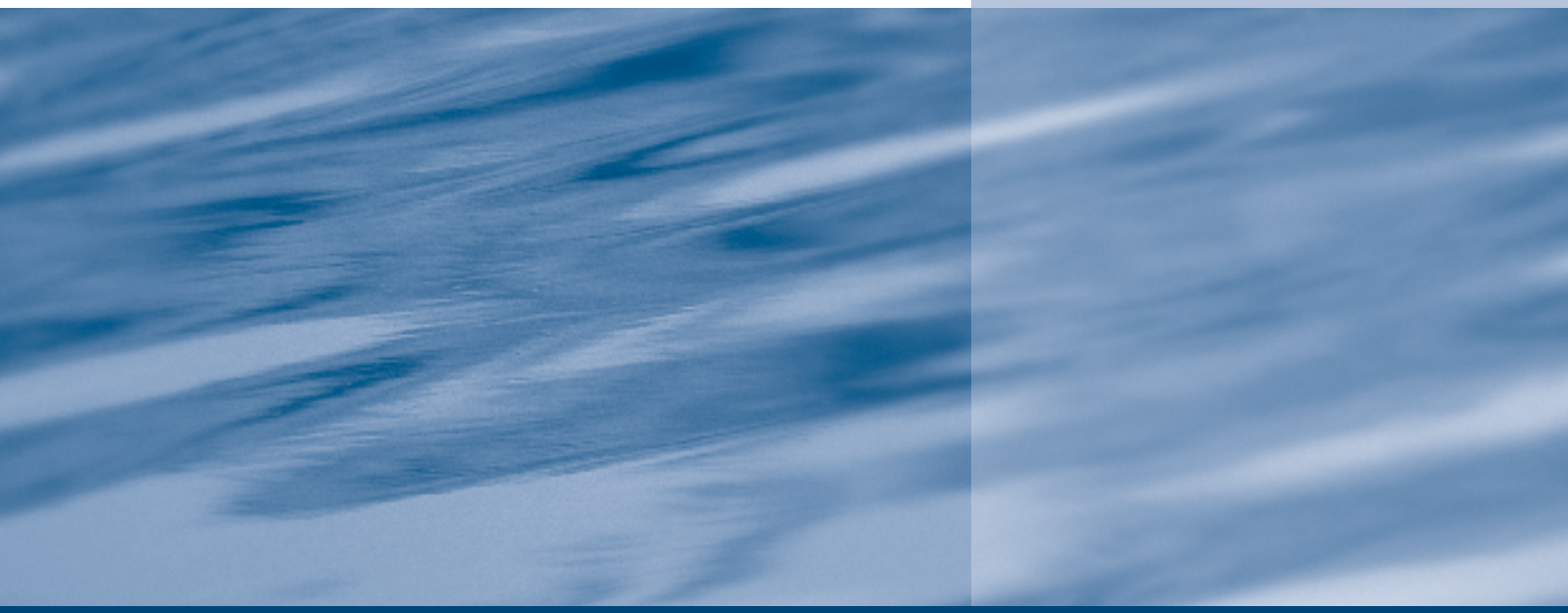

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Review of clean-up and techniques applicable to discharges from decommissioning

Science Report SC030165

ENVIRONMENT AGENCY

The Environment Agency is the leading public body protecting and improving the environment in England and Wales.

It's our job to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world.

Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

This report is the result of research commissioned and funded by the Environment Agency's Science Programme.

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Risk Management Consultants Ltd

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Research Contractor:
Risk Management Consultants Ltd, Suite 7 Hitching Court, Abingdon Business Park, Abingdon, Oxon OX14 1RA.
Tel: +44 (0) 1235 555 755

Environment Agency's Project Manager:
Chris Weedon, North west

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Science at the Environment Agency

Science underpins the work of the Environment Agency, by providing an up to date understanding of the world about us, and helping us to develop monitoring tools and techniques to manage our environment as efficiently as possible.

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The Environment Agency's Science Group focuses on five main areas of activity:

- **Setting the agenda**: To identify the strategic science needs of the Agency to inform its advisory and regulatory roles.
- **Sponsoring science**: To fund people and projects in response to the needs identified by the agenda setting.
- **Managing science**: To ensure that each project we fund is fit for purpose and that it is executed according to international scientific standards.
- **Carrying out science**: To undertake the research itself, by those best placed to do it - either by in-house Agency scientists, or by contracting it out to universities, research institutes or consultancies.
- **Providing advice**: To ensure that the knowledge, tools and techniques generated by the science programme are taken up by relevant decision-makers, policy makers and operational staff.

Professor Mike Depledge Head of Science

Executive Summary

The Environment Agency wants its regulatory officers who deal with the decommissioning of nuclear facilities to gain an improved understanding of the range of decommissioning techniques available in the nuclear industry and in other industrial sectors. This document explains how RM Consultants Ltd (RMC) undertook a short review of national and international experience in decommissioning techniques and presents a review of each identified technique. The Agency's officers will have this information available to them in the form of a Microsoft Access database. The database will help them to assess proposals from operators to dispose of radioactive waste arising from decommissioning operations. It will allow them to give regard to the concepts of Best Practicable Environmental Option (BPEO) and Best Practicable Means (BPM). The report and database will be freely available to anyone requesting them from the Agency on-line catalogue.

Contents

1. Introduction

In 2002 the government published a White Paper (*Managing the Nuclear Legacy*) setting out its proposals for restructuring the nuclear industry. It wishes to improve the management arrangements for the safe, secure and cost effective clean-up of the industry in a way that protects the environment for the benefit of current and future generations. A new body (the Nuclear Decommissioning Authority) will be responsible for driving clean-up initiatives.

Over coming years a large number of nuclear sites used for research and development, power generation and fuel cycle activities (including reprocessing) will need to be cleaned up. The activities involved in decommissioning will produce wastes, including discharges that need to be managed. This work will need to be done against the background of a government strategy to progressively reduce radioactive discharges, which recognises the need for the safe and timely clean-up of the legacy of radioactive waste.

Operators who wish to dispose of radioactive waste require authorisation under the Radioactive Substances Act 1993. Such authorisations are granted subject to limits and conditions, including conditions requiring them to use the best practicable means to minimise waste arisings and discharges. In England and Wales the authorisations are issued by the Agency and are reviewed at intervals.

In accordance with government strategy, the Agency has significantly reduced the "headroom" between discharges and authorised limits in many recently revised authorisations. In some cases, planned decommissioning activities mean that operators may seek to increase these limits by a variation of their authorisation, although this may be for a limited period only.

The Agency will be challenging operators on any proposed decommissioning techniques that result in increased discharges. To facilitate this it wishes to have the most up-to-date, relevant information available. The contract technical specification is provided in Appendix A.

This document explains how a review of national and international experience in decommissioning techniques was undertaken and presents a review of each identified technique.

2 Review methodology

2.1 Task 1: Review and report on decommissioning techniques

This task was undertaken in six consecutive, pre-determined steps:

- identification of decommissioning techniques for nuclear reactor and fuel cycle plant and facilities;
- identification of relevant information sources to be used in the desk-based literature research;
- development of information sourcing strategy;
- agreement of literature review datasheet format;
- undertake decommissioning techniques review;
- production of datasheets for each identified decommissioning technique.

Each of these steps is described below.

2.1.1 Identification of decommissioning techniques

RMC conducted a brainstorm to produce a list of nuclear decommissioning and decontamination techniques used at nuclear reactor and fuel cycle facilities. This list was then compared with published technical reports (e.g. International Atomic Energy Agency (IAEA) Technical Guidance) to validate its completeness. The methods and techniques used across the nuclear industry were grouped into categories, then classed into either decontamination or decommissioning techniques. Figures 2 and 3 categorise the types of decontamination and decommissioning techniques into 11 categories in total. After agreement with the Agency, these categories were used to facilitate the design of the database.

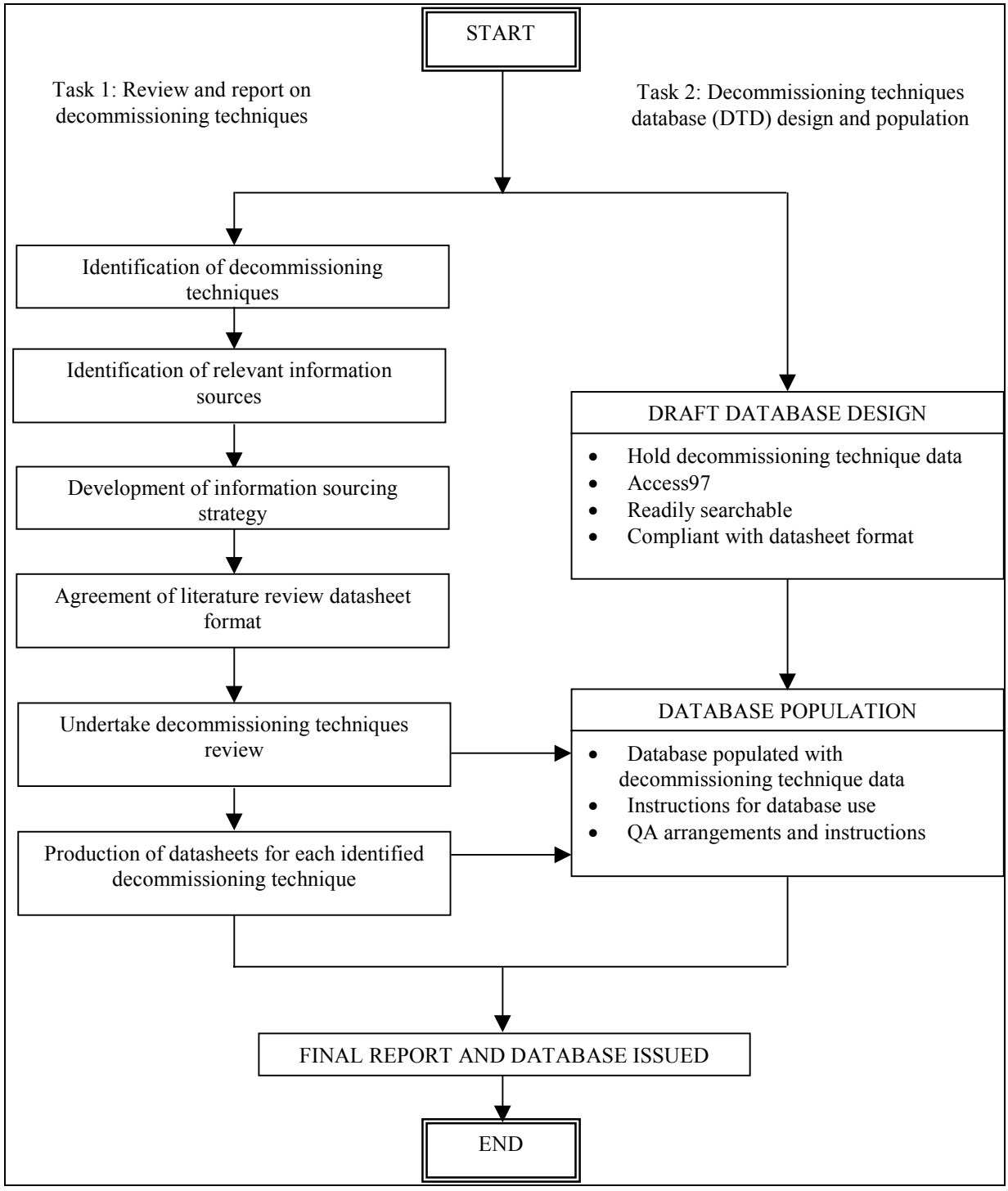
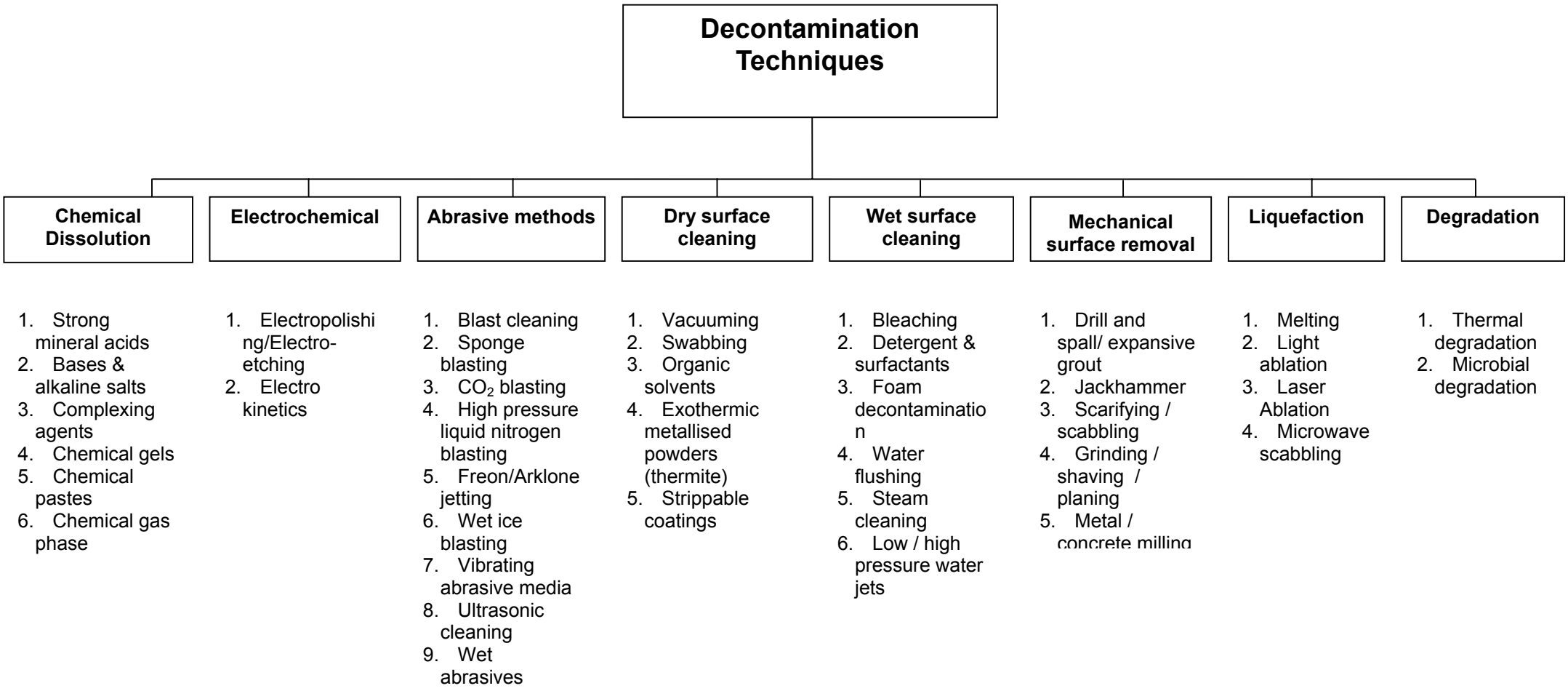


Figure 1: Flow chart to illustrate task 1 and 2 methodologies

Figure 2: Decontamination techniques grouping



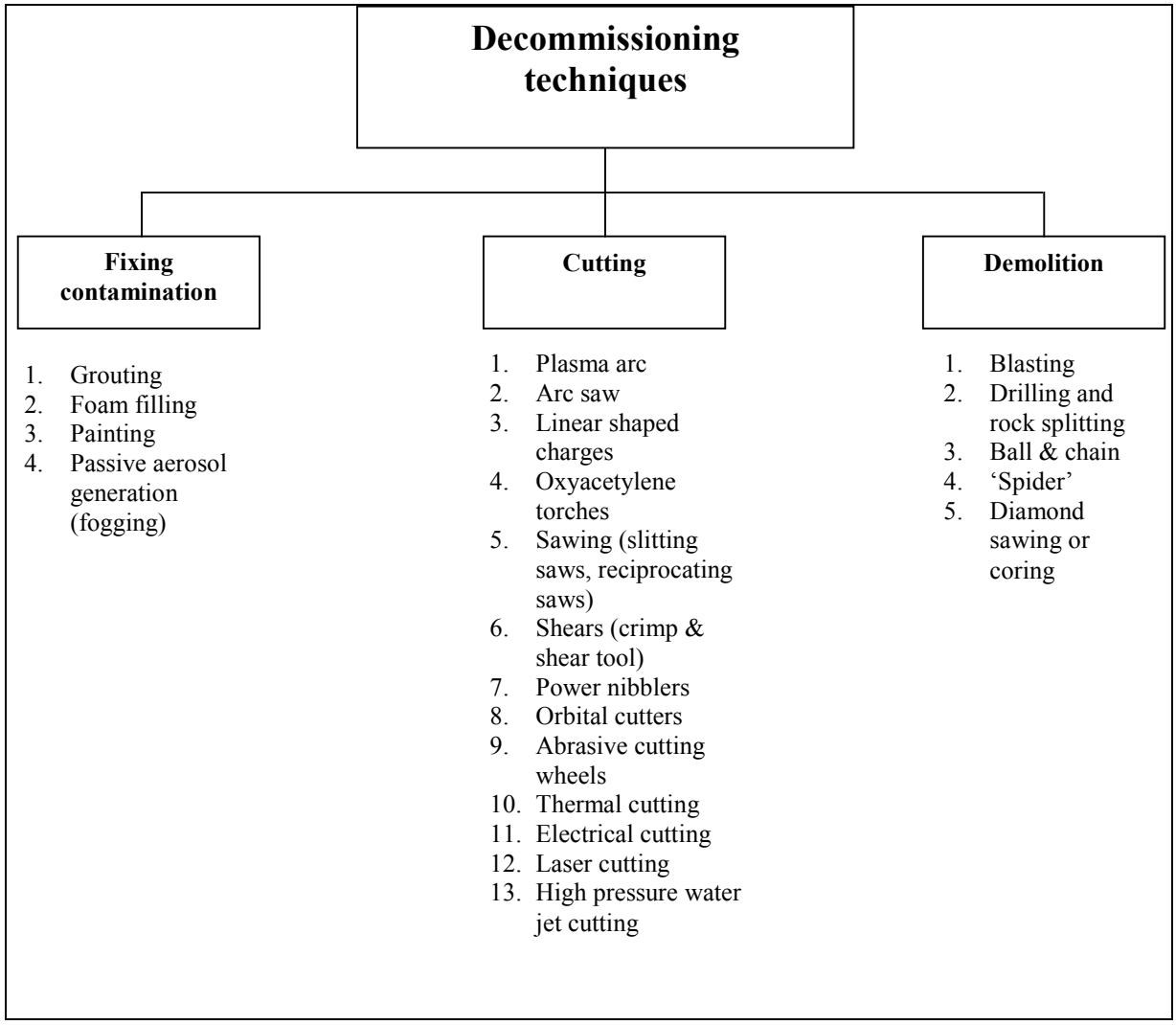


Figure 3: Decommissioning techniques grouping

2.1.2 Identification of relevant information sources

RMC conducted a desk-based literature review to determine the range of sources of relevant information on national and international decommissioning technologies. The proliferation in recent years of online databases, search engines and directory listings has enabled RMC to compile a good-sized listing of nuclear, non-nuclear and interdisciplinary resources. These resources were provisionally categorised under the following headings:

- **books**
- **conferences and proceedings**
- journals and periodicals
- **manufacturer technical datasheets**
- **nuclear operator technical reports** (produced internally or externally by contractor organisations)
- online databases and electronic archives
- online mailing lists and discussion forums
- **regulatory and advisory bodies**

- societies, associations and institutions
- trade bodies and service providers
- university departments and services
- waste management organisations
- web-based directory listings

With the agreement of the Agency five categories were selected for further detailed investigation. The selected categories are listed in bold typeface.

2.1.3 Information sourcing strategy

The selected categories were investigated in detail by RMC to extract relevant decommissioning information. Over 25 books with information relevant to nuclear and non-nuclear decommissioning technologies were resourced via suppliers over the internet, the British Lending Library, free internet downloads and the existing RMC library.

A number of conferences which focused on decommissioning and decommissioning techniques were identified. The conference proceedings were reviewed and relevant papers were examined. Non-nuclear conferences were also examined. These sources are detailed in Appendix B.

A list of 13 companies who manufacture or hire out plant or equipment used as part of the techniques listed in Figures 2 and 3 were identified. The largest companies were contacted and operational datasheets procured.

RMC identified over 80 nuclear and support services organisations that may provide relevant information on the constraints governing application of a technique or experience gained using a technique. RMC obtained many relevant internal and external documents from these contacts: for example, the UKAEA (United Kingdom Atomic Energy Authority) Decontamination Technology Register. In addition, plant managers were contacted for answers to specific queries (e.g. percentage of shot blast re-used after each blasting process).

An internet search was performed to find contact details for a list of regulatory and advisory bodies. Relevant regulatory publications and guidance notes were identified and considered.

2.1.4 Literature review datasheet format

An initial datasheet template was prepared before population to ensure a complete and consistent set of data was recorded for each decontamination or decommissioning technique. The data fields constructed included the description, historical usage (nuclear and non-nuclear), safety considerations, environmental impacts, costs and references. The layout of the template (Figure 4) was agreed by the Agency. It was decided that no size restriction would be placed on any field. A set of instructions concerning population of the datasheets was prepared to help those sourcing the information and to encourage continuity between datasheets.

Technique Name:			
Description:		History of Use:	*Where in use:* *Technical maturity:*
Safety Considerations:	*Radiological risk:* *Industrial risk:*	Costs:	Operational: Capital:
Environmental Impacts:	*Energy requirements, chemicals and water usage requirements:* *Resultant secondary wastes:* *Possible treatment techniques for secondary wastes:*		
References:			

Figure 4: Example of datasheet

2.1.5 Decommissioning techniques review

Initially a description of each technique was recorded and collated. This focused and directed the information reviewer and acted as an internal checking mechanism to provide confidence that the particular decommissioning technique was relevant to nuclear reactor and fuel cycle plant and facilities.

The remaining data fields were then completed. During September 2003 to February 2004, RMC reviewed numerous national and international information sources and contacted many individuals working in or supporting the nuclear industry to gather comprehensive data on decommissioning techniques for nuclear reactor and fuel cycle plant and facilities.

The information entered into each datasheet was subjected to an independent review to provide a degree of confidence in the provenance and accuracy of the database. Guidelines were prepared to help those reviewing the datasheets. Individual review panel members were assigned selected datasheets appropriate to their experience and invited to verify the information and its fitness for inclusion into the database.

The individuals selected for this task collectively had sufficiently broad-based experience to comment with authority on the whole database. Each of these specialists currently works in or for the nuclear industry and is abreast of technological developments and limitations in their specialised field. None of the review staff was involved in earlier stages of the work.

2.1.6 Production of datasheets per identified decommissioning technique

The information gathered during the review was recorded into an Access97 database in accordance with the prepared instructions. Section 3 describes the lessons learnt during this process and Appendix C presents a copy of the completed datasheets.

2.2 Task 2: DTD design and population

This task was undertaken in two consecutive steps:

- draft DTD database design
- DTD population

Each of these steps is described separately below.

System role	Associated functions
System administrator	1 Enter data 2 Delete data 3 Modify data 4 View data 5 Upload documents 6 Add users 7 Delete users 8 Modify users 9 View users 10 Generate reports 11 Search the database
Data entry	12 Enter data 13 Modify data 14 View data 15 Generate reports 16 Search the database
Read only	17 View data 18 Generate reports 19 Search the database

2.2.1 Draft DTD database design

2.2.1.1 Security

The user will access the system by providing a username and password. Each user will be a member of one of three groups characterised by their system role. The user's role will dictate the system functions that are available to them. The system roles and their associated functions are described in Table 1.

Agency personnel are provided with instructions for use of the database and administrator instructions for updating the central file database copy.

2.2.2 DTD population

The database contains data on a total of 61 different decommissioning and decontamination techniques.

Quality assurance (QA) arrangements performed include:

- checking of all inputted information by means of peer-review;
- checking of and recording of errors encountered during database construction.

For presentational purposes it is desirable to print the completed datasheets directly from Access97. It is possible to convert the output to a .rtf file, which can be readily converted to Word97. However, this may result in some loss of formatting.

2.3 System access

Administrator login is via a page similar to that shown below.

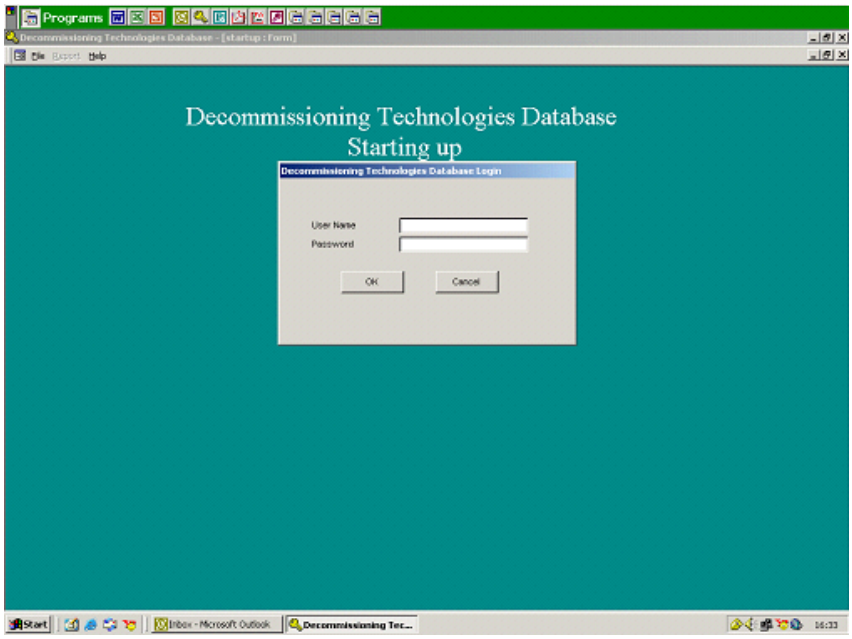


Figure 5: DTD login page

When the administration user has successfully accessed the system, they will be taken to the main interface screen. (The read-only version will go directly to the main interface screen.) This is presented in Figure 6 below. From here they will be able to add and view records, print reports and query the database using the buttons on the interface form. Brief instructions on the use of the DTD are provided under 'Help' in the menu bar.

Figure 6: DTD interface form

.

3 Lessons learnt

RMC conducted a brainstorm to produce a list of lessons learnt during this project. An understanding of the experience gained on this project may positively influence the success of future similar projects.
These lessons have been categorised into three components:

- data sourcing
- database development

Category	Lessons learnt
Data sourcing	1. Difficult to identify and attenuate biases (e.g. optimistic and/or pessimistic performance characteristics) in information from diverse informants. 2. Language barriers create information sourcing and interpretation difficulties. 3. Some information sourcing can be more complex, requiring more cost/time resources. 4. As it is not possible to know what information is available until it is identified, there is a risk that some information may not be identified (i.e. its absence will not be determined). Subsequently, it cannot be demonstrated that the review is comprehensive. 5. In some cases, the technique may have different names because of variances in regional or international custom. This makes data sourcing more complex. 6. It is useful to keep a record of non-productive information sources to verify that the search was undertaken and to rule out the source from further data gathering exercises. 7. It was more difficult to source technical information on simple and long-standing techniques e.g. painting. 8. Completing every data field was challenging, especially cost data. 9. The techniques need to be considered in a holistic manner, use of a particular technique may actually increase waste arisings.
Database development	1. It was more efficient to enter source decommissioning data directly into the Access database. 2. The source material was consecutively referenced and recorded on each datasheet. It may be better to hold the references on a central database, i.e. each reference has a single unique identifier. While this may make it more difficult to read the datasheet, it would enable those undertaking data gathering to compare opinions on particular sources with more efficiency.
Project management	1. Regular conference calls between contractor and client reduces the need for progress meetings. This leads to increased efficiency and value for money.

4 Use and updating of the decommissioning technologies database

There are two versions of the DTD application; the first is the master version and the second is a compiled read-only MDE version. Any changes that the Agency wants to make to the data or structure of the database should be made in the master version and then a new read-only version should be generated and issued to the users. In the read-only version of the application there is no login screen.
Methods for changing the data or structure of the database have been supplied separately to the Agency.

References & Bibliography

A list of the references used to complete each individual datasheet is included in the datasheets in Appendix C.

List of abbreviations

BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
DTD	Decommissioning Techniques Database
QA	Quality Assurance
IAEA	International Atomic Energy Agency
RMC	Risk Management Consultants Limited
UKAEA	United Kingdom Atomic Energy Authority

Appendix A

Specification

Ref: **13062**

Title: **P3-106 Clean-up and techniques applicable to reduction of discharges from decommissioning**

1 Overall objective

In 2002 the Government published a White Paper (*Managing the Nuclear Legacy*) setting out its proposals for restructuring the Nuclear Industry. It wishes to improve the management arrangements for the safe, secure and cost effective clean up of the industry in a way that protects the environment for the benefit of current and future generations. A new body (now to be called the Nuclear Decommissioning Authority) will be charged with the responsibility of driving through the clean up.

Over coming years a large number of nuclear sites used for research and development, power generation and fuel cycle activities (including reprocessing) will need to be cleaned up. The activities involved in decommissioning will produce wastes including discharges that need to be managed. This work will need to be done against the background of a Government Strategy to progressively reduce radioactive discharges but which recognises the need to serve the safe and timely cleanup of the legacy of radioactive waste.

With the reduction in headroom between discharges and authorised limits from operational plants which has resulted from implementation of the reduction strategy to date some operators have pointed to the possible future need for increased discharges, albeit for a limited period, to enable them to decommission. Thus we may receive applications seeking variations to authorisations to include increases in discharge limits.

The Agency can expect to be challenged on any acceptance of decommissioning techniques that result in increased discharges. It wishes to have the most up-to date relevant information available on which to base its acceptance of proposals from the industry and give regard to the concepts of the best practicable environmental option and best practicable means.

2 Target audience

The Agency

3 Programme of work

3.1 Main task

To provide the output of a review of national and international experience of decommissioning techniques (notably decontamination techniques) for nuclear reactor and fuel cycle plant and facilities focussing on the resultant wastes and especially discharges to

Enable the Agency to conduct its regulatory activities with an up-to-date knowledge;

Provide an authoritative source of reference for all those concerned with the decommissioning of nuclear plant.

Techniques for the treatment of contaminated ground need not be included.

As components of the review the contractor will:

3.1.1 Task 1

Provide a fully referenced report which describes each decommissioning technique including potentially relevant ones from non-nuclear industry, provides information on their technical maturity and illustrative examples of their use on an industrial scale and highlights the resultant wastes and discharges and their treatment. Safety, environmental and cost aspects of the techniques should be addressed.

3.1.2 Task 2

Provide a database that can be readily interrogated and updated holding all relevant details of the decommissioning techniques considered.

3.2 Skills sets required

The successful contractor will need to be active in this field and have knowledge of both the UK regulatory framework and scientific expertise in the area of radioactive waste management research.

The criteria upon which quotes will be evaluated will include:

- Overall tender cost
- Contractor expertise in the radioactive waste management research
- Ability of the contractor to write in clear and simple English
- Interpretation of objectives and tasks
- Delivery of report within the time limits

The above list is not exhaustive; the omission of a particular criterion does not preclude its use as an evaluation tool when determining the award of this contract.

4 Outputs and delivery dates

A final report is sought by the end of March 2004. An indicative breakdown of time is as follows:

Early Aug'03: Start of contract
Mid Aug'03: Inception meeting to discuss contractor's plan for work
Late Oct '03: Interim report on progress
Early Nov'03: Meeting with contractor to discuss interim report etc
Early Feb'04: Contractor submits draft of final report for Agency comments
Late Feb' 04: Meeting with contractor to discuss draft final report
Late Mar'04: Contractor submits final report

5 Deliverables

One unbound hard copy of the draft and final report will be submitted to the Agency Project Manager, together with an electronic version (format Word97). The report will be accompanied by a database (format Access97) holding all relevant details of the decommissioning techniques considered.

The final report will follow both the R&D guidance for producing R&D outputs, as well as complying with the 'Simple and Clear English' guide. Both documents are attached to the tender and will be an integral part of the contract conditions.

The contractor will not be responsible for co-ordinating the production and distribution of the final report.

6 Administrative details

6.1 Contact details and timescales

R&D Commissioning Function:
Project No. P3-106
Project start date August 2003
Project End date March 2004

R&D MC Olivia Giraud
Address Environment Agency, Head Office, Block 1, Government Buildings, Burghill Road, Westbury-on-Trym, Bristol, BS10 6BF

Project manager Dr Chris Weedon
Address Environment Agency,Ghyll Mount, Gillan Way, Penrith, CA11 9BP
Tel 01768 866666 ext.5708
Fax 01768 892456
Email Chris.Weedon@environment-agency.gov.uk

Senior procurement officer Shahida Mukadam, Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD
Tel 01454 205 583
Fax 01454 624 320
Email Shahida.Mukadam@environment-agency.gov.uk

7 Communication & delivery of outputs

7.1 All outputs are to be submitted in draft form to the Agency for comments and approval prior to their release.
7.2 Final versions of outputs are to be submitted in hard copy and disc version.
7.3 All Reports must be produced in accordance with Agency "Guidance for the Production of R&D Outputs".
7.4 All outputs will be made available by the Environment Agency.
7.5 The contractor is required to maintain close liaison with the Agency's Project Manager.
7.6 E-mail communications are acceptable during the contract period but the contractor is responsible for ensuring that the Agency does receive these in a timely manner, noting that the external gateway used for Agency e-mails is not 100% reliable.
7.7 The contractor is required to operate under an appropriate quality management system or be heading towards achieving such a system; e.g. conforming to the requirements of BSEN 9001 (1994), or similar.
7.8 A Project Board will be set up to act as the technical quality review panel for the work and the outputs will be subject to external peer review. The Project Board will review all draft reports produced by the contractor.

8 Environmental considerations

The Environment Agency is committed to continually improving its environmental performance. It has set itself tough objectives as a clear commitment and contribution to sustainable development throughout England and Wales. The Agency recognises that this can only be achieved through commitment from all sectors of society and it is intent on raising awareness amongst industry and commerce.
Contractors must adopt a sound proactive environmental approach, designed to minimise harm to the environment.

Environmental criteria should be considered as part of your tender submission with credit given for innovation. Factors to be considered could include areas such as:
Paper use: All documents and reports prepared by consultants and contractors are produced wherever possible on recycled paper containing at least 80% post consumer waste and printed double sided.
Travel: use of public transport, reduce face-to-face meetings by using email and videoconferencing. Meetings to be held in locations to minimise travel, and close to public transport links.
Packaging: should be kept to a minimum. Re-use and disposal issues must be considered.
Efficient Energy and Water Use.
Disposal of Waste: Whilst on site the contractor is responsible for the disposal of their own waste and can only use Environment Agency facilities with express permission from the on site facilities officer.
Whilst on site, contractors should comply with the local environmental policy statement which will be made available to you in advance or on arrival.

Appendix B

Conferences and relevant conference papers

Conference name	Venue	Date	Relevant papers
Waste Management Symposium	Tucson	Feb. 2003	• Release of residues from melting norm-contaminated steel scrap • Thorough chemical decontamination with the MEDOC process: batch treatment of dismantled pieces or loop treatment of large components such as the Br3 steam generator and pressuriser. • D & D technologies for pollution prevention
Waste Management Symposium	Tucson	Feb. 2002	• Improved technologies for decontamination of crated large metal objects • NPOX decontamination system
Waste Management Symposium	Tucson	March 2001	• Cogema experience on decontamination and underwater automatically remote cutting using ultra high pressure water during nuclear decommissioning operations
Waste Management Symposium	Tucson	March 2000	• Decontamination-melting of uranium-contaminated metal • Evolution of continuous melting and decontamination • Technology for dismantled metal by an induction cold crucible
Waste Management Symposium	Tucson	March 1999	• Cleaning and decontamination using strippable and protective coatings at the Idaho National Engineering and Environmental Laboratory • Use of surfactant molecules for nuclear decontamination • Simple and effective chemical decontamination of radioactively contaminated lead
Windscale Advanced Gas-cooled Reactor Stages Decommissioning Conference	UK	March 2002	• Decommissioning the Windscale AGR: the UK demonstration project for power reactor decommissioning
9th International Conference on Environmental Remediation and Radioactive Waste Management	Oxford	Sept. 2003	• Deployment of the RASP system for cutting a contaminated power reactor turbine shaft • The innovations, technology and waste management approaches to safely package and transport the world's first radioactive fusion research reactor for burial • The bandsaw: a highly sophisticated dismantling technique for the Karlsruhe Multi Purpose Research Reactor • D&D experience in VNIINM • TRIGA soil decontamination by electrokinetic method • Decontamination using foams: a brief review of 10 years French experience

Conference name	Venue	Date	Relevant papers
Fourth US Water Jet Conference	Berkeley, California	Aug. 1987	• Milling with abrasive-waterjets: A preliminary investigation • Abrasive-waterjet and waterjet techniques for decommissioning nuclear facilities
TLG's Biennial Decommissioning Conferences	Bridgewater, Connecticut	Oct. 2002	Conference papers were not judged relevant
TLG's Biennial Decommissioning Conferences	Bridgewater, Connecticut	Oct 2000	Conference papers were not judged relevant
Strategy Selection for Decommissioning of Nuclear Facilities	Tarragona, Spain	Sept. 2003	Conference papers were not judged relevant
Processing and Disposal of Minerals Industry Wastes '03	Falmouth, Cornwall	June 2003	Conference papers were not judged relevant
Conference papers that were not investigated			
Nuclear Decommissioning Conference	Edinburgh	March 2003	
8th International Conference and Exhibition on Decommissioning of Nuclear Facilities	London	Nov. 2002	
INSTN International Seminar on Dismantling Experience of Nuclear Facilities	France	Sept. 2003	
Annual Meeting of Nuclear Technology	Dusseldorf, Germany	May 2004	
EDA Conference	Limassol, Cyprus	May 2004	
EDA Conference	London	Oct. 2003	
EDA Conference	Istanbul, Turkey	May – June 2003	
EDA Conference	Pamplona, Spain	April 2003	
16th International Conference on Water Jetting	Aix en Provence, France	Oct. 2002	
15th International Conference on Jetting Technology	Ronneby, Sweden	Sept. 2000	
14th International Conference on Jetting Technology	Brugge, Belgium	Sept. 1998	

Appendix C
Completed datasheets

We welcome views from our users, stakeholders and the public, including comments about the content and presentation of this report. If you are happy with our service, please tell us about it. It helps us to identify good practice and rewards our staff. If you are unhappy with our service, please let us know how we can improve it.