonitrile butadiene styrene	ABS	D	B
Ethylene propylene diene monomer rubber	EPDM	D	A
Fluorocarbon rubber	FKM - Viton	A	B
Natural rubber		D	A
Nitrile rubber	NBR - Buna Nitrile	A	C
Perfluorinated rubber	FFKM - Chemraz		A
Perfluorinated rubber	FFKM - Kalrez	A	A
Polyester rubber	Hytrel		
Polyvinyl chloride	PVC	C	C
Chlorinated polyvinyl chloride	CPVC	C	B
Polyvinylidene chloride	PVDC - Kynar	A	
Polyamide	PA - Nylon	A	A
Polycarbonate		A	B
Polychloroprene	Neoprene	B	A
Polychlorotrifluoroethylene	PCTFE - Kel-F	A	A
Polyepoxide	Epoxy	A	A
Polyetheretherketone	PEEK		A
Chlorosulfonated polyethylene	CSPE - Hypalon	A	A
Conventional polyethylene	LDPE	D	B
High-density polyethylene	HDPE	C	A
Fluorinated polyethylene propylene	Tygon	C	C
Polyoxymethylene	Acetal	A	A
Polyphenylene oxide	Noryl	D	A
Polyphenylene sulphide	PPS - Ryton	A	
Polytetrafluoroethylene	PTFE - Teflon	A	A
Polyurethane			D
Silicone		D	B

A Excellent (durable for years)

C Medium (signs of deterioration after one week)

B Good (withstands at least one month)

D Not suitable



D.5 Waste treatment

The control of condensate pollution can lead to the creation of various wastes.

Polluted water

If it is a mixture with two distinct phases, water and condensate, the insoluble and superposing hydrocarbon phase should be separated by simple decanting.

If this water-condensate mixture is more or less dispersed, it can be filtered on hydrophobic absorbents that will remove the condensate. For example, on a small pollution site, feed the water-condensate mixture into a receptacle containing bulk absorbent materials, such as poly-propylene "spaghetti".

If the water is contaminated by the soluble elements of the condensate, then the contamination depends on the initial composition of the condensate and the proportion of BTEX. Such water cannot be released into the natural environment. If quantities are low and storage is possible, the treatment of contaminated water may be entrusted to a specialised company.

Another alternative is to treat this water with activated carbon (1 kg per 3.5 kg of compounds in solution). If the quantities are large and no longer permit this, it is possible to lagoon the water, preferably by aeration, in order to allow time for these volatile compounds to evaporate into the atmosphere. This process can also speed up the biodegradability of the soluble and biodegradable compounds of the condensate, namely light aromatics.

If the condensate has emulsified over time, it can be recovered by pumping.

Polluted sediments

Contaminated sediments will be sent into an industrial waste treatment channel where they will be incinerated or possibly made inert by special treatments (lime, clays, etc.). Given the biodegradability of condensates, the use of biopiles is not to be excluded.

If the condensate has emulsified over time and it arrives on the coast in the form of "chocolate mousse", potentially having stuck to natural and macro-waste debris, the removal of contaminated sediment may require very different solutions.

Polluted absorbents

Polluted absorbents will be sent to an industrial waste treatment centre for incineration.

For waste disposal

Consult:

REMPEC's guides and tools (<https://www.rempec.org/fr/>):

- The significance of a material safety data sheet (2001)
- Mediterranean Oil Spill Waste Management Guidelines (REMPEC, 2011) : <https://www.rempec.org/en/our-work/pollution-preparedness-and-response/response/tools/oil-spill-waste-management>
- Mediterranean Oil Spill Waste Management Study and Decision Support Tool: <https://wastemanagement.rempec.org/en>

E | ADDITIONAL INFORMATION

E.1 GLOSSARY.....	p. 32	E.4 BIBLIOGRAPHY.....	p. 34
E.2 INITIALISMS AND ACRONYMS.....	p. 33	E.5 CONTENT OF FIGURES.....	p. 34
E.3 USEFUL WEBSITES.....	p. 34		

E.1 Glossary

Absorption

Penetration and retention of the pollutant (fluid or viscous) in the material composing the absorbent.

Anoxic

Absence of oxygen or very low permeability.

Boiling point (measured at 1 ATM)

Temperature at which a liquid begins to boil; more precisely, the temperature at which the saturated vapour pressure of a liquid is equal to the standard atmospheric pressure (1,013.25 hPa). The measured boiling point depends on atmospheric pressure.

Biocidal

Destructive of living organisms.

Effective concentration 50 (EC₅₀)

Concentration causing an effect (mortality, growth inhibition, etc.) for 50% of the relevant population for a given time period.

Flashpoint

The lowest temperature at which a substance emits a vapour that ignites or burns immediately upon ignition.

Ignition source

Examples of ignition sources: heat, spark, flame, static electricity and friction. Sources of ignition must always be eliminated when handling flammable chemicals or working in hazardous areas.

Lethal dose 50 (LD₅₀)

The dose of a statistically deduced substance that, administered to a living organism, should cause death for 50% of exposed organisms.

Marine pollutant

A substance, object or material that, when released into the aquatic environment, may cause serious damage thereto.

Median lethal concentration 50 (LC₅₀)

Concentration of a statistically deduced substance that should cause death for 50% of exposed animals during or after exposure for a defined period of time.

Personal protective equipment (PPE)

This is a person's respiratory and physical protection. Levels of protection, including both protective clothing and respiratory protection devices, have been defined and accepted by professional agencies such as the United States Coast Guard:

- Level A: an APRA (self-contained breathing apparatus) and suits fully sealed against chemical agents.
- Level B: an APRA and clothing protective against liquids (splash-proof).
- Level C: a full or half-mask respirator and chemical-resistant (splash-proof) garment.
- Level D: full-body garment without respiratory protection.

Relative density

Density quotient of a substance and of the density of water for a liquid substance, or of air for a gaseous substance.

Saturated vapour pressure

The partial pressure of gas molecules in equilibrium with the liquid phase for a given temperature.

Solubility

Amount of substance dissolved in water. It is a function of salinity and temperature.

Tight areas (water)

Areas with difficult access (straits, canals, ports, etc.), where the water is shallow.



E.2 Initialisms and acronyms

ADN: European agreement on the international transport of dangerous goods by inland waterway.

ADR: European agreement on the international transport of dangerous goods by road.

API: *American Petroleum Institute.* API is an American standardisation agency.

ASTM: *American Society for Testing Material.* ASTM is an American standards agency that prepares and produces technical standards.

ATEX: explosive atmosphere.

BTEX: benzene, toluene, ethylbenzene, xylene. Light aromatic compounds.

CAS no.: Chemical Abstract Service number: a unique registration number in the American CAS database, which includes chemicals, polymers, biological sequences and alloys.

CONCAWE: European organisation of oil companies for the protection of the environment and health.

EC: European Community.

EC₅₀: effective concentration.

EC no: European Community number: a unique seven-digit identifier assigned to chemical substances for regulatory purposes in the European Union.

GHS: *Globally harmonised system.* A set of international recommendations developed within the United Nations, the aim being to harmonise the classification and labelling of chemical products worldwide.

HESS: an American oil company.

IATA: International Air Transport Association.

IFPEN: French institute of new petroleum energies.

IMDG: International Maritime Dangerous Goods: international guide for the transport of dangerous packaged goods.

IMO: *International Maritime Organization:* an institution of the United Nations specialised in maritime matters.

INERIS: national institute of the industrial environment and risks.

LC₅₀: median lethal concentration.

MNS: Mackay Nadau Steelman, the name of a test used for dispersants.

OACI: international civil aviation organisation.

OSCAR: *Oil Spill Contingency and Response:* oil accident modelling software developed by the Norwegian agency SINTEF.

OSPAR: The OSPAR Convention aims to prevent and eliminate marine pollution and thus protect the Northeast Atlantic from the harmful effects of human activity. As such, OSPAR develops many common tools, including tests.

PAH: polycyclic aromatic hydrocarbon.

ppm: part per million.

RID: regulations concerning the international transportation of dangerous goods by rail.

SDS: *Safety data sheet.* A descriptive form containing data relating to the properties of a chemical product.

UN no.: United Nations number: a four-digit identification number for cargo for which transportation is regulated.

VOC: volatile organic compounds.

E.3 Useful websites

Cedre (Centre for Documentation, Research and Experimentation on Accidental Water Pollution)

- Accident reports (accessed 25.11.2020). Available on: wwz.cedre.fr/Ressources/Accidentologie
- Operational guides (accessed 25.11.2020). Available on: wwz.cedre.fr/Ressources/Publications/Guides-operationnels
- Chemical intervention guides (accessed 25.11.2020). Available on: wwz.cedre.fr/Ressources/Publications/Guides-chimiques

Cole-Parmer scientific experts: chemical product compatibility database

- (accessed 25.11.2020). Available on: www.coleparmer.fr/chemical-resistance

INERIS (National institute of the industrial environment and risks)

- (accessed 25.11.2020). Available on: www.ineris.fr

INRS (National research and safety institute for the prevention of accidents at work and occupational diseases): occupational health and safety.

- Safety data sheet (accessed 25.11.2020). Available on: www.inrs.fr/media
- [Html?refINRS=ED%20954](http://www.inrs.fr/media/Html?refINRS=ED%20954)
- Toxicological information sheets (accessed 25.11.2020). Available on: www.inrs.fr/publications/bdd/fichetox.html

NOAA National Oceanic and Atmospheric Administration): incident news

- (accessed 25.11.2020). Available on: incidentnews.noaa.gov

International labour organisation: ICSC database.

International chemical safety data sheets

- (accessed 25.11.2020). Available on: www.ilo.org/safework/info/publications/WCMS_324855/lang-en/index.htm

REMPEC Website - Guidelines and Tools:

- <https://www.rempec.org/en/our-work/pollution-preparedness-and-response/response/tools>

E.4 Bibliography

AFNOR. Essais des eaux. Détermination du pouvoir absorbant. Capacité de rétention en huile. Norme NF T90-360 ⁽⁷⁾. Paris: AFNOR 1997 page 12.

ASCO. Matériaux des produits et compatibilité élastomères, matières plastiques et métaux. Available on: www.asconumatics.eu/images/site/upload/_en/pdf1/00012fr.pdf

Carter, J., MacGregor, C., Tidmarsh, G., et al.

Monitoring programs associated with the Uniacke G-72 gas/condensate blowout on the Scotian Shelf. IN *Proceedings of the 8th Arctic and Marine Oilspill Program (AMOP) Technical Seminar. Environment Canada, Ottawa, Ontario.* 1985, pages 403- 422.

Cedre. Elgin: accident sheet. 2014

Available on: wwz.cedre.fr/Ressources/Accidentologie/Accidents/Elgin

Cedre. Montara: accident sheet. 2013

Available on: wwz.cedre.fr/Ressources/Accidentologie/Accidents/Montara

Cedre. MT Sanchi: accident sheet. 2018

Available on: wwz.cedre.fr/Ressources/Accidentologie/Accidents/MT-Sanchi

Central Intelligence Agency (US), The World Factbook: lengths and types of pipelines for transporting products like natural gas, crude oil, or petroleum products.

Available on: www.cia.gov/library/publications/resources/the-world-factbook/fields/383.html

GILL, S.D., AC Bonke , Carter J. Management of the Uniacke G-72 Incident. IN: *International Oil Spill Conference Proceedings 1 February 1985.* 1985, Volume 1, pages 311-313.

Available on: doi.org/10.7901/2169-3358-1985-1-311

Thomas J. Hess, LCDR Ilene Byron, Heather Warner Finley, et al.

The Rockefeller Refuge Oil Spill: A Team approach to Incident Response. IN: *International Oil Spill Conference Proceedings 1 April 1997.* 1997, Volume 1, pages 817-821.

Available on: doi.org/10.7901/2169-3358-1997-1-817

⁽⁷⁾ Standard being revised from 2020.



Hess. Natural Gas Condensate Sweet. Safety data sheet (SDS) number 15017. Revision date: 10/26/2018, page 12.

Available on: [www.hess.com/docs/default-source/us-safety-data-sheets/natural-gas-condensate-\(sweet\).pdf?sfvrsn=4](http://www.hess.com/docs/default-source/us-safety-data-sheets/natural-gas-condensate-(sweet).pdf?sfvrsn=4)

Hess. Natural Gas Condensate Sour. Safety data sheet (SDS) number 7838. Revision date: 10/26/2018, page 14.

Available on: [www.hess.com/docs/default-source/us-safety-data-sheets/natural-gas-condensate-\(sour\).pdf?sfvrsn=4](http://www.hess.com/docs/default-source/us-safety-data-sheets/natural-gas-condensate-(sour).pdf?sfvrsn=4)

Knowledge of energies. Qu'appelle-t-on les condensats de gaz naturel? 9 July 2015. Available on: www.connaissancedesenergies.org/quappelle-t-les-condensats-de-gaz-naturel-150709

Pahl, J. W., I Irving, A. Mendelssohn et al. Recovery of a Louisiana Coastal Marsh 3 Years After *In Situ* Burning of a Hydrocarbon Product Spill. IN: *International Oil Spill Conference Proceedings 1 March 1999*. 1999, Volume 1, pages 1,279-1,282.

Available on: doi.org/10.7901/2169-3358-1999-1-1279.

Penland S., S. Thompson, Milanese A. et al.

Assessment and Restoration of a Condensate Spill in the Atchafalaya Basin, Louisiana. IN: *International Oil Spill Conference Proceedings 1 March 1999*. 1999 Volume 1, pages 613-618.

Available on: doi.org/10.7901/2169-3358-1999-1-613

Phillips 66. Crude Condensate. Safety data sheet (SDS) number 817925. Issue date 28 February 2019 Available on: w3apps.phillips66.com/NetMSDS/ViewPDF.aspx?fileName=817925&Language=BE&issueDate=2%2f28%2f2019&SubFormat=ASDS

Phillips 66. Natural Gas Condensate. Safety data sheet (SDS) number 817906. Issue date 4 April 2019 Available on: w3apps.phillips66.com/NetMSDS/ViewPDF.aspx?fileName=817906&Language=BE&issueDate=4%2f4%2f2019&SubFormat=EUDS

Total. Safety data sheet CONDENSATES, SDS number ATOF-051. Date of revision 2013-20-10. Version 13.1: page 17.

Total. Safety data sheet Akpo CONDENSATE, SDS number 081525. Date of revision 2013-01-22. Version 3.0: page 21.

Zitko, V., L.E. Burridge, Woodside M. et al. Low contamination of fish by hydrocarbon from the Uniacke G-72 (Shell Oil, Vinland) Wellsite Blowout in February 1984. 1984, page 43. (Canadian Technical Report of Fisheries and Aquatic Sciences, number 1305)

E.5 Content of Figures

Figure 0. Petroleum hydrocarbons produced in Italy.

Figure 1. Example of the main chemico-physical properties of condensates.

Figure 2. Positioning of condensates on the raw and refined petroleum product spectrum studied at Cedre.

Figure 3. Simplified chemical composition of the condensates studied.

Figure 4. Distillation curves of the condensates studied.

Figure 5. Illustration of the compositional diversity of some condensates studied at Cedre.

Figure 6. Typical chemico-physical data on condensates.

Figure 7. Main condensate designations.

Figure 8. Flammability data.

Figure 9. Definition of classes of flammability (source: Ineris).

Figure 10. Flashpoints of some condensates studied at Cedre and their distillation residues.

Figure 11. Ecotoxicological data for the Akpo condensate.

Figure 12. Relationship between condensate density at 20°C and their maximum rate of evaporation at sea.

Figure 13. Maximum asphaltene levels in condensates after ageing at sea and viscosity of emulsions formed in the laboratory.

Figure 14. Change in density and viscosity of the Akpo condensate during the Polludrome® test.

Figure 15. Monoaromatic compound levels in the condensates studied compared to a light Arabic crude oil, Al Khalij crude.

Figure 16. Modelling parameters.

Figure 17. Material report of the "deep spill" scenario.

Figure 18. Changes in the size of the surface of the condensate slick for the "deep spill" scenario.

Figure 19. Material report of the "surface condensate spill" scenario.

Figure 20. Changes in the size of the slick surface for the "surface condensate spill" scenario.

Figure 21. Evolution of dispersibility of the Handil condensate.



Appendix

Chemical products: classification, labelling and packaging EU classification according to EC Regulation no. 1272/2008 (Total SDS)

Hazard categories

- Flammable liquids - Category 1.
- Aspiration hazard - Category 1.
- Skin corrosion/skin irritation - Category 2.
- Specific toxicity to certain target organs - single exposure - Category 3.
- Germ cell mutagenicity - Category 1B.
- Carcinogenicity - Category 1B.
- Reproductive toxicity - Category 2.
- Specific toxicity to certain target organs (repeated exposure) - Category 2.
- Aquatic environment hazard, long-term - Category 2.

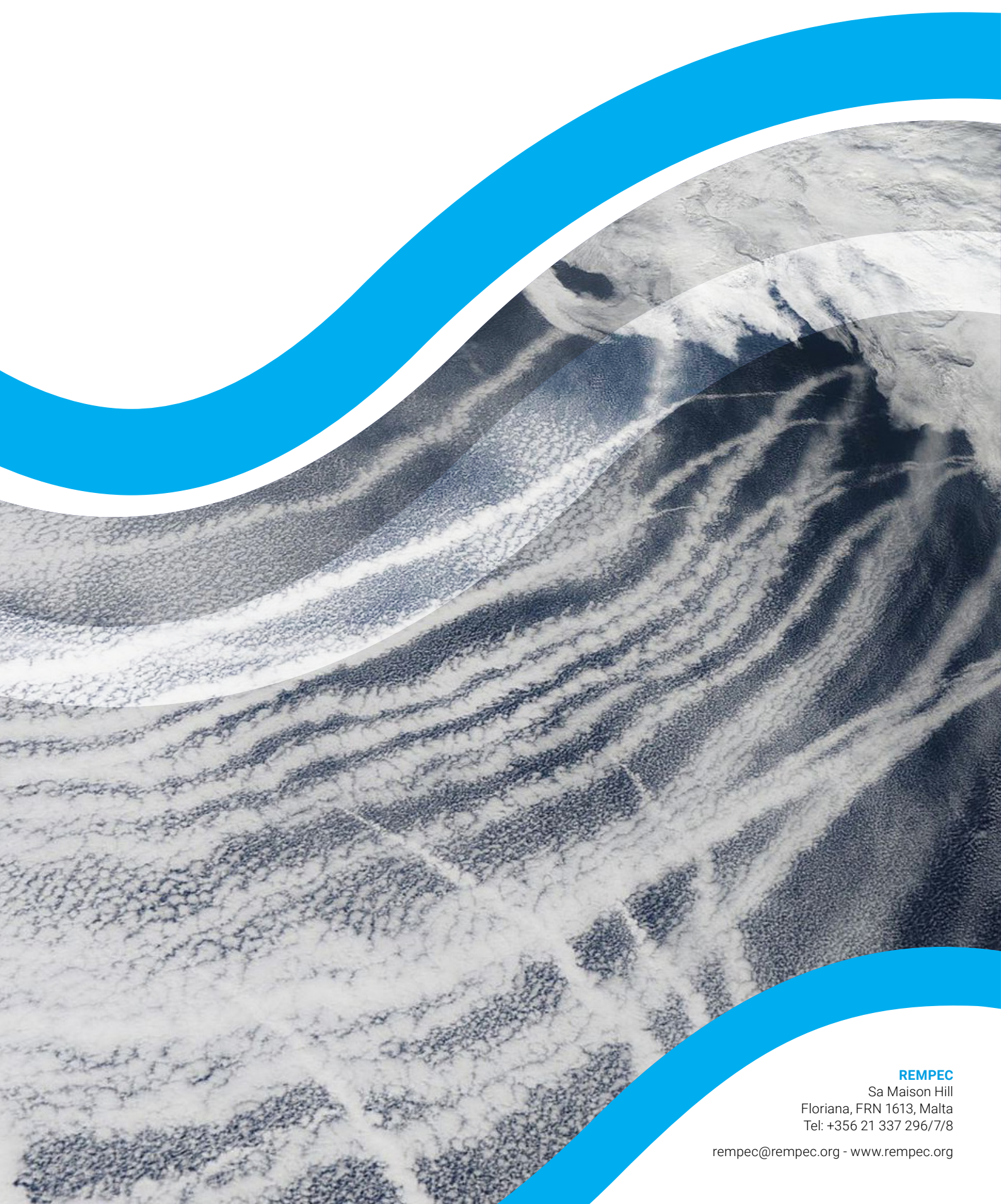
H grade "hazards"

- H224 - extremely flammable liquid and vapours.
- H304 - may be fatal if ingested and with respiratory tract penetration.
- H315 - causes skin irritation.
- H336 - may cause drowsiness or dizziness.
- H340 - may induce genetic abnormalities.
- H350 - may cause cancer.

- H361 - may harm fertility or the foetus.
- H373 - presumed risk of serious effects on organs after repeated exposure or a prolonged exposure through contact with the skin.
- H411 - toxic to aquatic organisms, causes long-term adverse effects.

P grades "prudence/prevention"

- P201 - Obtain instructions before use.
- P210 - Keep away from heat/sparks/open flames/hot surfaces. Do not smoke nearby.
- P243 - Take specific measures against electrostatic discharge.
- P260 - Do not breathe in dust/ fumes/gases/mists/ vapours/aerosols.
- P273 - Avoid discharge in the environment.
- P280 - Wear protective gloves/ protective clothing/ eye or face protection equipment.
- P301/310 - IN CASE OF CONTACT WITH SKIN (or hair): Remove contaminated clothing immediately; rinse skin with water or shower.
- P309/311 - IN CASE OF EXPOSURE OR DISCOMFORT: Call a poison control centre or a doctor.
- P403/235 - Store in a well-ventilated environment. Keep cool.



REMPEC

Sa Maison Hill
Floriana, FRN 1613, Malta
Tel: +356 21 337 296/7/8

rempec@rempec.org - www.rempec.org