European Commission

JRC SCIENTIFIC INFORMATION SYSTEMS AND DATABASES REPORT

Introduction to eNATECH

A user guide

Necci A., Krausmann E.

2022

Joint Research Centre

EU Science Hub
https://ec.europa.eu/jrc

JRC130281

PDF ISBN 978-92-76-55144-7 doi:10.2760/88277

Luxembourg: Publications Office of the European Union, 2022

How to cite this report: A. Necci, E. Krausmann, Introduction to eNATECH – A user guide, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/88277, JRC130281.

Contents

Acknowledgements

The authors are grateful to the Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO) which funded the preparation of this user guide in the frame of Administrative Arrangement "Enhancing the monitoring, early warning and analytic capacities of the Emergency Response Coordination Centre (ERCC) – 2021/2022".

The authors also acknowledge their former colleague Dr. Serkan Girgin, now at the University of Twente, who during his stay at the JRC developed the original design of the eNATECH database and implemented it.

Authors

Necci Amos

Elisabeth Krausmann

Abstract

The impact of natural hazards on industrial plants that contain hazardous substances can cause fires, explosions, and toxic or radioactive releases. Despite a growing body of research and more stringent regulations for the design and operation of industrial installations, these so-called Natech accidents remain a threat. The collection and analysis of accident and near miss data is crucial for learning lessons to prevent future Natech accidents and to better mitigate their consequences.

The quality of Natech accident data in general industrial accident databases is not uniform and frequently lacks the necessary details which renders their use for meaningful lesson learned studies difficult. In response, the European Commission Joint Research Centre has developed a dedicated Natech accident database called eNATECH which reflects the advanced accident representation needed to capture the characteristics of Natech events.

Access to the eNATECH database is public and free, and registered users can introduce their own accident data to increase the pool of information available for Natech forensic analysis. This document explains the philosophy behind the eNATECH data structure and provides short tutorials based on real accident cases to guide users in browsing the database and in introducing their own accident or near miss data.

1 Introduction

The impact of natural hazards on industrial plants, pipelines, offshore platforms and other infrastructure that handles, stores or transports hazardous substances can cause secondary effects such as fires, explosions, and toxic or radioactive releases. These so-called Natech accidents are a recurring but often overlooked feature in many natural disasters and have often had significant human, environmental and economic impacts (Krausmann et al., 2017). Successfully controlling Natech risk is a challenge, which requires targeted prevention, preparedness and response. Systematic analysis of the Natech risk, based on a strong understanding of the impact and damage mechanisms, is a prerequisite for this purpose (Krausmann and Baranzini, 2012).

Despite a growing body of research and more stringent regulations for the design and operation of industrial activities, Natech accidents remain a threat. This is partly due to the absence of accident data which impacts the development of dedicated risk reduction measures and the development of scenarios for risk analysis. The collection and analysis of accident data is crucial for identifying the causes, dynamics and consequences of past accidents, including the circumstances that facilitated their occurrence. Examples of past Natech accident analyses using data from various industrial accident databases are Ricci et al. (2021) for Natech accidents from all reported natural hazards, Misuri et al. (2019) for Natech accidents due to Hurricane Harvey, Necci et al. (2018, 2019) for storm impacts on onshore hazardous sites, as well on offshore infrastructure, Girgin and Krausmann (2016) for onshore pipeline Natech events, Krausmann et al. (2011) for Natech accidents due to earthquakes, floods and lightning. The lessons learned from such accident analyses can be used to prevent future Natech accidents or to better mitigate their consequences. In fact, one of the reasons that accidents keep occurring is that lessons from past events have not been learned (Krausmann and Necci, 2021).

Learning lessons requires the systematic collection and analysis of past accident data, including near misses. The usefulness of the analyses is strongly dependent on the quality of the underlying data. General accident data has been retrieved from industrial accident databases but the quality of the Natech accident data is not uniform and often lacks the necessary details for proper analysis (e.g., natural hazard information, such as flood height or wind speed at the location of the hazardous installation or site). Moreover, natural hazards can cause multiple and simultaneous Natech accidents which is also not reflected in conventional industrial accident databases. For this reason, the European Commission Joint Research Centre (JRC) has developed the eNATECH system, a free online platform that hosts a database of Natech accidents and near misses, and that reflects the advanced accident representation needed to fully capture the characteristics of Natech events (e.g., multiple accident sequences occurring in parallel or sequentially).

The aim of eNATECH is to systematically collect worldwide Natech accident data and to provide a medium for searching and analysing Natech accident reports for lessons learning purposes. This document explains the philosophy behind the eNATECH data structure and provides short tutorials based on real accident cases to guide users in browsing the database and in introducing their own accident or near miss data.

2 eNATECH

eNATECH is an online, collaborative system for the analysis of past accidents and near misses that occurred at industrial plants due to natural hazard impacts. The system has been operational since 2012 and is publicly available at https://enatech.jrc.ec.europa.eu. The primary aim of eNATECH is the systematic and structured collection of data on Natech accidents and near misses that occurred worldwide, and to allow the searching and analysis of Natech accident reports. The database is oriented toward supporting lessons learned studies. For this reason, the JRC aims to ensure that the quality of each record is as high and detailed as possible.

The eNATECH database contains four types of records: *Natural Hazards*, *Natech Accidents*, *Sites*, and their associated *Attachments*.

Natural Hazard records contain information regarding the natural event that triggered the Natech accident; *Sites* records provide information on the industrial site where the accident occurred, and *Natech Accidents* contains the description of the accident and its dynamics and consequences. Each record type is described in detail in Chapter 5.

All registered users can introduce data in eNATECH. In order to preserve confidentiality (if so desired by the user), eNATECH supports data access restrictions for critical information, such as industrial plant data. User registration is needed for data entry, and every record is checked by the system administrators before being published.

2.1 User Interface

eNATECH features a mobile-friendly, responsive user interface. The home page is illustrated in Figure 1. The home page includes a standard menu at the top with quick access links for signing in, logging out of EU Login ("ECAS Logout"), as well as legal notice and privacy statements. This menu is permanent, i.e., it is displayed on all pages of the system. While eNATECH is in principle set up to allow multiple interface languages, only English is supported currently.

Remark. Default language
eNATECH is a collaborative system, which aims to collect and share knowledge on Natech accidents. For this purpose, it is good practice to enter and share non-confidential data in English, so that it can be easily understood by a larger audience.

At the top right of the home page a series of icons are available, each of which is clickable and allows access to the listing pages of the different records provided in the system. These are: *Natural Hazards*, *Natech Accidents* and *Sites*. Below the icons, a table lists the most recent Natech accidents sorted in chronological order. For each event, the table indicates the triggering natural hazard type and name, date and country of accident occurrence, the industrial site of the accident and the record status (draft, final or published). Users can click on a record in the table for quick access. At the page bottom some recent scientific articles are shown.

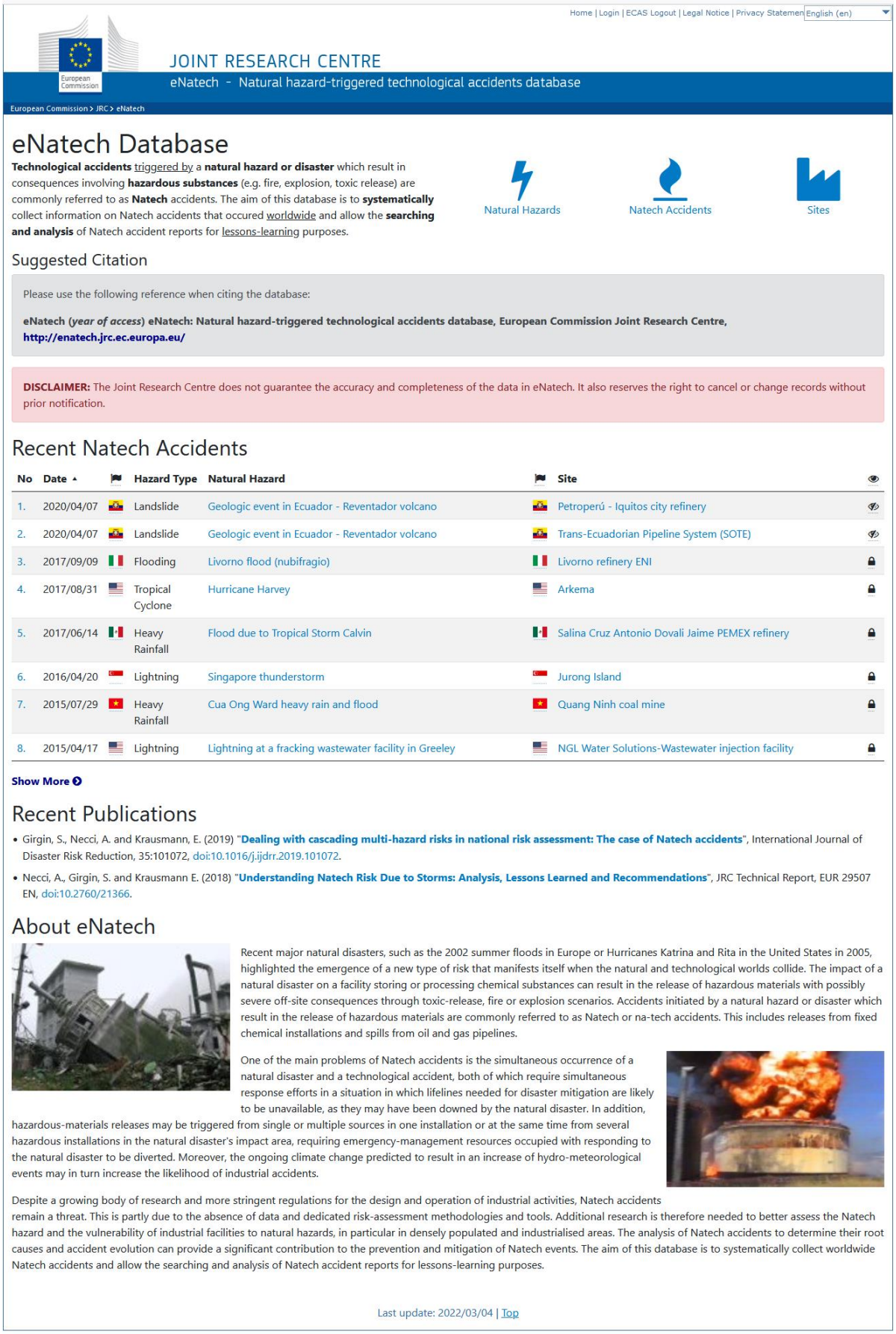
2.2 User Access

It is not necessary to sign in to the system to access information that is public. However, signing in allows you to create your own records. Therefore, signing in is highly recommended to be able to use all available features of the system.

Users can sign in to the system by clicking on the "Login" link in the top menu. Once you click the link, you will be forwarded to the European Commission's user authentication service known as "EU Login". If you already have a EU Login account, you can use your existing account to login to eNATECH. Otherwise, you can create an account by clicking the "Create an account" link on the EU Login page and following the instructions. Once you complete the sign-in process through EU Login, you will be redirected to eNATECH.

Remark. EU Login
If you already signed in to EU Login before using eNATECH, then EU Login will not display the login screen, but will immediately redirect you to eNATECH by using your active user account. If you have multiple EU Login accounts (i.e., work-related and personal) and want to use a specific one for eNATECH, first make sure that you have signed out from your EU Login accounts. Otherwise, EU Login may redirect you to eNATECH automatically as indicated above, without allowing you to change the account. You can use the "ECAS Logout" link on the top menu of eNATECH to access the EU Login sign-out page.

Figure 1. Home page of eNATECH.



The first time you sign in to eNATECH, the system will display a registration form when EU Login redirects you back to the system. This is the eNATECH registration form. By filling in the form with your information, agreeing to the terms and conditions, and clicking the "Update" button, you can complete your registration. After registration and also after all successive logins, your personal page will be displayed which shows your user information and icons for accessing record listing pages similar to the home page. You can modify your personal information at any time by clicking on the "Update" button, which leads to the user data entry form.

Remark. Personal information
Your name, surname, and e-mail address are provided automatically by EU Login to the eNATECH registration form. Therefore, if you need to modify this information you should use EU Login account settings. They cannot be changed in eNATECH. Your account password is also controlled by EU Login and should be changed through EU Login, if necessary.

2.3 Data Access Types

Some records available in eNATECH are publicly available to all while access to other records may be restricted to their creator only. eNATECH features a two-level access control for most of the record types, which includes the types **Public** and **Confidential**. **Public** records are available to all users, including the ones who did not sign in, i.e., visitors. **Confidential** records are only accessible to the users who created these records, i.e., the owners. The **Confidential** access level provides confidentiality for records with information possibly considered as sensitive or which may be protected by copyright, such as *Sites* and *Attachments*. Such records can be protected by using this state. Public and confidential records can only be deleted by their owners. System administrators can access all records to be able to fulfil their quality control responsibility. In some cases, administrators may delete a record if it is inaccurate, misleading, offensive, discriminatory, or if it could damage the image of the JRC or of the European Commission.

2.4 Data Status

The data status allows to identify records that are still incomplete (i.e., for which work is in progress) and those that are finalised. eNATECH has a three-level status control for most of the record types, which are **Draft**, **Final** and **Published**.

Information in **Draft** records is only accessible to the users who created these records, i.e., the owners. This is the default state while creating new records. The system shows that a **Draft** record exists to all users, but it will not disclose its full information. In this state, the data are assumed to be incomplete and the record can still be edited by its creator. Once the users have completed data entry and are ready to share their data, they can set the data status as **Final**.

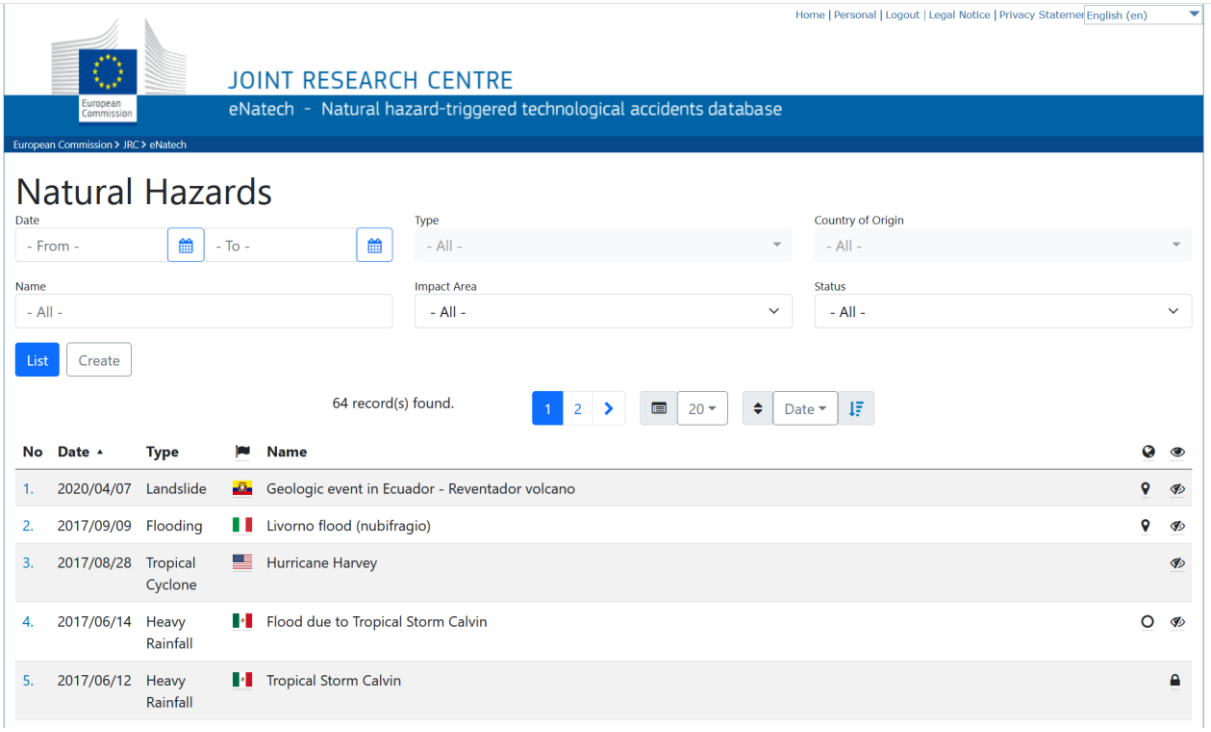
Setting the record status as **Final** means that the creator has completed working on the record and wants to share its content with the other eNATECH users. Setting a record to **Final** tells the system administrators that the record is ready for publication. Note that a record in **Final** state cannot be modified any further by its creator. Users that wish to change their final content should contact the database administrators at EU-ENATECH@ec.europa.eu and ask them to change the record status back to **Draft**. Once a record is set to **Final**, the system administrators will examine the record to check that the information provided is correct and legitimate. If the administrators have successfully verified the content, they will set the record access to **Published**.

In the state **Published**, a record is visible and its information is available in full to all users (logged or otherwise) that access eNATECH. The record in **Published** state cannot be modified by its creator. Users themselves are not allowed to set the data status of their records as **Published**, only system administrators can do so. Users that wish to change their published content should contact the administrators at EU-ENATECH@ec.europa.eu and ask them to change the record data status back to **Draft**.

3 Data Query and Listing

By clicking on the icons on the home page you can access the listing pages of the related record types. Although each listing page displays information on different record types, they have a common interface which is composed of filters, action buttons, a navigation bar, and a records table. An example listing page is given in Figure 2.

Figure 2. Example records listing page: Natural Hazard list.



By default, the listing pages list all records available in the system which are accessible by the active user. Specific records can be searched by using the available filters. Multiple filters can be entered at the same time. The system applies the logical *AND* operator to combine the filters; hence, entering multiple filters results in a more restricted query, usually yielding a lower number of matching records.

In order to perform the query, click on the "List" button after setting the filters. Pressing the "Enter" key on the keyboard while typing on a textual filter also automatically triggers the query action. Depending on user rights, a "Create" button might also be displayed next to the "List" button, which leads to the data entry form of the related record type.

eNATECH features 3 types of generic filters: **textual**, **drop-down list**, and **date**.

Textual filters allow free-text search by using keywords which can be further customized by using special characters and keyword groups. By default, keywords entered in the textual filters are searched as a whole in the related data fields of the records. For example, performing a search by entering the keyword `degree` into the "Name" filter on the "Units" listing page will return 4 matching records, which are "degree", "degree Celsius", "degree Fahrenheit", and "degree Rankine". However, the same query with the keyword `deg` will return no results, as there are no units in the database which include "deg" as a whole in the name field.

In order to extend the search to partial words, the asterisk (`*`) character can be utilized at the beginning and/or at the end of the keyword. The asterisk is regarded as a placeholder for zero or more characters, and therefore indicates "starting with", "ending with", or "including" criteria, if located at the beginning, at the end, or at both sides of a keyword, respectively. For example, a query with `deg*` will return the initial 4 matching records, as all records including the word "degree" also contain a word starting with "deg".

Multiple keywords separated by one or more space characters are combined with the logical *OR* operator. Therefore, a query with `deg* percent` keywords will return 8 records, which include 4 additional records containing the word "percent": "percent", "percent by volume", "percent by weight", and "percent standard gravity".

Keyword groups that are composed of multiple keywords can be entered using quotation marks to prevent evaluation as individual keywords. For example, the query with `deg* cel*` will return 4 degree records matched by the `deg*` keyword, as the second keyword `cel*` does not match any other unit. But, the same query with the `"deg* cel*"` keyword group will return only one record which is "degree Celsius", as "degree" matches the `deg*` keyword and "Celsius" matches the `cel*` keyword of the keyword group.

Remark. Order of the keywords

The order of the keywords in a keyword group is important and affects how the keywords are searched. For example, `"deg* cel*"` and `"cel* deg*"` are not identical.

In order to exclude a keyword or keyword group, the minus (`-`) character can be utilised at the beginning of the keyword or keyword group. For example, `deg* -cel*` will return 3 records, i.e., all degree records, except "degree Celsius" because "Celsius" matches the `cel*` keyword which is excluded.

By entering multiple keywords or keyword groups and utilising special characters, advanced queries can be performed easily by using the textual filters.

Remark. Textual filters

Textual filters are case insensitive, i.e., lower case and upper case characters are considered to be identical, unless the related data field of the record is case sensitive. For example, the `degree` and `DEGREE` keywords return the same results.

Drop-down filters match the records which have the same value in the related data field as the value selected in the drop-down filter. Usually drop-down filters correspond to the drop-down list input elements of the records and include the options presented by these input elements.

Date filters match the records with the specified date value in the related date field (see Section 4.1.1 for more details on the date fields). There are two filters that allow users to select a date range, or just display all records that are before or after a certain date.

The records matching the filters, if any, are listed on the listing pages in a tabular format. Each row in the table corresponds to a separate record. Because some queries may match a very large number of records, the results are tabulated through pagination, i.e., a limited number of records is tabulated based on the active page number and the number of rows per page (Figure 2).

Above the results table, a navigation bar is provided which includes tools to navigate through the results and modify how the results are listed. The first item on the navigation bar is an indicator, which displays the total number of records in the results set. Next to the indicator, a pagination element is provided which shows the active page and allows navigation through the other results pages.

Hint. Rows per page

The default number of rows per page is 20, which can be changed with the "Rows Per Page" drop-down list next to the pagination element. Setting a new number of rows per page does not reset the current starting row number.

Normally, results are tabulated as sorted by the default sorting column of the results table, which depends on the record type. The sorting column can be changed by clicking on the arrow symbol on top of the column. The direction of sorting (i.e., ascending or descending) can be specified by clicking again on the column, which toggles the sorting direction between the ascending and descending orders. The active sorting column is indicated by a triangle next to the column name, which points up or down for ascending or descending order, respectively.

Hint. Local sorting

The sorting settings affect not only the results visible on the active page, but also on all other pages related to the search, i.e., all results matching the query are sorted accordingly. By clicking the table column labels, you can also sort the results in the current page locally. Similar to the normal sorting, the sorted column is indicated with a triangle. Successive clicks on the same label change the sort direction. Local sorting is not permanent, i.e., the sorting column and direction will reset to the defaults specified in the sorting settings if the active page is changed or refreshed.

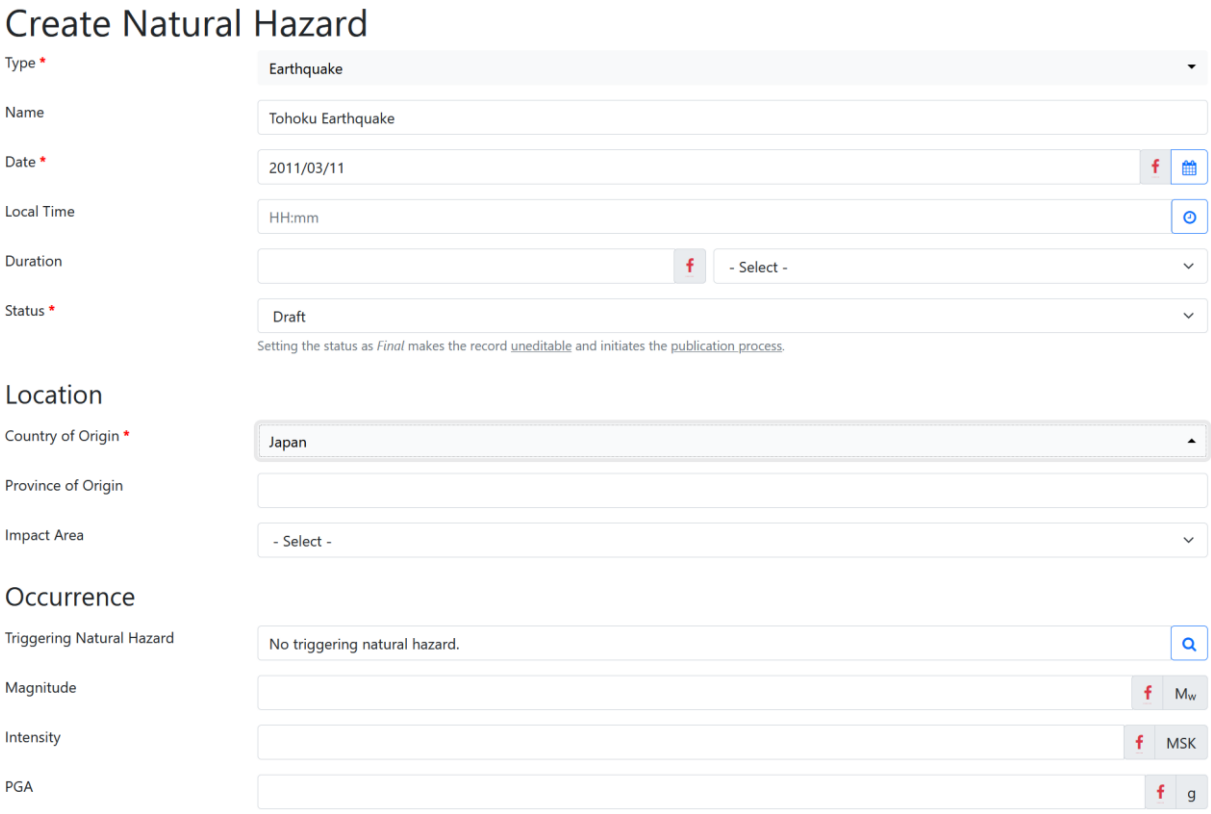
4 Data Entry

Data entry to the system is implemented using interactive data forms. Once signed in, you can access the record-specific data entry forms by clicking the "Create" button displayed on the record listing pages. Create buttons are also displayed for specific record types on the information pages of the related records. For example, the Natech Accident listing page displays a "Create" button for the Natech Accident record type, which leads to the Natech Accident data entry form.

Remark. Display of the "Create" buttons
"Create" buttons are only displayed if the user has the right to create an associated record. This means that the user has to be registered.

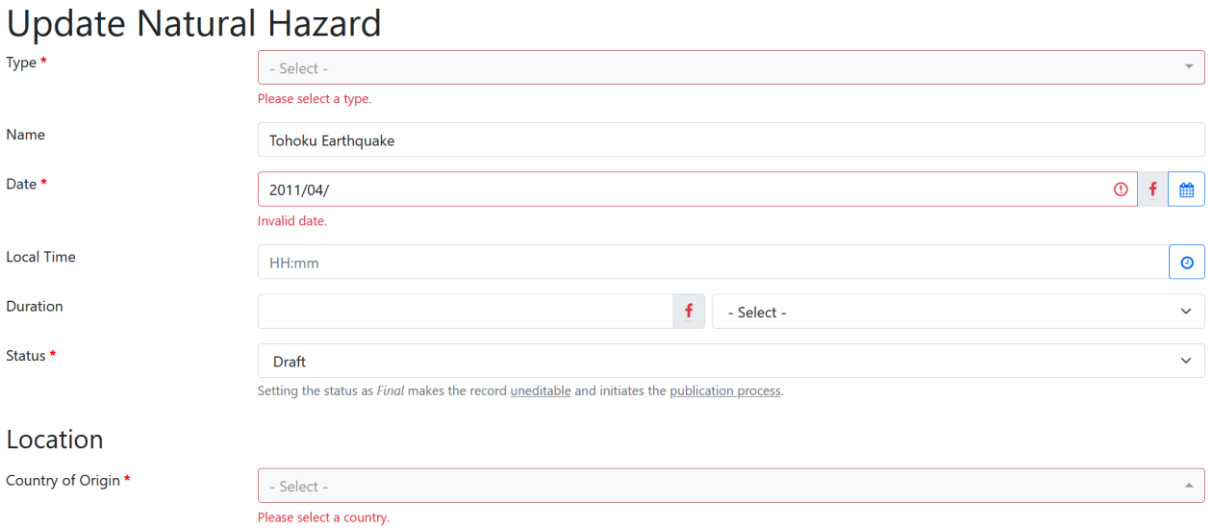
The data entry forms include mobile-friendly and responsive input elements, such as text fields, drop-down lists, and check boxes, which are common to web-based applications. There are also some enhanced input elements, such as fuzzy number fields (indicated by f), wiki editors, calendars, and input lists. The forms are dynamic, i.e., some of the input elements are shown or hidden according to the values of others. Input elements that must not be left empty (i.e., which are mandatory) are indicated by an asterisk (*) in their labels. Textual input elements are generally restricted to the entry of specific types of data, such as numbers, dates, or coordinates. Usually, such elements are indicated with special icons (e.g., f) appended to the input elements. An example data entry form illustrating different input elements is shown in Figure 3.

Figure 3. Example data entry form.



Form data is validated on the client-side before submission of the data to the server for processing. If empty or invalid input data are found, the related input elements are highlighted and error messages are displayed to indicate the identified errors (Figure 4). Form submission is not possible until all invalid inputs are corrected. After the submission, form data is also validated on the server side to prevent unauthorised actions and to perform additional validation which is not possible on the client-side. If all data is found to be valid, it is processed and the associated action is performed (e.g., the record is created or updated). Otherwise, the form is re-displayed with the entered data, and invalid input elements are indicated for correction as illustrated in Figure 4.

Figure 4. Example data entry form with invalid input data.



Input elements which are either specific to eNATECH or have some additional features not commonly found are as follows:

4.1.1 Date Input

Date input provides a calendar window from which you can choose the date easily. In order to display the calendar window, click the "Calendar" icon next to the input element. By default, the date format (i.e., YYYY/MM/DD, DD/MM/YYYY, MM/DD/YYYY) which is used to enter and visualise the dates depends on the language of the system.

Remark. Default time zone
Dates should be in entered in the Coordinated Universal Time (UTC) to prevent possible confusion among the records due to location-specific time zones.

4.1.2 Combo Box Input

Combo box input is a combination of a text input and a drop-down list, which allows the selection of existing values instead of re-typing manually. By clicking the button next to the input element, text input or drop-down list modes can be toggled.

Remark. Combo boxes
Because they allow standardisation of data values, the use of existing values through the drop-down list is good practice for combo box inputs.

5 Record Types

5.1 Natural Hazards

The *Natural Hazards* record type included in eNATECH contains information related to past natural events that triggered one or more Natech accidents. There are several sections with different headers for a Natural Hazard record (see Figure 5). The first section has no header and regards generic information, such as the type of natural hazard and the data status. The first header is *Location* where information about the natural event's geographic location is contained. Another header is *Occurrence* where additional details about the natural hazard are provided, including the possibility to link the current Natural Hazard record with a triggering Natural Hazard record. This is meant to connect two Natural Hazard records where one is the product of the other in a cascade of events (e.g., a tsunami triggered by an earthquake or a flood triggered by a storm). The last section describes the *Consequences* where the natural hazard impact is quantified in terms of losses, deaths and the level of emergency response capability required to cope with the event.

Natural Hazard records are always public.

Figure 5. Example Natural Hazard record.

Natural Hazard Draft

DISCLAIMER: The Joint Research Centre does not guarantee the accuracy and completeness of the data in eNatech. It also reserves the right to cancel or change records without prior notification.

Type	Tropical Cyclone
Name	Hurricane Harvey
Date	2017/08/28
Status	Draft

Location

Country of Origin	United States

Occurrence

Category	IV
Max. wind speed	215km/h km/h
Description of the Occurrence	Hurricane Harvey was the first major hurricane to make landfall in the United States since 2005. In a four-day period, many areas received more than 40 inches (1,000 mm) of rain as the system meandered over eastern Texas and adjacent waters, causing catastrophic flooding. With peak accumulations of 51.88 in (1,318 mm), Harvey is the wettest tropical cyclone on record in the contiguous United States.

Consequences

Level of Emergency Response	National
Population Affected	> 100,000
Casualties	10 - 100
Economic Losses	> 100 M USD
Description of the Consequences	The resulting floods inundated hundreds of thousands of homes, displaced more than 30,000 people, and prompted more than 17,000 rescues. Throughout Texas, more than 300,000 people were left without electricity. Harvey has caused at least 51 confirmed deaths; 1 in Guyana, and 50 in the United States. Catastrophic inland flooding occurred mainly in the Greater Houston metropolitan area. FEMA director Brock Long called Harvey the worst disaster in Texas history and expected the recovery to take many years. Economic losses are preliminarily estimated at between $70 to $190 billion, with a large portion of the losses sustained by uninsured homeowners. Texas Department of Public Safety stated more than 185,000 homes were damaged and 9,000 destroyed.

Attachments can be added to every Natural Hazard record to provide supporting information, such as newspaper articles, scientific articles, and data sets (see Section 5.4).

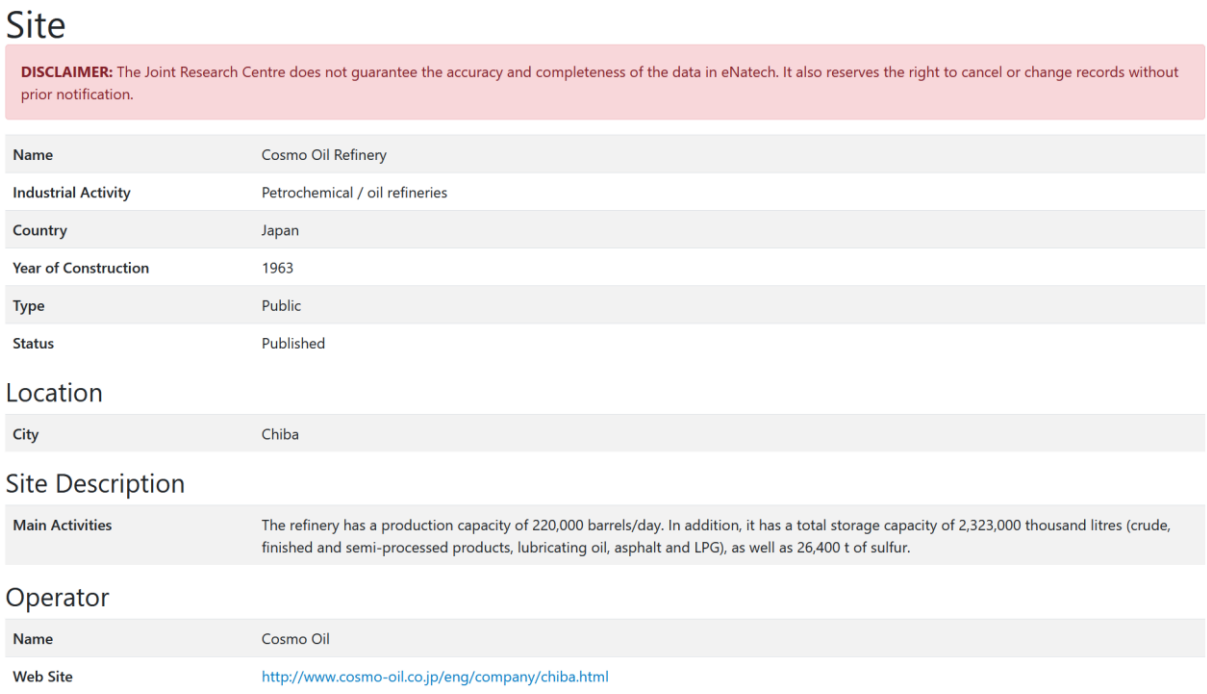
5.2 Sites

The *Sites* record type contains the data related to the industrial sites in which Natech accidents have occurred. There are several sections with different headers for a site record (see Figure 6). The first section has no header and regards generic information, such as the name and type of the industrial activity, as well as data access

type and data status. The first header is *Location* where information about the site's geographic location is contained. The second header is *Site Description* that contains details about the site's activities, and ideally about the natural hazards known to be present at the site. The last section is *Operator* and contains information about the company that operates the site.

Data access can be either Public or Confidential. This option helps to display information about the accident without sharing the identity of the company involved (only country and industrial activity type of the site are indicated if data access is chosen to be Confidential).

Figure 6. Example Site record.



Relevant attachments can be added to every Site record (see Section 5.4).

5.3 Natech Accidents

The *Natech Accident* record type contains information on the causes, dynamics, consequences of and response to Natech accidents. It also includes lessons learned available for a specific accident. The Natech Accident record is composed of a number of different sections. The first section (Figure 7) has no header and shows generic information, such as the record type and date, as well as data status. It also displays the natural hazard and site associated with the accident.

For every Natech Accident record, users **must** select a Natural Hazard record and a Site record that are associated to the Natech accident. In the Natech Accident record creation form, the associated natural hazard and site can either be chosen from a list of existing records or can be created from scratch. In the latter case, the newly created records will be selected automatically as Natural Hazard and Site records associated to the Natech Accident record under creation.

After the general accident information, additional data-entry sections follow, each containing information relevant for describing the accident in detail.

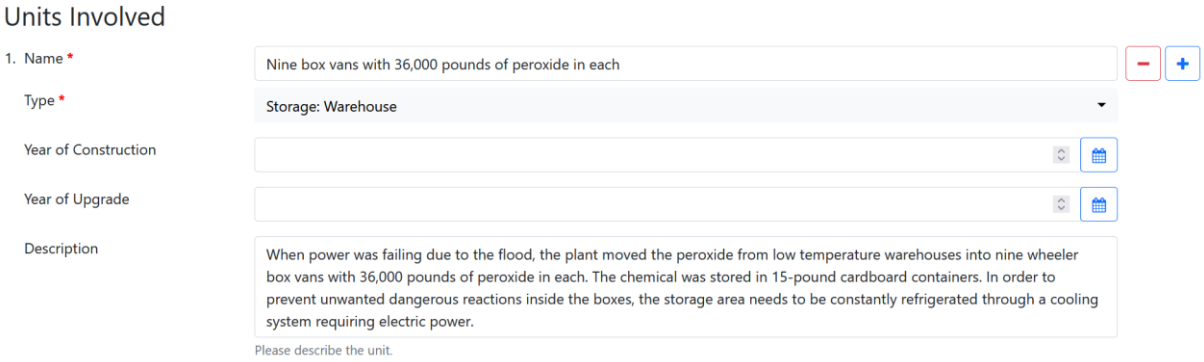
Data access to the Natech Accident record is always Public. However, depending on user preference, the Site information linked to the accident record may be public or can be kept confidential.

Figure 7. Example Natech Accident record.

5.3.1 Units Involved

In this section, users can add any unit that was involved in the Natech accident. One or more units can be added, and for each unit users can indicate the type of unit and its function (Figure 8). This feature allows users to account for multiple units involved in the Natech accident at the same time. This can occur either when units are damaged simultaneously or as a result of domino effect.

Figure 8. Example unit data entry.

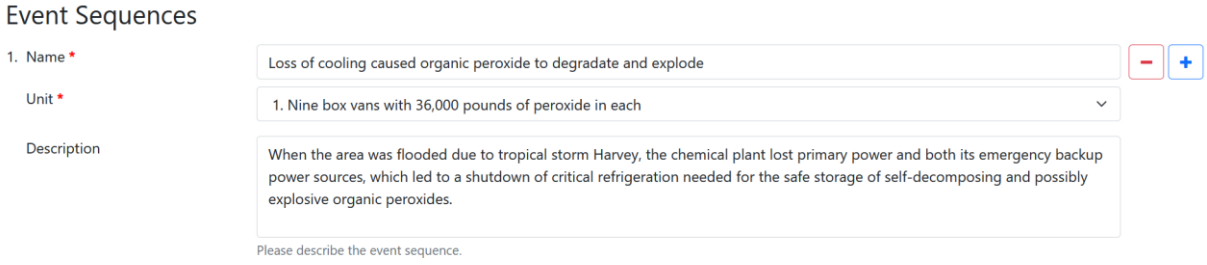


5.3.2 Event Sequence

This section is a unique feature of eNATECH. It collects information about the Natech accident in the form of an *Event Sequence* which consists of multiple *Events* that constitute the single fragments of accident information. Together, events tell the story of what happened during the accident. For each Natech Accident record, one or more event sequences can be indicated. Each event sequence is associated to a unit, and multiple event sequences may be associated to the same unit. Every event sequence has a name and contains a general description of what happened (Figure 9).

An event sequence can be the cause or the consequence of another event sequence (e.g., in case of domino effect). To represent this, each event sequence can be considered as an event in another event sequence (e.g., Event Sequence 1 can be the initiator of Event Sequence 2, etc.).

Figure 9. Example event sequence data entry.



5.3.2.1 *Events*

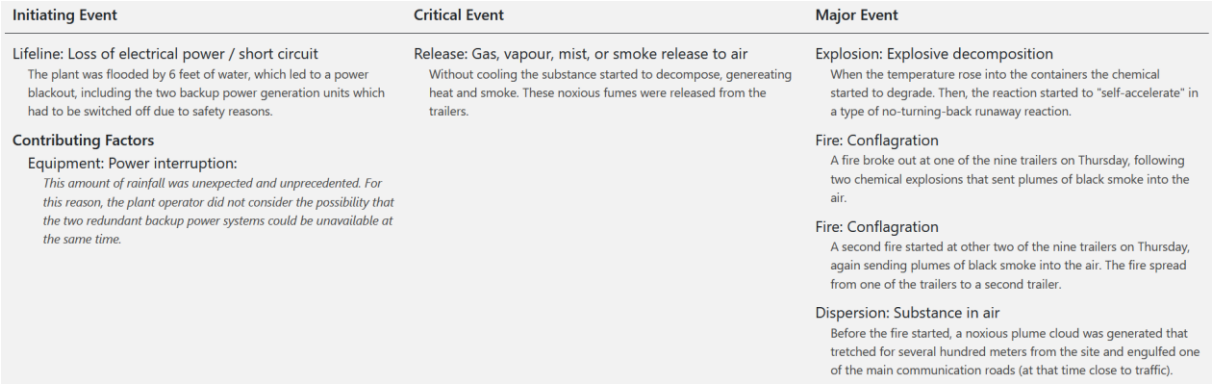
The structure of the event sequence resembles that of a bow-tie, in which *Events* are divided into three categories: **Initiating Event**, **Critical Event**, and **Major Event** (see an example in Figure 10).

Initiating Events designate all events that concern the direct or indirect consequences of natural hazard action that lead to equipment or facility damage and loss of containment of a hazardous substance. Initiating Events comprise, e.g., liquid sloshing, debris impact, tank shell buckling, loss of cooling.

Critical Events are events linked to loss of containment. Typically, there is one critical event per every event sequence, but there may be more in some cases. Critical Events include liquid release to ground, gas release to air, release due to overflow, liquid spill on roof, etc.

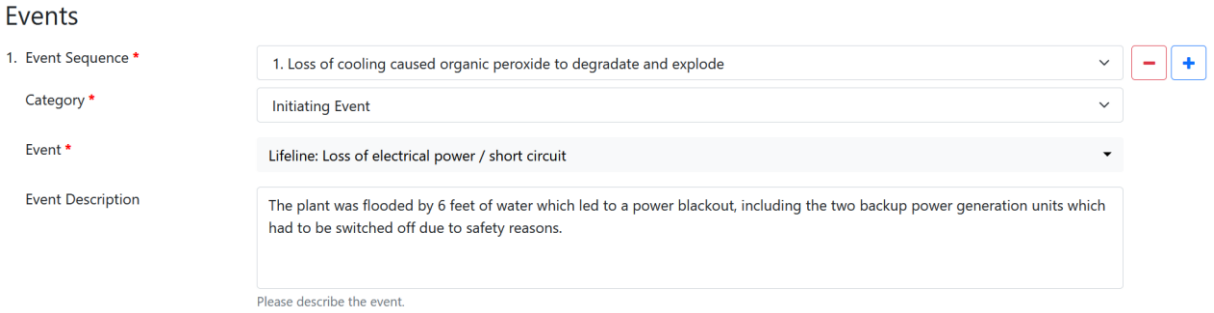
Major Events categorize the events that follow loss of containment and that lead to major consequences. Depending on the critical event and on the substance released, such events can be fires, explosions, and dispersion of hazardous substances in various media (e.g., land, water body, atmosphere).

Figure 10. Event categories: Initiating Event, Critical Event, Major Event.



Users can add any number of events to every event sequence in a Natech Accident record (e.g., the accident in Figure 10 features 4 major events). Users must select the relevant event sequence, the event category (Initiating, Critical or Major) and they must select the type of event from a list available through a drop-down menu. Then a free-text description of the event should be provided. All event types also include the option "Other" and "Unknown" if the user cannot find the event in the available options list or if the event type is not known. Figure 11 shows an example event data entry. The event types used for Initiating Event, Critical Event, and Major Event are shown in Table A1 in Annex 1.

Figure 11. Example data entry for events.



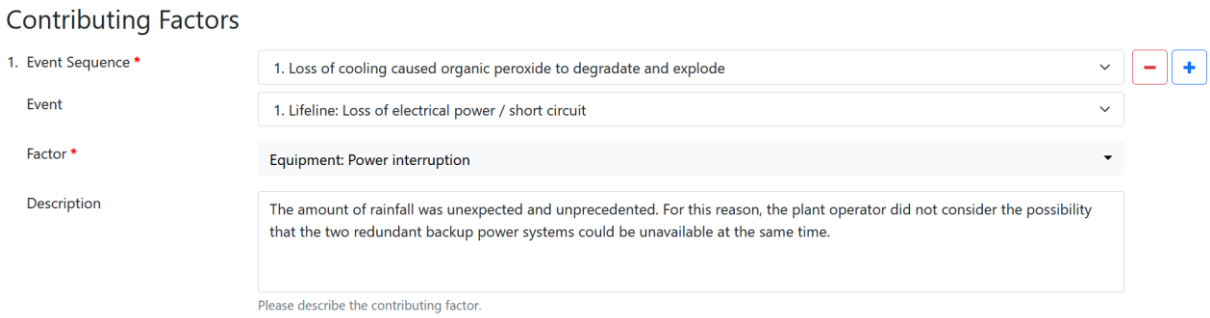
5.3.2.2 *Contributing Factors*

Contributing Factors describe events that are not part of the event itself, but contribute to the event occurrence. Examples of contributing factors are, e.g., absence of or inadequate safety measures, corrosion, operator error, or power loss. For some contributing factors, eNATECH allows users to add a status (Non-existent, Unavailable, Inadequate, Inappropriate, and Unclear*)* that specifies the reason why the selected factor contributed to the accident. An example of a contributing factor with a designated status is "Emergency water system" which can

be Unavailable or Inadequate. Other contributing factors do not need a status, e.g., "Loss of electrical power/short circuit". The availability of a status option depends on the phrasing of the contributing factor.

Users can add any number of contributing factors to every event. They must select the event sequence, the event and then the type of contributing factor from a list available through a drop-down menu. A free-text description of the contributing factor should also be provided. Figure 12 shows an example data entry for a contributing factor. The types of contributing factors used by eNATECH are listed in Table A2 in Annex 1.

Figure 12. Example data entry for contributing factors.

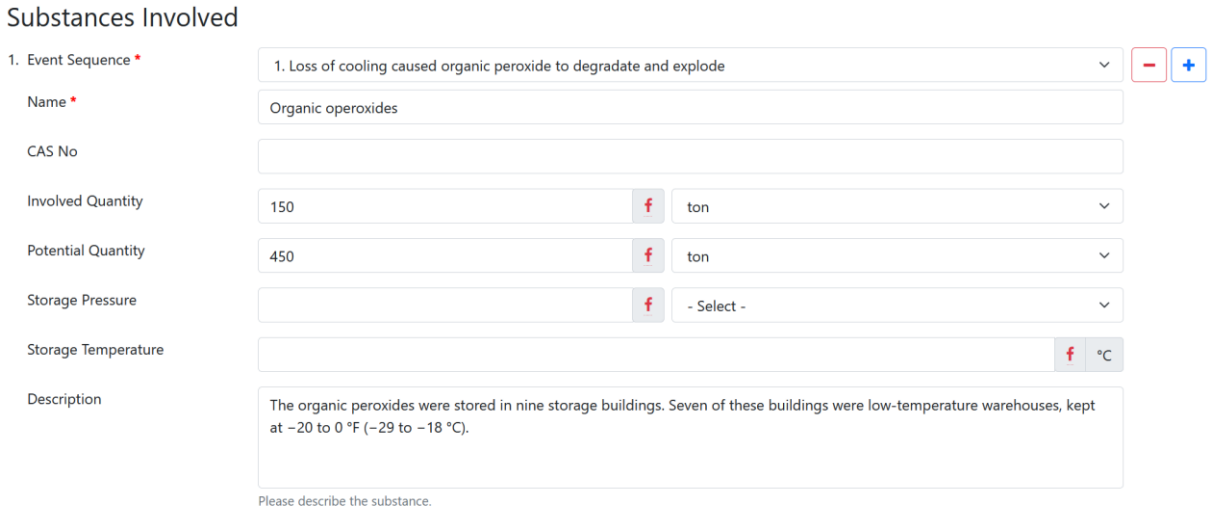


Remark. Events or contributing factors?
The system provides lists of types of events and contributing factors that are meant to guide the users. However, in some accidents the difference between contributing factor and event may not be obvious. In these cases, users should us their own judgement on how to encode the information in the respective Natech Accident record.

5.3.2.3 Substances Involved

In this section, users can add the hazardous substance(s) that is are involved in the Natech accident (Figure 13). Each substance added must be assigned to a single event sequence (and therefore to a unit) and its name must be indicated. The substance identifier, substance quantities (quantity involved in the accident and potential quantity available for release), storage conditions, as well as a free-text description can also be provided.

Figure 13. Example data entry for substances involved.



5.3.3 Weather Conditions

In this section, users can add information about the weather conditions at the time of the accident. Weather information includes type of precipitation (if any), wind speed, ambient temperature and humidity.

5.3.4 Emergency Response

This section in the Natech Accident record collects information about the emergency response to both the Natech accident and the triggering natural hazard. In the first part, the section includes a set of specific statements regarding emergency response for which the user can only select Yes or No, indicating the presence or absence of a given condition. This also includes statements related to response problems often observed during Natech accidents. The section continues with two checklists regarding details of the emergency response resources used and the implemented consequence mitigation strategies. Users can pick any number of items from both checklists. Furthermore, users are offered textboxes in which they can add additional details to explain or justify their selection.

5.3.5 Consequences

This record section contains information related to the consequences of the Natech accident, and it is aimed at the quantification of losses (deaths, injuries, economic losses, environmental impacts, etc.). Users can only enter a numerical value in the related fields. However, a further description of the consequences and losses can be provided in dedicated text fields. In addition, there are two checklists related to the environmental zones (e.g., freshwater, offshore) and types of built-up areas (e.g., industrial, residential, commercial) impacted by the accident. General information on experienced community disruption due to the accident can also be provided in this section.

5.3.6 Remedial Activities

This section collects information on remediation and restoration activities carried out after the Natech accident. The section is not guided like the previous sections and contains only three text boxes where users can describe actions taken related to decontamination, remediation and restoration activities, if applicable.

5.3.7 Lessons Learned

This section contains important insights – so-called lessons – from the Natech accident whose consideration can help to prevent such accidents in the future or to better mitigate their consequences. Although these lessons are specific to the accident described in this Natech Accident record, they may also be practically applied to other cases and other sites. This section provides information related to lessons identified with respect to equipment, human health, organizational aspects, mitigation measures and emergency response.

Like for Natural Hazard and Sites records, attachments can also be added to Natech Accident records (see Section 5.4).

An example of a full published Natech Accident record in eNATECH that features multiple event sequences, and initiating, critical and major events, is shown in Annex 2.

5.4 Attachments

The *Attachments* record type contains files that can be attached to every other record type as supporting documentation. However, attachments are also a record type on their own and as such can be queried and listed like any other record type. Attachments usually contain files that are the source of the information included in the Natural Hazard, Sites, and Natech Accident record, such as reports, journal articles, websites, data sets, etc. Figure 14 shows an example of an attachment record.

Data access can be either Public or Confidential. This is intended to protect the files and their owners. Some files may be confidential or they may require payment to get access (e.g., materials subject to copyright).

Figure 14. Example of an Attachment record.

Attachment

DISCLAIMER: The Joint Research Centre does not guarantee the accuracy and completeness of the data in eNatech. It also reserves the right to cancel or change records without prior notification.

Related Record Type	Natural Hazard
Related Record	Great Sichuan Earthquake, China, 2008
File	PDF Document (2.69MB)
Description	Krausmann, E. et al. "The impact of the 12 May 2008 Wenchuan earthquake on industrial facilities", Journal of Loss Prevention in the Process Industries, 23(2):242-248, 2010
Access Type	Confidential
Status	Published

References

Girgin, S., Krausmann, E. (2016) Historical analysis of U.S. onshore hazardous liquid pipeline accidents triggered by natural hazards, Journal of Loss Prevention in the Process Industries 40, 578-590.

Krausmann, E., Necci, A. (2021) Thinking the unthinkable: A perspective on Natech risks and Black Swans, Safety Science, 139, 105255.

Krausmann, E., Cruz, A.M., Salzano, E. (2017) Natech risk assessment and management – Reducing the risk of natural-hazard impact on hazardous installations, Elsevier, Amsterdam.

Krausmann, E., Baranzini, D. (2012) Natech risk reduction in the European Union, Journal of Risk Research, 15:8, 1027-1047, DOI: 10.1080/13669877.2012.666761

Krausmann, E., Renni, E., Campedel, M., Cozzani, V. (2011) Industrial accidents triggered by earthquakes, floods and lightning: lessons learned from a database analysis, Natural Hazards 59, 285-300.

Misuri, A., Moreno Casson, V., Quddus, N., Cozzani, V. (2019) Lessons learnt from the impact of hurricane Harvey on the chemical and process industry, Reliability Engineering & System Safety, 190, 106521.

Necci, A., Tarantola, S., Vamanu, B., Krausmann, E., Ponte, L. (2019) Lessons learned from offshore oil and gas incidents in the Arctic and other ice-prone seas, Ocean Engineering, 185, 12-26.

Necci, A., Girgin, S., Krausmann, E. (2018) Understanding Natech risk due to storms – Lessons learned and recommendations, EUR 29507 EN, European Union.

Ricci, F., Casson Moreno, V., Cozzani, V. (2021) A comprehensive analysis of the occurrence of Natech events in the process industry, Process Safety and Environmental Protection, 147, 703-713.

List of figures

List of tables

Annexes

Annex 1. eNATECH Events and Contributing Factor Classifications

Table A1. *Event* classification in use in eNATECH.

Event type	Events	Initiating	Critical	Major
Release	Gas, vapour, mist, or smoke release to air Gas release to water Liquid release to ground Liquid release to water body Liquid release to flood water Liquid release to groundwater Liquid spill on roof Solid release to ground Solid release to water Firewater runoff into ground Firewater runoff into water Release due to overflow Other Unknown		X	
Fire	Conflagration Pool fire Jet fire Vapour cloud fire/ flash fire Fireball Fire impingement on other equipment Fire spread Other Unknown			X
Explosion	Pressure burst BLEVE Rapid phase-transition explosion Runaway reaction explosion Dust explosion Explosive decomposition Vapour cloud explosion Physical explosion Detonation Deflagration			X

	Other Unknown			
Other	Other			X
Dispersion	Chemical in / on water Chemical in / on ground Chemical in air Combustion products in air Combustion products in / on water Combustion products in / on ground Rapid spread of oil or chemicals due to water flow Other Unknown			X
Natural Hazard	Liquid sloshing Sloshing of molten materials Sparking Exposure of pipelines / underground tanks Debris impact Floating off of storage tanks / equipment Floating oil in drainage systems due to inundation Rapid spread of oil and chemicals due to water flow Release due to overflow Hazardous reaction due to contact with water Sinking of floating roofs Foundation loss due to subsidence / soil liquefaction Heat radiation damage Fire impingement Over-pressurization Over-heating Ember flight due to wildfire (Self) Ignition due to high temperature Water intrusion Expansion due to high temperature Contraction due to low temperature Soil liquefaction	X		

	Water / mud inundation Wave slamming Wind pounding Other Unknown			
Component (Structural)	Complete collapse Partial collapse Collapse of support columns Damage to support columns Damage / deformation of tie-bars Buckling (tank shell, cylindrical shell, elephant foot) Bending of steel frame structure Overturning / toppling Inclining / tilting Dislodging / displacement Cracking / breaking Puncture Instrumentation damage or malfunction Sparking Unknown	X		
Component (Non-structural)	Insulation damage Roof damage Puncture Cracks in the welds of steel tanks Damage to rails, ladders, vents and other protruding parts Damage to emergency equipment Breaking / tearing of anchor bolts Dislodging / displacement Pipe break / damage Inclining / tilting Damage to flange connections Damage to pipe joints Damage to couplings between tanks and pipeline Damage to motors and pumps Unknown	X		

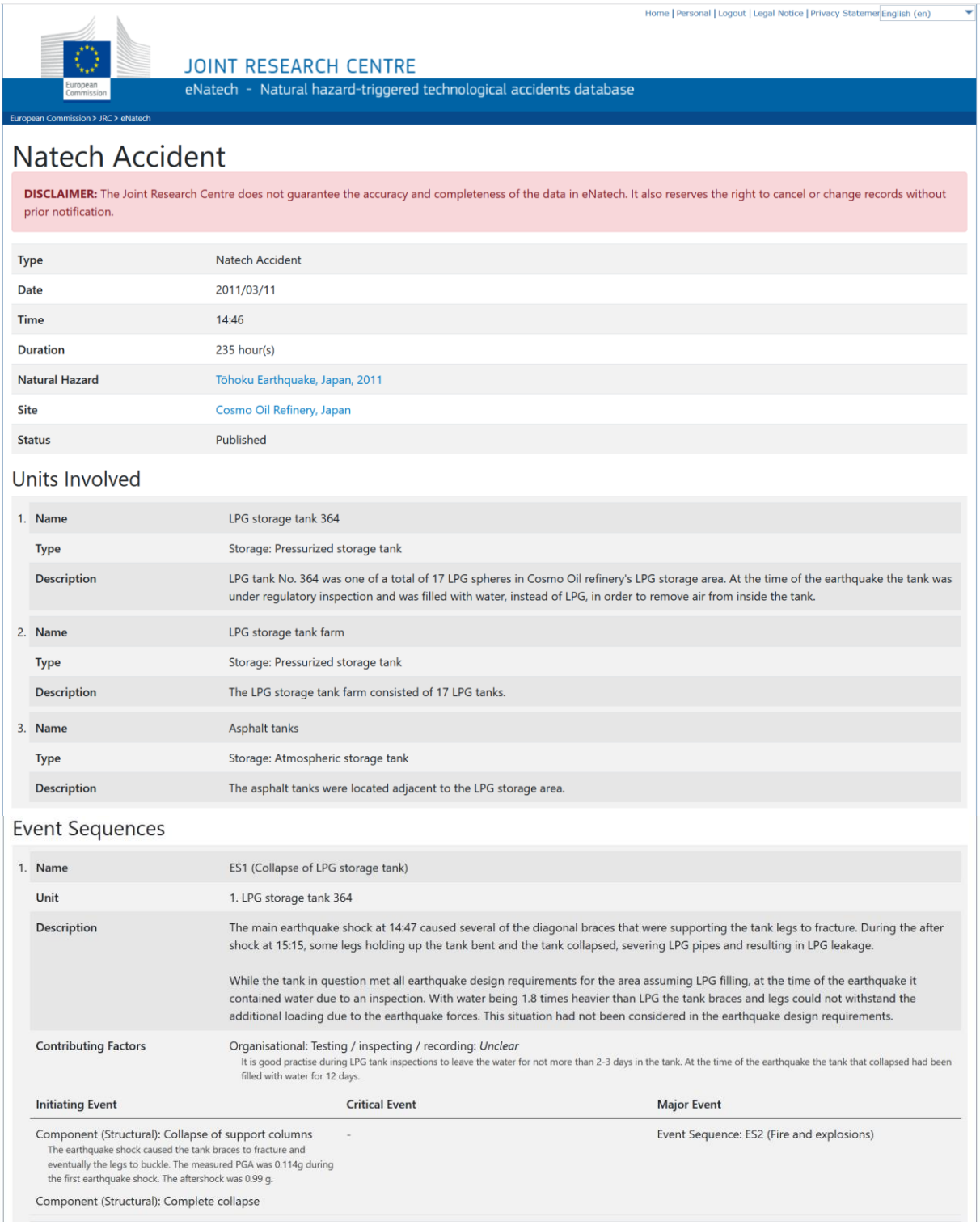
Building (Structural)	Complete collapse Partial collapse Collapse of support columns Damage to tie-bars and joints Inclining / tilting Dislodging / displacement Unknown	X		
Building (Non-structural)	Insulation damage Roof damage Wall damage Damage to electrical and emergency equipment Unknown	X		
Lifeline	Loss of water Loss of cooling / refrigerating capacity Loss of heating Loss of process air Damage to transformer stations and electrical turbines Loss of electrical power / short circuit Unknown	X		
Event Sequence	Event sequence	X		X
Substance	Hazardous reaction due to contact with water (Self) Ignition due to high temperature Over-pressurization Over-heating Other Unknown	X		

Table A2. *Contributing Factor* classification in use in eNATECH.

Type	Name
Equipment	Component failure
Equipment	Component malfunction
Equipment	Loss of process control
Equipment	Corrosion / fatigue
Equipment	Runaway reaction
Equipment	Unexpected reaction / phase-transition

Equipment	Blockage
Equipment	Electrostatic accumulation
Equipment	Power interruption
Measure	Containment system (e.g. walls, dikes, enclosed room)
Measure	Instrument / control / monitoring devices
Measure	Emergency water systems
Measure	Portable fire extinguishers
Measure	Back-up power
Measure	Restraining straps or chains
Measure	Anchoring mechanisms (e.g. anchor bolts, bracing)
Measure	Structural design / retrofitting for earthquakes
Measure	Bracing of pipes and connections
Measure	Flexible connections for pipes
Measure	Strapping and anchoring of emergency equipment
Measure	Emergency shut off / safety valves
Measure	Alarm systems
Measure	Water curtains for hazardous gases
Measure	Seismic detectors
Human	Operator error
Human	Operator health (e.g. death, illness, intoxication)
Human	Wilful disobedience
Human	Failure to carry out duties
Organisational	Management organization
Organisational	Management attitude
Organisational	Organized procedures
Organisational	Training / instructions
Organisational	Supervision
Organisational	Staffing
Organisational	Process analysis
Organisational	Design of plant / equipment / system
Organisational	User-friendliness (apparatus, system, etc.)
Organisational	Manufacture / construction
Organisational	Isolation of equipment / system
Organisational	Maintenance / construction
Organisational	Testing / inspecting / recording
Other	Other

Annex 2. Example Natech Accident Record in eNATECH



Home | Personal | Logout | Legal Notice | Privacy Statemer English (en)

JOINT RESEARCH CENTRE

eNatech - Natural hazard-triggered technological accidents database

European Commission > JRC > eNatech

Natech Accident

DISCLAIMER: The Joint Research Centre does not guarantee the accuracy and completeness of the data in eNatech. It also reserves the right to cancel or change records without prior notification.

Type	Natech Accident
Date	2011/03/11
Time	14:46
Duration	235 hour(s)
Natural Hazard	Tōhoku Earthquake, Japan, 2011
Site	Cosmo Oil Refinery, Japan
Status	Published

Units Involved

1.	**Name**	LPG storage tank 364
	Type	Storage: Pressurized storage tank
	Description	LPG tank No. 364 was one of a total of 17 LPG spheres in Cosmo Oil refinery's LPG storage area. At the time of the earthquake the tank was under regulatory inspection and was filled with water, instead of LPG, in order to remove air from inside the tank.
2.	**Name**	LPG storage tank farm
	Type	Storage: Pressurized storage tank
	Description	The LPG storage tank farm consisted of 17 LPG tanks.
3.	**Name**	Asphalt tanks
	Type	Storage: Atmospheric storage tank
	Description	The asphalt tanks were located adjacent to the LPG storage area.

Event Sequences

1.	**Name**	ES1 (Collapse of LPG storage tank)
	Unit	1. LPG storage tank 364
	Description	The main earthquake shock at 14:47 caused several of the diagonal braces that were supporting the tank legs to fracture. During the after shock at 15:15, some legs holding up the tank bent and the tank collapsed, severing LPG pipes and resulting in LPG leakage. While the tank in question met all earthquake design requirements for the area assuming LPG filling, at the time of the earthquake it contained water due to an inspection. With water being 1.8 times heavier than LPG the tank braces and legs could not withstand the additional loading due to the earthquake forces. This situation had not been considered in the earthquake design requirements.
	Contributing Factors	Organisational: Testing / inspecting / recording: *Unclear* It is good practise during LPG tank inspections to leave the water for not more than 2-3 days in the tank. At the time of the earthquake the tank that collapsed had been filled with water for 12 days.

Initiating Event	Critical Event	Major Event
Component (Structural): Collapse of support columns The earthquake shock caused the tank braces to fracture and eventually the legs to buckle. The measured PGA was 0.114g during the first earthquake shock. The aftershock was 0.99 g.	-	Event Sequence: ES2 (Fire and explosions)
Component (Structural): Complete collapse		

2. **Name** ES2 (Fire and explosions)

Unit 2. LPG storage tank farm

Description The LPG leaking out from the ruptured pipes spread out and caught fire. As a consequence, the tank adjacent to Tank 364 exploded (BLEVE), spreading the fire from tank to tank and eventually throughout the whole LPG tank farm, leading to several explosions.

Substances Involved

1. **Name** Liquefied Petroleum Gas
   Involved Quantity 5227 ton

Initiating Event	Critical Event	Major Event
Event Sequence: ES1 (Collapse of LPG storage tank) Component (Non-structural): Pipe break / damage **Contributing Factors** Measure: Emergency shut off / safety valves: *Unavailable* Human: Failure to carry out duties: *Non-existent* Prior to the earthquake an emergency valve on the LPG pipes had been manually locked "open" to prevent it from actuating due to minor air leakages during repair work. Once LPG started to be released from the damaged pipe and the fire ignited, the valve could not be reached and closed, thereby continuously providing LPG to feed the fire. This exacerbated the fire and made it burn out of control. By manually overriding the emergency valve, the company was in violation of the High-Pressure-Gas law. In a personal communication, the Chiba Prefecture Fire Department expressed its belief that the accident might have been manageable had the safety valve not been open.	Release: Gas, vapour, mist, or smoke release to air	Explosion: Vapour cloud explosion The shock waves and debris from the explosions triggered fires in the adjacent premises of Maruzen Petrochemical Co., Ltd., and Chisso Petrochemical Corporation. Explosion: BLEVE Event Sequence: ES3 (Asphalt release) Fire: Jet fire

3. **Name** ES3 (Asphalt release)

Unit 3. Asphalt tanks

Description Asphalt tanks adjacent to the affected LPG storage tank area were damaged and asphalt leaked out of the tanks.

Substances Involved

1. **Name** Asphalt
   CAS No 8052-42-4

Initiating Event	Critical Event	Major Event
Event Sequence: ES2 (Fire and explosions) The damage to the asphalt tanks occurred due to debris impact from the exploding LPG tanks.	Release: Solid release to ground Release: Solid release to water	Dispersion: Substance in / on water Asphalt reached the sea.

Emergency Response

Response Planning	Emergency response plan is sufficient in taking Natech events into consideration: *No*
Response Planning Activities	The facility/response teams were not prepared for an accident of this magnitude.
Difficulties in Response to the Natural Hazard	Insufficient personnel and equipment to respond to both emergencies: *Yes* Natech event prevents efficient operation of personnel in the natural hazard affected area: *Yes*
Response Teams and Equipment Involved	• On-site systems (e.g. sprinkler, water cannon) • On-site fire fighting team • Local fire fighting team • Fire fighting teams of nearby plants • Regional / national fire fighting teams
Sheltering and Evacuation due to the Natech event	• On-site evacuation • Off-site evacuation
Response to the Natech Event	Due to the fires and explosions 1142 residents had to be evacuated. The fire-fighting teams worked from both land and sea, however, due to the many release sources it was decided to let the tanks burn until the LPG was exhausted.

Consequences

On-site Injured	6
Human Health Impacts	1 severe and 5 minor injuries.
Environmental Impacts	There is very little information on environmental impact of the event, although some asphalt seems to have entered the sea. However, Cosmo Oil indicated that all asphalt was successfully recovered. They also highlight that there is no lasting impact on air, water or soil from the accident.
Economic Impacts	The explosions caused damage to nearby vehicles and ships. The shock waves also caused broken windows and damaged shutters and roof shingles in nearby residential areas.
Built-up Areas Impacted	• Industrial areas (e.g. factories) • Residential areas (e.g. housings, hotels) • Infrastructure (e.g. roads, railways, air transport)

Lessons Learned

Lessons Learned on Equipment	As a preventive measure, LPG tanks will be surrounded by flexible pipelines to prevent damage should a tank collapse on the pipelines.
Lessons Learned on Organisational Aspects	- Locking the safety valve in the open position was in violation of safety regulations and exacerbated the accident. Cosmo Oil has eliminated the practice of locking emergency shutoff valves in an open position. - In the future, the period during which a tank will be filled with water due to inspections, will be minimised. - There will be safety inspections to ensure that all personnel are aware of applicable laws and regulations regarding the safety of the facility and its processes. - Emergency drills will be executed to improve preparedness for large-scale disasters.

ID: 14, Created: Elisabeth KRAUSMANN, 2013-07-17 15:06:37 – Last Updated: Amos NECCI, 2021-10-13 13:27:02

Update Delete

Attachments

No	Description	File Size
1.	Cosmo Oil Press Release 02/08/2011	280.30KB
2.	Incident Summary Report by the Japan High Pressure Gas Safety Institute (in Japanese)	627.36KB
3.	Krausmann, Cruz, 2013	700.65KB
4.	Photo Status 31 March 2011	128.74KB
5.	Wada, Wakakura 2011	1.11MB

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

- at the following standard number: +32 22999696, or

- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

KJ-07-22-743-EN-N

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub

ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

Publications Office of the European Union

doi:10.2760/88277

ISBN 978-92-76-55144-7