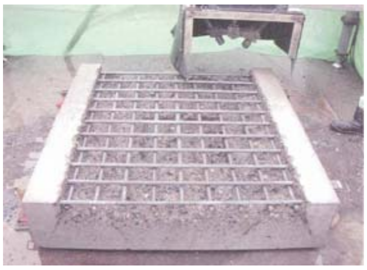
除染技術カタログ	技術区分 NO.		頁	

技術名称	コリジョンジェット工法	提案者	鹿島建設株式会社

【適用汚染形態】			【遠隔除染への適用実績】	
汚染形態	○液体・○個体・○紛体	適用除染場所環境	有・○無	橋げたの補修のためのかぶりコンクリートの撤去等、国内実績あり。
付　着	○ソフト・○ハード	○床・○壁・天井		
浸　透	○浅い・○深い	~~機器表面・機器内面~~		
核　種	○γ・○αβ	~~配管内部・他~~	反力	○有（100N　　）・ 無

【原理】
・2 本の水ジェットを衝突させることにより、ハツリ深さを調整することができる浸透除染技術。
・鉄筋を残して、コンクリートのみ剥離可能
・除染深さは～10cm 程度。
・廃水は回収し、スラッジ除去および除染を行い、ジェット用の水として再利用する。

コリジョンジェット


はつり試験結果

【原理説明】

【回収方法】
バキューム

【二次廃棄物の形態】
・スラリー
（汚染廃水、骨材、モルタル）

【必要ユーティリティ】
・電力：100～400kW
・水量：10～200 リットル/分

【基本機器構成】
・高圧ポンプ
・バキュームポンプ
・自走式カバー＋ノズル

【安全対策他適用留意点】

【適用除染実績・除染効果（DF）例】

・作業の障害となる鉄筋の有無/位置に係らず，汚染されたコンクリートの除去が可能である。（鉄筋の切断・除去は不要）
・浸透汚染については、下記の対応により残存部をクリアランス認定できるレベルまで低減することが可能である。
①汚染レベルが高い場合には、汚染厚さを一括でなく、数回に分けて除染することにより、最初に汚染レベルの高い部分を除去し、2 次汚染のリスクを低減する。
②最深部の層については、汚染深さに若干の余裕を考慮した深さ（汚染深さ 10mm+余裕 5mm）を除去する。

【除染能力・速度等】
・100～400kW→0.1～0.3 m^3/h
・厚さ 5cm の場合：0.2m^3/h→4m^2/h
・厚さ 1cm の場合：0.2m^3/h→20m^2/h

【寸法/質量（目安）】
・高圧ポンプ：1～6 トン

【福島第一原子力発電所への適用可と考える根拠、技術的課題】
・根拠：深い浸透汚染を除去可能
・課題：遠隔操作

【特記事項】

【引用・参考文献他】

［書式２－１］セクション１（除染）用

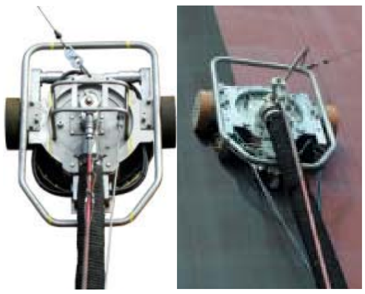
除染技術カタログ

除染技術カタログ	技術区分 NO.		頁	
技術名称	AQUABLAST®-PLUS surface cleaner Spiderjet® 3000	提案者	鹿島建設株式会社 （Hammelmann 社）	

【適用汚染形態】			【遠隔除染への適用実績】	
汚染形態	○液体・○個体・○紛体	適用除染場所環境	有 ・ ○無	Spiderjet：除染ではないが、船体の塗装剥離への適用実績あり。
付　着	○ソフト・○ハード	○床・○壁・天井		
浸　透	○浅い・深い	~~機器表面・機器内面~~		
核　種	○γ・○αβ	~~配管内部・他~~	反力	○有・　無

【原理】
・水ジェットにより、表面塗装やコンクリート表層を除去し、表面や浅い表面除染に適用可能な技術である。
・水ジェットで剥離した部分は、廃水と一緒に吸引回収する。

Surface Cleaner（床用）
（はつり幅：21.5cm）



Spiderjet（床・壁用）
（はつり幅：37.5cm）

【原理説明】

【適用除染実績・除染効果（DF）例】

・浸透汚染については、汚染深さに若干の余裕を考慮した深さを除去し、廃水を確実に吸引回収することにより、残存部をクリアランスレベルまで低減することが可能である。

【特記事項】

【回収方法】
バキューム

【二次廃棄物の形態】
・スラリー（廃水、モルタル）

【必要ユーティリティ】

【基本機器構成】
・高圧ポンプ
・バキュームポンプ
・Surface Cleaner　or　Spiderjet

【安全対策他適用留意点】

【除染能力・速度等】
・Spiderjet　剥離速度：～70 m²/h
（塗装の種類に依存する。）

【寸法/質量（目安）】

【福島第一原子力発電所への適用可と考える根拠、技術的課題】
・根拠：表面・浸透汚染を除去可能
・課題：遠隔操作（Surface Cleaner）

【引用・参考文献他】
ドイツ Hammelmann 社
AQUABLAST カタログ

除染技術カタログ

除染技術カタログ	技術区分 NO.		頁	

技術名称	パック除染工法	提案者	鹿島建設株式会社

【適用汚染形態】

汚染形態	~~液体~~・○個体・○紛体	適用除染場所環境
付　着	○ソフト・~~ハード~~	○床・○壁・~~天井~~
浸　透	~~浅い・深い~~	~~機器表面・機器内面~~
核　種	○γ・○αβ	~~配管内部・他~~

【遠隔除染への適用実績】

有・○無	一般構造物における表面汚れの除去の実績あり。
反力	有・○無

【原理】

・表面汚染を除去できる除染工法である。
・パック材を汚染表面に直接塗布し、汚染は、パック材に取り込まれ、パック材が乾燥して皮膜を形成する際に皮膜と一体化するので、皮膜を剥離することにより、除染が可能となる。

ハケによる塗布

乾燥した塗膜の剥離

【原理説明】

【適用除染実績・除染効果(DF)例】

【特記事項】

【回収方法】

【二次廃棄物の形態】
・塗膜（可燃性、水溶性）

【必要ユーティリティ】

【基本機器構成】
・刷毛 or スプレー

【安全対策他適用留意点】

【除染能力・速度等】

【寸法/質量（目安）】

【福島第一原子力発電所への適用可と考える根拠、技術的課題】

【引用・参考文献他】
コンクリート表面の洗浄方法（土木学会第 50 回年次学術講演会 H7.9）

除染技術カタログ

技術区分 NO.		頁	

技術名称	鹿島マイクロブラスティング(MB)工法	提案者	鹿島建設株式会社

【適用汚染形態】

汚染形態	~~液体~~・○個体・~~紛体~~	適用除染場所環境
付　着	○ソフト・~~ハード~~	○床・○壁・~~天井~~
浸　透	~~浅い~~・深い	~~機器表面・機器内面~~
核　種	○γ・○αβ	~~配管内部・他~~

【遠隔除染への適用実績】

有・○無

一般構造物におけるコンクリート構造物の破壊実績あり。

反力 有・○無

【原理】

・鉄筋コンクリート部材に一定間隔で削孔した小径孔に少量の爆薬を装填し、微少な発破によって部材をブロック割する工法である。

・浸透汚染が非常に深い部分に適用可能である。

・使用する爆薬は，導爆線と呼ばれる線状の火工品と電気雷管であり、装薬量は従来の発破工法と比較して 1/10 以下と少なくなる。

基礎梁試験体のブロック割

【原理説明】

【適用除染実績・除染効果(DF)例】

・浸透汚染については、汚染深さに若干の余裕を考慮した深さを MB 工法により区分することにより、残存部をクリアランスレベルまで低減することが可能である。

【特記事項】

【回収方法】

【二次廃棄物の形態】

・コンクリートブロック・ガラ・粉じん

【必要ユーティリティ】

【基本機器構成】

使用する爆薬：
・導爆線（線状の火工品）
・電気雷管

【安全対策他適用留意点】

・完爆の確認

【除染能力・速度等】

【寸法/質量（目安）】

【福島第一原子力発電所への適用可と考える根拠、技術的課題】

【引用・参考文献他】

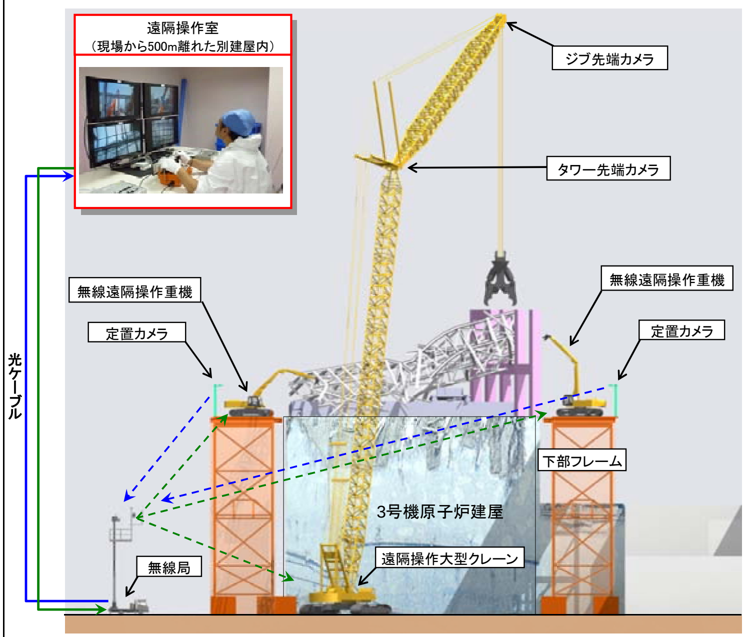
鹿島技術研究所
KaTRI リーフレット 2011-05

［書式２－２］セッション１（除染遠隔操作等）用

技術カタログ	
分類移動装置	遠隔操作
タイトル	無線・光ケーブルを用いた無人化施工システム
提案者	鹿島

１．技術内容（特徴、仕様、性能など）

・無線(LAN)と有線(光ファイバー)を併用することにより，遠距離からの重機操作が可能。
・LAN，光ファイバーによりカメラ画像を含む大量のデータ通信が可能。
・制御通信機器、カメラは放射線遮へい対策済。



福島第一原子力発電所
３号機カバー工事で実施中

・コリジョンジェット等の除染装置と組合せることにより，汚染した建屋内での除染作業を安全な場所から遠隔操作で行う，「遠隔除染」を可能にする。
・除染装置以外の様々な機器との組合せで，遠隔操作による作業の可能性を拡大する。

２．実績（国内プラント、海外プラント、他産業での実績を含む)

・福島第一原子力発電所３号機カバー工事

３．福島第一原子力発電所への適用可と考える根拠、技術的課題

・３号機周辺の高線量下においても誤作動・故障等の問題なく，稼動しているため。
・本システムは有線(光ファイバー)を併用しているため，電波の届かない建屋内においても，遠隔操作が可能なシステムを構築できると考えられるため。

４．開発すべき技術（例）

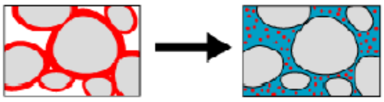
・建屋内での無線到達範囲等の検証が別途必要。

５．備考

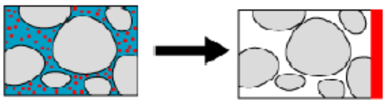
［書式２－１］セッション１（除染）用

<table>
<tr><td colspan="2">除染技術カタログ</td><td>技術区分
No.</td><td></td><td>頁</td><td></td></tr>
<tr><td>技術名称</td><td colspan="2">速乾・耐水性剥離塗膜除染（オライオン）</td><td>提案者</td><td colspan="2">バテルジャパン（株）/
Isotron 社</td></tr>
<tr><td colspan="3">【適用汚染形態】</td><td colspan="3">【遠隔除染への適用実績】</td></tr>
<tr><td>汚染形態</td><td>~~液体~~・固体・粉体</td><td>適用除染場所環境</td><td rowspan="3">有
・
無</td><td colspan="2" rowspan="3"></td></tr>
<tr><td>付着</td><td>ソフト・~~ハード~~</td><td>床・壁・天井</td></tr>
<tr><td>浸透</td><td>浅い・深い</td><td>機器表面・~~機器内面~~</td></tr>
<tr><td>核種</td><td>γ・αβ</td><td>配管内部・他</td><td>反力</td><td colspan="2">有（　　　）・無</td></tr>
</table>

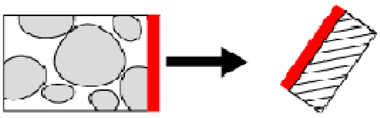
【原理】
除染対象物：コンクリートの場合



化学成分が孔に浸透、汚染物質の親和度がコンクリートから液体へとシフト、汚染物質が液体中を移動可能となる。



塗膜が乾燥する過程で、汚染物質が表面に集められる。



硬化した塗膜は剥離することができ、汚染物質は塗膜の中に閉じ込められたまま、ともに除去される。

【回収方法】
塗膜の剥離回収

【二次廃棄物の形態】
塗膜

【必要ユーティリティ】
電源

【機器構成】
現場環境に応じて以下（例）から選択：
・GRACO TRADEWORKS 150/170
・ペイントローラー、ハケ
・こて

【原理説明】
イオン交換性成分等を含んだ硬化性除染剤を、汚染された構造物に塗布。多孔質の構造物に有効。

【安全対策他適用留意点】

水性・非毒性

【適用除染実績・除染効果(DF)例】
●2012 年 1 月 福島市内にて、スレート屋根に塗布、約 26 時間経過後 剥離した結果、表面汚染密度が約 60%減少。
（除染前 約 240 cpm → 除染後 約 90 cpm）

●2008 年米国環境保護庁試験にて、汚染後 1 週間経過したコンクリート片に適用した結果、放射能量が約 79%減少。
（除染前 約 55μCi/片 → 除染後 約 12μCi/片）

【除染能力・速度等】

塗布後、約 20～24 時間で硬化

【寸法/質量（目安)】

塗布量　約 1.3ℓ/㎡
廃棄物量　約 0.5kg/㎡

【福島第一原子力発電所への適用可考える根拠、技術的課題】

理想的な屋内環境とは限らない現状の福島第一では、速乾・耐水性を兼ね備えた剥離性塗膜は作業効率を向上させると考える。

【特記事項】
Isotron 社の開発責任者は ALARA-1146（スリーマイル島事故他での除染に使用）を開発、その後、米国政府の依頼を受けオライオンを開発。他にも、Isolock（汚染拡散防止剤）、IsoFIX（土ぼこり飛散防止剤）を開発。

【引用・参考文献他】
・Isotron 社 HP、提供資料
・米国環境保護庁 公開資料
・Journal of Hazardous Materials
（Isotron 社論文を掲載）

［書式２－１］セッション１（除染）用

除染技術カタログ

除染技術カタログ	技術区分 NO		頁	

技術名称	レーザ誘起現象を利用した水中加工物加工技術（ハツリ、切断、穿孔）	**提案者**	日本海洋掘削㈱ 小林俊雄

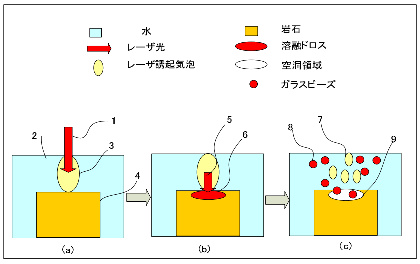
【適用汚染形態】

汚染形態	**液体・固体・粉体**	**適用除染場所環境**	
付着	**ソフト・ハード**	**床・壁・天井**	
浸透	**浅い・深い**	**機器表面・機器内面**	
核種	**γ・αβ**	**配管内部・他（外面）**	

【遠隔除染への適用実績】

有・無	但し、岩石、コンクリート材、鋼材、岩石等への除染向け切削加工の実績あり。
反力	**有（　　　　）・無**

【原理】本技術の溶融ドロスの飛散プロセスについて、CO_2 レーザ１を水２を介して岩石４に照射すると水２に吸収されてレーザ誘起気泡３を生成する（図 (a)）。レーザ誘起気泡３内を透過したレーザ５は、岩石４に到達し溶融ドロス６を生成する（図 (b)）。誘起気泡３の崩壊作用により溶融ドロス６を飛散させ微細ガラスビーズ８となって飛散して水中に拡散して排出される（図 (c)）。



1　レーザ光
2　水
3　レーザ誘起気泡
4　岩石など加工対象物
5　気泡内を透過したレーザ光
6　溶融ドロス
7　崩壊したレーザ誘起気泡
8　微細なガラスビーズ
9　照射後の加工空洞領域

図 3　レーザ誘起気泡による溶融ドロスの飛散プロセス

【原理説明】水への吸収率の高い CO_2 レーザを用いて生成気泡によるレーザ誘起力と熱作用により水中加工を行う。

【回収方法】入排水循環装置による

【二次廃棄物の形態】
・微粒子の屑
・水に微粒子屑が混じった懸濁液

【必要ユーティリティ】
電気、水、ガス（窒素 or 大気）

【基本機器構成】
・CO_2 レーザ発振設備
・冷却設備
・ユーティリティ供給設備
（圧縮機、循環ポンプなど）
・伝送管
・照射ノズル等

【安全対策他適用留意点】
・遮光メガネの着用等

【適用除染実績・除染効果（DF）例】除染実績は無い。その代替として、遮蔽コンクリート材に対して、表面ハツリ加工厚さ 20mm 以上の切削性能や切断、穿孔を検証した。

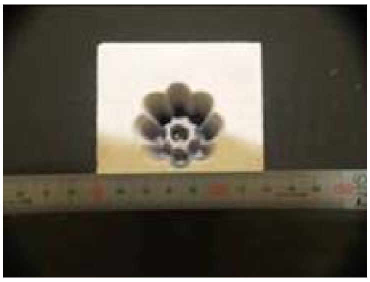


図 1　石灰岩の加工実績（深さ 30mm）

【除染能力・速度等】
詳細版：表 5-1 参照。
加工性能は更に改善の余地有り。

【寸法/質量（目安）】
床面：　表 5-2 参照/ 約 2.6 トン
容器：　表 5-2 参照/ 約 5.4 トン

【福島第一原子力発電所への適用可と考える根拠・技術的課題】
・根拠：付着した汚染物質を熱・機械的に洗い落す新規の加工処理法
・課題：ノズル構造改良等

【特記事項】本技術は、岩石、金属、コンクリート等の水中加工（切削、切断、穿孔）が可能であり、加工対象材料を選ぶ事はない。更に、液体の透明・不透明は問わず、中実部材の任意点からの水中切断加工が可能である。

【引用・参考文献他】

小林俊雄等、海洋資源開発へのレーザ応用、レーザ加工学会特集号　21 世紀を拓くレーザ応用ほか

［書式２－１］セッション１（除染）用

除染技術カタログ	技術区分 NO.		頁	
技術名称	エポキシ樹脂を使用した除染性向上	**提案者**	サンユレック(株) 原	

【適用汚染形態】			【遠隔除染への適用実績】	
汚染形態	**液体**・固体・粉体	適用除染場所環境	有 ・ **無**	
付　着	ソフト・**ハード**	**床**・**壁**・**天井**		
浸　透	**浅い**・深い	機器表面・機器内面		
核　種	γ・αβ	配管内部・他	反力	有（　　　）・無

【原理】

芳香族アミンを使用したエポキシ樹脂は、耐放射能性に優れており、コンクリートの上に塗布した後に除染が行い易くなります。
コンクリートは、多孔質な為、高圧洗浄等の除染効率が悪い。

【原理説明】

【適用除染実績・除染効果(DF)例】

【特記事項】

福島原発を建設した時に既にコンクリートの隙間に充填した。塗り床材としても採用された。

【回収方法】

【二次廃棄物の形態】

【必要ユーティリティ】

【基本機器構成】

【安全対策他適用留意点】

【除染能力・速度等】

【寸法/質量(目安)】

【福島第一原子力発電所への適用可と考える根拠，技術的課題】

【引用・参考文献他】

［書式２－２］セッション１（除染遠隔操作等）用

技術カタログ	
分類移動装置	
タイトル	芳香族アミンを使用したエポキシ樹脂の除染性向上
提案者	サンユレック（株）　原

１．技術内容（特徴、仕様、性能など）

一般的なエポキシ樹脂は、脂肪族アミンである。

芳香族アミンを使用した場合は、脂肪族アミンより１０倍耐放射能性がある。

　原子炉建屋内の除染（高圧洗浄等で）を行った後、

エポキシ樹脂を塗布することによって、染量が多くなったときに

コンクリートの下地より簡単に除染が行うことができる。

壁・天井・床の全ての面に施工が可能

２．実績（国内プラント、海外プラント、他産業での実績を含む）

バイオマスプラント等に使用されている。

３．福島第一原子力発電所への適用可と考える根拠、技術的課題

原子炉建屋止水格納容器下部補修に使用できる

４．開発すべき技術（例）

５．備考

[Format 2-3] Session2 Remote-control operation machine and measurement equipment for CV inspection

Technical Catalogue	
Mobile device classification	Decontamination
Title	Chemical Decontamination of Reactor Components and Piping
Proposed by	Westinghouse Electric Japan

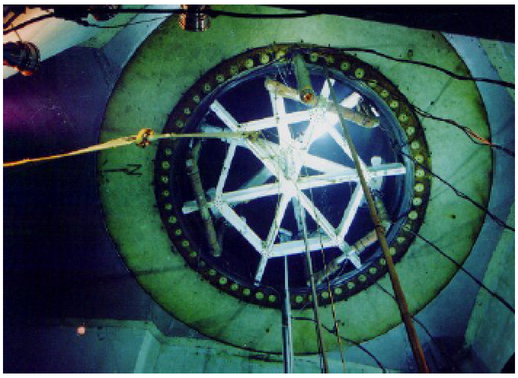
1. Technical description (Advantage, Specification, Performance)

Nuclear Services/Installation and Modification Services

Chemical Decontamination for Decommissioning

Background

The Electric Power Research Institute (EPRI) has a licensed decontamination for decommissioning (DFD) process to remove facilities, including operating nuclear power stations, from service. Westinghouse is experienced in providing this service, and specializes in a variety of applications ranging from individual component to full-system decontaminations.



At Maine Yankee, Westinghouse developed creative alternatives to provide "loop-to-loop" jumpers and isolation of the reactor from the decontamination process.

Benefits

- Significant reduction in personnel and site radiation exposure
- Reduction in radwaste volumes and costs using the EPRI DFDX process
- Free release of materials
- Improved productivity
- Improved conditions and schedules for facility decommissioning

Westinghouse, a full-service chemical decontamination company, provides artifact testing at its Richland, Washington, USA, laboratories. This testing compares the effectiveness of the different solvents on actual plant material providing to plant personnel the necessary data to choose the right solvent for their application. Artifact testing has been a useful tool in improving the decontamination factors at nuclear stations around the world.

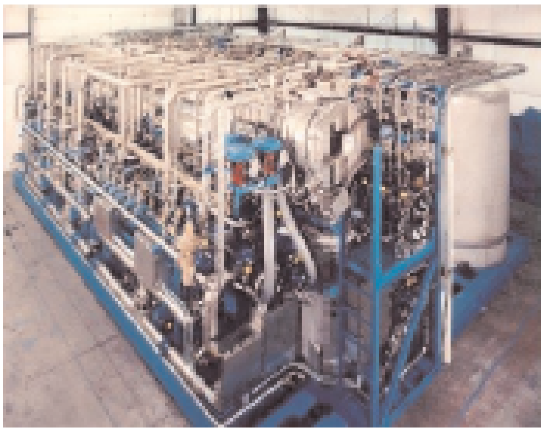
The chemical solvents used by Westinghouse are safe and can be applied on plant safety systems without detrimental effects from corrosion. Westinghouse can provide chemical decontamination solvents for operating or decommissioned nuclear stations.

Westinghouse provides optional equipment, such as water shields and specialized systems, to decontaminate specific components.

Full-system Chemical Decontamination

Background

Westinghouse designed, fabricated and installed the full-system decontamination modular system at Entergy's Indian Point Unit 2, and performed a 105,000-gallon, in-situ chemical decontamination of the pressurized water reactor (PWR) reactor, steam generators and plant-cooling systems. The ion exchange process system was designed to remove 10,000 curies of radioactive contaminants from the plant systems in a six-day decontamination solvent application.



The full-system decontamination skid as installed at Entergy's Indian Point Unit 2

Description

The system's operating weight is 280 tons with a minimum floor space requirement of 840 ft² (28 ft X 30 ft). The 1,500-gpm-rated modular system comprises:

- Nine 160 ft³ ion-exchange vessels
- Four 320 ft³ spent-resin storage tanks
- Full-flow backwashable filters
- Remote resin fill and transfer system
- Fully computerized/PLC control system

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

Westinghouse designed the first 4 PWRs in Japan. In addition Westinghouse has designed, built and repaired nuclear plants all over the world. Westinghouse based nuclear plant design is used in approximately one half of the worlds' nuclear plants.

Two examples of past Westinghouse chemical decontamination projects:

- Decontamination of the Reactor Coolant System at Maine Yankee prior to Decommissioning
- Decontamination of the full Reactor Coolant System at Nine Mile Point Unit 2 for dose reduction. This removed 10,000 curies (370 terabecquerels) of radioactive contaminants.

3. Applicability to Fukushima site, Technical challenges

The physical damage to the Fukushima Units 1 – 4 alone is enough to make stabilization and

decommissioning extremely difficult. The high radiation levels greatly increases the difficulty. Chemical decontamination of all systems of Units 1 - 3 not required to maintain Cold Shutdown conditions and for Spent Fuel Pool cooling could be decontaminated, significantly reducing the source term. Chemical decontamination of all systems in Unit 4 not required for SFP cooling would reduce the source term and prepare these components for easier dismantling and disassembly with lower overall personnel exposure
4. Technology Development (Example) Technology development would be required: to develop the equipment to adapt it to Fukushima specific systems; to make the process more remote and faster setup to adapt it to the Fukushima general working environment dose rates; and to do laboratory testing on Fukushima artifacts or simulated material to optimize the process for maximize effectiveness.
5. Note

[Format 3]

Self-evaluation on applicability for proposed technologies with project scope and needs in mind (Environmental condition, remaining technical challenges, etc)

Most applicable technical point-1 :
Self-evaluation: Extensive experience in designing and building equipment to service and repair nuclear plants in extreme environments.
Most applicable technical point-2:
Self-evaluation: Westinghouse designed the remote equipment used to remove the debris and melted fuel from TMI2. In addition a team of Westinghouse personnel have been working continuously in Japan on stabilization and restoration of Fukushima Units 1 – 4 so our technical experts are very familiar with the situation. Westinghouse has extensive worldwide experience in servicing BWRs. Often we are utilized by nuclear plant owners to do complete refueling outages.
Note: (Price, Delivery, photo, etc.) This equipment would be custom designed and fabricated to specific Fukushima parameters and requirements. Price and delivery information for an R&D program is available on request.

[Format 2-1]　Session1: Decontamination

<table>
<tr><td colspan="2">Decontamination Technology Catalogue</td><td>Category No.</td><td></td><td>Page</td><td></td></tr>
<tr><td>Title</td><td colspan="2">Inorganic sorbent Termoxid-35 for the decontamination of the salt solutions from cesium radionuclides</td><td>Proposed by</td><td colspan="2">Closed-Type Joint-Stock Company Termoxid</td></tr>
<tr><td colspan="3">Applicable contamination condition</td><td colspan="3">Experience in remote-control condition</td></tr>
<tr><td>Form</td><td><u>Liquid</u>/ solid/ powder</td><td>Location</td><td rowspan="2"><u>YES</u> / NO</td><td rowspan="2" colspan="2"></td></tr>
<tr><td>Adhesion</td><td>Soft / Hard</td><td>Floor/Wall/ceiling</td></tr>
<tr><td>Penetration</td><td>Shallow / Deep</td><td>Machine surface / inside machine</td><td rowspan="2">Reaction</td><td rowspan="2">Yes
(　　　　)</td><td rowspan="2">No</td></tr>
<tr><td>Nuclide</td><td><u>Gamma</u> / α β</td><td>Inside pipe, others</td></tr>
<tr><td colspan="3" rowspan="4">Principle

Selective sorption of cesium radionuclides from salt solutions</td><td colspan="3">Collection method</td></tr>
<tr><td colspan="3">Secondary waste form
Solid</td></tr>
<tr><td colspan="3">Necessary utility
Utilized by the same method as the ion-exchange resins.</td></tr>
<tr><td colspan="3">Basic machine structure</td></tr>
<tr><td colspan="3">Principle Explanation

Sorption of cesium occurs on the active sorbent component (on potassium- nickel ferrocyanide). The sorbent is used in the bulk layer in the column type apparatuses or filter-containers. The use for the radial filtration is also possible.</td><td colspan="3">Safety measures/cautions</td></tr>
</table>

Past experiences/Decontamination effectiveness(DF) **The sorbent is used at the liquid radioactive wastes complex of the Kolskaya Nuclear Power Plant (Russia); for laundry waters decontamination at the Kalininskaya Nuclear Power Plant (Russia); in the Iran and India projects of the nuclear plants.** **The sorbent successfully has been tested in AREVA NC.**	Decontamination capability/Performance speed Size/Weight Applicability to Fukushima site/Technical challenges **For the extraction of cesium radionuclides from NPP liquid wastes with medium or high salinity.**
Note **The sorbent is used for the extraction of cesium radionuclides from the solutions with pH value from 7.0 to 11.5 and with medium or high salinity (still bottoms of the evaporating apparatuses, sea waters, NPP liquid wastes, etc.)** **The sorbent consists of the spherical granules 0.4÷1.0 mm of size.** **The decontamination coefficient for cesium radionuclides depends on the sorbent operation conditions.**	Reference documents **Leonid Sharygin, Andrey Muromskiy, Maria Kalyagina, Sergey Borovkov “ A Granular Inorganic Cation-Exchanger Selective to Cesium” Journal of Nuclear science and technology. Vol. 44. No5. p. 767-773 (2007);**

[Format 2-1]　Session1: Decontamination

Decontamination Technology Catalogue			Category No.		Page	
Title	**Inorganic sorbent Termoxid-3A for the decontamination of the highly active waters from irradiated fuel cooling ponds**		Proposed by	**Closed-Type Joint-Stock Company Termoxid**		
Applicable contamination condition			**Experience in remote-control condition**			
Form	**Liquid**/ solid/ powder	Location	**YES** / NO			
Adhesion	Soft / Hard	Floor/Wall/ceiling				
Penetration	Shallow / Deep	Machine surface / inside machine	Reaction	Yes ( )	No	
Nuclide	**Gamma** / α β	Inside pipe, others				

Principle **Sorption decontamination of the irradiated fuel cooling ponds waters from the radionuclides of cesium, uranium, transuranium elements, cobalt, strontium, etc.**	Collection method Secondary waste form **Solid** Necessary utility **Utilized by the same method as the ion-exchange resins.** Basic machine structure
Principle Explanation **The sorbent is used in the bulk layer in the column type apparatuses or filter-containers. The use for the radial filtration is also possible.**	Safety measures/cautions

<table>
<tr>
<td rowspan="3">Past experiences/Decontamination effectiveness(DF)

The sorbent is used for the irradiated fuel cooling ponds waters decontamination at the Beloyarskaya Nuclear Power Plant (Russia).</td>
<td>Decontamination capability/Performance speed</td>
</tr>
<tr>
<td>Size/Weight</td>
</tr>
<tr>
<td>Applicability to Fukushima site/Technical challenges
To decontaminate the waters of the irradiated fuel cooling ponds.</td>
</tr>
<tr>
<td>Note
The sorbent is used to extract the radionuclides from the solutions with a low content of the salts and pH value 6.0÷8.0.
The sorbent consists of the spherical granules 0.4÷1.0 mm of size.
The coefficient of decontamination and radionuclides concentration depends on the sorbent operation conditions.</td>
<td>Reference documents
1. Sharygin L.M., Muromsky A.Yu., Moiseev V.E., et al.
"The tests of the selective sorbent Termoxid-3A for the decontamination of the coolant of the Beloyarskaya NPP fuel cooling pond" – J. "Atomic Energy", 1996, V. 80, Issue 4, pp 279-282 (in Russian).
2. Sharygin L.M., Muromsky A.Yu., Saraev O.M., et al.
"Irradiated fuel cooling ponds water decontamination using radiation resistant inorganic sorbents" - J. "Atomic Energy", 2001, V. 91, Issue 2, pp 126-130 (in Russian).</td>
</tr>
</table>

Format 1

The proposed method is not presented in catalogues.

Russia Federal Nuclear Center-VNIIEF
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tel.: +7-83130-28986

Format 2-1
Session 1: Decontamination

Decontamination Technology Catalogue The proposed method is not presented in catalogues		Category No.		Page	
Title	Modified Microspheres for Cleaning Liquid Wastes From Radioactive Nuclides		Proposed by	Dr. Stanislav Vesnovskiy Leading Scientist Russia Federal Nuclear Center-VNIIEF 37, Mira Av., Sarov, Nizhni Novgorod Region,Russia, 607190 e-mail: vesnovskii@expd.vniief.ru	
Applicable contamination condition			**Experience in remote-control condition**		
Form	Liquid	Location Water in atomic power plant basins and natural water bodies	YES / NO	No experience and equipment to be used in remote-control	
Adhesion	Hard	Floor/Wall/ceiling			
Penetration	Shallow	Machine surface / inside machine↵	Reaction	Yes ( )	No ( )
Nuclide	Gamma / α β Irradiators ^{233}Pa, U, Np, Pu, Am and fission products	Inside pipe, others			

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	------------
Title	**Visualization of conditions in CV for planning and personnel training purposes**
Proposed by	

1. Technical description (Advantage, Specification, Performance)

Based on the technical plant information and on the data available, make a consistent picture of the situation in the plant including:

- Solid, liquid, gaseous conditions in the CV
- Composition profile of the solid phase
- Temperature and radiation intensity mapping
- Mapping of accessible areas
- Points of leakage and/ or suspect leakage

The information will be placed on a Virtual Reality (VR) platform, enabling to map the radiation field and intensity, as well as to calculate the accumulated dose for travelling equipment or for humans being in neighbor locations. This tool will be very valuable for planning the decontamination-related activities, in that operations can be simulated in the VR environment, especially in consideration of the small space available and of the high radiation level.

Based on earlier experience, we suggest using this tool also for training the personnel involved in the decontamination work. This tool becomes particularly important when humans have to approach or enter a zone with risk of radiation exposure.

Finally, this tool may be very useful for interacting with the public.

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

We are a well reputed international nuclear center having 40 year experience with working together with Japanese institutions and industry.

We have a skilled international staff which includes Japanese members.

As the reference list below shows, Our department has considerable international expertise in visualization technology for training and planning for the decommissioning of nuclear installations. In addition to client business has also a research activity under the auspices of the OECD Halden Project.

In Japan, it is worthwhile noting that we have developed systems used in the decommissioning of the Fugen reactor in Tsuruga, Japan (1999-2004).

In 2005, we also carried out a mission at the Fukushima plant in Japan for TEPCO. This work consisted in visualizing the radiation level inside the plant in connection with the maintenance work on the main circulation pumps. We believe that the results from this project can be a good start point and a reference for providing VR solutions applicable to remote measurement of radioactivity at the facility.

Among our partners in Japan, we particularly emphasize the cooperation with the Kyoto University and professor Hidekazu Yoshikawa on augmented reality (AR).

Customer/Plant	Application	Year
Dynamic RadIation Visualisation Engine - DRIVE Andreeva Bay area, Russia	The DRIVE project aims to utilize radiation visulisation tools to enhance regulatory supervision and safety planning in the Andreeva Bay	2011- current
Danish Decommissioning Roskilde, Denmark	Halden Planner consultancy, support and training.	2011-current
Chernobyl NPP Chernobyl, Ukraine	Establish the Chernobyl Decommissio-ning Visualisation Centre for use in the planning, training and presentation of the decommissioning of Chernobyl NPP	2008-2010
Leningrad NPP Sosnovy Bor, Leningrad Russia	A simulator of a nuclear refuelling machine at Leningrad NPP	1999- 2010
Tokyo Electric Power Co. Inc. (TEPCO) and TEPCO Systems Corporation (TEPSYS)	Technology for automatic radiation measurement and display using posi-tion tracking, knowledge management, dose reduction and work planning	2005
European Space Agency (ESA) ESTEC Netherlands	DESIRE RadVis is a tool that displays predictions, created using the Geant4 -based DESIRE system for rapid as-sessment and visualisation of radiation flux and dose in space environments	2004 First delivery: 2003
Fugen NPS Japan Nuclear Fuel Cycle Development Institute (JNC) 3 Myojin-cho, Tsuruga-shi Fukui 914-8510, Japan	The application is used for planning the decommissioning of the Fugen reactor. Consisting of a VR-model, functions for work task management and radiation visualisation	2004 First delivery: 1999 / 2000
Ente per le Nouve Tecnologie, L'Energia e l'Ambiente (ENEA): VirtualDecom	Planning and administration for decommissioning of plutonium contaminated glove boxes	2003 First delivery: 2002

3. Applicability to Fukushima site, Technical challenges

As mentioned above, in 2005 we carried out a mission at the Fukushima plant in Japan for TEPCO. This work consisted in visualizing radiation level inside the plant in connection with the maintenance work on the main circulation pumps. We believe that the results from this project can be a good start point and a reference for providing VR solutions applicable to remote measurement of radioactivity at the facility.

4. Technology Development (Example)

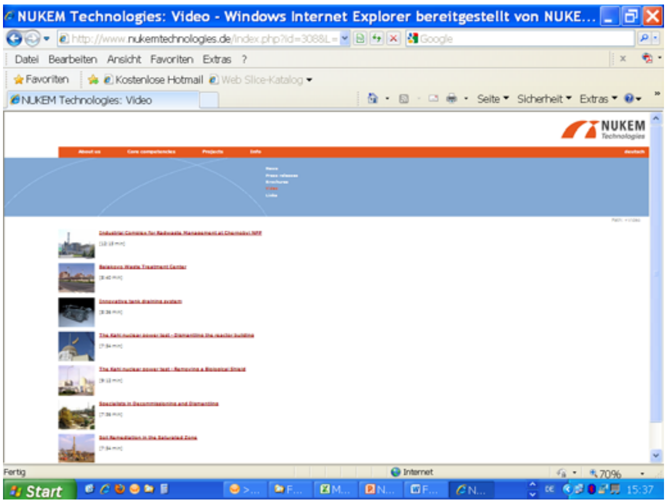
See attached PDF file with a presentation on "*Halden new software tools for dynamic radiological characterization and monitoring in nuclear sites*"

5. Note

[Format 2-1]　Session1: Decontamination

Decontamination Technology Catalogue		Category No.		Page	
Title	Remote Controlled Vehicle (Crawler) to remove sediments and floor contamination		Proposed by	NUKEM Technologies GmbH	
Applicable contamination condition			**Experience in remote-control condition**		
Form	Liquid/ solid/ powder / sludge	Location	YES / NO	Remote controlled operation in hazardous environment (high dose, agressive media, dirty media)	
Adhesion	Soft / Hard	Floor/Wall/ceiling			
Penetration	Shallow / Deep	Machine surface / inside machine	Reaction	Yes ( )	No
Nuclide	Gamma / α β	Inside pipe, others			

Principle The Remote Controlled Vehicle to remove sediments and floor contamination name “Crawler” is a small robot which can be operated under water, in sludge and in air, depending on its specific design.  	Collection method Suction Secondary waste form Depending on specific design and further treatment of removed RAW
It can be equipped with camera and measuring devices.	Necessary utility Power supply, glove box, collection tank
For detailed information please refer to the attached reference documents	Basic machine structure

<table>
<tr><td>Principle Explanation
For detailed information please refer to the attached reference documents</td><td>Safety measures/cautions</td></tr>
<tr><td rowspan="3">Past experiences/Decontamination effectiveness(DF)
The Crawler was designed and operated to remove crystallised salt, liquid RAW, sludge and IEX-resins from collection tanks at Kola NPP (Russia) for further treatment of the RAW</td><td>Decontamination capability/Performance speed</td></tr>
<tr><td>Size/Weight
Approx. 850 mm x 470 mm x 300 mm
Approx. 100 kg</td></tr>
<tr><td>Applicability to Fukushima site/Technical challenges
yes</td></tr>
<tr><td>Note

</td><td>Reference documents:
• Crawler video

For further information please refer to www.nukemtechnologies.de
Sublink ➡ Info ➡ Video
“Innovative Tank Draining System”</td></tr>
</table>

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	
Title	Remote Controlled Vehicle (Crawler) to remove sediments and floor contamination
Proposed by	NUKEM Technologies GmbH

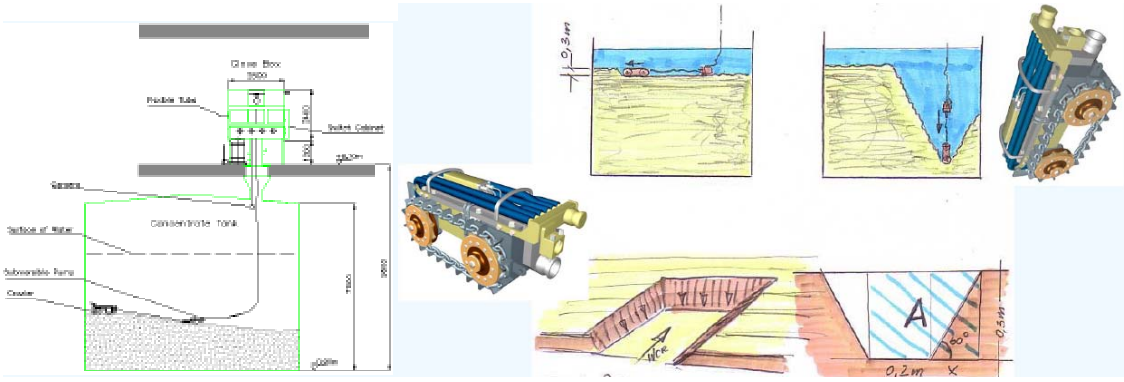
1. Technical description (Advantage, Specification, Performance)

The Crawler was designed and operated to remove

- crystallised salt,
- liquid RAW,
- sludge,
- IEX-resins

from collection tanks at Kola NPP (Russia).

Photo of Crawler



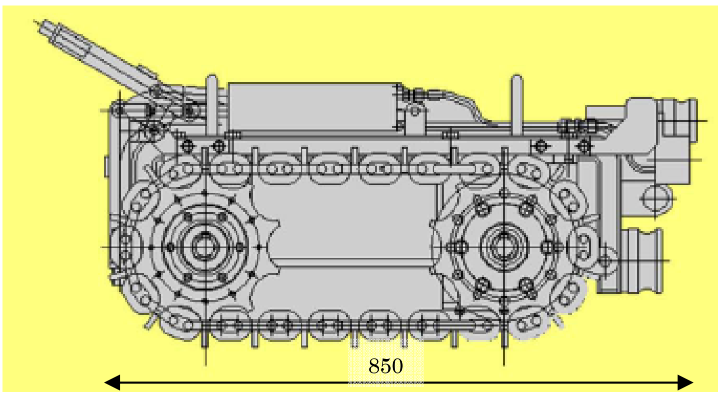
Working Principle

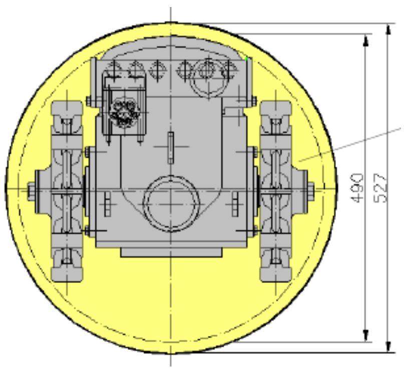
The Kola-Crawler was equipped with

- a pump to suck and pump the liquid solution
- 4 wheels and 2 pairs of chain
- an intake to suck the liquid solution
- jets to spray the liquid solution onto the surface to re-dispense salt or sludge or particles that they can be removed
- light and camera for observation

Moving is performed by the 2 chains which are powered by compressed air. Each pair of wheels is powered separately to enable direction changes.

To remove the crystallised evaporator concentrates (salt) from the collection tanks, the salts had to be re-dispensed. Therefore the liquid solution was re-circulated and heated. Heating as well as pH-adaptation was performed in a glove box. The glove box also served as a lock to move the crawler into the tanks and after execution to pack it free of contamination via a lock into a 200 liter drum.



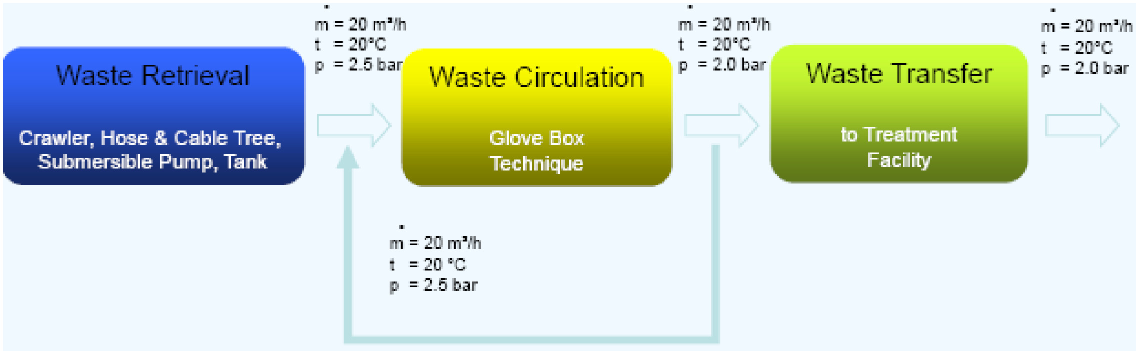


The Kola-Crawler can be used to remove

- liquids (liquid RAW and others)
- sludge and sediments
- crystallised salt

from areas, floors, rooms.

The processing of the “Kola Crawler” is outlined in the following scheme:



Modified versions of the Crawler also can be operated as remote controlled

- vacuum cleaner to remove dry sediments/particles from floors and walls
- high pressure water jet cleaner to remove soft and hard adhesion contamination on floors and walls
- inspection and sample device to analyse in-situ situations in hazardous environments.

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

The Crawler was successfully operated at Kola NPP (Russia) to empty and to clean collection tanks containing

- crystallised salt,
- liquid RAW,
- sludge,
- IEX-resins

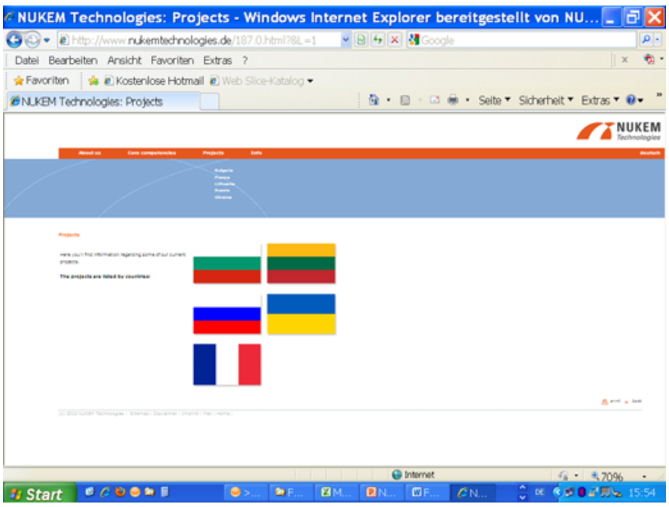
The operation of the Crawler is shown in a video. Please refer to chapter “Note” in format 2-1.

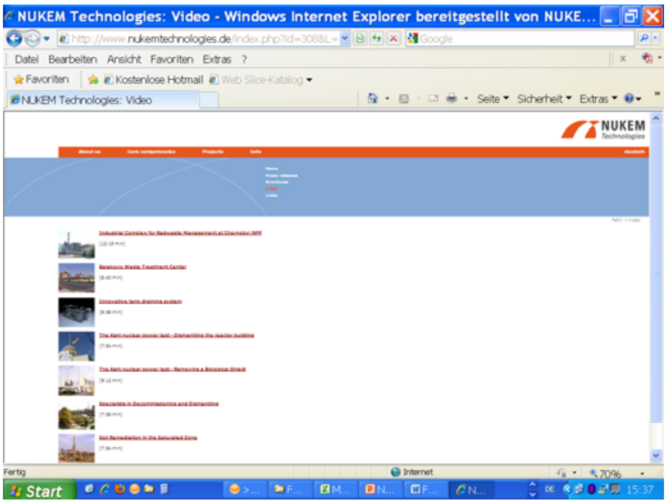
3. Applicability to Fukushima site, Technical challenges Remote controlled cleaning/decontamination of surfaces - removal of • liquids (liquid RAW and others) • sludge and sediments • crystallised salt from areas, floors, rooms. The Crawler mentioned above, can be modified that it can serve as inspection device (for example to solve some tasks of Session 1). Equipped with camera and perhaps a sample device, the modified Crawler can be used to analyse the situation in flooded areas as well as not flooded areas. It can move on the floor but it cannot cross obstacles.
4. Technology Development (Example) The Crawler was developed and constructed by NUKEM due to the specific requirements of the specific needs at Kola NPP. Furthermore NUKEM developed a variety of other decontamination and remote operation techniques due to the specific requirements of its clients.
5. Note With its experience in the mentioned Kola-project as well as the experience of a big number of nuclear projects dealing with decontamination behaviors (operation of Waste Treatment Centers/Facilities and Decommissioning or Dismantling Projects) NUKEM has the qualification and is able to modify and adapt its decontamination techniques due to the specific needs (operational and economical) at Fukushima site. Please refer to www.nukemtechnologies.de for further information and overview of NUKEM´s experience, competence and competition. Don´t hesitate to contact us in case of further questions or further information.

[Format 2-1]　Session1: Decontamination

Decontamination Technology Catalogue		Category No.			Page	
Title	Remote Controlled Decontamination Techniques		Proposed by	NUKEM Technologies GmbH		
Applicable contamination condition			**Experience in remote-control condition**			
Form	Liquid/ solid/ powder / sludge	Location	YES / NO	Remote controlled operation in hazardous environment (high dose, agressive media, dirty media)		
Adhesion	Soft / Hard	Floor/Wall/ceiling/equipment				
Penetration	Shallow / Deep	Machine surface / inside machine	Reaction	Yes ( )	No	
Nuclide	Gamma / α β	Inside pipe, others				

Principle	Collection method
Special technologies and procedures to decontaminate surfaces, rooms, floors, buildings, equipment from radioactive contamination, i.e. • high pressure water jet cleaning • abrasive blasting decontamination • chemical decontamination • coating removal • layer removal • etc.	Depending on specific design **Secondary waste form** Depending on specific design and further treatment of removed RAW **Necessary utility** Power supply, pumps, glove box, collection tank, blasting material, chemicals, robots, remote operating vehicles Depending on specific design **Basic machine structure**
Principle Explanation For detailed information please refer to the attached	**Safety measures/cautions**

reference documents	
Past experiences/Decontamination effectiveness(DF) Decontamination technologies i.e. • high pressure water jet cleaning • abrasive blasting decontamination • chemical decontamination • coating removal • layer removal were successfully operated during the dismantling of the first German NPP "VAK Kahl". Furthermore the above mentioned technologies were successfully implemented/applied at the several projects, for example • Dismantling of the German reprocessing plant "WAK" at Karlsruhe • Dismantling of the multi purpose reactor "MZFR" at Karlsruhe • Several Waste Treatment Centers	Decontamination capability/Performance speed In a lot of other projects, for example Size/Weight Depending on specific design Applicability to Fukushima site/Technical challenges yes
Note 	Reference documents: • Company Presentation • Projects • Video – "Dismantling of the first German NPP "VAK" • Video – "Crawler Innovative Tank Draining System" For further information please refer to www.nukemtechnologies.de Sublink → Projects Sublink → Info → Video "Dismantling of the first German NPP "VAK"



http://www.nukemtechnologies.de/314.0.html?&L=1

http://www.nukemtechnologies.de/312.0.html?&L=1

“Innovative Tank Draining System”

http://www.nukemtechnologies.de/309.0.html?&L=1

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	
Title	Remote Controlled Techniques to retrieve or decontaminate and remove radioactive material
Proposed by	NUKEM Technologies GmbH

1. Technical description (Advantage, Specification, Performance)

Special technologies and procedures to decontaminate surfaces, rooms, floors, buildings, equipment from radioactive contamination, i.e.

- high pressure water jet cleaning
- abrasive blasting decontamination
- chemical decontamination
- coating removal
- layer removal
- etc.

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

VAK Kahl Dismantling (1. German NPP):

Remote controlled and manual operated procedures were used to decontaminate and remove the radioactive material from the old NPP.

Detailed information is provided in the attached Video.

Decommissioning
Reference Project - VAK Kahl, Germany

First German Nuclear Power Plant – VAK Kahl

Before

After

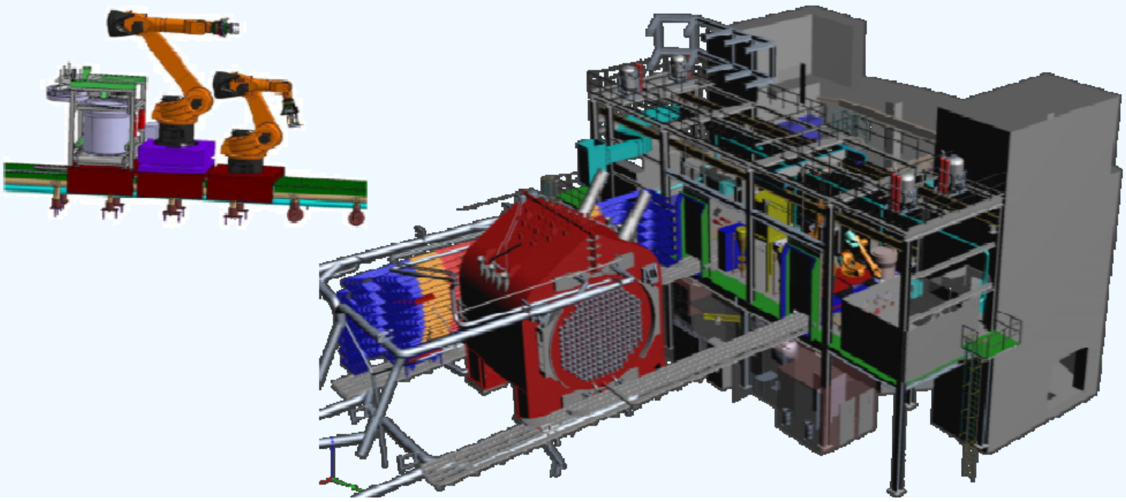
Decommissioning
Abrasive Decontamination

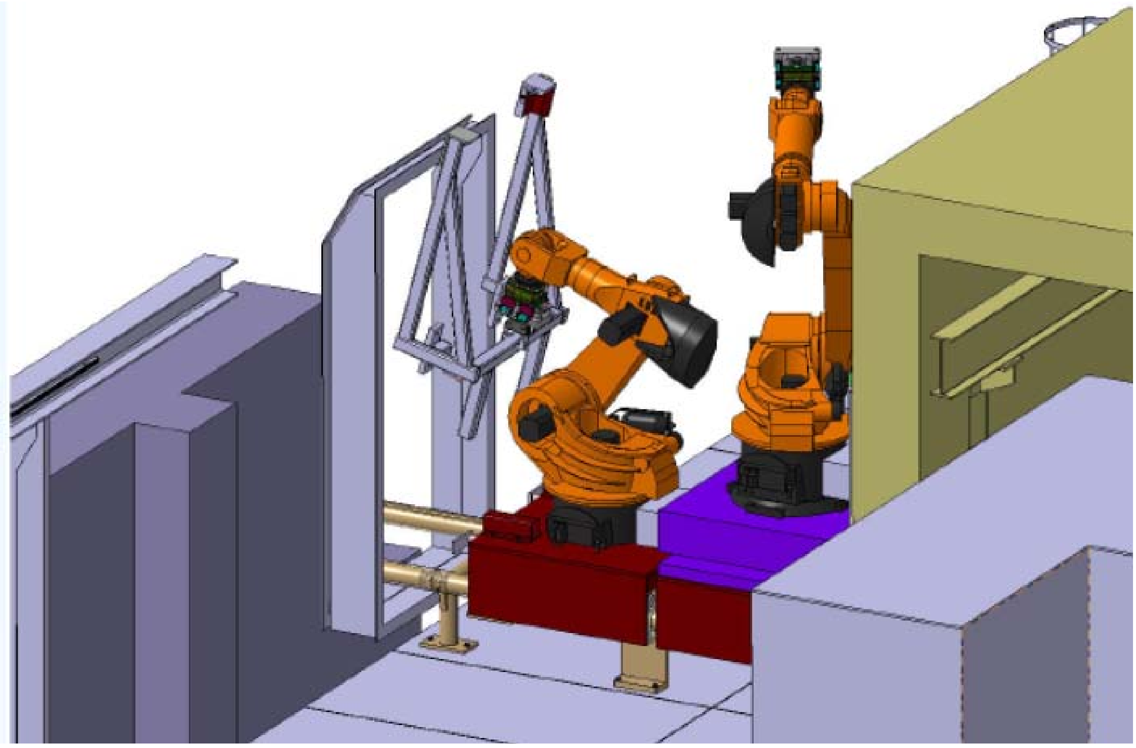
Dismantling of the Brennilis NPP, France:

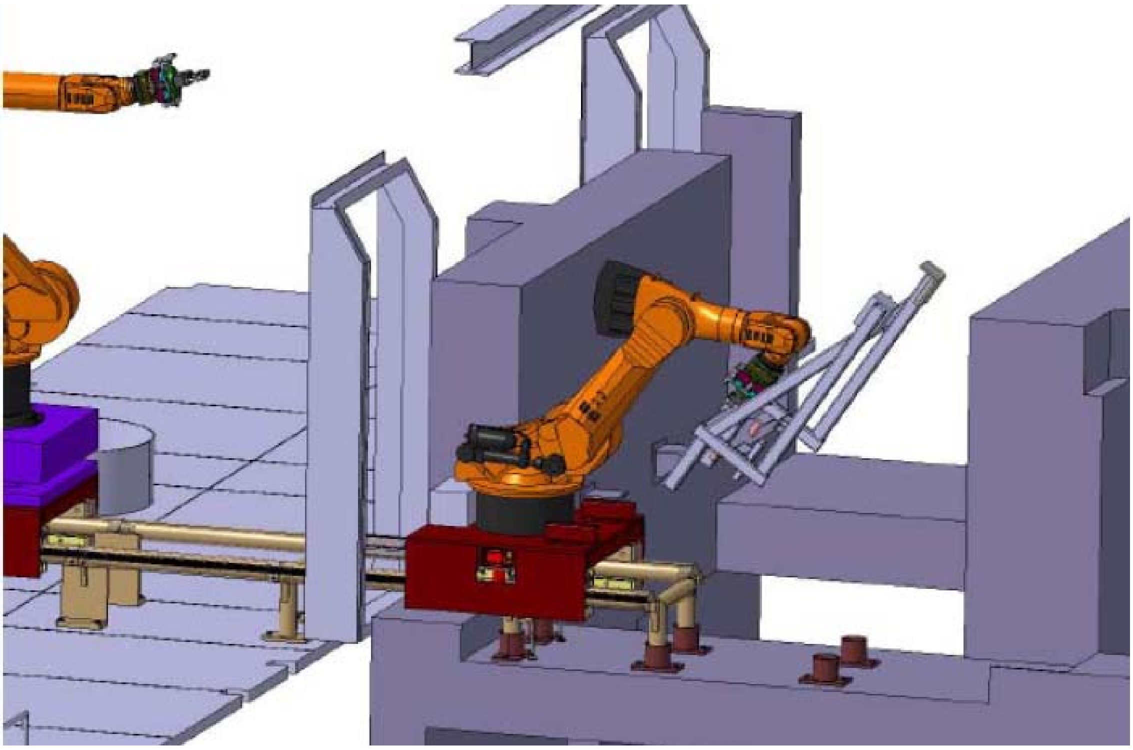
Decommissioning
Reference Project - Brennilis, France

First French Nuclear Power Plant – Brennilis

Use of remote controlled technology







Electro-chemical Decontamination:

Remote Waste Handling:

Please refer also to separate application **"Remote Controlled Vehicle (Crawler) to remove sediments and floor contamination"** send to you:

Title	Remote Controlled Vehicle (Crawler) to remove sediments and floor contamination
Proposed by	NUKEM Technologies GmbH

The Crawler was designed and operated to remove

- crystallised salt,
- liquid RAW,
- sludge,
- IEX-resins

from collection tanks at Kola NPP (Russia).

Photo of Crawler

3. Applicability to Fukushima site, Technical challenges

Cleaning/decontamination of surfaces (equipment and building structures)

4. Technology Development (Example)

The techniques exemplarily mentioned above were developed/designed or nuclearisised (adapted to nuclear environment and requirements) and constructed by NUKEM and special sub-suppliers due to the specific requirements of the specific needs.
5. Note With its experience in the experience of a big number of nuclear projects dealing with decontamination behaviors (operation of Waste Treatment Centers/Facilities and Decommissioning or Dismantling Projects) as well as in the mentioned Kola-project NUKEM has the qualification and is able to modify and adapt its decontamination techniques due to the specific needs (operational and economical) at Fukushima site. Please refer to www.nukemtechnologies.de for further information and overview of NUKEM´s experience, competence and competition. Don´t hesitate to contact us in case of further questions or further information.

[Format 2-1] Session 1: Decontamination

Decontamination Technology Catalogue		Category No.		Page	
Title	Decontamination of civil construction, using remotely controlled manipulators - scabbling		Proposed by	AMEC	

Applicable contamination condition			**Experience in remote-control condition**		
Form	~~Liquid~~/ solid/ ~~powder~~	Location	YES / ~~NO~~		
Adhesion	Soft / Hard	Floor/Wall/ceiling			
Penetration	~~Shallow~~ / Deep	~~Machine surface~~ / ~~inside machine~~	Reaction	Yes ( )	No
Nuclide	Gamma / α β	~~Inside pipe, others~~			

Principle Remotely controlled manipulator using mechanical tool (scabbler) with ventilation/dust suction system. Manipulator is deployed on contaminated surface (concrete, surface paint is acceptable) and contaminated concrete layer is mechanically removed with collection of secondary waste – dust/debris	Collection method *Vacuum suction (cyclone)*
	Secondary waste form *dust/debris*
	Necessary utility *Electricity, ventilation system*
	Basic machine structure *Remotely operated manipulator on rails*
Principle Explanation *See above*	Safety measures/cautions

Past experiences/Decontamination effectiveness(DF) NPP A1 Jaslovske Bohunice - decontamination of contaminated concrete surface (reactor hall floor, stairs) NPP Dounreay – decontamination of contaminated concrete surface of hot cells Decontamination effectiveness - very high, above 100 NPP Trawsfynydd – decontamination of Cooling Ponds structure completed three weeks ahead of schedule	Decontamination capability/Performance speed Depending on specific application
	Size/Weight Depending on specific application
	Applicability to Fukushima site/Technical challenges Applicable to high contaminated concrete surfaces

 	
Note	Reference documents

Technical Catalogue	
Mobile Device Classification:	Radioactive soil assay with automated segregation and sorting
Title:	Orion *ScanSort*^{SM}
Proposed by:	AMEC

1. Technical Description (Advantage, Specification, Performance)

AMEC's Orion *ScanSort*^{SM} is a conveyor-based radiation detection/measurement system that detects radiation in excavated soil/materials and segregates it from unimpacted soil/materials. It can sort upwards of 300 tons/hour of soil and other solid flowable debris. Benefits of the system are:

- *Accurate monitoring and threshold alarms detect and sort waste, contributing to reduction of the volume of material and cost associated with packaging, transport and disposal;*
- *Faster processing (up to 300 tons of soil and material per hour) than conventional methods reduces the project schedule;*
- *Computerized processing and quality control reduces manpower requirements; and*
- *Surveys can be designed to accommodate a variety of decommissioning activities and Final Status Survey requirements.*
- *Technology has exceeded customer expectations and demonstrated significant cost savings in the millions of dollars.*

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

- "Japan Town" Technology Demonstration Project in Naraha Town for JAEA. Used to assay and sort radiologically impacted soils removed from agricultural field and rice paddy. *AMEC demonstrated the ability for significant waste volume reduction through segregation/sorting.*

Technical Catalogue

- Plum Brook Reactor Facility Decommissioning Project (Ohio, USA). Assayed and surveyed >100,000 tons of soil achieving a volume reduction in contaminated soil for disposal of >95%. *Waste volume reduction achieved by the ScanSort^{SM} reduced the cost associated with the packaging, transportation and disposal of low-level radioactive waste, saving our customer $30 Million Dollars.*

- Painesville FUSRAP Remediation Project (Ohio, USA). Scanned >47,000 tons of soil and achieved a volume reduction for disposal of 35%. *Less than 2% of the impacted soil volume processed required disposal as radioactive waste, saving the customer more than $10 Million Dollars in project cost associated with the packaging, transportation, and disposal of radiologically contaminated waste.*

Summary of Orion *ScanSort*[SM] Soil Sorting System

Project	Volume Processed	Limits		
USACE, Painesville FUSRAP Site	47,000 tons	Ra-226	6.1 pCi/g in 70 tons 12.2 pCi/g in 7.0 tons 18.3 pCi/g in 0.7 tons	
NASA Plum Brook Reactor Facility	105,000 tons	Cs-137	0.2 Bq/g	5.2 pCi/g
Louisiana TENORM	6945 tons	Ra-226 averaged over 1/10 ton	0.1 Bq/g	3 pCi/g
Point Source Soil Sorting Pilot Study	Demo	Ra-226	3.7k Bq	0.1 µCi
Thorium Remediation Project	247,140 tons	Th-232 averaged over one ton	1.2 Bq/g	31.0 pCi/g
Saxton: Soil Survey II	5,000 tons	Cs-137 averaged over 300 kg, 10 µCi (0.4 MBq) Pt. Src.	0.1 Bq/g	2.9 pCi/g
Saxton: Soil Survey I	18,000 tons			

3. Applicability to Fukushima Site, Technical challenges

- Highly contaminated near surface soils: *Provides 100% assay of volumetric solid waste streams making waste characterization extremely confident*.
- Soils that are radiologically impacted at concentrations near the approved limits: *Provides 100% assay plus segregates materials that are above the limit from those below the limit to minimize waste disposal volume to a minimum.*
- Radiologically impacted debris: *Earthen debris (such as concrete, asphalt, block, wood, etc) can be crushed or shredded and then assayed as a volumetric material which can then be sorted based on volumetric limits in order to minimize waste volume.*
- Heavily contaminated materials & debris: *Segregate waste that is acceptable for disposal at low-level waste storage/disposal site from heavily contaminated materials that require special handling.*

Technical Catalogue

4. Technology Development (Example)

- Orion *ScanSort*^{SM} can be modified and fitted to a dredge barge to perform assay and sorting of sediments that are dredged from the seabed. This would provide a comprehensive means of removing sediments with significant levels contamination from discharges to the bay.
- Orion *ScanSort*^{SM} has been designed to operate in a radiological environment where radioactivity is present in relatively low levels (such as environmental remediation of soils off of the Fukushima Dai-Ichi plant site. However, the technology could be readily adapted to perform assays and segregation activities for much higher activity levels that are likely to be present on and near the plant site.

5. Notes

- AMEC with Obayashi demonstrated the technology to JAEA at Naraha Town [11/2011 – 3/2012].
- Equipment is already in storage in Japan.

[Format 2-2] Session 1: Decontamination

Technical Catalogue	
Mobile Device Classification:	Overland Radiation Scanning & Mapping System
Title:	Orion *ScanPlot*SM
Proposed by:	AMEC

1. Technical Description (Advantage, Specification, Performance)

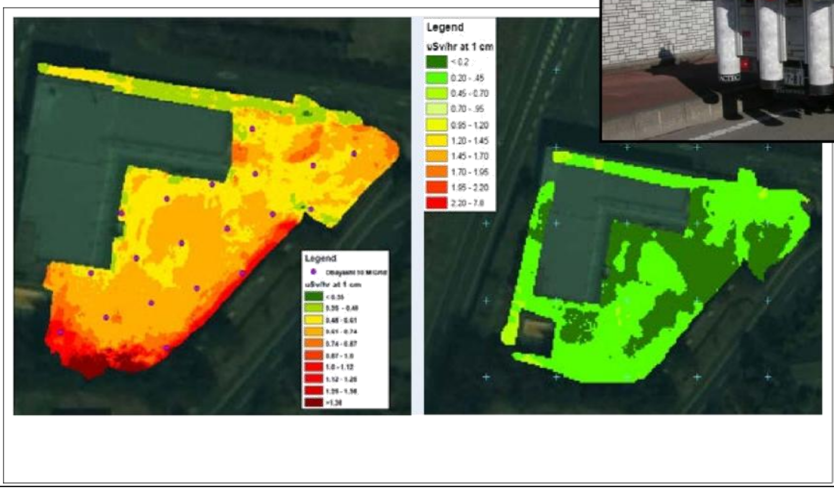
AMEC's Orion *ScanPlot*SM is an advanced radiation detection/measurement system that employs scanning spectroscopy to isotopically identify and quantify radioactivity. It is a mobile platform that can undertake radiological field surveys identifying contaminated land and verifying the effectiveness of remedial action. Benefits of the system are:

- *Incorporates high resolution spatial position sensing and mapping to provide the analysts and decision makers with unprecedented insight into the radiological environment represented by the data it collects;*
- *The mobile platform can survey 10 – 20 acres / day;*
- *Faster survey and data processing (than conventional methods) reduces the project schedule;*
- *There are a number of variants of deployment platform that range from backpack carried systems to large towed-array platforms designed for operating in marshlands, tidal wetlands and foreshore areas, uneven or rocky terrain, and vegetated areas.*

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

- "Japan Town" Technology Demonstration Project for JAEA. Used to perform surveys of school yards in Hirona Town in December 2011. *AMEC's ScanPlot*SM *demonstrated highly accurate field survey results.*

*A sample of the map reports generated with data collected with the Orion ScanPlot*SM *system is presented below.*



Technical Catalogue

Summary of Orion *ScanPlot*^{SM} Survey Projects

Project	Coverage	Limits		
Tuba City Dump Site RI	515 Acres	U-238 (Ra-226) K-40 Th-232	Any identifiable signal above background	
Fukushima, Japan	3 School Yards	Cs-137 Dose Rate	500 Bq/kg 1 µSv/h	13.5 pCi/g 0.1 mRem/h
UNC Church Rock	1.2 acre	Ra-226	185 mBq/g	5 pCi/g
El Toro Naval Air Station	1.5 acre	Ra-226	37 mBq/g	1 pCi/g
Hunters Point Naval Shipyard/ CA	Demo	Ra-226 Cs-137	37 mBq/g 37 mBq/g	1 pCi/g 1 pCi/g
UKAEA Beach Monitoring Trials 2005	Demo	Cs-137 Cs-137/Co-60 Cs-137	30 kBq Cs-137 100 kBq Cs-137 300 kBq Cs-137	0.8 µCi 2.7 µCi 8.1 µCi
LaSalle County Nuclear Generating Station	15 acre	Cs-137 Co-60	0.4 Bq 0.1 Bq	11 pCi/g 3.8 pCi/g
Nuclear Fuel Services	5 acre	Any identifiable signal above background including U-234, U-235, U-238, Th-232, Ra-226, TRU and Am-241		
Saxton: Radiological Site Survey	8 acre open grass land, 7 acre wooded	Cs-137	0.3 Bq/g	8.5 pCi/g
Yankee Rowe Nuclear Generating Station	1 acre	Cs-137 Co-60	41 mBq/g 141 mBq/g	1.1 pCi/g 3.8 pCi/g
Rancho Seco Nuclear Generating Station	76 acre	Cs-137 Co-60 Cs-134	204 mBq/g 70 mBq/g 105 mBq/g	5.5 pCi/g 1.9 pCi/g 2.85 pCi/g
Point Beach Nuclear Generating Station	1 acre	Cs-137	37 mBq/g	1 pCi/g
Forked River Site Oyster Creek Nuclear Generating Station	1 acre	Cs-137	136 mBq/q	3.68 pCi/g
ETTP K-1070a Landfill	Demo	Any Enriched Uranium Signal		
ORAU Scarboro Facility	Demo	Cs-137 at 16 inch (40 cm) depth	0.4 kBq	1 µCi

Technical Catalogue

3. Applicability to Fukushima Site, Technical Challenges

- Orion *ScanPlot*^{SM} is uniquely designed to deploy large volume gamma spectrometers as well as a variety of other sensors that may be used to characterize the radiation environment in a spatial context. Auxiliary detectors such as gamma radiation dose rate sensors (µSv/hr) can be readily added to the system.
- Difficult terrain is always the greatest technical challenge. With a variety of *ScanPlot*^{SM} deployment platforms, most of the terrain issues that may be encountered can be accommodated.

4. Technology Development (Example)

- Typically, *ScanPlot*^{SM} surveys are performed to characterize environmental contaminants after significant discrete sources of radiation have been removed. The conditions at the Dai-ichi facility create unique challenges with respect to radiation levels. AMEC has conceived the design of collimation collars that could be fitted to the external housing of the detector modules to dramatically reduce the influences of nearby discrete sources of radiation and allow a more accurate assessment of radioactivity in the adjacent “environment.”

5. Notes

- AMEC has teamed with Obayashi and has demonstrated ScanPlot ^{SM} to JAEA.
- The equipment is already in storage in Japan.

[Format 2-2] Session 1: Decontamination

Technical Catalogue	
Mobile device classification	N/A
Title	Rocky Flats D&D
Proposed by	AMEC

1. Technical description (Advantage, Specification, Performance)

AMEC engineered the solution for full-scale D&D of a former plutonium production facility at the Department of Energy (DOE) Rocky Flats Site in Golden, Colorado (USA). This facility was identified by the DOE as being the most dangerous building in the DOE with the highest levels of contamination (beyond measurement instrumentation).

In one area of the facility, called the "Infinity Room", the high levels of contamination were due in part to pump failure during operations, leaving the room contaminated beyond measurement. The room was sealed/welded shut and remained sealed for nearly 30 years prior to AMEC entry. AMEC designed a path forward to contain the high levels of contamination, dismantle the room, and safely dispose of the waste materials. AMEC used a combination of a concrete overlay on the floor and pump pedestals and spray fixative on walls and ceilings. In other areas of the facility, AMEC engineered/applied a fully encapsulated hydrolasing decontamination technology in conjunction with a water treatment system to recycle contaminated water used in the hydrolasing process. The ultra-high water pressure hydrolasing system used supersonic jets of water to remove surface and subsurface coatings and contamination, 'vacuumed' the water used, and directed it to the water treatment system for recylcing. Activities involved in this full-scale D&D project included:

- *Decontamination and decommissioning of Category 3 nuclear facility (Building 771 / 774 complex);*
- *Managing hydrolasing operations and water treatment system installed to collect contaminated water;*
- *Dismantling and removal of contaminated piping systems;*
- *Developing approach to apply fixative coating to walls and ceiling to contain plutonium contamination;*
- *Using diamond-wire saws to cut concrete into sizes suitable for waste containers.*

2.	**Past experience** (Plant in Japan, overseas plant, application in other industries, etc.) Application of surface fixative, high pressure water jet concrete decontamination, and diamond wire concrete cutting were used. Waste water generated as a result of the high pressure water jet decontamination was processed for reuse at the site using a mobile water treatment plant.
3.	**Applicability to Fukushima site, Technical challenges** The application of contamination fixatives and decontamination using high pressure water jet to decontaminate concrete surfaces (or other surfaces), where the highest levels of radioactive contamination exist, are very applicable to the Fukushima site D&D. Additionally, diamond saw cutting to reduce waste material (concrete and steel) physical size for handling and shipping are very applicable to the Fukushima site D&D. The greatest technical challenge for these applications are accessibility to areas of high contamination and high radiation levels.
4.	**Technology Development (Example)** N/A
5.	**Note**

[Format 2-1]　Session1: Decontamination

<table>
<tr><td colspan="2">Decontamination Technology Catalogue</td><td>Category No.</td><td></td><td>Page</td><td></td></tr>
<tr><td>Title</td><td colspan="2">Decontamination and Recovery using Hydrolasing Technology</td><td>Proposed by</td><td colspan="2">S.A.Technology</td></tr>
<tr><td colspan="3">Applicable contamination condition</td><td colspan="3">Experience in remote-control condition</td></tr>
<tr><td>Form</td><td>embedded/absorbed/solid/liquid/powders</td><td>Location</td><td rowspan="2">YES</td><td rowspan="2" colspan="2">B-30 Sellafield,
K-Basin
Hanford, Pile 1
Sellafield</td></tr>
<tr><td>Adhesion</td><td>Hard</td><td>All
(floor/wall/ceiling)</td></tr>
<tr><td>Penetration</td><td>Deep (up to 12mm in concrete)</td><td>Machine surfaces that are relatively smooth and flat</td><td rowspan="2">Reaction</td><td rowspan="2">Yes
Total
-20kg
(suction)</td><td rowspan="2"></td></tr>
<tr><td>Nuclide</td><td>All (except for gaseous)</td><td>Inside and outside pipe on relatively smooth surfaces</td></tr>
<tr><td colspan="3" rowspan="4">Principle
Hydrolasing is a commercial process that uses ultra-high pressure water (between 200-4000 Bars) to remove coatings, contamination, and bulk material.　S.A.Technology has developed a number of hydrolasing systems that are designed for use in nuclear environments for contamination removal.
These systems include hydrolasing heads with full recovery shrouds, and waste collection and processing systems.</td><td colspan="3">Collection method
Vacuum and Air/Liquid & Solid Separation</td></tr>
<tr><td colspan="3">Secondary waste form
Water</td></tr>
<tr><td colspan="3">Necessary utility
Electrical @ approximately 75kW
Water at approximately <10lpm</td></tr>
<tr><td colspan="3">Basic machine structure
Blast head, collection shroud, collection skid, vacuum skid, UHP pump skid</td></tr>
<tr><td colspan="3">Principle Explanation</td><td colspan="3">Safety measures/cautions</td></tr>
</table>

Hydrolasing is very powerful and flexible because the volume and pressure can be varied to alter the aggressiveness of the decontamination (i.e. The higher the pressure or volume the more material removed). The process is particularly well suited for concrete where it can be controlled to remove surface material or bulk concrete. Hydrolasing concrete has the advantage of being able to remove absorbed and embedded contamination by bulk removal of grout.	Safety systems must be used to ensure sealing to surface to prevent airborne contamination from overspray. A system for this was deployed and proven at Sellafield.
Past experiences/Decontamination effectiveness(DF) During testing at K-Basin, concrete with absorbed Cs-137 up to 12mm deep was removed with surface dose levels going from 40mSv to 4mSv for a DF of 10. SAT has used this technology for nuclear decontamination on three projects: **K-Basin Fuel Pool Decontamination:** This project was to develop a fully remote system to clean absorbed Cs-137 from fuel pool walls. This was done underwater using a remote manipulator and replaceable hydrolasing heads. The liquid and solid wastes were captured, filtered and returned to the pond.  **Sellafield B30 Decontamination Project:** This project was to develop a system to remotely clean a vertical concrete surface with high activity deposits. This included the development of a robotic deployment platform, hydrolasing head, cyclone filtration skid, vacuum skid, and UHP pump skid.	**Decontamination capability/Performance speed** Concrete removal up to 12mm with full recovery. Non-metallic coating removal on metallic surfaces. Removal rates are approximately 14m^2/hr but are dependent on material, flow and pressure. **Size/Weight** Approximately 300mm in diameter and <50kg weight. The waste management, vacuum, and UHP pump skids are approximately 3m x 4m x 3m and less than 1 tonne each. **Applicability to Fukushima site/Technical challenges** Contaminated concrete removal, coating and contamination removal on metal. Potential for

<table>
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Pile 1 Concrete Removal Demonstration Project:

This project was to demonstrate the ability to remove bulk concrete using hydrolasing while maintaining full recovery.　This included the development of a deployment platform, hydrolasing head, vacuum skid, and UHP pump skid.


</td>
<td>straight pipe cleaning with job specific head.</td>
</tr>
</table>

Note	**Reference documents** “Decontamination Measurement for the K-Basin (East) Hydrolasing Demonstration Project” Rev 0 AG/TR-0401

[Format 2-2] Session1: Remote-Control Decontamination

Technical Catalogue	
Mobile device classification	Remote Tool (Manipulator)
Title	Remote Pipe Hot-Tapping and Decommissioning
Proposed by	S.A.Technology / MMIC EOD Ltd.

1. Technical description (Advantage, Specification, Performance)

As part of a decommissioning project at Sellafield, SAT worked with MMIC to take their existing tool for tapping into chemical weapons and modified it for remote use on a nuclear facility.

MMIC has designed a very compact tool that allows safe and sealed tapping into containers and is used heavily in chemical weapons demilitarization. The equipment is designed to insert a gas-tight self-sealing probe through target casings in a wide range of materials including metals and plastics with a considerable range of wall thickness. Once installed the probe gives fully sealed access for sampling, extraction or decontamination of the target contents.



SAT and MMIC realized that with minor modifications this same equipment could be used to access nuclear piping with radioactive liquids. This would allow the remote access, draining and decontamination of nuclear piping with a proven commercial product. By making a few previously manual operations into fully remote operations and attaching to the end of a manipulator system the tool could be used in a fully remote, high radiation environment.

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

SAT and MMIC worked together to make the unit fully remote and deployed as part of a larger project at Sellafield in the UK. The scope of this tool on the project was to drill into a vertical pipe with the potential to contain liquids. The remote tapping capability allowed the tap to be inserted into the pipe to allow the liquid to be drained in a controlled and sealed manner. The unit was deployed with a remote manipulator.

3. Applicability to Fukushima site, Technical challenges

With many pipe systems as part of the reactor facilities, there may be a need to remotely tap and drain pipe systems in remote areas. Once drained, decontamination fluid could also be deployed and drained with the system. This system is ideal for this work as it has been proven both in a commercial and nuclear environment. This same system could be used for smaller pressure vessels as well.

4. Technology Development (Example)

No further technology development is required except for project specific modifications if required.

5. Note

[Format 2-1] Session1: Decontamination

Proposal 1

<table>
<tr><td colspan="2">Decontamination Technology Catalogue</td><td>Category No.</td><td></td><td>Page</td><td></td></tr>
<tr><td>Title</td><td colspan="2">Technology for applying dust suppressing coating with confinement effect</td><td>Proposed by</td><td colspan="2">OOO Firma «Radez-2»
Alexandrov NITI</td></tr>
<tr><td colspan="3">Applicable contamination condition</td><td colspan="3">Experience in remote-control condition</td></tr>
<tr><td>Form</td><td>Solid</td><td>Location</td><td rowspan="2">YES</td><td colspan="2" rowspan="2">Using spray equipment including high-pressure sprayers</td></tr>
<tr><td>Adhesion</td><td>Soft</td><td>Floor/Wall/ceiling</td></tr>
<tr><td>Penetration</td><td>Shallow</td><td>Machine surface</td><td rowspan="2">Reaction</td><td rowspan="2">Yes
( )</td><td rowspan="2"></td></tr>
<tr><td>Nuclide</td><td>Gamma / β α</td><td>Inside</td></tr>
<tr><td colspan="3" rowspan="4">Principle: Dust suppression coatings are applied on road sides, soil covering, sand pits, waste areas, and other dust-raising surfaces.

Technology for applying dust suppression coatings with confinement effect is intended to reduce or stop desorption of radionuclides from dust-arising surfaces to the environment; to significantly decrease radioactive dust dispersal by wind effects etc.</td><td colspan="3">Collection method
Mechanical removal (if necessary)</td></tr>
<tr><td colspan="3">Secondary waste form
Solid radwaste</td></tr>
<tr><td colspan="3">Necessary utility
Preparation and delivery of compositions</td></tr>
<tr><td colspan="3">Basic machine structure
Tanks and vessels, decon trucks, transportation tanks, fire trucks, helicopters etc.</td></tr>
<tr><td colspan="3">Principle Explanation: Adhesion of radionuclides onto particles to form conglomerates resistant to wind erosion</td><td colspan="3">Safety measures/cautions
Normal safety precautions to observe when working with chemicals</td></tr>
<tr><td colspan="3" rowspan="3">Past experiences/Decontamination effectiveness(DF):
Application in the 30 km radius zone of the Chernobyl NPP / Site decontamination with this technology reduced airborne activity in the atmosphere by 60 times as of September 1986.</td><td colspan="3">Decontamination capability/Performance speed
High</td></tr>
<tr><td colspan="3">Size/Weight
Depending on performance demands</td></tr>
<tr><td colspan="3">Applicability to Fukushima site/Technical challenges
Ready for use</td></tr>
<tr><td colspan="3">Note</td><td colspan="3">Reference documents</td></tr>
</table>

Proposal 2

Decontamination Technology Catalogue		Category No.		Page	
Title	**Technology for decontamination («dry» decontamination), isolation and confinement of contaminated surfaces (soil, rooms, equipment, rolled roofing) using polymer coatings**	Proposed by	**OOO Firma «Radez-2» Alexandrov NITI**		

Applicable contamination condition			**Experience in remote-control condition**		
Form	**Solid**	Location	**YES**	**Using manipulators and sprayers**	
Adhesion	**Soft**	**Floor/Wall/ceiling**			
Penetration	**Shallow**	**Machine surface**	Reaction	**Yes** ( )	No
Nuclide	**Gamma /** α β	**Accessible equipment surfaces**			

Principle: **Decontamination, isolation, and confinement liquids are applied on contaminated surfaces, left to set until they harden, and then removed. The technology reduces or eliminates contamination and significantly limits radioactivity dispersal.** **PVA- or PVB- based coating is used on room and equipment surfaces; PVAC- or polyvinylacetatel-based coating is used on rolled roofing.**	Collection method: **mechanical removal** Secondary waste form **Solid radwaste** Necessary utility **Preparation and delivery of compositions** Basic machine structure **Tanks and vessels, sprayers, etc.**
Principle Explanation: **radionuclides are trapped by a polymer matrix which is then removed from a surface.**	Safety measures/cautions **Normal safety precautions to observe when working with chemicals**
Past experiences/Decontamination effectiveness(DF): **Application in the 30 km radius zone of the Chernobyl NPP, at other NPPs (hot cells), nuclear fuel industries and research centers (e.g. Kurchatov Institute, VNIIHT) / Application of the technology reduces surface contamination to background level (decontamination factor is 40-1000 for one decontamination cycle).**	Decontamination capability/Performance speed **high** Size/Weight **Depending on performance demands** Applicability to Fukushima site/Technical challenges **Ready for use**
Note	Reference documents

Proposal 3

<table>
<tr><td colspan="2">Decontamination Technology Catalogue</td><td>Category No.</td><td></td><td>Page</td><td></td></tr>
<tr><td>Title</td><td colspan="2">Complex technology for decontamination of residential houses, offices, neighboring territories and private lands</td><td>Proposed by</td><td colspan="2">OOO Firma «Radez-2»
Alexandrov NITI</td></tr>
<tr><td colspan="3">Applicable contamination condition</td><td colspan="3">Experience in remote-control condition</td></tr>
<tr><td>Form</td><td>Solid</td><td>Location</td><td rowspan="2">NO in respect of the complex of activities</td><td colspan="2" rowspan="2">Certain operations</td></tr>
<tr><td>Adhesion</td><td>Soft / Hard</td><td>Floor/Wall/ceiling</td></tr>
<tr><td>Penetration</td><td>Shallow / Deep</td><td>Soil and building surfaces</td><td rowspan="2">Reaction</td><td rowspan="2">Yes
( )</td><td rowspan="2">No</td></tr>
<tr><td>Nuclide</td><td>Gamma / β α</td><td>Accessible surfaces</td></tr>
<tr><td colspan="3" rowspan="4">Principle: 1) Mechanical removal of contaminated soil layers and other, disposal and recovery;
2) Treatment of walls, windows, roofs with washing solutions, concentration of contaminants in near surface soil layers, and mechanical removal. Treatment of cleaned surfaces with special solutions to prevent recontamination (water repellent treatment).
3) Dust suppression or decontamination liquid coatings are applied to surfaces, left to set until they harden, and removed in the solidified form.
The technology reduces or eliminates contamination and significantly limits radioactivity dispersal.</td><td colspan="3">Collection method: mechanical removal</td></tr>
<tr><td colspan="3">Secondary waste form
Solid radwaste</td></tr>
<tr><td colspan="3">Necessary utility
Motor transport (bulldozers, decon trucks, transportation tanks, fire trucks), Equipment for preparation and delivery of compositions</td></tr>
<tr><td colspan="3">Basic machine structure
Motor transport, tanks and vessels, sprayers, etc.</td></tr>
<tr><td colspan="3">Principle Explanation: contaminated substances are mechanically removed from surfaces; radionuclides are trapped by a polymer matrix which is then removed from a surface.</td><td colspan="3">Safety measures/cautions
Normal safety precautions to observe when working with motor transport vehicles, water solutions, and chemicals</td></tr>
<tr><td colspan="3" rowspan="3">Past experiences/Decontamination effectiveness(DF):
Residential and non-residential areas affected by the Chernobyl accident (Bryansk and Kaluga regions of Russia), buildings and territories in Pripyat (the Ukraine). Complex treatment reduces surface contamination to background levels.</td><td colspan="3">Decontamination capability/Performance speed
Medium or high</td></tr>
<tr><td colspan="3">Size/Weight
Depending on performance demands</td></tr>
<tr><td colspan="3">Applicability to Fukushima site/Technical challenges
Ready for use</td></tr>
<tr><td colspan="3">Note</td><td colspan="3">Reference documents</td></tr>
</table>

Proposal 4

Decontamination Technology Catalogue	Category No.		Page	
Title	**Complex technology for decontamination of construction machinery and transport vehicles**	Proposed by	**OOO Firma «Radez-2» Alexandrov NITI**	

Applicable contamination condition			**Experience in remote-control condition**		
Form	**Liquid / Solid**	Location	**NO in respect of the complex of activities**	**Certain operations**	
Adhesion	**Soft**	**Machine surfaces**			
Penetration	**Shallow / Deep**	**Surfaces**	Reaction	**Yes** ( )	No
Nuclide	**Gamma / β α**	**Accessible surfaces**			

Principle: 1) Mechanical removal of contaminated soil layers and other, their disposal; **2) Treatment of surfaces using high-pressure equipment, such as Karcher high-pressure washers and steam jets. Collection and treatment of water.** **3) Removal of contaminated paint coatings by washing with solvents.** **4) Decontamination polymer liquids are applied to surfaces, left to set until they harden, and removed.** **The technology reduces or eliminates radionuclide contamination.**	Collection method: **mechanical removal** Secondary waste form **Solid radwaste, LRW** Necessary utility **Decontamination stations, mechanical and liquid (chemical) decontamination equipment, equipment for preparation and delivery of chemical compositions** Basic machine structure **Motor transport, tanks and vessels, sprayers, etc.**
Principle Explanation: **contaminated substances are mechanically removed from surfaces, contaminants are removed by using washing solutions and together with paint coating, radionuclides are trapped by a polymer matrix which is then stripped from a surface.**	Safety measures/cautions **safety precautions to observe when working with high-pressure equipment, motor transport vehicles, water solutions, and chemicals**
Past experiences/Decontamination effectiveness(DF): **Decontamination of construction machinery and vehicles (more than 2500 machines) involved in remedial activities after the Chernobyl accident.** **For example, decontamination of the "Демаг-CC-400" № 16" crane which had been operated in Chernobyl Unit 4 rooms since July 1986 led to a decrease in exposure rate from 10 r/h to background level, surface contamination – from 5·10^{4} Bq/cm^{2} to < 1 Bq/cm^{2} (beta); other cranes: surface contamination – from 10^{5} Bq/cm^{2} to < 1 Bq/cm^{2} (beta) and exposure rate from 0.5 r/h to 0.8 r/h.** **A large amount of decontamination work was done on**	Decontamination capability/Performance speed **Medium or high** Size/Weight **Depending on performance demands** Applicability to Fukushima site/Technical challenges **Ready for use**

various motor cars and their engines, as well as helicopters.	
Note	Reference documents

[Format 2-2] Session1: Remote-control decontamination

Proposal 1

Technical Catalogue	
Mobile device classification	**Device for remote decontamination of contaminated surfaces**
Title	**Adhesive web for remote decontamination**
Proposed by	**OOO «Firma «Radez-2», Moscow** **Alexandrov Research Institute of Technology (NITI), Sosnovy Bor, Leningrad region**
1. Technical description (Advantage, Specification, Performance) **The proposed decontamination technology is based on using specially designed devices, so-called "adhesive webs". The "adhesive web" is a web-shaped structure coated with adhesive material. The web size and weight-lifting capability, as well as adhesive composition depend on specific job demands. Adhesive webs were used to remove both fine-dispersed contamination (radioactive dust, crushed fuel and fuel rod pieces, etc.) and contaminated equipment parts of up to 1.5 t weight (fragments of fuel assemblies, structural and graphite bricks, etc.) which were thrown out onto roofs during the Chernobyl accident.** **The adhesive web technology is an "unmanned" approach to decontamination. This approach significantly reduces exposure of personnel and thus improves working conditions for both radiation emergency workers and those who participate in decommissioning operations.** **The adhesive web technology used for decontamination of surfaces does not produce liquid radioactive waste. As to solid wastes, they can be conditioned and compacted to reduce their volume by 1.5-2.**	
2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.) **The decontamination technology based on "adhesive webs" was widely used to clean roofs and land in the first phase of Chernobyl post-accident activities in 1986.**	
3. Applicability to Fukushima site, Technical challenges **The technology is ready for use at Fukushima site. No technical challenges are faced.**	
4. Technology Development (Example) **The technology can be used for remote removal of contaminated equipment, including components with fuel inside, and concrete structures from the plant site and damaged reactor rooms at Fukushima NPP.**	
5. Note	

Proposal 2

Technical Catalogue	
Mobile device classification	**Quick setting polymer composition**
Title	**Technology for deactivation of contaminated items using quick setting polymer compositions**
Proposed by	**OOO «Firma «Radez-2», Moscow** **Alexandrov Research Institute of Technology (NITI), Sosnovy Bor, Leningrad region**
6. Technical description (Advantage, Specification, Performance) **Under post-accident conditions, there may be required to temporarily stabilize radiation-hazardous**	

items or securely isolate contaminated buildings and equipment for prevention of radioactivity dispersal and further damage to engineering structures. **The technology for deactivation of contaminated items using quick setting polymer compositions mainly consists in remotely applying special-purpose compounds to nuclear- or radiation-hazardous items. The proposed compound is fire-, radiation-, heat, and acid/alkali solution resistant and efficiently sorbs radionuclides. With this technology, the composition locally fills voids, gaps, apertures and other hard to access places, thus, reducing the area of contaminated surface-atmosphere contact and, consequently, radioactivity dispersal.**
7. Past experience (Plant in Japan, overseas plant, application in other industries, etc.) **A similar technology was used to isolate the surfaces of fuel-containing debris and structures in the Chernobyl Shelter.**
8. Applicability to Fukushima site, Technical challenges **The technology is ready for use at Fukushima site. No technical challenges are faced.**
9. Technology Development (Example) **The polymer composition can be used for isolation/deactivation of damaged nuclear fuel during its transport and storage.**
10. Note

[Format 2-3] Session2 Remote-control operation machine and measurement equipment for CV inspection

Technical Catalogue	
Mobile device classification	**Device for remote measurement of ambient gamma dose rate**
Title	**Festoon system for dose measurements**
Proposed by	**OOO «Firma «Radez-2», Moscow** **Alexandrov Research Institute of Technology (NITI), Sosnovy Bor, Leningrad region**
1. Technical description (Advantage, Specification, Performance) **The festoon system for dose measurements consists of a cord made of anti-adsorption material (nylon, PVC, PU, etc.) and gamma-ray dosimeters (e.g. pellets with dirt-protective coating) attached along the cord length at intervals (e.g. 0.25-1.0 m) which are specified depending on monitoring requirements. The cord with dosimeters is transported to the monitoring area by a crane of manipulator and fixed in local geometry. After specified exposure time the dosimeters are removed and doses are measured. The measured gamma ray dose and exposure time are used to assess the dose rate and determine the gamma ray field in the control area. The cord with dosimeters can be fixed at a metal (aluminum or steel) tube for better rigidity (to prevent swinging of the structure).**	
2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.) **Similar festoon systems were used for dose rate measurements and reconstruction of gamma ray fields in the area of fuel-containing debris and structures in the Chernobyl Shelter (damaged reactor hall, under reactor space, walls, roofs, etc.)**	
3. Applicability to Fukushima site, Technical challenges **The technology is ready for use at Fukushima site. No technical challenges are faced.**	
4. Technology Development (Example)	
5. Note	

[Format 2-1]　Session1: Decontamination

<table>
<tr><td colspan="2">Decontamination Technology Catalogue</td><td>Category No.</td><td></td><td>Page</td><td></td></tr>
<tr><td>Title</td><td colspan="2"><u>Ultrasonic Cleaning of Contaminated Fuel Assemblies, Channels, and Reactor Components</u></td><td>Proposed by</td><td colspan="2">Dominion Engineering, Inc.</td></tr>
<tr><td colspan="3">Applicable contamination condition</td><td colspan="3">Experience in remote-control condition</td></tr>
<tr><td>Form</td><td>Fuel crud, foreign material, & similar solid or powder</td><td>Location</td><td rowspan="2">YES</td><td rowspan="2" colspan="2">Equipment is normally operated underwater from topside control console</td></tr>
<tr><td>Adhesion</td><td>Soft or Hard</td><td>Fuel surfaces, internal/external surfaces of components</td></tr>
<tr><td>Penetration</td><td>Can clean partially or fully occluded areas (e.g. tube bundle interior).</td><td rowspan="2">Inside & outside of components (e.g. clean inside of a channel from the outside)</td><td rowspan="2">Reaction</td><td rowspan="2"></td><td rowspan="2">NO</td></tr>
<tr><td>Nuclide</td><td>Not specific</td></tr>
<tr><td colspan="3" rowspan="4">Principle
The Ultrasonic Fuel Cleaning system uses ultrasonic energy to cause cavitation on contaminated surfaces, which releases contamination from the component. The contamination becomes suspended in solution and is removed by a suction and filtration system.
No cleaning agents or other chemicals are required.</td><td colspan="3">Collection method: Suction and filtration</td></tr>
<tr><td colspan="3">Secondary waste form
Filter cartridge or other filter form</td></tr>
<tr><td colspan="3">Necessary utility
~60 kVA electrical power</td></tr>
<tr><td colspan="3">Basic machine structure
Cleaning fixture is sized to receive fuel and/or other components. Parts are placed into cleaner for decontamination.</td></tr>
<tr><td colspan="3">Principle Explanation
The cleaning action in ultrasonic cleaning is the result of cavitation on the contaminated surfaces, which breaks up and releases solids from the fuel or other component. The process does not produce macroscopic vibrations, shaking, or high forces, and is safe for use on delicate items (e.g. fuel cladding).</td><td colspan="3">Safety measures/cautions
Ultrasonic cleaning is a very safe process. There is no risk of damage to components associated with the cleaning process. Normal safety precautions are appropriate for working with high voltage.</td></tr>
</table>

<table>
<tr>
<td rowspan="3">Past experiences/Decontamination effectiveness(DF)
This technology is proven and well established. It has been applied almost 100 times in the US, Europe, and Korea. DEI's latest generation of ultrasonic cleaning equipment (Figure 1) represents a significant increase in power density and cleaning effectiveness compared with earlier generation systems (Figure 2)

Current ultrasonic fuel cleaning equipment has an estimated DF of 100 to 1000 for loosely adherent crud and an estimated DF of 10 to 15 for tenacious crud.
See attached figures of before/after cleaning results:
Figure 3) High-Efficiency UFC (HE-UFC) before and after cleaning on PWR fuel crud (DF ~15).
Figure 4) 1st Generation UFC results for cleaning fuel with channel in place (DF ~3).</td>
<td>Decontamination capability/Performance speed
~ 3 minutes to clean 1 fuel assembly
Production cleaning (including fuel movement) ~4-6 assemblies/hour.</td>
</tr>
<tr>
<td>Size/Weight (HxWxL) / kg
Cleaner: 5m x 0.6m x 0.6m / 1000 kg or as required for the application
Filtration equipment: configuration dependent on specific application</td>
</tr>
<tr>
<td>Applicability to Fukushima site/Technical challenges
The cleaning equipment can be easily operated remotely so long as items can be remotely delivered to the cleaning chamber. The equipment can be configured to accept a variety of shapes/sizes of items to be cleaned, and could thus support cleaning of all types of items in addition to fuel (for example, cleaning of pool debris before removal from the water, or cleaning of reactor vessel component pieces during decommissioning). The equipment is submerged in the pool and the cleaning fluid is regular pool water, so items can be cleaned before they are removed from the water. Optionally, the equipment can be integrated with additional water jet flushing and vacuuming for collection of larger debris.</td>
</tr>
<tr>
<td>Note</td>
<td>Reference documents</td>
</tr>
</table>

[Format 2-1] Session1: Decontamination

<table>
<tr><td colspan="3">Decontamination Technology Catalogue</td><td colspan="2">Category No.</td><td></td><td>Page</td><td></td></tr>
<tr><td>Title</td><td colspan="4">High Capacity Regenerable & Radiation Tolerant Filter Elements</td><td>Proposed by</td><td colspan="2">Dominion Engineering, Inc.</td></tr>
<tr><td colspan="5">Applicable contamination condition</td><td colspan="3">Experience in remote-control condition</td></tr>
<tr><td>Form</td><td colspan="2">Liquid with suspended particulate</td><td colspan="2">Location</td><td rowspan="2">YES</td><td colspan="2" rowspan="2">Filter normally installed underwater and manipulated remotely.</td></tr>
<tr><td>Adhesion</td><td colspan="2">Not applicable</td><td colspan="2" rowspan="3">Effluent from EDM, waterjetting, ultrasonic cleaning, or general pool vacuuming.</td></tr>
<tr><td>Penetration</td><td colspan="2">Not applicable</td><td rowspan="2">Reaction</td><td rowspan="2"></td><td rowspan="2">NO</td></tr>
<tr><td>Nuclide</td><td colspan="2">Not specific to any nuclide</td></tr>
<tr><td colspan="5" rowspan="4">Principle
A 0.5 micron rated filtration module is built from radiation tolerant materials for long-term stability when filled with highly active waste. The design of the filter module allows for redistribution of waste within the module via an internal regeneration process. After regeneration, the filter media can be loaded with additional particulate. The process is repeated until the ultimate physical capacity of the module is reached.</td><td colspan="3">Collection method: N/A</td></tr>
<tr><td colspan="3">Secondary waste form
N/A</td></tr>
<tr><td colspan="3">Necessary utility: 100/200 VAC for ultrasonic regeneration process</td></tr>
<tr><td colspan="3">Basic machine structure
Filter module can be configured in a variety of shapes and sizes. The currently preferred configuration resembles a fuel assembly for ease of handling and storage in the pool.</td></tr>
<tr><td colspan="5">Principle Explanation
Regeneration of the filter is accomplished through ultrasonic agitation of the filter media. Once the waste is released from the filter media, it settles via gravity into a collection region at the base of the module, leaving the media clean and able to filter additional waste.</td><td colspan="3">Safety measures/cautions
Due to the high storage capacity of the filter module, it is possible to achieve very high dose rates when filtering highly radioactive waste streams. Appropriate provisions are required for handling and disposal.</td></tr>
</table>

<table>
<tr><td rowspan="3">Past experiences/Decontamination effectiveness(DF)
The proposed filtration module has been used at a number of different US units for the purpose of treating waste generated by ultrasonic fuel cleaning activities. The filter modules have proven to be highly effective at removing the waste particles from the liquid stream, and at reducing the amount of filter waste generated during each cleaning campaign.</td><td>Capacity
A BWR assembly-sized filter module has an estimated waste holding capacity of 25-40 kg of fine powder waste.</td></tr>
<tr><td>Size/Weight
The filter module can be tailored to any number of sizes and capacities in order to meet the unique needs of the customer and disposal facility constraints.</td></tr>
<tr><td>Applicability to Fukushima site/Technical challenges
There are a variety of different cleanup activities that must be performed at Fukushima. Many of those activities will generate liquid waste with suspended particulate. The proposed filter module provides a means of filtering and storing large amounts of waste, and includes provisions for remote handling and changing of filters. This solution could eliminate many of the filter replacement activities that would otherwise be required in association with the various cleanup and decommissioning activities.</td></tr>
<tr><td>Note</td><td>Reference documents</td></tr>
</table>

除染技術カタログ	技術区分 NO.		頁	

技術名称	Ｓ－Ｊｅｔ（少水量型超高圧ウォータージェット）による汚染コンクリート除去	提案者	清水建設(株)／(株)スギノマシン

【適用汚染形態】			【遠隔除染への適用実績】	
汚染形態	液体・固体・粉体	適用除染場所環境	有・無	
付　着	ソフト・ハード	床・壁・天井		
浸　透	浅い・深い	機器表面・機器内面		
核　種	γ・αβ	配管内部・他	反力	有（　　　　）・無

【原理】

写真
- 左上：超高圧ポンプ
- 左下：噴射状況
- 右上：作業方法

【原理説明】
超高圧水により、コンクリート表面数mmを切削する。切削片を含む、除染廃液は廃液回収システムと組合せて，切削片を回収しながら作業が可能。天井，壁，床面で適用可能

【適用除染実績・除染効果(DF)例】

切削時間によりＤＦ2～10

土間コンクリート・壁の除染状況

【特記事項】
反力が３kgと極めて小さいため，小型重機等で効率の良い作業が可能。

【回収方法】
局所フードにより，除染廃液を回収

【二次廃棄物の形態】
はつり片
回収装置フィルタ

【必要ユーティリティ】
電気，圧縮空気

【基本機器構成】
- Ｓ－Ｊｅｔ本体
- 先端ツール（局所フード含む）
- 回収装置

【安全対策他適用留意点】
切削片を同時に回収できるので，作業員の被ばくを低減できる。

【除染能力・速度等】
ＤＦ２まで：約15m2/h（特殊ノズルにより高効率：ツイストロータリーノズルヘッド）

【寸法/質量(目安)】
Ｓ－Ｊｅｔ本体：950 kg
先端ツール　：20kg
廃液回収システム　：50kg

【福島第一原子力発電所への適用可と考える根拠，技術的課題】
遠隔重機等と組み合わせ，遠隔で切削片の回収が可能

【引用・参考文献他】
特になし

［書式２－１］

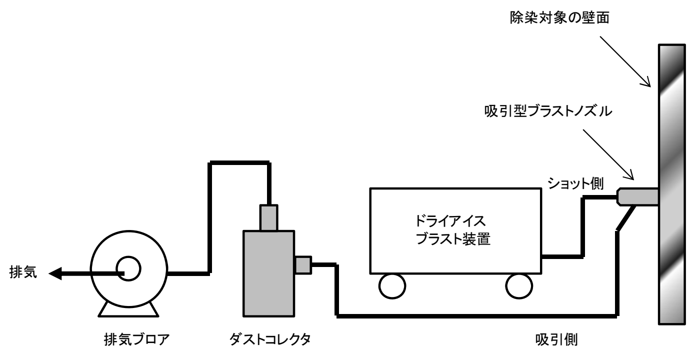
セッション１（除染）用

除染技術カタログ	技術区分 NO.		頁	

技術名称	吸引型ドライアイスブラスト	提案者	福井　康太

【適用汚染形態】			【遠隔除染への適用実績】
汚染形態	液体・固体・粉体	適用除染場所環境	有・無
付　着	ソフト・ハード	床・壁・天井	
浸　透	浅い・深い	機器表面・機器内面	
核　種	γ・αβ	配管内部・他	反力　有（　　　）・無

【原理】



【原理説明】

壁床面等に付着した汚染にドライアイスブラストで剥離し、剥離した汚染物及びショットしたドライアイスを同一ノズル内で吸引回収する。

【適用除染実績・除染効果（DF)例】

ドライアイスブラストについては、独)日本原子力研究開発機構　大洗研究開発センター内の固体廃棄物前処理施設において、高線量α廃棄物の除染設備として利用しており、実廃棄物(金属類)について、10～100 の DF が得られることを確認している。

吸引型ドライアイスブラストについては、ホット試験の実績はないが、鋼板にペイントした模擬廃棄物を用いたコールド試験を実施しており、剥離したペイント及びショットしたドライアイスの殆どを回収できることを確認している。

【特記事項】

ブラスト材や剥離した汚染物を飛散させることなく除染することが可能である。

【回収方法】

剥離した汚染物をダストコレクタにより回収する。

【二次廃棄物の形態】

炭酸ガス

【必要ユーティリティ】

電気、圧空

【基本機器構成】

- ドライアイスブラスト装置
- 吸引型ブラストノズル
- ダストコレクタ
- 排気ブロア

【安全対策他適用留意点】

低温及び炭酸ガスの滞留に対する安全対策が必要

【除染能力・速度等】

除染能力：DF　10～100

処理速度：0.06m²/min(小規模実験の実績であり、実機では 10～20 倍程度と推定)

【寸法/質量(目安)】

1m² あたりドライアイス 67kg

【福島第一原子力発電所への適用可と考える根拠，技術的課題】

平面に対し、簡易かつ短時間に実行でき、二次廃棄物の発生も少ない。

【引用・参考文献他】

特願平 8－226910「吸引ドライアイスブラストノズルを用いた除染方法及び除染装置」、発明者：福井康太　他

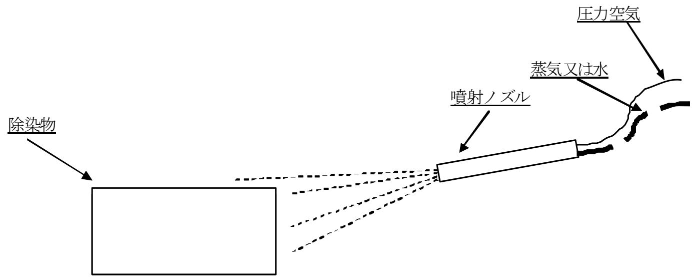
［書式２－１］

セッション１（除染）用

除染技術カタログ	技術区分 NO.		頁	
技術名称	スチームジェット洗浄装置	提案者	小川　柳一郎	

【適用汚染形態】			【遠隔除染への適用実績】	
汚染形態	液体・**固体**・粉体	適用除染場所環境	有・**無**	
付　着	**ソフト**・ハード	**床**・**壁**・**天井**		
浸　透	**浅い**・深い	**機器表面**・機器内面		
核　種	**γ**・**αβ**	配管内部・他	反力	**有**（　　）・無

【原理】



【原理説明】

蒸気又は水を圧縮空気により高圧でノズル先端から噴射し、除染対象物の表面に付着した汚染物を剥離させ除染を行う。

【回収方法】

噴射した水及び剥離した汚染物は廃液貯槽に回収する。

【二次廃棄物の形態】

放射性廃液

【必要ユーティリティ】

圧力空気：6kg/cm²
蒸気：6kg/cm²　水

【基本機器構成】

スチームジェット洗浄装置
コンプレッサー
ボイラー

【安全対策他適用留意点】

・高温蒸気の噴出及び除染水が飛散するため、作業場所周辺への立入監視が必要

【適用除染実績・除染効果（DF)例】

大洗研究開発センターで発生した機器汚染物の除染実績がある。

除染物の形状によって異なるが、表面が平滑で、固着した汚染でなければ、DF 10以上の効果がある。

【除染能力・速度等】

除染能力：DF　10以上
除染速度：平滑な面で固着した汚染でなければ 1m²/分

【寸法/質量(目安)】

スチームジェット洗浄装置
：約 1.5m　3.0kg

【福島第一原子力発電所への適用可と考える根拠，技術的課題】

平面に対し、簡易かつ短時間に実行できる。

【特記事項】

水及び剥離した汚染物が飛散するため、周辺を養生する必要があるが、廃液は回収せず、階下に落とすことにより滞留水処理システムにより処理が可能である。

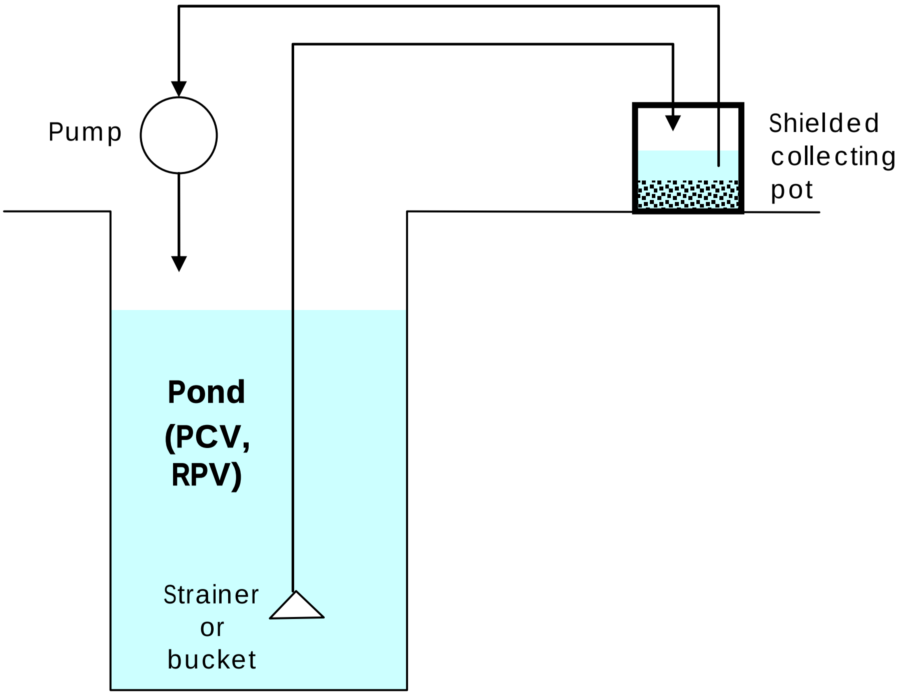
【引用・参考文献他】

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	
Title	Underwater vacuum cleaning
Proposed by	Onet Technologies

1. Technical description (Advantage, Specification, Performance)

Remote operated, underwater retrieval of debris, including fuel debris.



This technology is applicable to ponds or pressure vessel or containment vessel filled with water. The vacuum pump creates a negative pressure into the collecting pot, so that the debris, collected through the strainer or the bucket, are pumped to this collecting pot. The collecting pot is shielded according to the expected activity of the debris. Dose rate is monitored is order to stop retrieval before is grows too high. The debris settle in the collecting pot. When the collecting pot is full, or when the dose rate reaches the limit, the supernatant water is pumped back to the pond and the collecting pot is evacuated from the installation. A new collecting pot is installed in order to continue retrieval.

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

This technology has been successfully used in pond 907 in la Hague (France), for retrieval of 20 m^3 of sludge, 6 m^3 of spent fuel claddings, and 1 m^3 miscellaneous. Works stared end 2009, and finished recently.

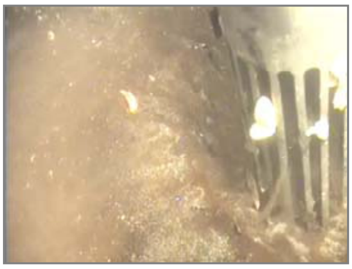
3. Applicability to Fukushima site, Technical challenges

Operation of the strainer or the bucket requires remote handling with an underwater remote operated vehicle, or a manipulator. In la Hague, we used a manipulator (see pictures below).

The pump is the only moving parts of the system, and is not subjected to high dose rates.

The manipulator, or the underwater vehicle, is equipped with radiation resistant lightings and camera.

4. Technology Development (Example)



Strainers, customized to the debris to retrieve

Manipulator for handling the bucket

5. Note

Place of the pump and place of the collecting pot should be selected according to maximum differences of altitude (5 m max above the level of the water).

Strainer has to be selected according to the dimensions of the debris or grain size of the sludge.

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	
Title	Two hands telescopic manipulator
Proposed by	Onet Technologies

1. Technical description (Advantage, Specification, Performance)

Able to open an access through tangle of debris, with full remote operation. Able to cut, to handle and to evacuate irradiating objects.

The equipment draws a waste bin.

2 arms:

- Skilled right hand
- Ordinary manipulator as left hand
- Right hand cuts when left hand holds the piece under cutting.

Mounted on a telescopic pole: range up to 6m.

The telescopic pole is on rails. The manipulator installs itself the rails for moving forward.

A waste container may be associated to the manipulator, moving on the same rails, drawn by the equipment.

Underwater or in air operation.

Right hand:

- Handling capability: 60kg
- Able to handle various cutting tools or cleaning tools
- Tool auto change
- 6 axis + rotation of the wrist
- Continuous rotation of the wrist
- Robust, easy maintenance.

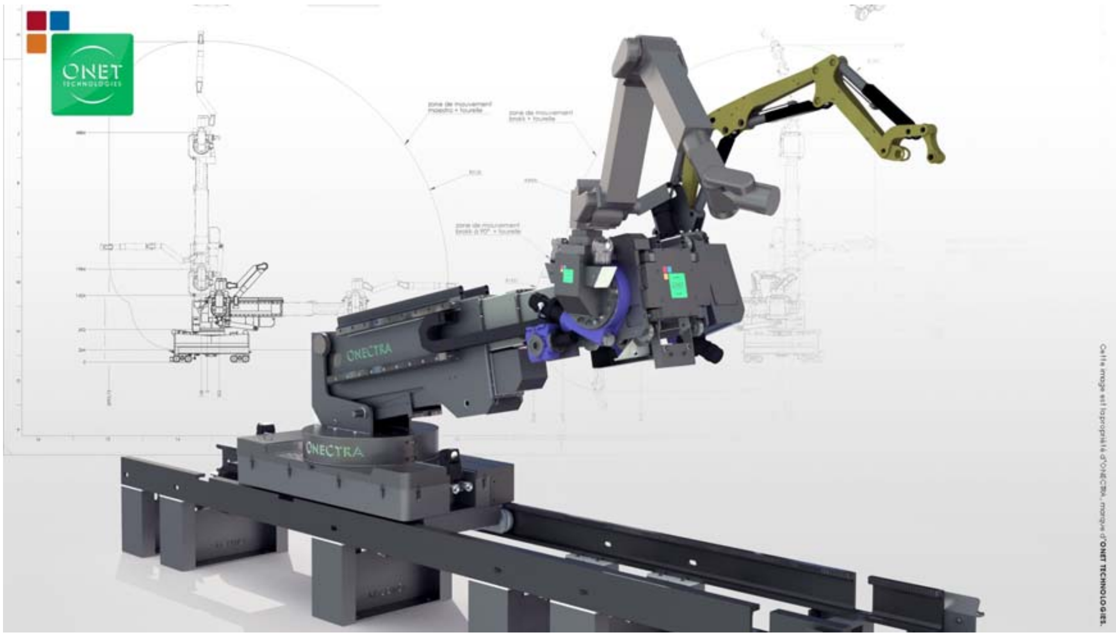
2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

Equipment based on parts available on the market. For instance, the right hand is an industrial manipulator, 150 units have been manufactured every year since 15 years. Tens of thousands operational hours have been registered.

Equipment designed for dismantling the first reprocessing plant in France (Marcoule).

3. Applicability to Fukushima site, Technical challenges Full remote operation, no necessary utility in the irradiated area, fully autonomous equipment. Withstand high doses, up to 100 kGy. Equipped with radiation proof lightning and cameras.

4. Technology Development (Example)



5. Note

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	
Title	Heavy remote operated manipulator
Proposed by	Onet Technologies

1. Technical description (Advantage, Specification, Performance)

Able to handle 1 ton in a 10 m range.

Tool auto change.

Tools for: cutting, gripping, collecting, concrete scabbling, concrete demolishing.

Robust, hydraulic manipulator, skill improved by the use of a 3 axis wrist.

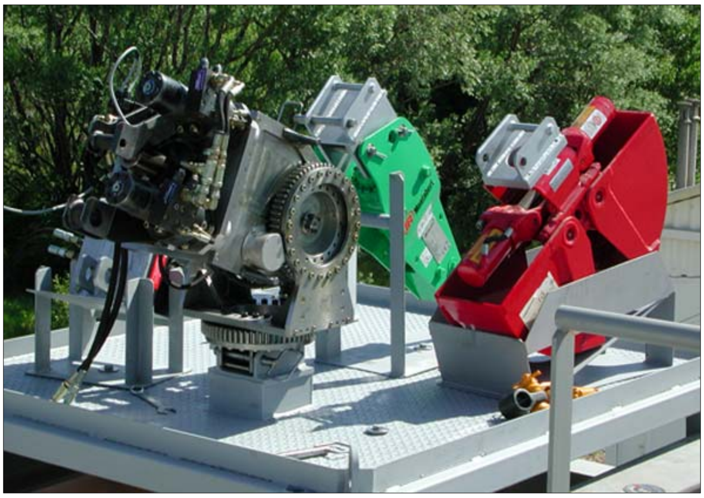
2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

Equipment for dismantling of the "DMC cell" (decladding cell in the first reprocessing plant in France, Marcoule).

3. Applicability to Fukushima site, Technical challenges

May be mounted on fixed or moving support. For instance, possibility to mount it on a crane.

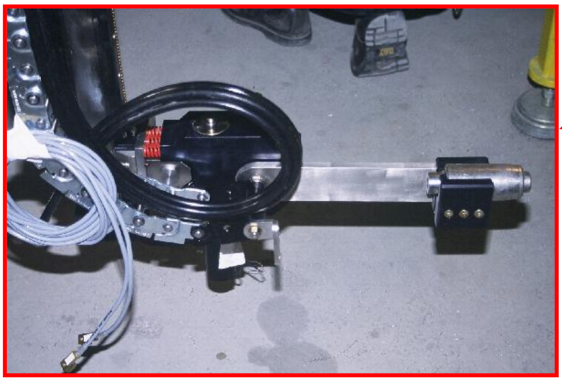
Withstand high doses, up to 100 kGy. Equipped with radiation proof lightning and cameras.

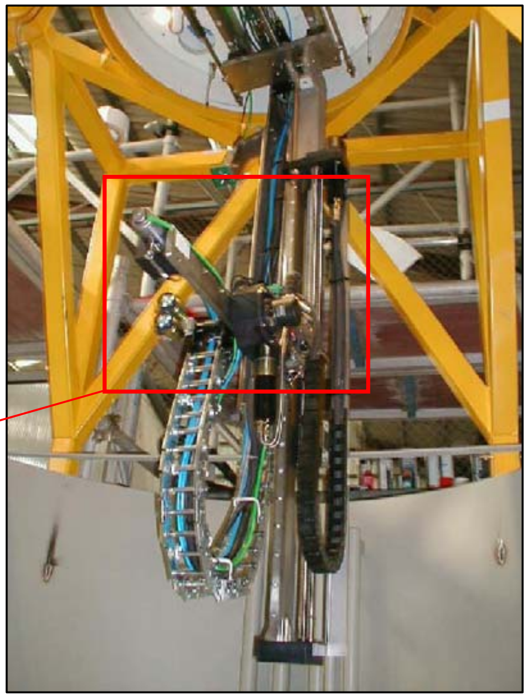
4. Technology Development (Example)  3 axis wrist and standard tools Manipulator 
5. Note

[Form 2-2] Session 1 (Decontamination remote operation, etc.)

Technical catalog	
Category of mobile equipment	Remotely operated equipment for radioactive decontamination
Title	**UHP/VHP equipement for radiactive decontamination**
Proposer	ONET TECHNOLOGIES

1. Technical description (Advantage, Specification, Performance)





Overall dimensions : 2220 x 945 mm

Weight : 910 kg

Movements:
- Rotation: 360 °
- horizontal movment : 450 mm
- vertical movment : 1840 mm
- Nozzle rotation: 60 ° + / - 90 °

Actuators :
- 4 motors powered by a hydraulic :
- Electrical power: 1.5 kW
- Fluid : oil

Instrumention & Command Control :
- 4 absolute encoders with display controlled by a PLC
- A sensor docking
- An anti collision sensor

Tool : a rotating nozzle Monroe 2500 bar

Additionnal equipments : 2 cameras + lighting

The use of water jet VHP (Very High Pressure) or UHP (Ultra High Pressure) is adjusted according to the need to treat the surface. Clean up, scraping, deep decontamination.

The choice of the couple pressure / flow rate used, the type of nozzle, and the combination of head movement allows to reach results on all types of surfaces (metal, concrete, epoxy ...).

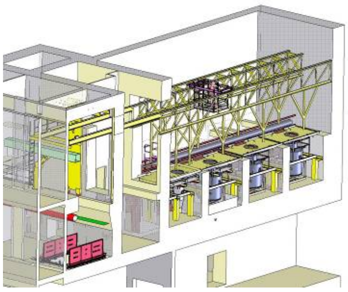
Our equipement allows the transport of water up to lancing head.

The entire network is integrated into the design of the equipment by using rollers, drilled blocks, while avoiding the risks of this utility (cracking, leakage ...).

Coupled with radiation inspection tools and measures, the shots of THP/UHP can be localized to the affected areas and decontamination results can be immediately observed

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

Cleaning up & dismantling – Workshop n°55 – UP1 plant of CEA center of Marcoule (France)



3. Applicability to Fukushima site, Technical challenges

Robust solution with fully remote operation for :
- Mapping of hot spots
- Cleaning up of contaminated surfaces,

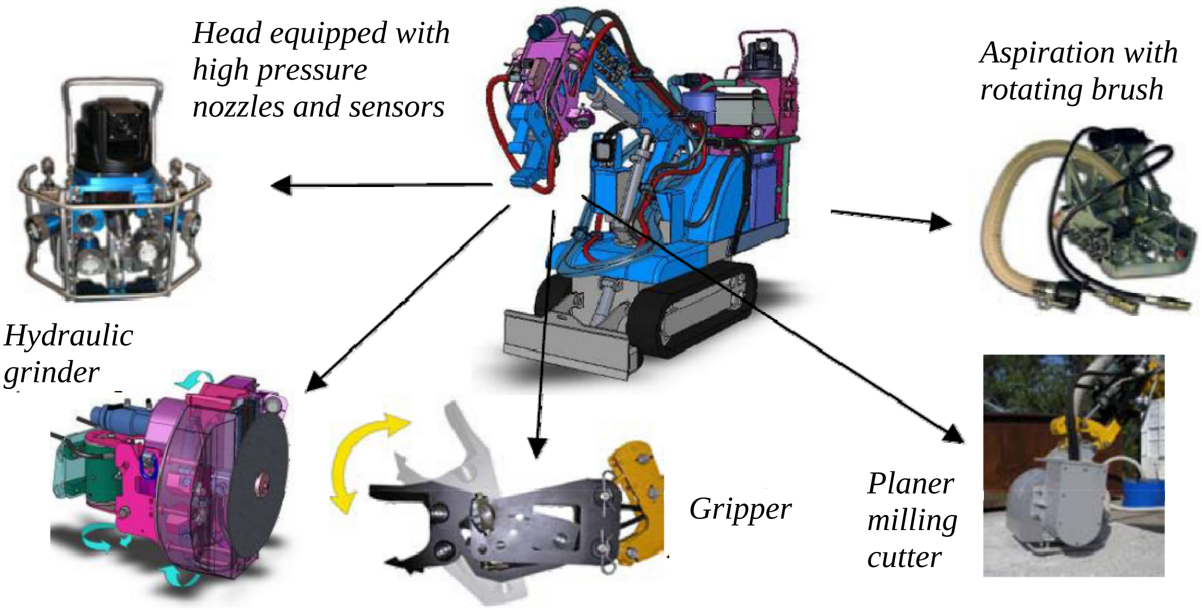
Necessarely coupled with a radioactive effluent treatment system.

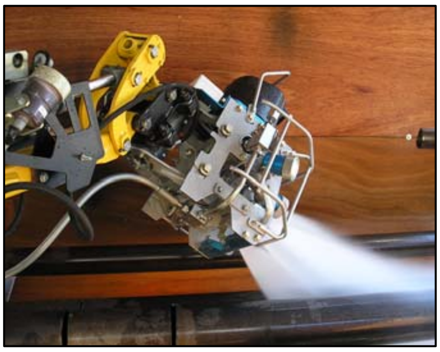
4. Technology Development (Example)
Automatic connection from utility VHP and UHP to lancing system.

5. Notes
The UHP/THP head positioning is achieved by the remote-operated equipment, which to allow to operating technicians to work away from contaminated area.

Technical catalog	
Category of mobile equipment	Remotely operated equipment for radioactive decontamination
Title	Versatile mobile machine for decontamination
Proposer	ONET TECHNOLOGIES

1. Technical description (Advantage, Specification, Performance)

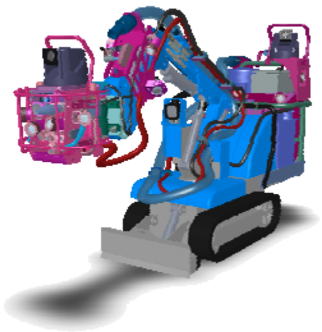




This remotely operated equipment is based on a demolition machine nuclearized associate to high flexibility of tools : cleaning, cutting, handling & control.

The mobile carrier
Based on Brokk demolition machine
Implemented with :

- Second hydraulic unit onboard
- An specific interface tools for cleaning up & dismantling
- The design of new utilities (high pressure pipe, aspiration pipe, …)
- Hoops protections
- Electronic deported, radiation resistant,



Head of radioactive cleaning up
Inspection head : mapping of hot spots

- Radiation sensor
- Telemeter
- Rotatable cameras / lighting

2 cleaning lines :

- 1 drilling rotative nozzle 900 atm
- 1 x 5 fan nozzles 400 atm

Aspiration brush
Cet outil permet un nettoyage par la rotation de deux brosses à poils rigides couplés à une aspiration

Hydraulic grinder
For cutting stainless steel tubes.
Specifically developped to be coupled with Brokk arm and steered by remote control.
This hydraulic grinder integrates two positioning axes and a linear axis of cutting.

hydraulic gripper
Designed to radioactive waste collection, combined with a recovery dump mounted on the front of the mobile carrier.

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

Cleaning up & dismantling pipes of service gallery - Dégainage plant of CEA center of Marcoule (France)
Length: more than 50 m,
• Width: 1.5 m (narrowest passage: 800 mm),
• Pipes Ø: 40 mm to 160 mm,
• Dose rate: 60μGy / h to 100 mGy / h,
• Contamination max: 8400 Bq / cm ²

Cleaning up & dismantling – Workshop n°55 – UP1 plant of CEA center of Marcoule (France)

3. Applicability to Fukushima site, Technical challenges
Versatile & robust solution with fully remote operation for : - Mapping of hot spots - Cleaning up of contaminated surfaces, - Cutting of fluid pipes, - Aspiration of waste fragments, - Handling of various waste, Necessarely coupled with a radioactive effluent treatment system.
4. Technology Development (Example)
5. Notes

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	Mobile Robot
Title	Water Blast Remote Controlled System
Proposed by	ATOX- AREVA

1. Technical description (Advantage, Specification, Performance)

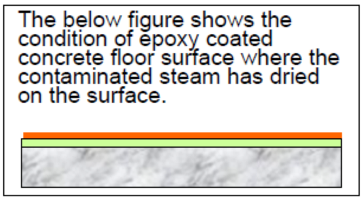
This tool is fitted for decontamination and removal of contaminated concrete.本ツールは汚染コンクリートの除染及び除去に適しています。

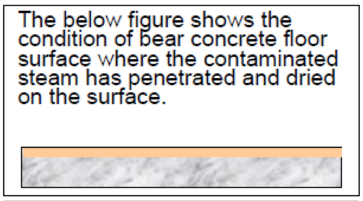
Water Blast process treats contaminated concrete, which is an issue on Fukushima Daiichi NPP dismantling process.ウォター・ブラースト・プロセスでも汚染コンクリートの処理が可能ですが、福島第一原発では問題があると思います。

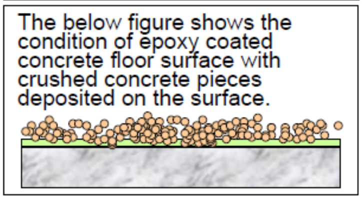
Indeed, Hydro demolition is a blasting process based on mechanical removing of concrete thanks to high pressure water.ハイドロ・デモリッションは高圧水を用いてコンクリートを機械的に除去するブラースティング方式です。

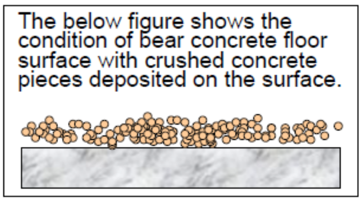
With one unique device including several types of nozzles, and only modifying operational conditions (pressure, flow rate), it is possible to perform three types of operation:数種類のノズルを含む他に類のないデバイス 1 個を用いて、また使用条件（圧力、流量）を変えることによって、下記に述べる 3 種類の作業が可能です。

- 1/ High pressure water jet surface decontamination cleaning of lining/painted concrete,高圧ウォーター・ジェット洗浄によって行うコーティング、塗装コンクリートの表面除染
- 2/ Removal of contaminated painting or lining from concrete surface,コンクリート上の塗装、またはコーティングされた汚染表面の除去
- 3/ Hydro demolition, i.e. removal of a few mm to a few cm of contaminated concrete, when concrete does not have lining or when this lining had been damaged due to extreme conditions in R/B such as radiation, high temperature and moisture.ハイドロ・デモリッションは、コンクリートにコーテ









ィングが施されてない場合に、もしくは原子炉建屋（R/B）が照射、高温、高湿度など極端な条件下にあり、コーティングが損傷している場合に、汚染コンクリートから数 mm から数 cm 取り除く方法です。

In that case, water blast can be used for any of the 4 situations of concrete which had been described (see opposite) in the document “Development of remote Decontamination Technology inn the Reactor Building” of March 14th 2012 for the “international symposium on the Decommissioning of TEPCO’s Fukushima Daiichi NPP units 1-4”.このような場合、東電福島第一原発 1-4 号機の除染・解体作業に関する国際シンポジウムのために 2012 年 3 月 14 日に作成された図書“原子炉建屋における遠隔操作で行う除染テクノロジー”に記載されたコンクリートの 4 種類のどの状況でもウォーター･ブラーストの使用は可能です。

<u>Main advantages of the process:</u>

- One equipment = Three main operations of dismantling 装置 1 台で 3 種の解体作業の実施
- Remote controlled operation available 遠隔操作による作業が可能
- One of the easiest heavy decontamination process to implement 深刻な汚染を比較的簡単に実施できる方法のひとつです。
- For scabbling and decontamination:削り取り及び除染
  - innocuousness in regards of iron in concrete コンクリートに含まれる鉄筋の処理に際しては害は発生しない。
- Only two waste:2 種類のみの廃棄物の発生
  - Concrete part removed from decontaminated surface 汚染された表面から取り除かれたコンクリートの断片
  - Liquid water effluents that can be treated with the existing water treatment facilities on site. Water is easier to manage than off-gas, since it flows down by gravity.廃液は現存する工場内廃水処理施設で処理することが可能です。廃水は重力の原理で流れて行くため、廃ガスの管理よりは容易です。

Solid concrete and water retrieved are then separated with a nuclearized centrifugation process to separate solid waste to dispose and water effluents to recycle for hydro demolition or to send to contaminated water tanks.

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

Classic operation in civil works.
Nuclearization of many decontamination tools in AREVA facilities.

3. Applicability to Fukushima site, Technical challenges

Possibility to apply the technology in a mobile robot to perform water blast process in Reactor with some adaptations, such as adaptation on a remote controlled robot.

4. Technology Development (Example)

Some adaptation of existent devices are required:
- Modification of nozzles is needed.
- Modification of vacuum device and further separation solid/liquid is needed.
- …

These technology developments and remote controlled adaptation could be performed in collaboration by AREVA and ATOX on a “commercial base robot”. General robotics remote controlled know how of ATOX and nuclear know how of AREVA will be used to develop a final solution totally remote controlled and adapted to specific Fukushima needs…
As an illustration, such robotic concept below (left) from ATOX can be used as principles for adaptation of water blast system and vacuum device system on a commercial robot (e.g robot below right).

5. Note

[Format 2-2] Session1: Remote-control decontamination

Technical Catalogue	
Mobile device classification	
Title	**NiThrow™ solution**
Proposed by	AREVA NC JAPAN PROJECTS

1. Technical description (Advantage, Specification, Performance)

Part of decommissioning work in Fukushima will required tools for decontamination and management of contaminated concrete.福島における解体作業に関しては、汚染コンクリートの除染及び管理用に一部ツールが必要になります。

NiThrow™ is a nuclearized solution for concrete scabbling, cutting and decontamination of a technology based on the spraying of liquid nitrogen at a temperature of -140°C and a pressure of 3 500 bars NiThrow™方式とはコンクリートを削り取り、切断し、除染する方法です。同方式は、温度-140°C、圧力 3 500 バールで液体窒素を吹き付けて除染するテクノロジーです。.

This process can be useful for the three main process of decommissioning:この技術は解体作業における下記の 3 種類の主要プロセスに有用です。

- Concrete Scabbling　コンクリートの削り取り
- Cutting process　コンクリートの切断
- Decontamination works　コンクリートの除染作業

More photos are given in format 3.

Concrete Scabbling:

- Depth of cut from 1 to 30 mm (function of time and concrete type).
- From 1 to 8 m²/h of scabbling (and around 30 L/h of concrete removed).
- Works on any types of concrete (vibrated/non vibrated, high/low densities).

Cutting:

- Cutting of all types of material (stainless steels, bitumen…) with or without abrasives (depending on the hardness)
- 50 mm depth for stainless steel, 200mm for bitumen
- Productivity of 4 cm/min for stainless steel (50 mm depth).

For hardest type of material (stainless steel e.g.), an additional abrasive material have to be added to nitrogen to perform efficient cutting.

Decontamination:

- Can be used for various types of contamination (paints, grease, rust…)
- Productivity:
  - o Over 5 m²/h for paints
  - o Over 10 m²/h for grease, rust…

Key figures:

Operating pressure:	800 to 3,500 bar (11,603 to 50,763 psi)
Operating temperature:	-130 to -150 °C (-202 to –238 °F)
Consumption of liquid nitrogen:	~ 20 L/min (0.7 CFM)
Size of pressurization skid:	2,920 x 1,270 x 1,651 mm (115 x 50 x 65)
Weight of pressurization skid:	3,600 kg (8,000 lbs)
Power supply:	400 V, Three-phase, 150 kVA

Remote controlled operation:　遠隔操作で行う作業

Remote controlled operation is available with specific carrier. One carrier (3 in photo below) has been developed for an AREVA project. A carrier may be developed for a specific customer need.特定のキャリアーを使用して遠隔操作作業を行います。AREVA プロジェクト用にキャリアー1 台（下の 3 写真）を開発しました。もし顧客の特別な二ーズに応じて、新しく開発することも可能です。

Distance of 100 m is acceptable with specific high performance insulation of nitrogen pipes (photo 4)絶縁を施した.高性能の窒素パイプ（写真 4）を 100m の長さで納入できます。

Remote controlled sucking of retrieved parts of support thanks to an adapted capping (1) of the nitrogen gun nozzle (2).窒素用ガン・ノズルを先端に装着することによってコンクリートから削り取った断片を遠隔操作で吸引し、回収することも可能です。

Main advantages of the process:　この方式の主な利点

- Single operation for three main tasks of D&D　D&D（解体）の主要な 3 件の作業を 1 回の作業で処理可能
- Dry process with no effluents generated　乾式であるため、廃液が発生しない。
- For scabbling and decontamination:　削り取り及び除染に関しては
  - easy to deal with irregularities　でこぼこがあっても対応可能
  - innocuousness in regards of iron in concrete　コンクリートの中に鉄筋を処理しても無害
- For cutting:切断に関して
  - No hot spots　ホット・スポットは存在しない。

- Possible use with Mg, Na Li (sensitive materials)（注意を要する元素である）Mg、Na Li に対しても使用可
2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.) Non nuclear use of this solution in France (in R&D Center) and in United States for cleaning of heat exchangers (not performed by AREVA). Nuclear development made in France with Air Liquide. Real test had already been performed in SICN Veurey, operated by AREVA . New projects will use this Nithrow™ solution in 2012 and 2013, operated by AREVA .
3. Applicability to Fukushima site, Technical challenges Applicable to Fukushima. Remote controlled solution until 100 meter distance.
4. Technology Development (Example) Optimization of the remote controlled carrier to fit the specific needs and constraints of Fukushima Daiichi decommissioning works.
5. Note This solution is proposed thanks developments made by AREVA with partners.提案するこの方式は AREVA が協力会社の支援を得て開発したものです。 The experience gained by AREVA in nuclear testing of the solution makes AREVA and partners the only one able to operate this solution in active areas.この方式に関して、AREVA は放射能環境対応テストを行い、経験を積んだ結果、AREVA と協力会社はこのやり方で唯一高線量区域で作業を行える企業になったものです。

[Format 2-1]　Session1: Decontamination

<table>
<tr><td colspan="2">Decontamination Technology Catalogue</td><td>Category No.</td><td></td><td>Page</td><td></td></tr>
<tr><td>Title</td><td colspan="2">“Dry” decontamination of NPP Equipment</td><td>Proposed by</td><td colspan="2">“Joint Institute for Power and Nuclear Research – Sosny” National Academy of Sciences of Belarus</td></tr>
<tr><td colspan="3">Applicable contamination condition</td><td colspan="3">Experience in remote-control condition</td></tr>
<tr><td>Form</td><td>Strippable coatings on the base of water solutions of polyvinyl alcohol and active additives</td><td>Location</td><td rowspan="2">YES / NO</td><td rowspan="2" colspan="2"></td></tr>
<tr><td>Adhesion</td><td>Soft to metal/ Hard to porous surface of brick</td><td>Floor/Wall/Ceiling</td></tr>
<tr><td>Penetration</td><td>Shallow/Deep</td><td>Machine surface / inside machine</td><td rowspan="2">Reaction</td><td rowspan="2">Yes
(　　　　　)</td><td rowspan="2">No</td></tr>
<tr><td>Nuclide</td><td>Gamma/ β</td><td>Inside pipe, others</td></tr>
<tr><td colspan="3" rowspan="2">Principle
The employment of strippable coatings makes it possible to minimize the quantity of liquid radioactive waste. The selection of strippable decontaminating coatings was carried out on the basis of general requirements to decontaminating solutions: successfully dissolve a deposits; ensure the desorption of radionuclides from the surfaces and absence of resorption; perform minimal corrosion effect on construction materials; to be relatively cheap and available in reagents.</td><td colspan="3">Collection method</td></tr>
<tr><td colspan="3">Secondary waste form: Solid</td></tr>
</table>

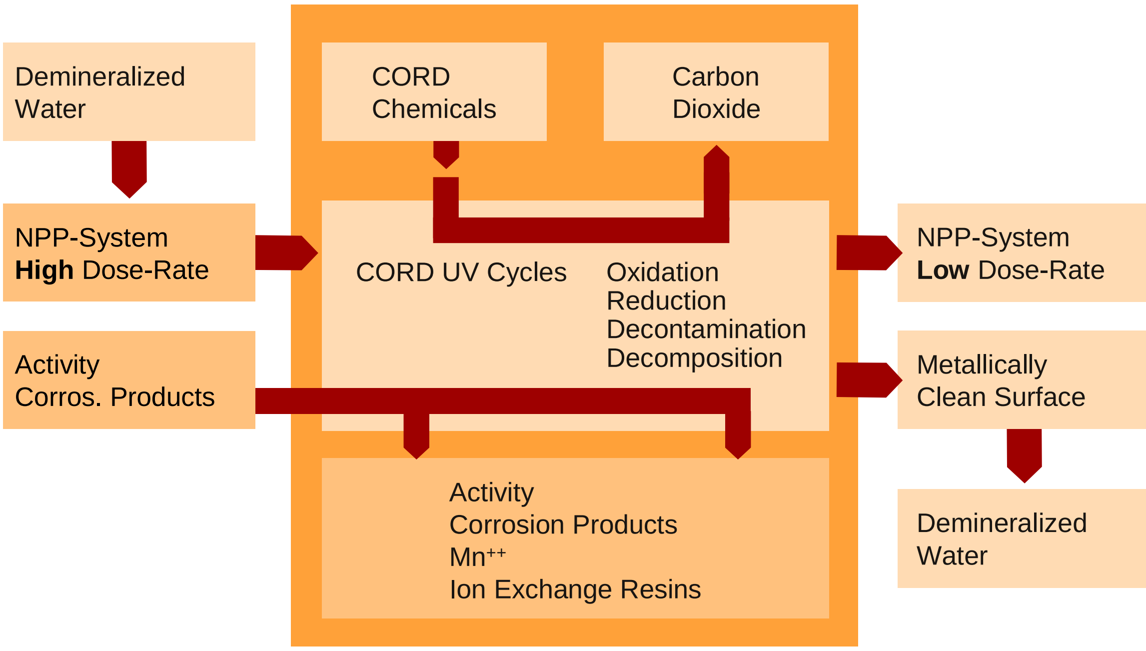
	Necessary utility: The solid films and coverings should be collected and treated together with another compactable radioactive waste. The decontaminating films are combustible, do not contain corrosive active Cl- - ions and hence, could be utilized by incineration. Combustible solid films are normally collected in transparent plastic bags. After filling, the plastic bags are removed from the bins and closed with adhesive tape.
	Basic machine structure
Principle Explanation	Safety measures/cautions
Past experiences/Decontamination effectiveness(DF) Stainless steel: DF~10^3 (Cs-137, Co-60) Carbon steel with corrosion depositing: DF~10^2 (Cs-137, Co-60) Motors (painted cast- iron): DF ~ 19 (Cs-137) Air channels (zinced iron): DF ~ 32 (Cs-137) Working wheels (painted iron): DF ~ 19 (Cs-137) Truck surface: DF ~ 22 (Cs-137)	Decontamination capability/Performance speed Size/Weight Applicability to Fukushima site/Technical challenges
Note	Reference documents

Technical Catalogue　/　技術カタログ	
Mobile device classification 分類移動装置	
Title タイトル	**Chemical Decontamination CORD®　Family**
Proposed by / 提案者	AREVA （アレバ）

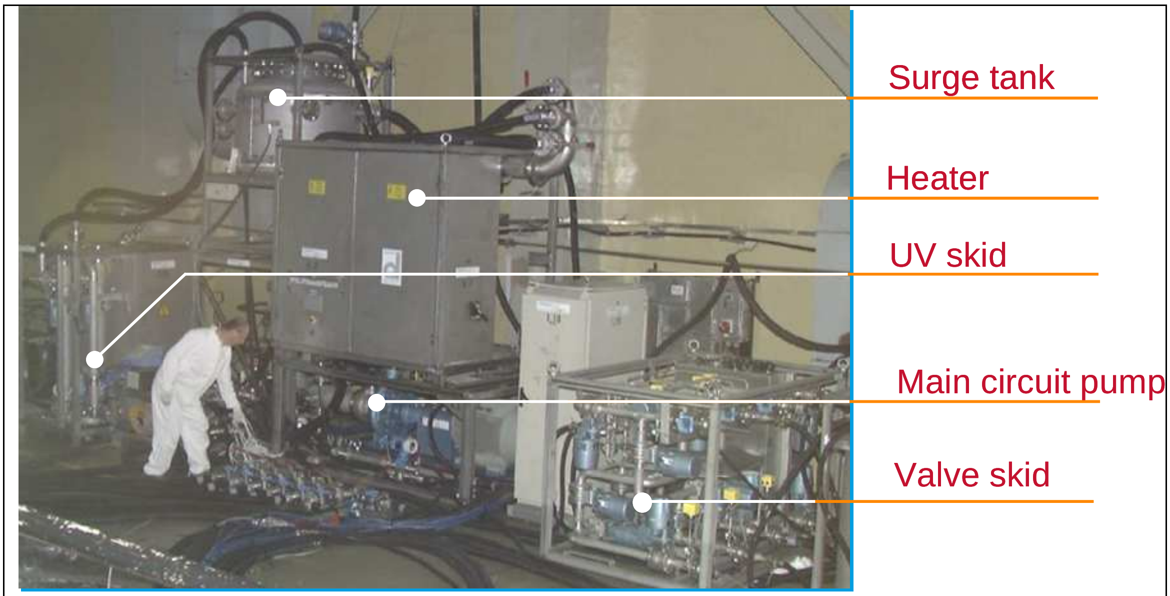
1.　Technical description (Advantage, Specification, Performance)
１．技術内容（特徴、仕様、性能など）

Description:
Chemical decontanination to remove contamination from inner surfaces of components and systems inclusive alpha conatmination

Operation principle:
Decontamination equipment (AMDA®) is connected with the system to be decontaminated. In the decontamination circiut chemical for decontamination are injected and the dissoluted activity / contamination is transferred on ion-exchange resin.



CORD Family Logistics



Example for AMDA Installation at site

The decontamination can placed in a optimized way, that dose exposure is minimized for operating personnel. All main functions are remote controlled.

With CORD Family the Decontamination Concept for Decommissioning (DCD) can be applied:

- Removal of oxide layers with activity / contamination
- Initiate controlled base metal removal with high accurcay
- Removal of alpha contamination and losse contamination

Advantages:

- Decontamination concept tailored to actual task with respect to chemistry and process engineering concept
- High flexibility
- Strict application of ALARA principle
- High decontamination factors achievable for alpha, beta and gamma nuclides
- Low secondary waste generation
- No chelates on ion exchange waste

Only one fill of system necessary due to regenerative deconatmiantion process

2. Past experience (Plant in Japan, overseas plant, application in other industries, etc.)

- Decontamination factors up to 1000 possible

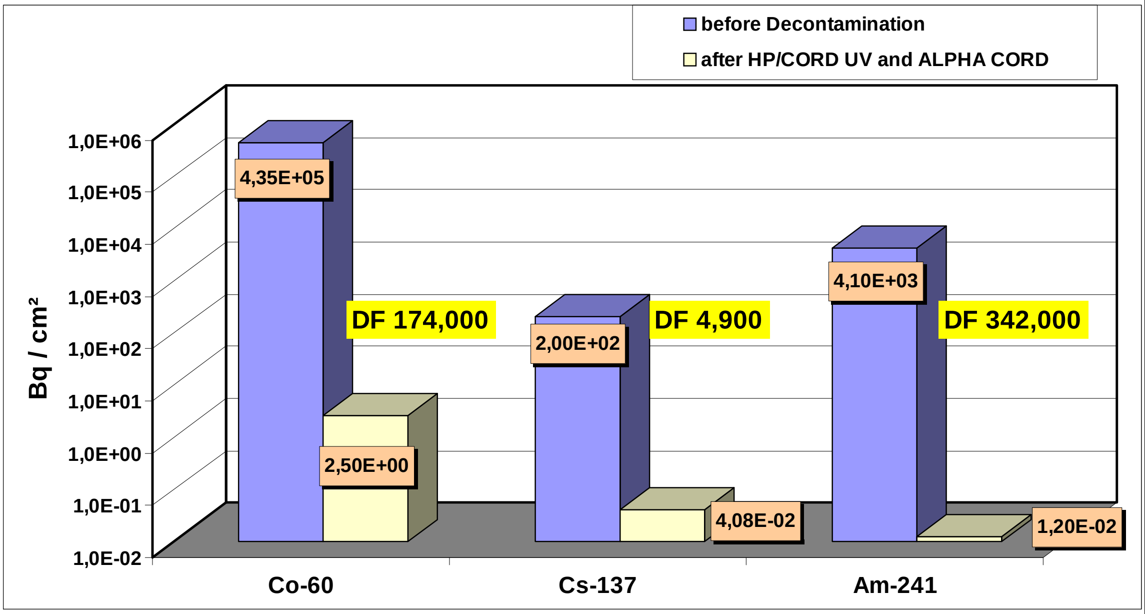
	Pu-239 & Pu-240 / (Bq/cm²)	Am-241 / (Bq/cm²)	Cm-243 & Cm-244 / (Bq/cm²)
Original	7,72E+00	5,43E+01	5,95E+00
after HP CORD UV	5,56E-01	2,64E+00	1,74E-01
after CORD Alpha	6,15E-03	2,72E-02	1,34E-03
Decon Factor	**1254**	**1996**	**4453**

DF Result especially for alpha nuclides with application DCD

Cut Sample	1		2		3	
	Act bef. Bq/g	DF	Act bef. Bq/g	DF	Act bef. Bq/g	DF
Total act	8.7 E5	6200	2.2 E5	1955	2.3 E5	850
Co-60	8.8 E4	4700	2.3 E4	540	2.2 E4	470
Fe 55	3.4 E5	18200	6.5 E4	4500	7.3 E4	3100
Ni-63	3.9 E5	105000	1.1 E5	14000	1.2 E5	7100
U-238	4.0 E-1	1100	1.0 E-1	513	5.0 E-1	1200
Pu-241	3.9 E4	> 10000*	1.2 E4	> 10000*	6.6 E3	> 10000*

*below detection level

DF result on cut samples for decon at heavy water reactor MZFR Germany



DF result for decontamination in German BWR Lingen

CRD Housings (bottom of RPV) after decon at Unit 2

Core shroud stand (bottom of RPV) after decon at Unit 2

Metallically clean Surfaces after decontamination in Swedish BWR Barsebäck

Dose rates before/after decon and DF achieved:

- Dose rates before: 730 µSv/h
- Dose rates after: 29 µSv/h
- Achieved DF (61 measuring points): 286

Release: 2.3 E12 Bq, 30 kg corrosion products
Personnel dose savings: 20 000 mSv
DF 20 to > 1000, IX resin waste: 2.5 m^3
Smearable contamination after FSD at RPV bottom: 4 Bq/cm^2

FSD at Swedish BWR Oskarshamn 1

Results:

before FSD: ~20–25 mSv/h

After FSD: ~0,015–0,02 mSv/h without interferences

- decontamination for decommissioning with CORD Family and AMDA is performed since 1986

NPP	NPP Type	Application Time	Decontamination Process	System (Extent of Decontamination)
FR 2, Germany	PWR (Siemens)	1986	HP/CORD	Primary Loop
MOL/BR3, Belgium	PWR (Westinghouse)	1991/92	HP/CORD	FSD, including SG, RPV and auxiliary systems
VAK, Germany Kahl	BWR (GE)	1992/93	HP/CORD D UV	FSD, incl. SG (superheater), RPV and auxiliary systems
NPP Rheinsberg	VVER (Russian)	1994	HP/CORD D UV	Steam generator
MZFR, Germany	PWR heavy water (Siemens)	1995	HP/CORD D UV	FSD including SG and auxiliary systems (5 systems)
KWW, Germany Würgassen	BWR (GE)	1997/98	HP/CORD D UV	FSD without RPV (11 systems)
ConnYankee, USA Haddam Neck	PWR (Westinghouse)	1998	HP/CORD D UV	FSD without RPV
KWL, Germany Lingen	BWR (GE)	2001	HP/CORD D UV	Auxiliary systems (4 systems)

NPP	NPP Type	Application Time	Decontamination Process	System (Extent of Decontamination)
Caorso, Italy	BWR (GE)	2003	HP/CORD UV	Recirculation, RWCU
Trino, Italy	PWR (Westinghouse)	2004	HP/CORD UV	Steam generators and loop sections
Stade, Germany	PWR (Siemens)	2004/05	HP/CORD UV	FSD, primary circuit incl. RPV and auxiliary systems
Obrigheim, Germany	PWR (Siemens)	2007	HP/CORD UV	FSD, primary circuit incl. RPV and auxiliary systems
Barsebäck 2, Sweden	BWR (ABB)	2007	HP/CORD UV	FSD including RPV and auxiliary systems
Barsebäck 1, Sweden	BWR (ABB)	2008	HP/CORD UV	FSD inlcuding RPV and auxiliary systems
Chooz A, France	PWR (Westinghouse)	2011/12	HP/CORD D UV	Steam generator, pressurizer loops
Unterweser	PWR (Siemens)	2012	HP/CORD UV	FSD inlcuding RPV and auxiliary systems

3. Applicability to Fukushima site, Technical challenges

4. Technology Development (Example)

5. Note