Demolition of Cooling Towers from the World’s First Commercial Reactors – the Nuclear Factor

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ABSTRACT

The demolition of hyperbolic cooling towers would be a relatively routine demolition project because the method of demolition has been proven straightforward and repeatable with the successful demolition of over 200 similar structures in the last 30 years. This paper will detail the unique aspects of the planning and execution of the cooling tower demolition project due to its location on a nuclear site and proximity to active nuclear operations.

INTRODUCTION

Since its opening in 1951, Sellafield has been a major nuclear facility focusing on energy production, reprocessing, and defense materials development. Sellafield is located on the northwest coast of England, 20 kilometers north of the seaport town Barrow-in-Furness on the Irish Sea.

Prime Minister, Winston Churchill, ordered the building of the four reactors at Calder Hall, on Sellafield, in 1953. On October 17, 1956 Her Majesty the Queen officially opened Calder Hall, at which time reactor No. 1 was operative. The reactors were the first nuclear reactors in the world to be employed in the production and supply of electricity, and operated until March 2003 when the power plant was shutdown.

Calder Hall power station has four essentially identical cooling towers. Over the past 30 years, over 200 similar structures have been successfully demolished in the United Kingdom using the proposed technique. The technique requires that approximately 60% of the circumference of the shell and legs be removed by explosive charges causing the structure to deform, rotate and collapse into the basin directly beneath the tower.

The technique for the demolition of these structures is not unique and has been demonstrated to be repeatable and reliable. However, the location of these cooling towers is within 40 meters of a nuclear fuel handling plant, on a site with numerous active nuclear operations conducted within aging structures of questionable status. Additionally, the profile of these structures has long been associated with the Sellafield Site, and as the major employer for the area, the demolition of the cooling towers by March 2006 will be a visible demonstration of the site’s progress towards cleanup.

FACILITY DESCRIPTION

Each cooling tower is approximately 91.1 m in height from the pond base and has a hyperbolic reinforced concrete shell that was constructed in 914 mm high lifts. The minimum thickness of shell from the top down to approximately 28.9 m above the pond base is 114 mm below this level; the thickness increases linearly to the bottom of the shell where it is 406 mm.

Each tower has 64 raking legs that support the shell; they are 7.3 m high and 406 mm in diameter. The internal diameter at the top of each tower is 32 m, and 58 m at the base. The estimated mass of each tower shell including legs is 5,200 metric tons.

Each tower has a pond structure below the shell. The base and the walls to the pond are reinforced concrete construction and designed as water retaining structures. The pond is octagonal in shape and is 68.2 m between the external faces of opposite flat sides. The walls extend 2.6 m above the base and externally extend above the adjacent ground level. Fig. 1. shows towers 1 and 2 with tower 4 in the background.

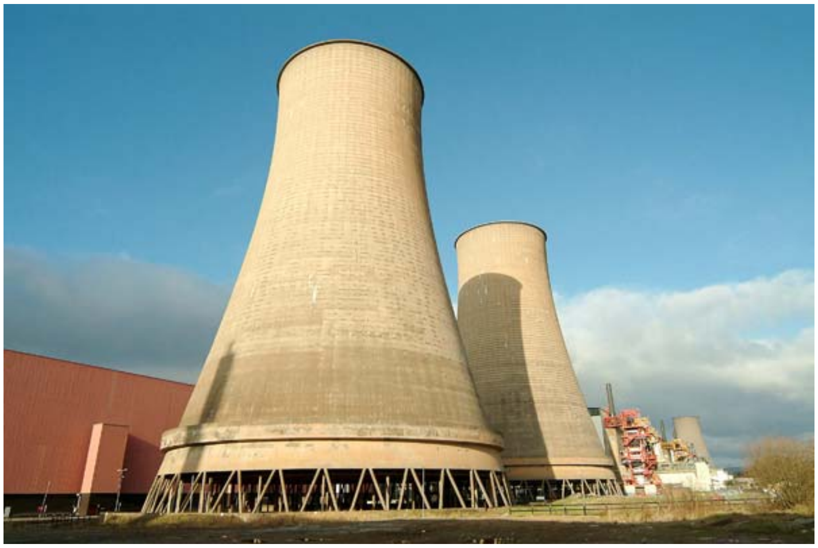

Fig. 1. Calder Hall cooling towers 1 and 2

The Calder Hall cooling water system was a closed system, i.e. cooling water was circulated from the cooling towers to the adjacent turbine hall condensers and back again. At the cooling towers, pumped water would rise to a distribution culvert between the two towers that gave an equal flow distribution between the towers. Water flowed into the external culvert of each tower that fed radially arranged asbestos cement pipes to the spray nozzles within the tower. Originally, water droplets would fall onto a stack of wooden slats some 4.5 m in depth (the wood slats were replaced by the plastic pack). The pond had a water depth of about 2.5 m from the pond basins, water flowed through ducts to the pumping station, from where it was pumped to the associated turbine hall via 1.4 m diameter underground bitumen lined steel pipes.

The progressive deterioration of the Calder Hall cooling towers has been documented during various inspections throughout their history. From these inspection reports, it can be seen that the towers are in a reasonable condition for structures of their age and type and are not amongst the more seriously damaged cooling tower shells in the UK. Inspection and repairs were carried out throughout the 1980s, most notably on the legs and areas of spalled concrete. The towers are approaching 50 years old. For towers of this age, there is some concern that the effects of aging of the towers could become an issue increasing the potential for an inadvertent collapse. This concern was warranted because several towers of similar construction have inadvertently collapsed, which resulted in a modification to the construction standards.

SLATED FOR DEMOLITION

Once the towers were identified for demolition, a project team was formed to evaluate potential demolition methods. These methods were evaluated against the following high-level safety principle:

- The demolition of the Calder Hall cooling towers must not present an unacceptable nuclear, conventional or environmental safety hazard that could adversely affect the operation of safety significant systems, structures and components or essential services on the Sellafield Site or result in significant workforce, public or environmental consequences [1].

The evaluation included piecemeal demolition-full scaffold, piecemeal demolition-climbing scaffold, piecemeal demolition combined with mechanical demolition, and explosive demolition and involved industry experts from around the UK. The research demonstrated that the best practical method for cooling tower demolition was explosive demolition, and over the past 30 years, more than 200 similar structures have been successfully demolished using the proposed technique. The project team documented their findings and evaluations in a Preliminary Safety Report (PSR) that was presented to the Nuclear Safety Committee (NSC).

It was the project team's belief that based on this detailed research that the project could progress into implementation because the demolition method was standard and best practice. However, the review by the NSC resulted in a number of potential hazards/implications that required additional evaluation due to the tower locations on an active nuclear site including:

- Debris spread
- Ejected high velocity small fragments
- Ground vibrations
- Air overpressure
- Dust release
- Use of explosives

The primary comment from the nuclear safety committee was that the PSR assumed that everything went right, and future project documentation should be based on what could go wrong. Subsequently, a larger project team was established, and the work was broken down into preparation of safety documentation, management of stakeholders, site preparation, removal of the cooling tower internal materials, and shell demolition.

SAFETY DOCUMENTATION

The project safety documentation consists of the PSR, six technical notes, surrounding plant assessments, and the Pre-Commencement Safety Report (PCSR). All of this documentation is in addition to the documentation required by the British Standards for demolition and explosive demolition, which involve the contractor's method statement and associated risk assessments.

Technical Notes

After the approval of the PSR, work was initiated on a series of technical notes intended to underpin the overall project risks. These technical notes address ground vibration, debris spread, projectiles, noise, overpressure, dust, the use of explosives, and an assessment of the radiological status of the towers. The technical notes were based on the standard demolition practice for these types of structures referred to as 2/3-leg and shell method.

Once the technical notes were completed, the results of the hazards and impacts were used to assess the potential impacts to the surrounding plants. A zone of 200 m was used as a benchmark for the plants that could be potentially affected by the demolition activity. Due to the accelerated nature of the project, most of the technical assessments were prepared in parallel based on a proposed method statement prepared by an independent explosive engineer that was used throughout the project.

The primary difficulty associated with the development of the technical notes is that there was little material to reference. Although this method was well established, the information on the method, risks, and impacts were passed from one explosive engineer to another and had not been gathered into documented evidence. The technical notes that have resulted from this research contain a complete historical evaluation of cooling towers and historic demolition methods, hazards and controls.

The technical notes evaluated the potential results if the demolition went according to plan and if it did not. All of the fault conditions that were evaluated were not credible, but were still evaluated and documented to address the comment from the NSC. The following outlines the general results from the technical notes:

Debris

Debris spread is generally 10-20 m from the cooling tower after demolition, but can extend up to 30 m from the pond wall in the event of an incomplete/inadvertent collapse [2].

Vibration[1]

The normal condition indicated that the vibration above 50 mm would be restricted to the predicted debris zone. Incomplete break-up and inadvertent collapse increased the vibration impact up to 33 to 55 m from the pond wall, respectively. A biased sit-down, which was not

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1 The vibration assessment is complicated by the different acceptable standards for vibration, based on building construction types. Only the standard for commercial buildings, 50 millimeters per second peak particle velocity (mm/s ppv), is reported, but the technical note also contained comparison and consequences for exceeding the standard for residential buildings and sensitive equipment of 15 mm/s ppv.

considered a credible condition with this method, resulted in vibrations exceeding the standard up to 80 meters from the pond wall [3].

Projectiles

Projectiles can travel approximately 30 m from the towers during demolition and that increases to over 50 m if blast protection is not used [4].

Noise

The peak noise threshold would not be exceeded outside the exclusion zone and posed no hazard to persons in buildings within the exclusion zone [4].

Overpressure

Buildings within 30 m of the cooling tower pond walls are susceptible to window breakage. If the charges are placed incorrectly, window breakage can occur up to 140 m from the cooling tower pond wall [4].

Dust

Dust is highly dependent on the weather and was evaluated for the most probable and worst case conditions. The occupational health limit was not exceeded in any of the scenarios, and the public exposure limit off-site was only exceeded in one scenario with a low probability, which is permissible 35 times per year [5].

Use of Explosives

This assessment concluded that the provision of adequate safety measures will ensure that the probability of inadvertent detonation of explosives during on-site transport is negligible, and once transported to the cooling towers; the subsequent inadvertent detonation of explosives is highly unlikely [6].

Surrounding Plant Assessments

All of the facilities within the 200 m zone of the towers were identified in addition to the utilities and railroads that run through the project area. The technical note results indicate that most of the potential impacts are restricted to the Calder Hall Site. However, dust and vibration do have some potential impacts outside the project area.

The Sellafield Ventilation Technical Support Group was engaged to assess the potential impact of the dust on surrounding plants. Since the dust dispersion is highly dependent on the weather, the project wanted to implement conservative controls to eliminate the need to set a window of allowable weather for the demolition. The assessment indicated that if the plants reacted by placing their facilities in the same configuration they adopt for emergency exercises that the risk would be minimized. This is an established procedure and process at Sellafield that would result in minimal impact to the project and the surrounding plants.

The vibration results indicated that there were underground utilities that could be impacted by the vibration. Measures were taken to assess the status and location of these lines in order to assess whether they would require engineering controls or re-routing.

Pre-Commencement Safety Report and Approval Process
The PCSR is a compilation of all of the assessments completed for the project. It builds on the PSR and incorporates the underpinning documentation from the technical notes and the surrounding plant assessments.

The approval process for the safety documentation required that the technical notes were prepared with specialist contractors in vibration, dust modeling, explosive transportation, and explosive placement. Once the technical notes were complete, the notes were verified through the project independent explosive engineer or subject matter expert and engineering department. In addition, an Independent Nuclear Safety Advisor review was completed on all of the technical notes and PCSR. The documentation was also assessed through a Calder Hall Management Safety Committee that includes members from the surrounding plants.

A summary paper of the findings was prepared and submitted to the NSC. Once the project documentation completed this gauntlet, it was submitted to the Nuclear Installations Inspectorate (NII) for noting and approval. Prior to the NII responding, they ensured that the Environmental Agency (EA) was satisfied with the environmental documentation for the project, which include Best Practical Environmental Option (BPEO) and Best Practical Means (BPM) documents.

The implementation of this documentation and actual work execution documentation consist of a Plant Modification Proposal, Contractor's Method Statement, risk assessments and Work Safety Plan, which were approved through a document review committee and Calder Hall Management Safety Committee.

MANAGEMENT OF STAKEHOLDERS

As the cooling tower project developed, it was identified that a large number of people and plants could be affected, and the project would generate interest on site and in the community. To address this part of the project, a separate work stream was identified for stakeholder engagement. A stakeholder engagement plan was developed by outlining any individual, plant, or group that might be affected or interested in the project. The comprehensive list of stakeholders can be categorized into seven main groups, as follows:

1. Potentially affected plants
2. Regulators
3. Sellafield site stakeholders
4. Security
5. Calder Hall workforce
6. External stakeholders
7. Management Services, Sellafield employees

After this extensive list was developed, the stakeholders were ranked into four categories based on the degree of their ability to influence the project. For example, the NII was a stakeholder that required extensive interaction, information and involvement because their approval was required before the project could proceed. While the Friends of the Lake District would be notified out of courtesy, but no approval or extensive involvement was required.

In total, 114 stakeholders were identified with 30 key to project success, 53 to be kept informed, 15 to be kept satisfied, and 16 required minimal effort and notification. A communications plan was developed to support stakeholder engagement and ensure that consistent messages about the project were delivered to all stakeholders.

A key in the stakeholder involvement strategy was the surrounding plants. It was known that some of the plants would be impacted by the project and required physical engineering controls based on the technical evaluations, and some plants would be asked to evacuate their buildings during the demolition to maintain the exclusion zone. These stakeholders were engaged for over 18 months during the project development and many opportunities were given for them to express their questions and concerns. This process helped make them part of the project team and invested in its overall success.

Security

Security organizations were key stakeholders and an integral part of project success. The security for the project involved several organizations and was regulated by the Office of Civil Nuclear Security (OCNS), which required approval of the project security plan 28 days before the demolition. Sellafield has its own security force the Civil Nuclear Constabulary (CNC). British Nuclear Group also has a security group that integrates with the CNC. Since the project exclusion zone extended off site, the Cumbrian Constabulary had to be involved. The towers were clearly visible from a major thoroughfare; this required involvement from the Highways Department.

The project security requirements involved controls for bringing explosives onto a nuclear site, safe explosive transportation and maintenance of the exclusion zone. Security off-site involved fencing off the area of the exclusion zone, setting up signs, and establishing rolling roads blocks that would keep the traffic moving, but minimize the potential for accidents.

Extensive discussions were held about crowd control on the day of the demolition. The external security groups wanted an area established, but no one wanted to take the responsibility (liability) for establishing a viewing area. In the end, it was agreed that spectators would be discouraged by eliminating areas for them to park, and methods would be set up to allow people to view the demolition from home by setting up a live webcast.

SITE PREPARATION

Site preparation involved the identification of surrounding utilities and removal of redundant plant. Given the age of the plant, the identification of utilities was complex. Numerous organizations were contacted, and a comprehensive map was prepared. Based on that map, two potential issues were identified, a process waste line next to one set of towers, and an interceptor sewer line that seemed to virtually run under another set of towers.

Extensive work was undertaken to locate individuals that were familiar with the installation of the lines to verify the construction and location. At the same time, the explosive demolition contractor was notified of these lines and asked to recommend protective measures both in the actual demolition method (i.e. reduction of vibration) and physical protection measures (i.e. steel plates and ballasting).

There were numerous redundant plants around the structures including the pump pits for the towers and a water treatment plant. These structures were prepared for demolition and removal, but given the accelerated schedule for the cooling tower demolition, not all of the structures could be demolished. These facilities were placed in a configuration that eliminated the need to protect the structure during the cooling tower demolition. For example, utilities were disconnected making the area cold and dark, and asbestos was removed.

While preparing the scope of work for the contractor, research was conducted on the surrounding area, and it was identified that there were piles of soil around the towers that contained residual contamination. The work to remove this soil had not been included in the cooling tower project or the contaminated land strategy. A change order was prepared and samples collected to expedite the removal of the soil. The results for the samples were delayed, and the soil had to be doubled handled to move it out of the way for the internals removal contractor. This double handling also eliminated any possibility that the soil could be free released.

REMOVAL OF INTERNALS

Within each tower, sit square/rectangular reinforced concrete columns and beams supporting timber beams, which support the plastic pack. The tower internals consist of an internal structure set around a central void including:

- Five sets of reinforced concrete ring beams supported on columns
- Reinforced concrete radial beams supported on the ring beams
- Timber beams supported by the radial beams
- Timber columns supported on the radial beams
- Timber joists supported by the timber beams
- Plastic packers supported on the timber joists
- Asbestos cement pipe-work on hangers and crosspieces supported from the timber columns and are situated above the plastic packers
- Plastic packers that act as a drift eliminator, and overlie the asbestos cement pipe-work

The towers were re-packed in 1978 and 1994. The total volume of material anticipated in the removal project is approximately 75 metric tons (1 mile) of asbestos piping, 6,000 m^3 plastic packing, and 260 metric tons of tanalised timbers from each tower. Fig. 2. shows a portion of the volume of asbestos piping from Tower 1 as it has been removed.

Fig. 2. Asbestos pipe from tower 1 to be containerized

The contracting strategy for the tower demolition was based on the accelerated nature of the project and required that the internals work be separated from the demolition, and two tender exercises were conducted. An extensive pre-qualification process was undertaken in conjunction with the initial project planning. The contractors were pre-selected for the work based on their experience with cooling tower demolition and internals removal. Each tender exercise involved five contractors: four contractors experienced in both cooling tower demolition and internals removal and one specialist contractor that only performed one of the activities.

The contractor selected to perform the internals removal was Robinson and Birdsell. Their extensive experience in cooling tower projects and their approach to the job, both in method and in safety, demonstrated best value, although they were not the lowest bidder. Their method for removing the internals maximized the waste segregation while minimizing the workers risk at height. The asbestos would be removed in sections manually, but the remainder of the material would be removed mechanically.

Delays in project implementation were incurred due to multiple verification of the structural calculations associated with the removal of one leg from each of the tower to allow access. The calculations were completed by the contractor, verified by multiple engineers, and put through several boards where the assumptions and process was repeatedly challenged. The basis for this rigorous challenge was the proximity of the towers to active operations. Although all involved accepted that this was standard practice, and the collapse mechanism associated with the towers was such that it could not affect surrounding areas and would fall within its footprint. Fig. 3. demonstrates the process for removing one of the legs from the tower. The actual removal took less than 30 minutes, while the approval to conduct the removal took several weeks.

Fig. 3. Removal of leg

Waste management for this part of the project was linked into the overall characterization of the structures. The plastic packing, wood, and asbestos pipe were sampled before initiating the work. The plastic packing and wood were free released; however, adequate samples of the asbestos piping could not be collected and required samples to be taken as it was removed and stored and until the samples were returned. The plastic packing was sent for recycling, which eliminated the need to dispose of 24,000 m^3 of plastic.

SHELL DEMOLITION

The proposed demolition technique requires that approximately 60% of the circumference of the shell and legs be removed by explosive charges. This will cause the tower to tilt and collapse approximately five degrees from vertical. The tilting mechanism will cause the rear legs to eventually fail through bending and overload. The thickened section of shell (commonly referred to as "the ringbeam") will collapse and remain almost intact to a height of approximately 10 m, dependent on the thickness and configuration of the steel reinforcement within the ring beam. The remainder of shell will deform, rotate, and collapse into the cooling pond directly beneath the tower. It is likely that a small area of the shell will land outside the pond area up to a distance of 10 m. The distance this debris travels can be controlled to a limited degree by the use of delay detonators.

Northern Explosives Limited developed the proposed method in 1972. This method has been used since the early 1970s with an almost 100 % success record. The few cases where incomplete demolition has occurred have been associated with thicker shells (up to 60cm) and poor explosive practices. With the arrival of explosives that are more sophisticated and initiation systems, the methods of charging structures for demolition has changed significantly. The availability of non-electric detonation systems has meant that high levels of air overpressure and the risk of cut-offs has virtually been eliminated. The use of structural engineers in the planning and execution phases of the works has also ensured that a more predictable outcome is achieved [2].

The two main failure mechanisms for hyperbolic cooling towers from planned collapse are known to be buckling failure and rotational bias. Biasing is proposed for the Calder cooling towers to assist in protecting adjacent structures from debris spread, mitigating ground vibrations by delayed charges, reducing air overpressure and other hazards. Rotation (bias) of the tower using a heel and toe effect by exploding carefully placed charges around 2/3rd of the shell and/or supporting columns to induce plastic hinges in the columns and shell.

The contractor for the shell demolition is Controlled Demolition Inc. (CDI). The selection of an American firm for the demolition did cause internal concern within the project team. However, CDI was the only contractor that tailored their method statement to the unique aspects of a nuclear facility. They proposed the standard cooling tower demolition method with some minor variation that they proposed would reduce vibration and overpressure for the project, which was a major concern. Their proposal also accounted for the additional paperwork and oversight required at a nuclear facility. Fig. 4. represents the controlled collapse.

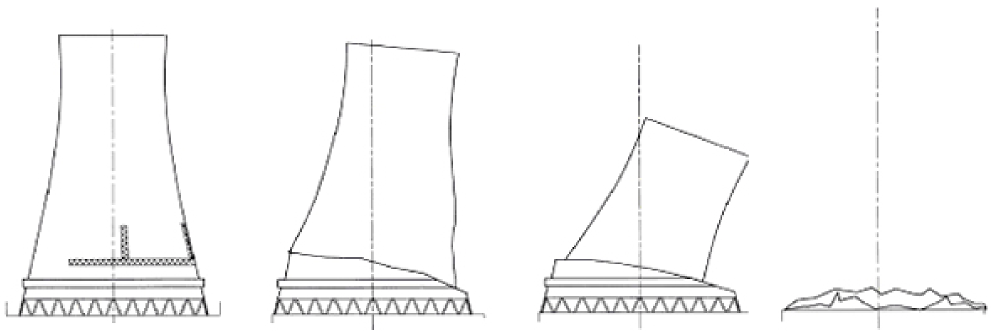

Fig. 4. Cooling tower demolition collapse mechanism

PROJECT COST

It is generally accepted that work on a nuclear site is more costly than work on a non-nuclear site. There are valid reasons for this cost increase as the consequence of an ill-conceived project can be catastrophic. Arguably, the cost increase is not commensurate with the increased risk and consequence, and there are instances when the additional checks and balances do not provide value. Table I provides a cost comparison between the Calder cooling towers and a similar non-nuclear project; the difference is clearly the price we pay to demonstrate that situations are incredible.

Table I. Project Cost Comparison[2]

	Calder Cooling Towers	Non-Nuclear Comparison[3]
Project Management	£562K – $1017K	£270K – $489K
Preliminary Safety Report / Feasibility Study	£107K – $194K	£50K – $91K
Technical Notes Preparation	£128K – $232K	Included in Feasibility Study
Characterization	£516K – $934K	£30K – $54K
Preliminary Commencement Safety Report	£200K – $362	Included in project management
Stakeholder Involvement	£60K – $109K	£30K – $54K
Site Preparation	£20K – $36K	£20K – $36K
Internals Removal *including waste disposal*	£1454K – $2632K	£1020K – $1846K
Shell Demolition *including waste disposal*	£850K – $1538K	£700K – $1267K
TOTAL	£3897K – $7054K	£2120K – $3837K

LESSONS LEARNED

Although this project has not been completed, there are still several lesson learned associated with the work to date. Specifically, the key lessons learned to date include the project planning and sequence, characterization, and subcontract strategy.

Project Planning and Sequence

The project development and financial process at Sellafield requires that a project be well defined before the release of funding. This system originally established to ensure that a project received appropriate evaluation prior to kick-off, works well for construction and operations type projects, but is out of place in decommissioning and demolition projects. In order to obtain project money, the method for demolition and the evaluation of risks associated with that method had to be defined. All of this work was completed before contracting a demolition contractor.

As a result, the demolition method was established, discussed, and accepted before preparing the scope of work for the project. Work on the safety documentation was 80-90 % complete before a contract was in place. The contractor selected for the demolition was extremely experienced and did recommend minor variations in the overall method, which was difficult for the project team members to accept. The result was numerous meetings and re-work with individuals that had been studying explosive demolition for 18 months, challenging explosives engineers with over 30 years of explosive demolition experience. The research and project documentation development required to obtain funds convinced some of the project team members that they knew everything there was to know about the process, and they could not accept deviations.

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[2] The currency conversion was based on the average in 2005 using 11 days in December of £1 GBP to $1.81 USD.

[3] The non-nuclear costs were provided by RVA Engineering Solutions Limited; a firm that provides specialist demolition support in the UK on nuclear and non-nuclear sites. RVA personnel include an individual that has demolished over 60 cooling towers in the UK. Subcontractor costs were modified based on discussions with the contractors performing the work on the Calder Cooling Towers, and their indications of the required uplift to work at Sellafield from additional documentation and on-site supervision. A further cost comparison with six cooling towers demolished in Ireland indicate that the contractor nuclear uplift may be as high as 100%.

Characterization

The characterization of the cooling towers was originally undertaken to provide information for the radiological assessment technical note, which focused on aerial release. A few samples were collected from each tower, based on a draft sampling and analysis plan. It was believed at the time that the towers were going to be free of radiological contamination. It was during that sampling that it became evident that two of the towers had some contamination above background from an event in the 1960s when contaminated water had been circulated through the system. Since the towers had been re-packed and millions of gallons of water had circulated, it was still thought that the towers might not have significant levels of contamination.

The NII and EA were engaged, and the sampling protocol was expanded. Shortly after this round of samples was collected, a new standard (Nuclear Industry Code of Practice for the Clearance and Exemption Principles) was introduced for free releasing structures. The existing sampling was compared with the new standard and additional samples were collected.

The numerous iterations of the sampling protocol were inevitable because the project strategy changed and so did the standards. However, the expansion of the characterization program moved onto the critical path. The subcontractor performing the analysis failed to perform, which amplified the issue. As the internals contractor initiated work, the concrete samples had not been analyzed, and the regulatory negotiation and safety documentation was delayed.

Subcontracting Strategy

There are numerous lessons learned with respect to the subcontracting strategy. The approach to separate the internals removal from the demolition did allow the project duration to be shortened, but increased project management requirements. The two contractors had to be integrated to ensure that neither contractor performed actions on the towers that affected the others work. In addition, field oversight had to be increased to work both contractors within a small project area.

The tender evaluation process was difficult because the submissions were completely inadequate for both the internals work and demolition. Although specific instructions were given in the scope of work on the requirements for the proposals, all of the tenderers returned submissions with significant deficiencies. After the internals tender process, the contractors were counseled during the pre-bid meeting to ensure that they included all of the necessary information; however, several of the contractors did not include very straightforward information like safety statistics, designated supervisors and project experience. This could potentially be due to the fact that the tenderers had been in contact with the project team for over 18 months and may have believed that information they had provided previously would be used in the bid evaluation process and did not need to be submitted.

CONCLUSION

A demolition project of this magnitude should never be taken lightly, regardless of its location. It could be argued that this project might not be the place to start in skyline reduction given the experience of the Sellafield Cleanup Organization and the NDA. It is certain that if this project were initiated today that it could be completed more efficiently. However, the demolition of cooling towers from the world's first commercial reactors is more than just a demolition project, and it is more than skyline reduction.

In 1954, Roger Bannister demonstrated that the mile could be run in less than 4 minutes. Many had tried before and failed, but Roger approached the task with determination, and planned the record breaking event using pacemakers, which was a paradigm shift for the sport. Running the first mile in less than four minutes was a psychological barrier that had finally been broken and athletes suddenly knew that it was within the capability of humans to run that fast. Consequently, Roger Bannister's record lasted only 46 days. Once it was demonstrated possible, the sub-4-minute mile became achievable.

The cooling tower demolition project is the Sellafield Cleanup Organization's sub-4-minute mile. Once successfully completed, the critics that said it could not be done will be silenced. It will encourage those that have spent hours fighting the bureaucracy and give them the resilience to succeed. The absence of those towers will be an undeniable demonstration of British Nuclear Group's capabilities and progress.

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