Cutting & dismantling techniques
JRC – 5th International Summer School

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Cutting techniques, why?

1/ To separate components

2/ To resize waste in order to engage properly the conditioning
Cutting techniques “families”

**Mechanical methods:**
- Using mechanical property (“displacement” of material, tensile strength), without hot generation
- By tearing or removal of material

**Thermal or electromechanical techniques:**
- Using melting / spraying properties, high temperature

**Others techniques:**
- Pyrotechnic techniques (explosive cord),
- Chemical or electrochemical process (chemical attack of the material or electrolysis)
Make the right choice!
Criteria to choose the right cutting techniques:

Material properties: nature, hardness

Thickness: to determine the performance of the process

Shape:
- Complex shape → dexterity of the tools / human dexterity base
- Simple shape → automated means?

Environmental aspects:
- Fumes, gas or liquid waste produced by the cutting techniques (risk of dispersion)
- Secondary waste generation (by the process),
Criteria to choose the right cutting techniques:

Operational constraints:

✓ Radiological constraints, ALARA: the techniques are influenced by the necessity to reduce the integrated doses
✓ Compatibility of the cutting technique with remote operation
✓ Low space / accessibility for the operation
✓ Underwater / air operation
✓ Design adapted to facilitate the decontamination of the tool

Radiation protection / human health, according to the cutting techniques, more/less:

✓ Exposure to the radiation,
✓ Risks for workers (cut, burn, anoxia, ..),
✓ Risk of internal contamination (risk of dispersion)

Safety requirement:

✓ Compatibility with the confinement barrier, fire risk for thermal techniques
Cutting techniques : detail review

Mechanical methods (cold cutting)

**Nibblers:**
- A punch rips pieces of material.
- For flat or slightly curved sheets.
- Handy tool (electric, pneumatic or hydraulic) allows for quick cuts, max 12 mm (stainless steel)
- Size of nibbler according to the thickness.
- Need a pre-hole when not possible to start from the end of the sheet (case of a closed tank)

**Hydraulic shears:**
- Used to cut and crush.
- Heavy version for large metallic parts, thickness capacity until 100 mm
- Handling version interesting for pipe cutting (under 80 mm of diameter), Closes the pipe before cutting it (interesting for containment).
Cutting techniques : detail review

Mechanical methods

Grinder (abrasive rotating saw) :
✓ Cut all, max thickness 75 mm (hand tool), or 100 mm (fixed tool), limited to the radius of the disk.
✓ Operational feedback : disks break more easily when the machine is fixed.

Panel of solutions with saw technology
✓ Circular saw: used in special cases. Slow, but no hot spot. Counter-rotating double disc version.
✓ Power hacksaw: short blades, hand or fixed tool, cutting all metals, needs some time (human cutting force).
✓ Reciprocating saw: hand tool that can be fixed. Max length 60 cm. Human cutting force, but possibly through a lever. Quite fast, straight cut.
✓ Crown saw : slow, but possibility of deep cutting.
Cutting techniques: detail review

Mechanical methods

Orbital cutting machine and tube cutting:

✔ Well adapted for circuit cutting, large pipe
✔ Once installed, can be remotely operated, interesting for area highly irradiated
✔ Each tool addresses a range of diameters.

CLEANING & DISMANTLING OF PRIMARY CIRCUIT OF CHOOZ A NPP (EDF)
Scope: cleaning up, dismantling, cutting, sorting and conditioning primary circuit including equipments: steam generator, primary pipes - ended
Cutting techniques : detail review

Mechanical methods (non cold cutting)

Diamond cable saw :

✓ Well adapted to heterogeneous components, big volume, large thickness (concrete cutting)
✓ Specific cable each matter, 200 €/m. 60 k€ for a small machine
✓ Cooling extends the life of the cable, but generate liquid waste and sludge
Cutting techniques: detail review

Thermal techniques

Plasma:
- High temperature (1500 to 2000 °) plasma ejected under pressure
- Thickness up to 80 mm (until ~ 160 mm), very fast cutting on stainless steel,
- Operate almost in contact but if touched, the plasma head is damaged.
- The flame must get through the material, it induces melting metal projections and gaseous emission

Arc-air:
- Graphite pencil with a jet of air. This creates an electric arc between the pencil and the piece to be cut; the air washes out the molten metal.
- Similar to plasma, may be less precise in the contact. Several passes possible (no necessity to get through). Wide cut line.

Thermal lance
- Concrete cutting, low precision
Cutting techniques : detail review

Thermal techniques

Laser :

✔ Nd-YAG mainly (neodymium-doped yttrium aluminium garnet), typically in range 4 to 6 kw
✔ Cutting by melting material by laser, an air flux injected through the laser beam washes out the molten metal
✔ Can be use with many kind of material,
✔ Thickness up to 50 mm, fast cutting (50-300 mm/min)
✔ Low dispersion, low secondary wastes
✔ Very expensive

EDF - Segmentation of spent fuel racks in our nuclear facility (Pierrelatte)
Cutting techniques : detail review

Other techniques

Water Jetting UHP for cutting
✓ A tiny jet (less than 1 mm of diameter) under Ultra High Pressure (3000 to 5000 bars), with additive (abrasive material)
✓ Stainless steel until 250 mm of thickness
✓ Induce contaminated liquid waste

Cutting with explosives cord
Decontamination techniques for concrete

Concrete shaver
✓ 3 to 6 mm deep / pass
✓ Good control of the thickness removed (optimise waste volume)
✓ Sensible to flatness defect, continuity of the floor/wall

Concrete scabbler
✓ Until 10 mm deep / pass
✓ Good performance
✓ Reliable
✓ For large surface
✓ Less precise than concrete shaver

DECONTAMINATION OF ATUE (INB 52) OF CEA ON CADARACHE SITE (FRANCE)
Scope: cleaning up of civil structures (wall, floor ...) by scabbling technic, 10 000 sq.m, 200 metric tons of waste,
Decontamination techniques for concrete

Water Jet

Remote operated jetting, "galerie technique", Marcoule

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 bars</td>
<td>HP</td>
</tr>
<tr>
<td>150 bars</td>
<td>VHP</td>
</tr>
<tr>
<td>700 bars</td>
<td>UHP</td>
</tr>
<tr>
<td>1,000 bars</td>
<td></td>
</tr>
<tr>
<td>2,500 bars</td>
<td></td>
</tr>
</tbody>
</table>

- Rinsing
- Removal of fixed contamination
- Concrete scabbling
- Removal of a surface layer from concrete and metal

CLEANING UP & DISMANTLING – WORKSHOP N° 55 – UP1 PLANT OF CEA CENTER OF MARCOULE (FRANCE)
Chemical Decontamination techniques : DFD (under EPRI license)

The EPRI DFD reagent is based on the mineral acid, fluoroboric acid. Fluoroboric acid is used in manufacturing industry for the preparation of clean metal surfaces as it is capable of removing metal oxides and metal surface of many metal alloys commonly used in manufacturing.

Target :

✔ Full Decontamination System (primary circuit, large components)

✔ Free release of contaminated metallic waste

Experience : Maine Yankee, Big Rock Point, Zorita

Project : FULL CIRCUIT DECONTAMINATION OF THE PRIMARY CIRCUIT OF D2 BOHUNICE (Slovakia)
Status : on going
Large dismantling

Conventional excavator, modified for operating in a nuclear environment
✓ Electric powering (no emission of toxic gases)
✓ Remote operation

DECONSTRUCTION OF THE RADIOACTIVE WASTE TREATMENT PLANT - CEA NUCLEAR SITE OF GRENOBLE (FRANCE).

Scope: Deconstruction of a set of buildings with the following main characteristics:
Total floor area: 6000 m², Highest building: 22 meters.
Management of 12 000 metric tonnes of radioactive waste generated during the deconstruction phase.
Remote operation for cutting & dismantling

Basic principles

✓ Expensive, time consuming, but sometimes required (dosimetry)
✓ Anticipate maintenance
✓ Reliability and resistance to irradiation: typical case of the failure of the vehicle in an inaccessible area...(experience from the first operation of remote equipments by the end of 80’ → MTBF: 100 h!)
✓ Dosimetry is not zero, sometimes exceeding dosimetry without remote operation!
  • Maintenance, repair, decontamination
  • Change of tool => also remotely operated
✓ The equipment will be an additional waste...
✓ Human Factors & Ergonomic as key design aspect
Remote operation for cutting & dismantling

Basic concepts

✓ one vehicle with a set of tools,
Remote operation for cutting & dismantling

Basic concepts

✓ Pendular remote equipments, mono or multi arms

A 1217 Wallischmiller TELBOT

KONDOR (SIT)

PYTHON (SIT)
Remote operation for cutting & dismantling

Basic concepts
✓ Several cases of a set of 2 robotic arms and a wastebasket, on self-installed rails
  ▪ Able to handle usual dismantling tools
  ▪ 6+1 axis, 60 kg at 2m
  ▪ Piloting: master arm
  ▪ To be mounted on all supports and carriers (picture: on a rail truck, with a second arm)
  ▪ Resistance up to 100kGy
  ▪ Underwater operating capability
  ▪ Tool auto change
  ▪ Continuous rotation of the wrist
Case study: benefits of using virtual reality simulation

Remote dismantling of blind cells with a laser system

MAR200 facility on the CEA site of Marcoule

- Remote handled dismantling of 2 dissolvers and their associated equipment
- Dissolvers made of large thickness Uranus stainless steel
- Blind cell environment with high radiation level
- Wide range of equipment types
  - Tanks (4600 kg)
  - Pipe circuits
  - Neutron counters
  - Etc...
- Final manual dismantling

Radiological initial state (of the tank)

<table>
<thead>
<tr>
<th>Part</th>
<th>Activity Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper part</td>
<td>10 to 70 mGy/h</td>
</tr>
<tr>
<td>Intermediate part</td>
<td>270 mGy/h</td>
</tr>
<tr>
<td>Most active parts</td>
<td>1 Gy/h</td>
</tr>
</tbody>
</table>

Pipe circuits

Dissolver

Neutron counter
Case study: benefits of using virtual reality simulation

Remote dismantling of blind cells with a laser system

MAR200 facility on the CEA site of Marcoule

Two independent systems working together

Remote handling shell
✓ Contains all the means necessary for the cutting
✓ MAESTRO system on specific carrier
✓ Telescopic sections
✓ Vertical (8 m) and rotating movements

Waste station
✓ Transfer container for cut elements
✓ Receives cut elements from MAESTRO clamp
✓ Radiological measurements
✓ Final waste packaging

MAESTRO tools
- Clamp
- Probe
- Nd YAG Laser
- Hydraulic grinder

Remote handling shell
Waste station
Case study: benefits of using virtual reality simulation

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ACCESSIBILITY STUDIES BY ONET - Objectives

✓ Validate intervention scenarios, by simulating at scale one
✓ Verify accessibility
✓ Show scenarios in a more user-friendly way
✓ Validate task ergonomics
✓ Train workers and indicate risks

CEA IMMERSIVE ROOM USED BY ONET

A motion capture system (4 IR cameras and specific targets placed on glasses) which follows user head motion
A passive stereoscopic visualization system with a 3.7m x 2.3m image wall (WUXGA resolution: 1920 x 1200)
Loudspeaker to simulate sounds
6D virtuose 35-45 by HAPTION
Case study: benefits of using virtual reality simulation

Remote dismantling of blind cells with a laser system

MAR200 facility on the CEA site of Marcoule

**PREPARATION - BUILDING OF THE 3D MODELS**

- Modelling of the environment based on plans, photos and videos
- CAD files of the remote handling system from design studies
- Simplifications of the whole mockup
  - Unnecessary details were removed
  - Non visible or hidden objects were removed
  - Surface models of buildings were created
- Creation of kinematics
  - 6 rotation DOF of the MAESTRO slave arm
  - Translation and rotation of the carrier
  - Real moving speeds
Case study: benefits of using virtual reality simulation

Remote dismantling of blind cells with a laser system

MAR200 facility on the CEA site of Marcoule

SIMULATE REALISTIC BEHAVIORS

✓ HMI similar to those found in reality
  ▪ Carrier controlled by a joystick
  ▪ MAESTRO controlled by a HAPTION
✓ Master arm
✓ Force-feedback when the MAESTRO is in collision
✓ Manipulation blocked when axes reach end stop

Results

✓ 5 days of testing
✓ All phases of the scenario tested and validated or modified according to test results
✓ Camera positions validated with real points of view
Thank you

for your attention