The Use of Records to Manage Risks Associated with the Decommissioning of Nuclear Facilities

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The search for detailed information about the configuration and operating history of a nuclear installation is a key, initial step in dismantling this type of installation. Archives and related record groups can contribute significantly to reducing the risks associated with decommissioning. This article describes the methods applied by the archive unit of the Alternative Energies and Atomic Energy Commission at Marcoule in France in support of dismantling projects. The first section proposes some definitions of an archive. The second describes the unit's method, and illustrates its application to the record group of a nuclear facility. The third presents some examples of the operational use of archives in dismantling projects and the results obtained. The fourth section outlines the limits of the use of archives by comparing them with the other sources of information available to engineers.

Keywords: Nuclear Facility, Decommissioning, Radioactive Risk, Archives, Records, Digitisation.

1. Introduction

Dismantling is usually seen as the last phase in the life of a nuclear installation. It consists of deconstructing and disposing of all hazardous and radioactive substances present at the end of its operation (IAEA, 2014). In France, partial dismantling operations first began in the 1960s, but it was only in the late 1970s that the question became pressing as installations built in the 1950s reached the end of their working life. The issue is a particular concern for the Alternative Energies and Atomic Energy Commission Office (CEA) which carries out research and is responsible for production in all nuclear energy sectors (electricity production, military, and medical uses). The CEA is faced with the problem of dismantling installations that are unique in terms of their design, size and nature. The major financial, environmental and technical challenges they present have led to the establishment of various decommissioning strategies that are a function of the context and associated risks.

At the international level, there are three main methods: immediate dismantling, deferred dismantling or burial (Pelleterat de Borde et al., 2013). Whichever is chosen, they all involve the use of many and varied sources of information: plans, calculations, oral communication, photographs, databases, etc. Feedback from engineers responsible for dismantling projects systematically underlines the critical importance of being able to find, save and share information that traces the history of the installation and its successive configurations throughout the duration of the project and beyond (IAEA, 2002). From the archivist's point of view, this need for archival information is a classic example of the exploitation of a collection of documents built up over time.

Drawing upon the experience of the CEA's archive unit at Marcoule (in the Gard department of France), this four-part article demonstrates how archival methods can significantly reduce risks associated with the decommissioning of a nuclear facility. The first section presents a definition of archives in the French context and its implications for their management. The second presents some archival techniques and their application to the record group of a nuclear facility. The third provides an example of the use of archives in dismantling, and outlines the results that can be obtained. Finally, the fourth section highlights some of the limits of using archives for dismantling projects.

2. What are archives?

What constitutes an 'archive' can differ as a function of sensitivities and cultures. It is therefore essential to define the term in order to

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clearly identify the scope of this article and to clarify the archival content related to a nuclear installation.

2.1 *Definition of archives*

A 2003 European Union Regulation on opening up the archives of the European Economic Community and the European Atomic Energy Community to the public defines archives as "*all those documents and records of whatever type and in whatever medium which have originated in or been received by one of the institutions or by their representatives or servants in the performance of their duties, which relate to the activities of the European Economic Community and/or the European Atomic Energy Community*" (EC-Euratom Regulation 2003). This definition establishes the principles generally used to distinguish archives from other types of documents (e.g. books or periodicals) that are more typical of publishing. Thus, three elements characterize the archive:

- Its typology: it encompasses all forms of graphic (drawings, written material) or audio-visual (photography, moving images) representation.
- Its material support, which can be very varied: parchment, glass, plastic, paper, magnetic, etc.
- Its relationship to an activity: an archive traces the history of any kind of activity. Therefore, a meaningful archive must systematically be associated with the context of its production defined by the activities of its creator. It is this point that differentiates the archive from the book. The latter is the result of the author's work, while the archive is simply due to the activity of its creator.

In France, the legal definition of the archive was formulated in 2016. It shares the same principles as those of the European Union regulation, but introduces three additional concepts that clarify the scope of archiving: "*Archives are all documents, including data, whatever their date, place of conservation, form and medium, produced or received by any natural or legal person in the course of their activity*" (*Code du patrimoine*, 2016). The first point to note is the express mention of *data* as a type of document falling within the scope of archives. This observation consolidates the principle that the form of the archive support is irrelevant at a time when thinking about the use of digital data is still developing. The second key point this definition introduces is the date criterion. Under French law, a document does not become an archive once a certain period of time has passed, instead, it is an archive from the time of its creation. Finally, where archives are kept does not change their status. Whether they are located in the office of the person who wrote them, or in a dedicated centre, they are considered as archives, which can result in specific regulatory requirements in the French context.

2.2 *Public and private archives*

The *Code du patrimoine* distinguishes archives produced by national and local administrations and public bodies from private archives resulting from the activities of other natural or legal persons. The management of public archives requires compliance with certain regulations (imprescriptibiliy, deadlines for communication, management by the archive authority, trained staff and appropriate storage facilities) driven by the reason for keeping them. Article L211-2 of the *Code du patrimoine* (2016) states that public archives must be conserved not only to preserve the rights of natural or legal persons, but also as a historical resource for researchers to draw upon when recording the country's history. This implies the indefinite conservation of certain documents beyond any practical use. This point distinguishes it from the management of private archives. In the latter case, there is no requirement to preserve material beyond legal stipulations and the specific needs of individuals or private organisations.

ISO 15489 (2016) addresses the management of private archives. This international standard, which is based on Anglo-Saxon practice, proposes a more pragmatic approach to the lifecycle of documents by considering only the management of documents that are binding on the organisation that produces them: preparatory documents and documents whose content is obsolete with respect to the creator's regulatory obligations must be destroyed, unless a future need can be foreseen.

2.3 *The archives of a French public nuclear research centre: the CEA's Marcoule centre*

The Marcoule archives fall under the auspices of the public archive regime insofar as the CEA is a public research establishment. Its research areas cover energy, military applications of nuclear energy, basic research in the life and material sciences, and technological research.

Initially, the work undertaken at Marcoule focused on nuclear energy. Created in 1955, the initial aim was to produce plutonium for the manufacture of the French nuclear bomb and develop the first French reactors for electricity production. Since the 1970s, the centre has specialised in spent fuel reprocessing. In parallel, dismantling the site's earliest installations began in the 1980s. Since the early 2000s, it has become a hub for CEA teams responsible for research into the entire nuclear fuel cycle. Today, this is a major challenge as it concerns a dozen, very different installations in terms of type and size (production reactors, reprocessing plants, effluent treatment plants), and significant quantities of radioactive materials. These large-scale projects are expected to take several decades to complete.

Documents generated by the site's actors date back to 1955. They are very varied and have been managed in different ways over time. This documentary heritage can be classified into three main categories: administrative, scientific and technical and, finally, those related to nuclear installations. Administrative documents include paperwork related to management, human resources, procurement, etc. However, activities related to the management of the safety and security of persons, the environment and property are subject to special attention.

Scientific and technical archives include documents related to research and development. In this case, typologies are fairly standardised even if their form has substantially changed. They include laboratory notebooks to record research hypotheses, raw results obtained on a daily basis during experiments and the scientist's initial conclusions. Once presented in paper form, they are now electronic and their content is enriched by the use of digital tools. Documents related to facilities consist of paperwork concerning the configuration and operation of buildings housing research or production equipment. They include plans, calculations, shift records, production records, periodic inspection reports, etc. A significant proportion of these documents were prepared in order to comply with regulatory obligations (safety, security, maintenance) and their production was subject to verification by authorities responsible for managing nuclear installations.

Despite their very different nature, all of these documents fall under French regulations regarding public archives. However, their long-term management requires strategies that are tailored to their use. If we take the example of the laboratory notebook, we know that it will have to be conserved for an indefinite period at the end of its operational life insofar as it will make it possible to trace the work of a research team. It can even be used as proof of anteriority when filing a patent. On the other hand, the destruction of an equipment maintenance report at the end of a retention period determined by operational needs and legal requirements is equally justified.

These conservation strategies, based on what could be said to be a risk analysis, are developed by CEA archivists who support the units and ensure the conservation of a large part of the archives. Marcoule plays a particularly important role in dismantling projects, and is the historical location of operational units responsible for the clean-up of dismantling projects—consequently, the unit has developed a method and expertise to meet the needs of these projects. Their work draws upon the record groups of installations to establish the basic data for industrial scenarios. The creation of these record groups and the way they are used, influence the quality and reuse of information, as we will see in the next section.

3 The archival method applied to the record group of a nuclear installation

Based on a centuries-old tradition, the archival method of describing documents and their production context aims to ensure the continuity of knowledge over time. In this section, we revisit some of the key principles of archival practice, before applying them to the specific case of the archives of a nuclear facility.

3.1 *The archival method*

The archivist's work can be summarized into four main activities: the collection, classification, conservation and communication of archives.

Collection corresponds to the deposit of documents by their creators, or the recovery of so-called 'orphan' record groups when the creator no longer exists. The first situation is ideal because the archivist can, when the documents are physically transferred, ask the creator for any information required in the next steps of archive management. A remittance slip

is prepared, which is signed by a representative of the producing department and the archivist who receives the documents. This document describes the archives deposited, their purpose, their maximum lifetime, the type of documents and the service that produced them, which may be different from the department that provided them. Physical aspects, such as the volume and their support are also recorded. In the case of orphan archives, the archivist must reconstruct the description based on their knowledge of the organisation and its activities. Whenever possible, this person requests help from experts in the domain. Each deposit is recorded in a register and assigned a unique number. Each box or other container containing the deposit can be found using this identifier.

Archives can be classified before they are deposited. In this case, the remittance slip is based on the search tool (inventory, database) established by the department making the deposit. However, in most cases, deposited archives are reclassified by archivists. Classification requires drawing up a classification schema that structures the record group as a function of the activities the files and documents to be processed relate to. Depending on the type of record group, a filing system may already exist. In this case, archivists will endeavour to maintain this system as far as possible, respecting the principle of not disrupting the initial order of documents insofar as it can help in the general understanding of their content.

The filing system is established according to chronological or thematic criteria, and it must seek to find the best concepts possible to serve as an entry point for future research. In technical fields such as nuclear engineering, authoritative lists (a thesaurus or technical index) may be the answer, but this requires ensuring the widest interpretation of the vocabulary. Classification involves sorting archives according to the criteria already mentioned, namely compliance with regulatory requirements, internal operational needs, the scientific value of documents and, finally, their value for historical research.

Archives to be destroyed are identified by a disposal slip approved by the archives' management authority. On the physical level, filing includes the removal of elements likely to degrade the integrity of the support (metal, plastic, etc.). Each item, defined as the smallest unit of classification, is noted and its description is entered in a search tool along with the corresponding reference.

Conservation activities mainly concern the physical management of archive supports. Checks of their condition may, for example, lead to them being copied due to their gradual or foreseeable deterioration if they are repeatedly consulted. For example, large-format plans can be scanned and reproduced to avoid deterioration and facilitate access. Paradoxically, another aspect of conservation concerns the destruction of archives. Deposited documents can be disposed of once the legal deadline has passed, or when there is no further operational need.

The communication of archives is based on the search tools developed during the filing process. These instruments allow users to search the record group and obtain documents as a function of their needs and access rights, which vary according to the sensitivity of the information. Documents are made available to users to consult on the premises of the archive unit. Following consultation, copies can be made of relevant documents. In most cases, these copies are now digital.

The entire archival practice, from collection to communication, is governed by the need to be able to reproduce, as accurately as possible, the context in which documents were produced. It is imperative that the record group created by the activity of a given creator can be consulted while at the same time, guaranteeing its authenticity. Consequently, archivists use flowcharts and documents that describe successive organisations to establish the origin of documents and their reliability. Knowledge of the specific terms used over time (project names, unit names, experiment names) is also an essential tool that archivists use to understand and respond to the different requests for information they receive. Next, we illustrate this method by applying it to archives relating to a nuclear installation in France.

3.2 *Mapping a nuclear installation record group*

Typically, there are three main phases in the lifecycle of a nuclear facility: design/ construction, operations and, finally, clean up/ dismantling. Different archive creators intervene in each of these phases, and generate information that, over time, will form the installation's record group.

First, there are the documents that record the circumstances of the decision to build the facility. These documents, which are generally found in the record groups of central departments, are useful for understanding the

objectives of the future facility and the circumstances under which it was created. Design documentation corresponding to the different phases of the construction project (pre-project summaries, final pre-project documents) provide an initial vision of the installation's configuration. In France, this first step also includes an administrative procedure for declaring the new facility to the Nuclear Safety Authority and local authorities. At the site that will host the new installation, safety and security, utility (electricity, water, IT networks) and radiation protection support teams provide their expertise and prepare the construction site.

The first major record group for future dismantling needs is produced at the end of this phase, in the form of documents describing the initial configuration. They are mostly produced by subcontractors who act as prime contractors or as assistants to CEA contracting authorities. These companies establish and maintain their own records. This initial documentation is given by the manufacturer to the future operator when the installation is put into service. The reliability of these documents is critical, as some of the facility's structures become inaccessible once it enters into service. It is therefore essential that documents marked 'as built', whether on physical or digital media are a faithful representation of the building and the equipment they describe (IAEA, 2008).

During operation, new protagonists come into play, notably, teams responsible for the operation of the installation, and those responsible for its correct functioning and any changes. Depending on the organisational setup, operations may be carried out by CEA staff or subcontracted, which, as in the construction phase, leads to the existence of a record group that is external to that of the CEA. Support units, some of which are directly located in the installation, also generate vital information for its operation and monitoring activities. This is notably the case for radiation protection teams, who carry out daily monitoring of activities involving radioactive materials. In the case of research facilities such as the CEA, scientists who use the facility to conduct experiments generate the most interesting record groups in terms of historical value. Their documentation can supplement the operator's information when tracing the history of the installation during decommissioning.

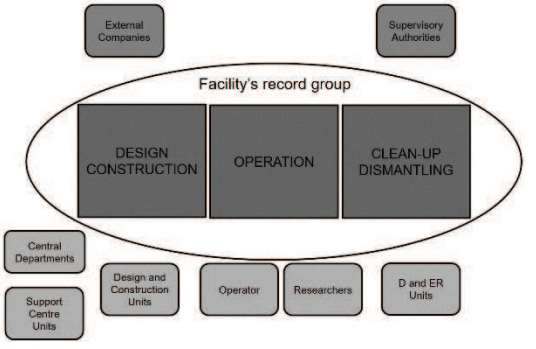

Fig. 1 Representation of the documentary corpus relating to a nuclear installation. Record groups external to the CEA are noted above the facility's own record group. Record groups belonging to CEA units that complement the facility's corpus are shown below.

The production of the first documents related to the remediation or dismantling phase of a nuclear installation takes place well before its activities finally end. They concern, in particular, the regulatory process for reporting its final closure to authorities, financial studies and the definition of the dismantling strategy. At this stage, all documents that record changes to the installation's configuration and the history of its operation are of interest. Figure 1 highlights all of the record groups likely to help teams responsible for dismantling to reconstitute basic data. In the following section, we outline how the archival method makes it possible to exploit this massive amount of information and limit risks associated with the absence or misinterpretation of documents.

4 The use of archives in dismantling

While the examination of archives is generally recognized as an essential step in preparing for dismantling, it is often seen as time-consuming and expensive by engineers. Archivists must therefore seek to anticipate the need for relevant archives and justify the investment in their constitution.

4.1 *What archives are useful in dismantling?*

The documentation needed during dismantling is well-known, and it is possible to draw up a list (IAEA, 2002). It includes:

- Civil engineering plans and the installation's principal internal equipment, together with calculations and specifications of the materials used.
- The entire safety record group, consisting of safety reports, general operating rules,

commissioning authorisations and documents exchanged with safety authorities.
- Compliance and maintenance checks.
- Incident reports.
- Logbooks recording the installation's day-to-day activity.
- Radiation protection shift logbooks and successive radiological maps.
- Installation records prepared by former operators and researchers.

Particular attention is paid to photographs and video material as they provide a visual record of a particular construction or operation in cases where the plan may give rise to doubts.

The facility's own record group is generally consulted first as it contains the most complete set of documents. However, for older Marcoule installations (some of which are over sixty years old), it was very difficult to maintain a complete record up to the point of dismantling due to various factors. Most often, the record group became fragmented as installation was associated with successive organisations. For example, at one time several facilities were coordinated by the same unit when previously they had been autonomous units. A direct consequence of the new organisation was that some documents relating to certain activities (maintenance, safety) were grouped together. It has therefore become necessary to consult the archives of the unit that operated the merged installations, in addition to information held by each installation individually. Another example from Marcoule concerns a change in the operator. From 1976 to 2006, most of the site's facilities were operated by COGEMA. This company was created in 1976 to handle activities related to uranium production. It became Areva NC in 2006, and Orano Cycle in 2018, and it has its own document management rules. When the CEA took over responsibility for these facilities in 2006, it became necessary to recover the archives and understand their structure in order to be able to access them with CEA methods and tools.

Understanding the history of the organisation is therefore essential in order to know where to look for missing information. This is even more urgent if archives have disappeared due to destruction, loss, accidents (fires, floods) or the degradation of the physical medium. In these situations, it is possible to search for missing documents by studying the relationships between the different creators. For example, in the context of exchanges with safety authorities, the installation does not send regulatory documents directly – instead it sends them to a unit attached to the centre's senior management, which is the only contact point for safety authorities. This unit establishes and maintains monitoring documentation that is equivalent to that of the installation. In this case, it is possible to use these central record groups to supplement the installation's corpus.

However, this solution cannot be applied in all cases as only one copy exists of some types of documents. This notably applies to all day-to-day records, such as operating or radiation protection shift logbooks, which dismantling teams find particularly useful. The correct storage of these documents is made difficult by their frequent handling. Like photographs and videos, the physical support is subject to degradation. Efforts are being made to duplicate these unique archives. While microfilming methods (microfiche, microfilm) were used in the 1990s and the early 2000s, digitisation techniques are now widely used to meet the needs of dismantling projects, as the example presented in the next section shows.

4.2 *Processing strategy and results*

The Marcoule archive unit is asked on a daily basis to help in dismantling projects. It has consequently defined a strategy for identifying and processing archives in order to be able to anticipate the needs of these projects as effectively as possible, and thus reduce their radiological, technical and financial risks.

As section three underlines, information about a facility is produced by various parties. One challenge is, therefore, to identify the creators specific to each installation and verify the existence and state of conservation of their documentary collections. While this exercise is relatively easy in the case of creators located in the centre, it is more difficult in the context of record groups held offsite, by parties other than the CEA. Companies that contributed to the construction of the first facilities at the site in the late 1950s have often been able to help but, in some cases, access restrictions have prevented them from being used effectively.

The identification of existing record groups, combined with their knowledge of the types of documents required by dismantling projects, has enabled the archive unit to establish a strategy for archive processing. For example, when the CEA took over operation of the site in 2006, the corpus of the unit responsible for monitoring the

safety of the installation under COGEMA's management were transferred to the archive unit. The classification of this corpus (which filled over 200 metres of shelving) was undertaken very quickly after its receipt, due to the high value of its contents for operators and dismantling projects. At the same time, a collection of more than 150,000 photographs taken by the site's technical services was recovered. These photographs, taken during the construction of the installation or while work was carried out are a particularly useful resource for all current or future dismantling projects. The archive unit has therefore digitized the complete collection from negatives. These digital files have been made available to all users in the form of a photo library.

This method represents a real return on investment and a significant reduction in project risks, thanks to the collection and classification of record groups. The use of archives in the recovery of drums of radioactive waste stored in pits is one of the most important illustrations of the usefulness of this work. In 2013, the project team responsible for these pits requested the archive unit's help in finding any documents that might help them to understand their structure and content. Following the Fukushima accident, French nuclear authorities had asked the operator to demonstrate that these constructions, dating from the early 1960s, had indeed been designed to meet the risks associated with an earthquake. If the CEA was unable to provide assurances that this was the case, it was required to carry out work estimated at several hundred million euros. The corpus concerning these pits is typical of the situation at Marcoule. The archives of the operator that was responsible for them in 2013 were incomplete, which is what prompted the request to the archive unit.

The lack of completeness was quickly explained by the fact that several operators had monitored the pits, including the Radiation Protection Service (SPR), which was responsible for their construction. Although the SPR archives provided significant additional information, other calculations and photographs were needed. Two other record groups—those belonging to the site's technical services and its management before 1976—were able to provide these additional elements, including very detailed photographs of their reinforcement and interior design. Data from a total of five record groups belonging to different creators were used in the submission to the Safety Authority. It is clear that the relationships between these sources could not have been established without the work of the archive unit. The CEA made savings of several hundred million euros, a sum that can be compared with the cost of archive processing and digitisation services, which amount to only one hundred thousand euros, while the results of the unit's work can be used by all of the site's installations.

5 Limits in the use of archives for dismantling

Archives are not the only resource when preparing data for a dismantling project. It is therefore necessary to evaluate and interpret them to assess their true value.

5.1 *What archives tell us*

As we have already noted, a corpus is always subject to external factors that may affect its understanding and use. The loss of documents due to a flood, missing files that have been taken away but not brought back, or the lack formal documentation all cast doubt on the reliability of a corpus. While archivists strive to document the production context as best they can, by identifying the general chronology of creators and their work, they cannot guarantee the accuracy of the content of the documents they preserve. Each user must evaluate for his or herself the reliability of the document they are looking at.

However, this assessment is not always simple. An informal, handwritten note may contain valuable information, while a formal document that is expected to be more reliable may prove to be of no interest. In addition, activity or facility-specific knowledge must be brought to bear in correctly interpreting archival content. For example, changes to radiation protection measurement units requires knowledge of their equivalence in order to be able to correctly interpret radiological maps produced several decades apart. The volume of the material to be consulted can be a barrier for engineers who are unfamiliar with the process. Some installations have record groups that cover over a kilometre of shelving, and a methodical approach is needed in order to avoid drowning in this mass of information. The evaluation and exploitation of archives can take up time that is in short supply for teams, and may end in outcomes that are only relatively reliable.

5.2 *One of many resources*

Decommissioning projects have other resources to draw upon in establishing their baseline data. While archives fall within the scope of explicit knowledge, implicit knowledge that is gained from interviews with former operators or

researchers is regularly used. These are opportunities for dismantling teams to verify archival information and gather new knowledge. Recordings of these interviews can constitute a new archive that has the advantage of being clearly contextualized for dismantling teams, since they made them.

Verification of the configuration of the installation at the end of its life can take the form of *in situ* surveys and measurements, although these can be very costly and complex. Such surveys end in the production of radiological inventories or facility inventories that serve as a basis for dismantling scenarios. They are based on archives and address doubts about the reliability of plans or measurements recorded in the documentary corpus. 3D building scanning technologies have recently emerged for use in dismantling operations. They have been proven to produce reliable numerical models of facilities and will probably replace plans. This technique undoubtedly provides a level of reliability that cannot be guaranteed by consulting archives.

6 Conclusion

Archives, together with other technical investigation resources, make a significant contribution to our knowledge of installations that will be dismantled. They provide access to historical information that is needed to develop and implement dismantling scenarios. To make full use of their potential, they must be classified and systematically evaluated along with other relevant record groups. The experience acquired by Marcoule's archive unit shows that the archival method reduces the risks of information loss and its consequences in all domains of activity (technical, financial, environmental). Given our current state of knowledge, a method could be developed to acquire and consolidate information at the design stage of new nuclear installations, to reduce the risk of loss for future decommissioning projects.

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