2013 WJTA-IMCA Conference and Expo
September 9-11, 2013 ● Houston, Texas

Paper

RECONDITIONING OF SOLID RADIOACTIVE WASTE USING SIMULATED CONCRETE WITH FORCED PULSED WATERJET

A.Tieu, B. Daniels, M. Vijay, W.Yan
VLN Advanced Technologies Inc.
Ottawa, On, Canada

ABSTRACT

Radioactive wastes from nuclear reactor power plants stored in land repository from early years (1940-60s) do not meet current environmental standards warranting upgrading.

A laboratory investigation was conducted to demonstrate whether waterjet (without abrasives) could be used to cut through the steel pail and dislodge its solid concrete content with minimal time and energy. The pails containing the concrete represented actual radioactive waste drums buried under the ground for more than 50-years.

The reconditioning effort required that the technique be automatic, fast and cost effective. The other condition was to capture and recycle the water for post processing of the rubbles.

Tests were conducted with the continuous waterjet (CWJ) and the forced pulse waterjet (FPWJ) at a constant pressure of 15-kpsi (103.5-MPa) without abrasives. The results showed that while FPWJ was quite effective in cutting and dislodging the concrete, CWJ did not cut the pail.

Organized and Sponsored by WJTA®-IMCA®

1. BACKGROUND

A cursory review of the literature shows that waterjets in various forms have been used for several applications in the nuclear industry (Refs. 1 to 28). The applications range from decommissioning and dismantling of obsolete nuclear power plants (Refs. 1, 2, 6, 8, 10, 11, 12, 21, 23, 27 and 28), removal of corrosion and maintenance of pipes, etc., (Ref. 3, 5, 13 and 15), cutting of fuel elements and other components (Refs. 4, 7 and 9). Very few investigators have dealt with the naturally occurring radioactive materials (Ref. 14) or, the dislodging and removal of radioactive wastes from large buried tanks (Refs. 16 to 20, 22 and 24). In all of these investigations, CWJs with or without abrasives (abrasive-entrained and abrasive suspension jets) and cavitating jets were employed. Only two references reported on the efficacy of FPWJ for chemical and radioactive decontamination (Refs. 25 and 26). Furthermore, as indicated in **Table 1** in the **Appendix**, most of the investigations were basically laboratory studies and, it appears, that the topic of cutting drums containing radioactive materials were not addressed.

While nuclear power has been touted as clean and inexpensive, the problem of managing safe disposal of radioactive waste remains quite formidable. As shown in **Tables 2** and **3** in the **Appendix**, raw radioactive waste comes in the form of solids and liquids, and in various grades of radioactivity from low level radioactivity to intermediate and high levels (Ref. 29). Nuclear waste can only be neutralized through a natural decay cycle known as its half-life. Depending on the raw material, some wastes such as, plutonium and uranium, can be radioactive for thousands to millions of years.

Fig. 1. A typical steel drum containing concrete mixed with the radioactive waste materials (Ref. 30).

The responsibility of containing and managing the nuclear waste product is a daunting task. Before any permanent storing takes place, raw nuclear waste must be transformed into a stable format to prevent leaks or dispersion (Refs. 30 to 33). This requires the waste solid to be mixed and cured in either concrete or glass until solidification.

Various treatment options such as incineration, compaction, cementation (Fig. 1) and vitrification techniques have been developed to contain radioactive materials. Depending on the level of activity (low, medium and high, see **Tables 2** and **3**), the drums are then stored under the ground (Ref. 29) in pits (Fig. 2) or, in abandoned mines. This method offers the possibility of retrieving and recondition-ing after a certain period of time. Currently there is a need to recondition old cemented waste metallic drums. These drums that contain radioactive solid waste were placed in repositories for many decades. The corrosion products and the residual radioactivity in the materials in the drums are proving to be hazardous. Furthermore, the current stringent environmental regulations (essentially due to public pressure) compared to the regulations at the time they were buried, have radically changed requiring reconditioning of these drums.

Fig. 2. A general view showing the storage of drums containing low and high-level radioactive waste materials (Ref. 31).

2. OBJECTIVE

CANMET, a division of Natural Resources Canada (NRCAN) in conjunction with the Atomic Energy Canada Limited (AECL) was interested in the idea of using FPWJ to recondition buried steel pails containing solid concrete simulating nuclear waste. CANMET also stipulated receiving the pails processed with the FPWJ (that is, with the aggregates) for detailed analysis. The mandate was not to use any abrasives in the FPWJ due to the unknown nature of the contents, which could be flammable.

2.1 PART 1

The objective of reconditioning was to remove the concrete content from old steel drums. As reported by several investigators (for instance, Refs. 22 and 24), the final requirement was to recommend reconditioning operations by remotely controlled automated system. In the context of the experiment, the primary objective was to cut open the drum, dislodge the solid content to separate the steel from the concrete.

2.2 PART 2

Once cutting and dislodging were proven successful, the secondary objective was to reduce or, comminute the concrete to the minimum possible aggregate sizes, preferably at low water flow rates. The other consideration was to use the spent water in a subsequent leaching process to separate the radioactive waste from the rubbles into a concentrated form to be repackaged.

In addition to the requirements stated above, overall efficiency in terms of cost of reconditioning was considered to be quite important.

3. EXPERIMENT

In the experiments conducted in the laboratory, as stated elsewhere, new drums containing simulated concrete were used. While Fig. 3 shows a typical 40-litre steel drum lined with plastic and filled with concrete to about 80% full, Fig. 4 shows the pail with the lid locked. From a practical standpoint, tests on the new pails were considered to be better (it would be much easier to process the deteriorated buried drums).

Fig. 3. View of drum showing solid concrete inside.

4. EXPERIMENTAL SETUP

Tests were conducted by placing the drums in a 1000-liter size tank (basin). This made it possible to collect the debris for analysis after each test (to determine the shape, sizes of aggregates, etc.).

The pail was firmly braced to a fixture via straps. The content and water were free to spill out in the basin. However, to ensure all the debris remained within the basin, the top opening was covered with tarpaulin while conducting the tests.

Figure 4. View of lid securely locked on pail.

4.1 EQUIPMENT

The equipment consisted of:

- Kinematics (movement of the nozzle) was provided by a 6-axis robot that could generate circular paths and speed accurately.

- A triplex pump delivering 11-usgpm (41.6-lpm) at 15-kpsi (103.5-MPa) using a 0.055-in (1.4-mm) orifice.
- A RFM-2020 (Retro-Fit-Module) to generate pulses of water (FPWJ).

5. PROCEDURE

The configuration used in processing the pails is depicted in Fig. 5. With this arrangement and, by programming the robot to generate a circular path (Fig. 6), it was possible to remove the lid in one complete motion, rendering the method highly efficient.

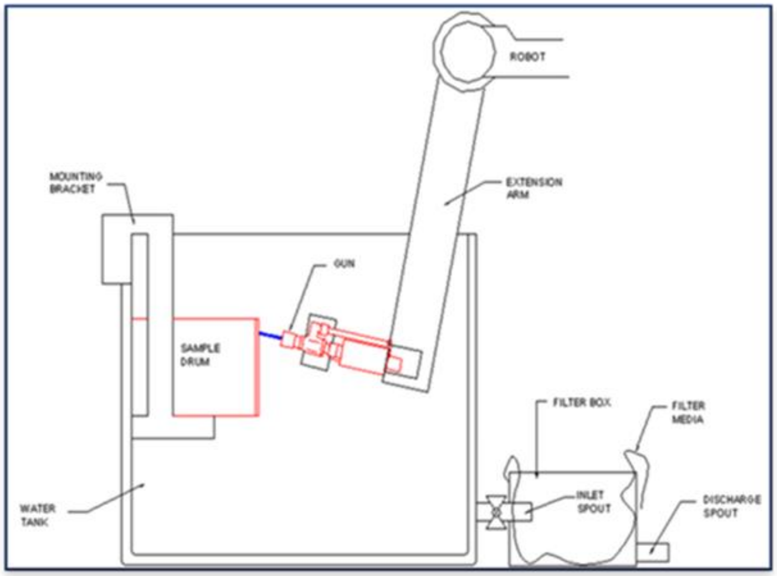

Figure 5. Schematic showing overall setup of basin, drum, fixture, gun, and robot arm manipulator.

Given the thickness of the steel to be cut (≈1-mm), the optimum operating parameters (that is, to obtain powerful pulses of water) were determined by conducting preliminary tests. Except where noted, the operating variables were as listed below:

P = Pump pressure = 15-kpsi (103.5-MPa)
Q = Flow rate = 9-usgpm (34-litre/min)
H_p = Hydraulic power = 79-hp (59-kW).
V_{tr} = Traverse speed = 50-in/min (21.2-mm/s)
S_d = Standoff distance = 3.5-in (89-mm)

6. RESULTS - Part 1

Figures 5 to 8 summarize the results. Details of the runs have been omitted for clarity. The sample results reported herein were considered to meet the objectives set forth by CANMET. Although it would have been possible to further optimize the performance (that is, overall efficiency of the process) by selecting other operating parameters, the time and budgetary restriction did not permit continuation of the project.

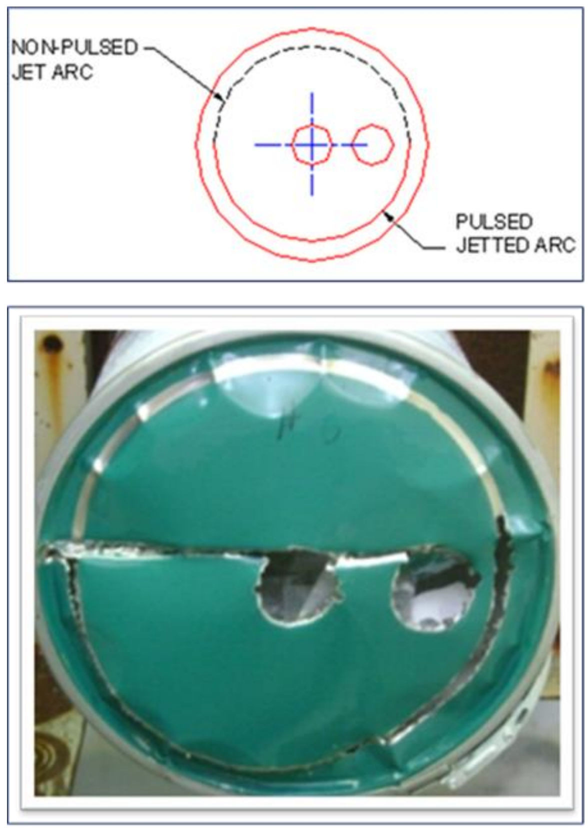

Fig. 6. A view of the lid exposed to CWJ and FPWJ.

7. DISCUSSION

Figure 6 shows the result after exposing the lid of the pail to both CWJ and FPWJ at the same operating conditions. The photograph clearly shows while the lid was cut with the FPWJ in one pass, CWJ just removed the paint.

Figure 7 shows the result of cutting the lid, 250-mm in diameter, with the FPWJ. The lid was cut in one pass and took 38-s. The amount of 5.6-usgal (21.2-litre) water consumed was considered to be beneficial for comminuting the concrete in the pail.

Figure 8 shows the method used for complete dislodging of concrete from the pail. Using spiral movement of the FPWJ nozzle over the lid, it was possible to completely remove the concrete in just two passes. The standoff distance was varied to dislodge the concrete and the total time taken was 140-s, which was considered to be satisfactory.

Figure 9 shows that it is possible to fragment (comminute) the concrete without completely cutting the lid. Basically, it is due to the stirring action of the jet within the pail. The fragmentation shown in Fig. 9 was achieved in two passes and took about 140-s.

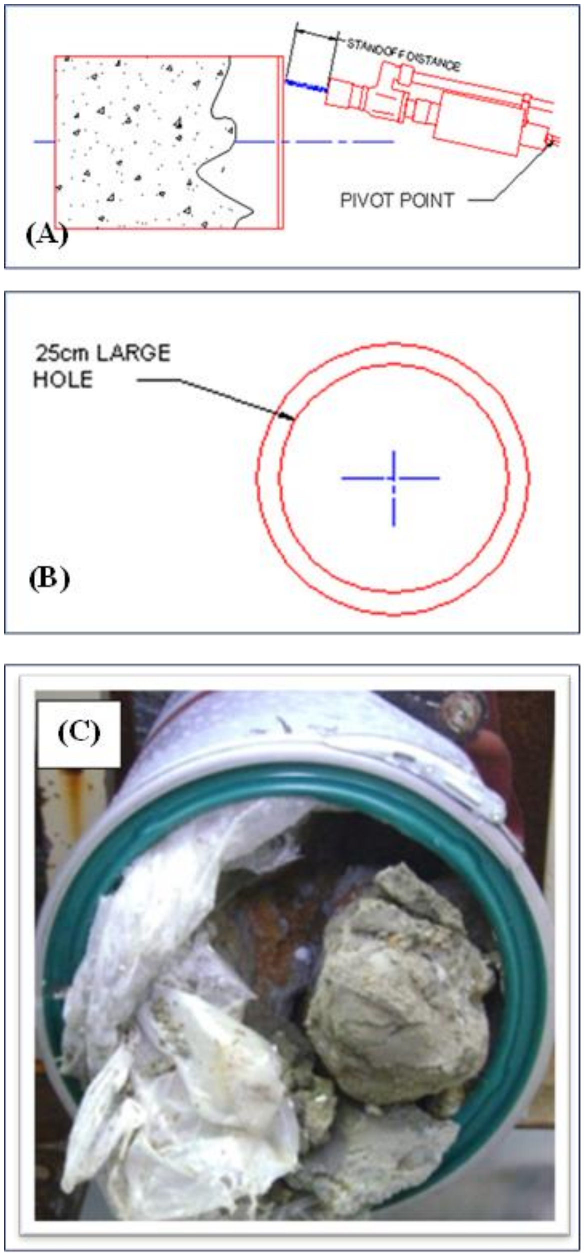

Fig. 7. Photograph showing the cutting of the lid with the FPWJ, exposing the concrete in the pail.

8. CONCLUSIONS

The conclusions from the very limited tests conducted in the laboratory are:

- From our observations, the FPWJ appears to be an effective tool to remove encased concrete in the supplied steel drums.
- Once the lid is cut, it is possible to reduce the pressure for dislodging and comminuting the solid concrete.
- Continuous waterjet (CWJ) operating at the same conditions was not able to penetrate the lid.
- As indicated in **Table 1**, although extensive work has been conducted on the use of waterjets for nuclear applications, this is the first investigation on processing of aging radioactive containers.
- FPWJ has great potential for this application.

9. RECOMMENDATIONS

There are two aspects to the problem: (1) cutting the steel pail and (2) dislodging/comminuting the concrete. In the investigation, both tasks were addressed using a single-orifice diameter. However, work done by Summers, et. al (Ref. 20) and Fossey, et. al (Ref. 24) indicates that it may be beneficial to use more water at lower pressure to deal with the waste material and, higher pressure with smaller orifice diameters for cutting the metal. This makes sense because all one needs to do is cut a narrow kerf in the metal by using as small orifice diameter as possible. Once the jet penetrates the pail, dislodging/comminuting occurs in a very confined space. Therefore, it is quite possible to reduce the overall consumption of water to improve the efficiency and reduce cost per pail. Therefore, by conducting further tests, it would be possible to meet the requirement of CANMET, namely, reducing the water consumption to about 20-litre/pail (sufficient for leaching).

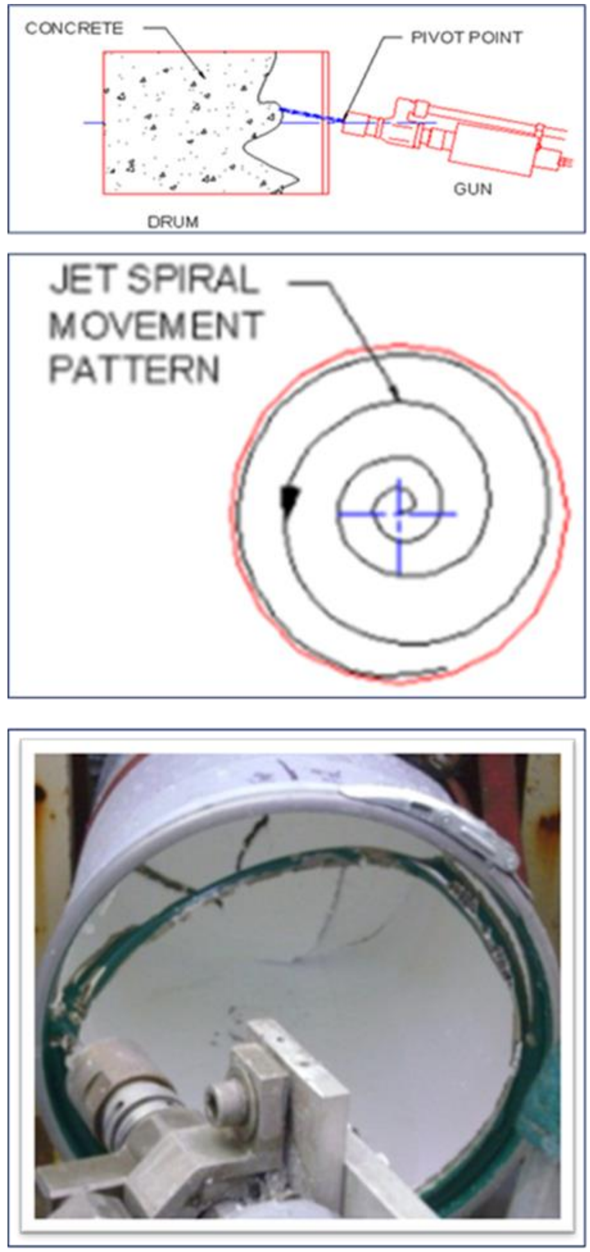

Fig. 8. Nozzle configuration and the procedure (spiral movement) used for dislodging the concrete from the pail.

The RFM used in the current investigation offers another benefit. Depending on the structure of the concrete in the pail, CWJ may dislodge and fragment it. With the ultrasonic power off, RFM produces the CWJ. This procedure should be considered in any future work.

Finally, in the actual field work, it would be possible to implement a totally integrated remotely operated automated system for processing aged drums. A typical system, which can be easily designed and manufactured, is illustrated in Fig. 10.

10. ACKNOWLEDGMENTS

The authors are thankful to CANMET - NRCAN for partial funding of this investigation. Particular thanks to Mr. Magella Bilodeau and Rolandro Lastra of CANMET for collaborating with the VLN team in conducting the tests in the laboratory.

11. REFERENCES

1. Kluk, A.F., “Management of the DOE inventory of excess radioactivity contaminated facilities,” in Decontamination and Decommissioning of Nuclear Facilities, Edited by M.M. Osterhout, Plenum Press, NY, 1980.
2. Manion W.J., and T.S. LaGuardia, “Decommissioning Handbook,” US DOE, DOE/EV/10128-1, Section 7, November 1980.
3. Sanders, M.J., and R.D. Bond, “The use of high pressure waterjetting to remove the corrosion deposit from samples of the WSGHWR primary circuit pipework,” Paper C1, Proc. 7th Int. Symp. On Jet Cutting Technology, BHRA, UK, 1984.
4. Gelfort, E., J. Mischke, C. Boltze, H. Haferkamp and W. Schikorr, “Application of jet-cutting on spent fuel elements of nuclear power plants,” Proc. 7th Int. Symp. On Jet Cutting Technology, BHRA, UK, 1984, pp.135.
5. Mellors, W., D.A. MacLeod and C.J. Astill, “Clearing of the Douglas Point Heat Exchanger Blowdown Lines by Water Jetting,” Ibid, Paper P4, pp.519.
6. Hashish, M., M. Halter and M. McDonald, “Abrasive-waterjet deep kerfing in concrete for nuclear facility decommissioning,” Proc. 3rd U.S. Water Jet Conference, WJTA, St. Louis, USA, 1985.
7. Gelfort, E., J. Mischke, H. Blickwedel and H. Haferkamp, “Submerged cutting of nuclear fuel elements by high speed water jets,” Proc. 8th Int. Symp. On Jet Cutting Technology, BHRA, UK, 1986, pp.315.
8. Echert, D.C., M. Hashish and M. Marvin, “Abrasive Waterjet and Waterjet techniques for decontamination and decommissioning nuclear facilities,” Proc. 4th U.S. Water Jet Conference, WJTA, St. Louis, USA, 1987.
9. Haferkamp, H., H. Louis and G. Meier, “Cutting contaminated material by abrasive water jets under the protection of water shield,” Proc. 9th Int. Symp. On Jet Cutting Technology, BHRA, UK, 1988, pp.271.

Fig. 9. Fragmenting the concrete within the pail with the FPWJ using the configuration as indicated in (A) and in (B).

10. Seiki, Y., H. Nakamura, T. Narazaki and Y. Yokota, "Application of water jet to dismantlement of reactor biological shield," Ibid, p.289.
11. Ogawa, Y., J. Sakakibara and T. Sumitomo, "Underwater arc processing with water jet for dismantling commercial reactor vessel," Ibid, p.297.
12. Walters, C.L., and D.H. Saunders, "DIAJET cutting for nuclear decommissioning," Chapter 29, Proc. 10th Int. Symp. On Jet Cutting Technology, BHRA, UK, 1990, pp.427.
13. Malaugh, J., M. Upton, S. Ryder and D. St. Louis, "High pressure waterlancing application at Ontario Hydro nuclear generating stations," Ibid, Chapter 31, pp.449.

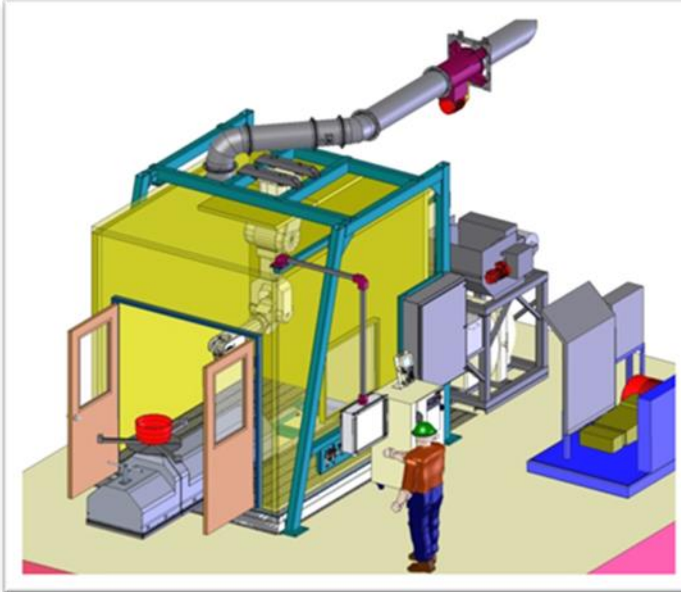

Figure 10. Automated cell equipped with pulsed jet technology capable of cutting steel pails and coring solid concrete masses with only water.

14. McArthur, A., "Personnel and environmental risk reduction through high pressure jet cleaning of NORM," Paper 53, Proc. 7th American Water Jet Conference, WJTA, St. Louis, USA, 1993.
15. Mainbourg, B., and P. Pontvianne, "Nuclear reactor repair by high pressure hydroabrasive jet," Ibid, Paper 54.
16. Bamberger, J.A., and D.E. Steele, "Developing a scarifier to retrieve radioactive waste from Hanford single-shell tanks," Ibid, Paper No.55.
17. Yoshida, H., T. Isobe, R. Kobayashi, T. Yahiro, M. Takei and K. Horii, "Air jet cutting technology for clay cover at radioactive waste storage sites," Ibid, Paper 56.
18. Hatchell, B.K., M.W. Rinker and O.D. Mullen, "Hazardous waste retrieval strategies using a high pressure water jet scarifier," Paper 45, Proc. 8th American Water Jet Conference, WJTA, St. Louis, USA, 1995.
19. Summers, D.A., G. Galecki, M.W. Rinker, C. Christienson and J.D. Randolph, "The use of low reaction dislodging tools for waste retrieval from underground storage tanks," Ibid, Paper 46.
20. Summers, D.A., G. Galecki, M. Rinker and J. Randolph, "The development of a light-weight system for excavating high level radioactive waste from underground storage tanks," Proc. 13th Int. Conf. on Jetting Technology, BHR Group, 1996, p.393.
21. Brandt, C., H. Louis, G. Tebbing and Ch. Witzsche, "Abrasive water suspension jets for nuclear decommissioning – final investigation for the first application," Paper 50, Proc. 9th American Water Jet Conference, WJTA, St. Louis, USA, 1997.
22. Galecki, G., R.D. Fossey, D.A. Summers, M. Rinker and O.D. Mullen, "Designing a waste retrieval system for radioactive waste recovery," Ibid, Paper 52.

23. Brandt, C., S. Brandt, H. Louis, W. Milchers, Ch Von Rad, N. Eickelpasch, H. Kalwa, H. Alba and H. Brehmer, "Application of abrasive water suspension jets for nuclear dismantling," Proc. 14th Int. Conf. on Jetting Technology, BHR Group, 1998, p.467.
24. Fossey, R., D.A. Summers and G. Galecki, "High volume-low pressure nuclear waste removal – the sluicing concept," Paper 49, Proc. 10th American Water Jet Conference, WJTA, St. Louis, USA, 1999.
25. Tieu, A., W. Yan, M. Vijay, T. Cousins, D.S. Haslip, S.E. Sparkes, T.A. Jones and D. Estan, "Chemical and radioactive decontamination of armored vehicles using high-frequency forced pulsed waterjet machine," Proc. 16th Int. Conf. on Water Jetting, BHR Group, 2002, p.609.
26. Yan, W., A. Tieu, B. Ren, M. Vijay, D.S. Haslip, . Cousins, D. Estan, T. Jones, E.J. Waller, B.E. Sandstrom, K. Lidstrom, T., Ulvsand and G. Agren, "Radiological decontamination of armored personnel carriers with continuous and pulsed Waterjet at Umea, Sweden," Paper 2-E, Proc. 2003 WJTA American Waterjet Conference, WJTA, St. Louis, USA.
27. Denissen, L., L. Ooms and H. Davain, "Remote high pressure water jet cutting used at the BR3 nuclear dismantling site," Proc. 17th Int. Conf. on Water Jetting, BHR Group, 2004, p.351.
28. Kleiman, J., "Water abrasive suspension (WAS) cutting under water in decommissioning nuclear power plants," Paper 2-I, Proc. 2009 American WJTA Conference and Expo, WJTA, St. Louis, USA.
29. Anon, "Regulating Canada's Geological Repositories," Fact Sheet, Canadian Nuclear Safety Commission, February 2011 (nuclearsafty.gc.ca).
30. Anon, "Nuclear Safety and the Environment: Report on the Magurele Radioactive waste Treatment Plant," Report EUR 19259, European Commission, May 2000. (http://ec.europa.eu/energy/nuclear/studies/doc/other/eur19259.pdf)
31. Anon, "Treatment and Conditioning of Nuclear Wastes – Radioactive Waste Management," Appendix 1, World Nuclear Association, 2013 (http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Nuclear-Wastes/Appendices/Radioactive-Waste-Management-Appendix-1-Treatment-and-Conditioning-of-Nuclear-Wastes/#.Ub8gSJy1OF9).
32. Anon, "Country Nuclear Power Profiles – South Africa," IAEA, 2009 Edition (http://www-pub.iaea.org/MTCD/publications/PDF/cnpp2009/pages/countryprofiles.htm).
33. Anon, "Radioactive Waste," Wikipedia, (http://en.wikipedia.org/wiki/Radioactive waste), June 2013.

APPENDIX

In the following table highlights of the brief literature search on the applications of waterjets in nuclear industry are listed. The applications range from decontamination of radioactive materials to decommissioning of nuclear reactor stations. The use of FPWJ was reported only in two publications (Refs. and xx). Except or the first two references, all the investigations were reported in the BHR and WJTA conferences. The authors believe that this information would be useful to readers of this paper.

Table 1. Highlights from cursory literature search.

Reference	Highlights
1	Dating back to 1980, the investigations are concerned with the decontamination and decommissioning of nuclear facilities in the US.
2	***This is an excellent handbook to learn decommissioning problems. As the nuclear power stations age, decommissioning takes a major role all over the world.***
3	***Investigated the potential of submerged waterjets to remove corrosion deposits from primary pipework of WSGHWR (Winfrith Steam Generating Heavy Water Reactor). While LOMI (low-oxidation-state metal-ion) treated samples required pressure of the order of 3-kpsi, the untreated samples required 5-kpsi to clean the pipes.***
4	Basic experiments were conducted in the laboratory in support of cutting spent fuel elements with both submerged and 'in-air' environments. Pressure was of the order of 11-kpsi. Concluded that the technique could be useful for cutting fuel elements.
5	Basic study was conducted on deep kerfing of nuclear grade concrete with several types of abrasive-entrained watejet (AWJ) nozzles. No actual work was conducted on nuclear decommissioning. Table 1 in the paper lists several types of concrete removal techniques (good source of information).
6	Basic study on cutting of tubes and dummy fuel rods with submerged cavitating waterjets. Actual fuel elements were not cut. The Waterjet was surrounded by a sheath of air. The results indicated that the technique could be used for cutting nuclear fuel elements.
7	***The authors described the work done on the clearing of blowdown lines at the Douglas Point nuclear power station in Canada. An interesting paper when it comes to working in nuclear power stations.***
8	This is basically continuation of the work reported in Ref. 5. Described various nozzle designs and configurations which could be used for decontaminating and decommissioning of nuclear facilities.
9	Although the paper alludes to decommissioning and decontamination, tests were conducted with the submerged AWJ. The results appeared to indicate that the special AWJ could be of use for decommissioning.
10	The authors describe the use of AWJ in dismantling the radio-activated hard concrete biological shield of the JPDR (Japan Power Demonstration Reactor). The reported the basic results of cutting concrete with the AWJ, in preparation for the dismantling of the shield.
11	This is basic study of using the underwater arc Waterjet for cutting of stainless clad steel of nuclear reactor vessels. Describes the technique for producing the arc jet and the encouraging results obtained with it.
12	Experiments were conducted to investigate the feasibility of DIAJET cutting for decommissioning of nuclear reactors. The authors concluded that DIAJET is significantly better than the conventional AWJ for such applications.
13	***A very interesting paper describing the use of high pressure water for cleaning and decontamination of fuelling machines at the Bruce and Pickering nuclear generating stations in Ontario, Canada. The paper clearly indicates the***

	complexity involved in such operations.
14	***The paper is concerned with the removal of the NORM (naturally occurring radioactive materials), generally Radium and Radon gas, which has been found in oil and gas and other industries. The author concludes that high pressure waterjetting is the best method for cleaning of NORM.***
15	***This paper describes the work conducted with hydroabrasive Waterjet for repairing a nuclear reactor in France. As stated by the authors, this was one of the major and actual application performed inside a nuclear reactor core.***
16	The authors described work conducted to dislodge and remove the solidified salt cake and sludge deposits from single-shell tanks, containing the radioactive waste materials (Hanford Reservation in Washington, USA). A prototype scarifier using ultra-high pressure was developed and tested. Actual work on the tank was not conducted.
17	*The authors developed air-bentonite jet technology for repairing clay covers over the radioactive wastage storage sites. The covers consisted of 15% bentonite and 85% sand. However, no actual work was done on the storage sites.*
18	***The investigation reported in this paper is concerned with dislodging and retrieval of high-level radioactive wastes from tanks buried under the ground. The highlight of the investigation is the development of a scarifier consisting of three rotating waterjets at a pressure of 50-kpsi(344-MPa) and a total flow rate of 6-usgpm (22.7-litre/min). The feasibility of using the system was demonstrated by conducting tests on simulated waste materials.***
19	***This paper also describes the same problem as reported in Ref. 15. Special nozzle configuration, called end-effector was designed to dislodge the waste material in the buried tanks. No actual work was done on the buried tanks.***
20	***This investigation is basically the continuation of the work reported in Ref. 16. Improvements in the design were made and trials were conducted on simulated sand. No actual work was reported on the buried tanks.***
21	The authors conducted design and experimental work with the AWSJ (abrasive water suspension jets) for possible application for decommissioning of VAK nuclear power plant in Germany. Described the challenges associated with decommissioning of nuclear reactors. However, no actual work on the nuclear reactor was conducted.
22	This paper reports further improvements made to remove the radioactive waste materials in the buried tanks. The work reported is continuation of the investigations reported in Refs. 16 and 17.
23	This is a continuation of the work reported in Ref. 18. However, the paper does describe the actual work conducted at the VAK nuclear power plant. From this work, the authors conclude that AWSJ is a viable tool for dismantling of reactors.
24	The work reported in this paper is the continuation of the investigations reported in Refs. 16, 17 and 19. This is good paper to read on the description of aging tanks containing the hazardous radioactive and other toxic materials, indicating the importance of removing them to new tanks.
25	This paper describes the use of high-frequency forced pulsed waterjet (FPWJ) for chemical and radioactive decontamination of armored vehicles. Based on the field trials, the authors concluded is highly promising for decontamination applications,

	possibly in the nuclear industry as well.
26	Based on the successful field trials conducted at Ottawa, Canada (Ref. 22), working in collaboration with the National Defence of Canada and FOI NBC-Defence, Sweden, the authors conducted further trials on radiological decontamination of armored vehicles in Sweden. The results did indicate the potential of FPWJ for decontamination, warranting further investigations.
27	***The authors describe the work done on the dismantling of the small BR3 (Belgian Reactor no.3) with the AWJ. Actual in situ work was conducted to dismantle the Reactor Pressure Vessel (RPV). The project was considered to be successful.***
28	***Decommissioning work was conducted on two nuclear power stations in Germany. AWJ was used for the work. The work was considered to be successful.***
29	In this fact sheet, radioactive waste data from 2007 to 2050 are listed (See Tables 2 and 3).
30	In this report, extensive details are given on the management radioactive wastes in Romania (a joint venture between the British BNFL and the Romanian National Institute of Physics and Nuclear Engineering). The details discussed, however, are applicable to all, countries in the world.
31	General information on nuclear wastes
32	General information on nuclear power plants in the world
33	General information on radioactive wastes.

Table 2. Waste Data to 2007.

Waste category	Waste produced in 2007	Waste inventory to the end of 2007
Nuclear fuel waste	311-m^3	8,130-m^3
Intermediate level radioactive waste	890-m^3	30,350-m^3
Low level radioactive waste	4,560-m^3	2.33-million-m^3

Table 3. Waste Inventory Projections to 2008 and 2050.

Waste category	Waste inventory to end of 2008	Waste inventory to the end of 2050
Nuclear fuel waste	8,500-m^3	21,300-m^3
Intermediate level radioactive waste	31,000-m^3	79,000-m^3
Low level radioactive waste	2.33-million-m^3	2.57-million-m^3