UK Full-Scale Non-Active Vitrification Development and Implementation of Research Findings onto the Waste Vitrification Plant

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ABSTRACT

This paper describes the historic and current status of inactive research in support of UK Highly Active (HA) waste vitrification. Experimental work performed to date on the UK's inactive vitrification research facility is summarised along with estimates of the potential impact of this research work on the reduction of HA Liquor (HAL) stocks stored in the UK at Sellafield. The current position regarding implementation of research learning onto the UK’s operational vitrification plants is described.

INTRODUCTION

There are three operating active vitrification lines in the UK's Waste Vitrification Plant (WVP) at Sellafield (WVP Lines 1, 2 and 3). The two original vitrification lines (Lines 1 & 2) have under-performed their original design intent since operations began in 1989-91 resulting in the requirement for the construction of a third, which entered active operations in 2002. The UK Government through the Nuclear Installations Inspectorate (NII) has set targets to reduce HAL volumes to buffer stock levels by 2015 and whilst significant progress has been achieved to date, it is recognised that more needs to be done to ensure that these targets will be met.

The Vitrification Test Rig (VTR) began operations in October 2004 and has been built to provide a development tool to optimise and improve the operation of the UK's High-Level Radioactive Waste Vitrification facilities (WVP) at Sellafield. The facility is a full-scale inactive replica of the core vitrification processes on the active plants, with additional instrumentation and sampling capabilities, processing an inactive simulant representative of the HAL processed in WVP. The VTR represents significant research and development investment and demonstrates the commitment of the BNFL Group to reducing HAL stock levels.

A previous paper discussed accomplishments of the VTR up to December 2005 [1]. This paper describes the aims of the experimental program on the VTR, the progress against this program to December 2006, and the realised and expected impact on HAL stocks achieved by applying the results obtained from the VTR onto the UK's operating active vitrification facilities.

VITRIFICATION TECHNOLOGY

The immobilisation or incorporation of HAL into glass is known as vitrification. HA liquor stored in the UK is generated from spent Oxide and Magnox fuel reprocessing operations. The origin of the liquor is an important consideration for the vitrification process, as the characteristics of the material vitrified will affect the product glass parameters. There are constraints on parameters associated with the glass product including heat generation, activity, fission product content and durability. A 75:25 blend of Oxide and Magnox liquors (by waste oxide content) typically represents the feedstock for vitrification. By utilising a blended feed strategy the waste oxide loading efficiency in the product can be maximised whilst meeting commercial and technical restrictions on the vitrified waste form.

Prior to vitrification the HA liquor is in the form of a suspension containing mainly metal nitrates in solution and comprising of fission products, activation products, process additives, some minor actinides and fuel cladding materials. The liquor contains around 10% by volume of insoluble solids including caesium phosphomolybdate and zirconium molybdate, and is typically fed into the vitrification process with a total solids concentration of 150-180 g/l.

The vitrification plants in the UK use a two-stage vitrification process to incorporate the HAL into glass. An overview of the key vitrification equipment is shown in Figure 1. The HAL, along with other calcination additives, is fed into a rotating kiln furnace known as a calciner to evaporate the liquor and de-nitrate the resulting solid thus producing an intermediate calcine product. The calcine product is a granular material consisting of mainly metal oxides with a residual nitrate content. The calcination process generates an off-gas stream and this requires abatement. The primary off gas system includes a dust scrubber to remove entrained calcine and to recycle this material back into the process. A condenser removes condensable gases such as water vapour, nitric acid vapour and absorbs some nitrous oxide from the process. The third main vessel for off gas abatement is the NOx absorber, present to remove NOx from the gaseous effluent by absorption of the soluble gas in water / nitric acid. Secondary off gas cleanup is achieved using electrostatic precipitators and HEPA filters.

The intermediate calcine product from the calciner is mixed with borosilicate glass in an elliptical melter crucible and heated to temperatures of around 1050°C using an induction heating system. Mixing of glass and calcine within the vessel is achieved via an air bubbler, convection currents and the release of gases from the decomposition of the residual nitrate content in the calcine. On completion of the feed period, provided the temperature of the glass melt is sufficient the glass is poured from the vessel into a product container. After the second pour the product container is then allowed to cool prior to being decontaminated and swabbed, then moved into storage in the Vitrified Product Store (VPS) at Sellafield. The product glass containers resulting from commercial reprocessing activities will be returned to the reprocessing customer for long term storage according to the high-level nuclear waste storage policy of the receiving

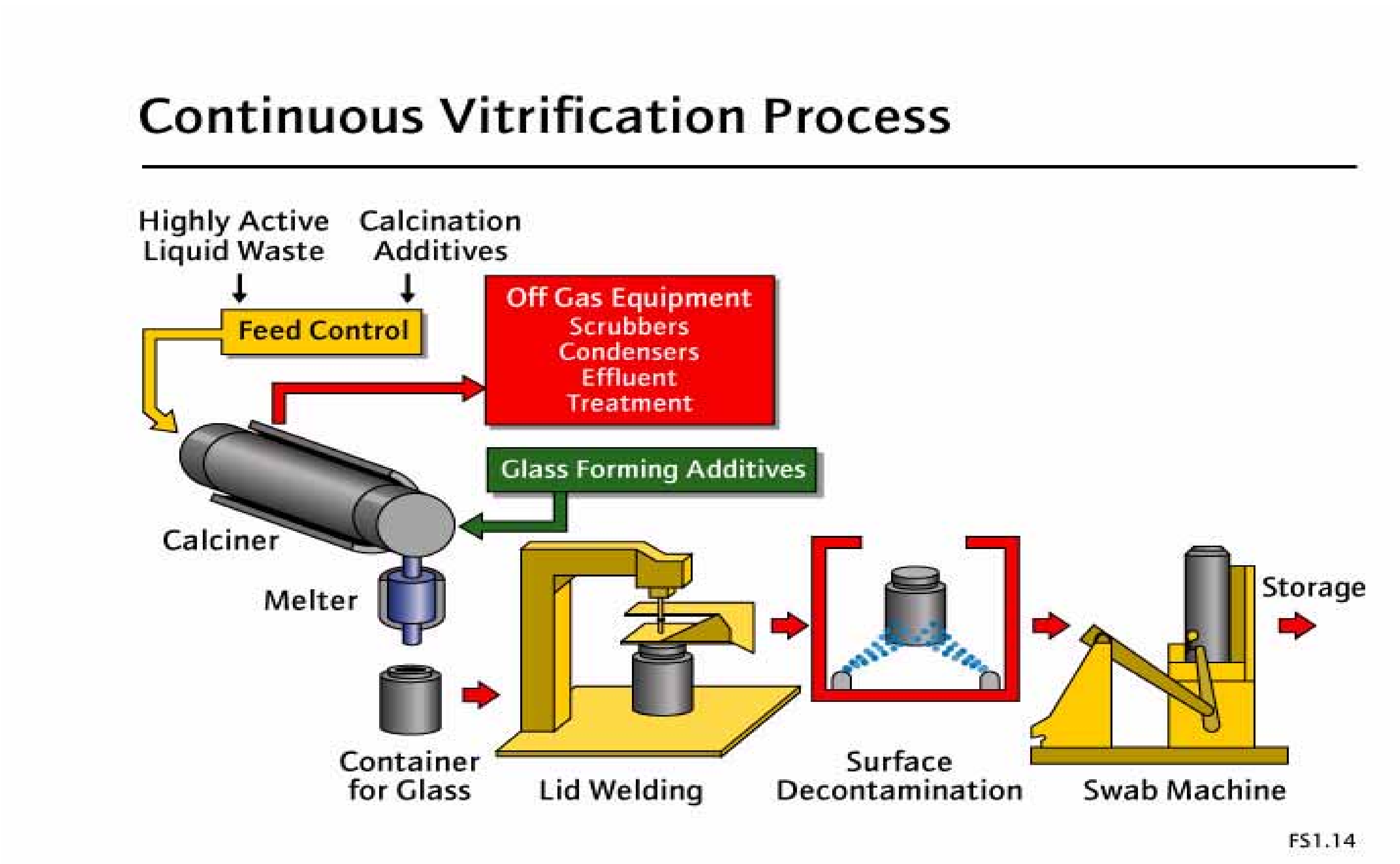

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Figure 1: Vitrification Process Overview

HIGH ACTIVE LIQUOR (HAL) MANAGEMENT IN THE UK

HAL Inventory Reduction

Reduction of the storage inventory of HAL generated during reprocessing operations at Sellafield is an important goal of the UK Government. In January 2001 the UK nuclear regulatory body, NII, issued BNFL with a Specification to formalise the programme to reduce levels of HAL stored at Sellafield. The stock reduction plan is aimed at minimising the amount of HAL and achieving the residual or "buffer" stock required to feed the vitrification process by the year 2015.

The BNFL Group

The BNFL Group comprises of a number of subsidiary companies including British Nuclear Group, and Nexia Solutions. Although still a part of BNFL, British Nuclear Group is a stand-alone nuclear site Management Company and provider of nuclear clean up and decommissioning services and Nexia Solutions provides technology services and solutions across the nuclear fuel cycle.

On 1 April 2005, the Nuclear Decommissioning Authority (NDA) took strategic responsibility for the decommissioning and clean-up of all 20 of the UK's civil nuclear sites. Established by the Government under the Energy Act 2004, the NDA is a non-departmental public body, set up to take strategic responsibility for the UK's nuclear legacy. The NDA does not perform site remediation itself but oversees the task performed via contractors. On nuclear sites previously under British Nuclear Fuels plc (BNFL) ownership, including Sellafield, the work was initially contracted to the various businesses under the BNFL Group.

British Nuclear Group is currently contracted by the Nuclear Decommissioning Authority to operate the UK's waste vitrification plants at Sellafield.

VITRIFICATION DEVELOPMENT IN THE UK

The Waste Vitrification Plants at Sellafield are based on the French AVH (Atelier de Vitrification de La Hague) Vitrification Process. The original BNFL development programme on vitrification was aimed at supporting the HARVEST (Highly Active Residue Vitrification Experimental Studies) single stage batch process, but in 1979 BNFL decided to purchase the two stage AVM (Atelier de Vitrification de Marcoule) process. The AVM process had a higher design throughput than HARVEST, which was desirable given the need to reduce HAL stocks and the process used a calciner and a cylindrical melter. A Full Scale Inactive Facility (FSIF) replica of the AVM plant was installed at Sellafield, with the installation process starting in 1981 and completed in 1983. During that time, however, in 1982, a decision was taken that the UK's vitrification plants would be based on the second-generation French AVH vitrification process design due to the higher throughputs achievable. The AVH is a larger plant than AVM with a larger calciner and an elliptical melter system. The operational differences due to scale and melter design between the AVM development rig (the FSIF) and the operational AVH plants were determined during WVP commissioning. Due, however, to programme and production pressures during the commissioning of WVP Lines 1 & 2, only a limited envelope of conditions was studied at full scale.

The vast majority of the development work, both laboratory and FSIF, was done on Magnox wastes. There were 30 FSIF Magnox campaigns including 15 full vitrification campaigns of around 20 - 30 pours each. By contrast there were only 2 full vitrification campaigns with Oxide wastes, and 2 campaigns of various blends of Oxide and Magnox waste. WVP Lines 1&2 were commissioned exclusively on Magnox simulants, whereas the majority of the waste processed through WVP during its lifetime will be blended waste.

Three trials were done at Marcoule with Magnox simulants. The third trial was done using an AVH type melter. In effect the third trial at Marcoule provided a bridge from the in-house development work on an AVM type plant to WVP operations with the AVH type plant.

In addition to the differences between AVM and AVH described above, the AVH process was installed in WVP with a different dust re-cycle system to that used on the FSIF, which is one reason why dust scrubber recycle problems encountered during WVP operations were not detected during the development work. The other reason is the fact that the FSIF campaigns were generally short and the dust scrubber was cleaned between campaigns which is why the long term effects such as blockages were not detected.

The Requirement for a New Vitrification Research Facility

During the early years of active WVP operations it became clear that the design and operational differences between the AVM-FSIF and WVP had led to certain long term operability issues being not fully investigated during the development programme. The FSIF development work could be characterised as mostly a case study approach, which was adopted because the objective was to prove flowsheets with BNFL wastes and to confirm the glass product quality over a range of variations around those flowsheets. Operations and product quality were only underpinned for a limited envelope of blended feeds. Changes outside of this envelope, for example increases in throughput and incorporation rate, require new technical work to support the product quality case.

Considering the ongoing requirement to further optimise the active vitrification lines, the significant benefits of a new research facility were recognised. In 2001 a decision was taken to construct and operate a full-scale vitrification research facility, the Vitrification Test Rig as part of BNFL's Vitrification Improvement Plan.

THE VITRIFICATION TEST RIG (VTR)

The Vitrification Test Rig (VTR) has been built to provide a development tool to optimise and improve the operation of WVP. The facility is a full-scale inactive replica of the core vitrification processes on the active plants, with additional instrumentation and sampling capabilities, processing an inactive simulant representative of the HAL processed in WVP. The facility contains identical feed systems, calciner, melter and primary off gas systems to those on the active facilities, and was designed to be as representative as possible with similar detail down to length and angles of pipework.

The VTR represents significant research and development investment and demonstrates the commitment of the BNFL Group to reducing HAL stock levels. Following a year of commissioning the VTR was handed over to Nexia Solutions (BNFL Group's research and development subsidiary) in October 2004.

Operating the VTR

In total around 30 people form the core VTR project delivery team, composed of an Experimental Team charged with planning, overseeing and reporting the experimental work, and the Operations Team responsible for the safe and accurate operation of the test rig. Nexia Solutions expert groups in the fields of Materials, Glass Technology, Waste Chemistry, Modelling and Operational Research support this core membership.

The facility is controlled via a Distributed Control System (DCS). The DCS allows the operations team to perform the majority of control procedures via computer screens, and plant monitoring is also possible using this system. In accordance with the requirements of an experimental facility the VTR is equipped with a wealth of additional instrumentation compared to the active vitrification plants. To assist the analysis of the significant amount of data generated by the equipment state of the art process monitoring software is installed allowing online and archived monitoring and trending of any captured process parameter(s). The system used is identical to that installed on WVP and allows easy comparison of inactive and active plant performance.

The VTR operates on a continuous 24-hour shift cycle for around 60% of the year, with the operations team returning to day support for the remainder of the time and this represents the most cost-effective way of operating the facility. Experimental work is based around 8 to 12-week operational blocks known as Campaigns, each with an overall aim but split into smaller sub-experiments as necessary.

It is important to perform extensive sampling on an experimental facility of this nature and numerous gas, liquid and solids sampling points are available covering all of the key process streams and unit operations. Sampling is regularly carried out on the feed systems, off gas effluent, calcine and the glass product and these are summarised in Table I below. Nexia Solutions analytical teams perform analysis of the VTR samples, although outside contractors are utilised for some routine analytical work.

Table I. Summary of Sampling Performed on the Vitrification Test Rig.

Sample Type	Routine Analysis
HA Simulant	Acidity Density Elemental Composition Solids Content
Off-Gas Liquor	Acidity Elemental Composition Solids Content
Calcine	Bulk Density Elemental Composition Particle Size Distribution Residual Nitrate Content
Glass Product	Bulk Density Durability Elemental Composition Optical Analysis

Why Full Scale?

Due to significant radiological and cost constraints, sampling of the highly active product glass is not performed as a matter of course. It is however, essential to ensure confidence that the glass product meets requirements on physical properties, chemical resistance, radiation, stability, appearance and consistently represents a waste type that is suitable for storage, transport and ultimate disposal.

Without regularly analysing the active glass produced from WVP the approach to product quality is based around defining the limits of product acceptability initially through laboratory testing then defining the process envelope by operating at full scale with inactive simulants. The inactive glass product is comprehensively analysed to confirm that an acceptable waste form is generated throughout the innovative operations tested on the VTR. The analysis performed includes assessment of durability, bulk density, elemental composition, homogeneity and transition temperatures. New methods of digital glass analysis have been developed by Nexia Solutions to reduce time required to perform measurements such as percentage crystalline phase content in glass, and these developments also help move towards more quantitative methods of glass assessment than those used in the past.

THE VTR EXPERIMENTAL PROGRAM

British Nuclear Group currently funds Nexia Solutions to perform research on the VTR, with contracts between the two companies overseen by the NDA. This arrangement represents an industrial team dedicated to realising the UK Government's goal of HAL stock reduction, and ensures that the VTR experimental program is very focused towards satisfying the NDA's requirements of British Nuclear Group i.e. optimised management and operation of the UK's vitrification facilities. Detailed cost-benefit analyses are always performed prior to progressing an experimental campaign; this ensures that maximum benefit is derived from the planned experimental work. The short-term focus is on immediate improvement in throughput and incorporation utilising existing equipment. In the longer term there are other potential benefits, for example next generation equipment development.

Nexia Solutions, supported by British Nuclear Group, developed an experimental programme covering the first 2 years of operation on the VTR. This initial program was developed to target significant benefits in many areas of vitrification process technology including plant throughput, waste oxide incorporation, plant availability, glass formulation, expanded operational envelopes and product quality underpinning. The programme aims to help improve the vitrification plants by addressing the following three main areas.

- **Throughput** - Increase the glass production rate usually through optimisation of plant operating methodology. Throughput improvements of around 35% are being attempted by experimental campaigns addressing this issue.
- **Incorporation** - Increase the amount of waste that can be vitrified per product container. Incorporation improvement campaigns are targeting a 12% increase in the amount of waste vitrified per product container in the short term, rising to 40% further on in the program.
- **Availability** - Potential availability improvements are usually included as part of campaigns with one of the above wider aims, such as calciner heater failure recovery.

When a proposal for a specific period of work is completed by Nexia Solutions this information is presented to a Steering Group comprise of vitrification process experts and plant operations specialists from British Nuclear Group and Nexia Solutions for peer review and acceptance. The Nuclear Decommissioning Authority also reviews the proposal. At this stage clear, well-defined deliverables and success criteria are agreed, which helps to ensure scope creep is avoided.

The experiments are then planned in detail and operated on the VTR. Results are reported back to the Steering Group when available, who review, accept and endorse the final reports. The reported information is the then available for implementation onto the active facility, and this is realised by an implementation group charged with prioritising and addressing improvements from the VTR and other initiatives.

The involvement of Nexia vitrification scientists is not limited to operating the VTR facility; they offer support and a consultancy service to the active facilities and interact regularly with the Technical and Manufacturing Support teams on WVP. This close interaction ensures that the experimental proposals for work on the VTR take into account detailed understanding of the difficulties and requirements of the active plants, and keep the VTR process team informed of the issues faced by WVP.

SUCCESS ACHIEVED

As of November 2006, five operational Campaigns have been completed on the VTR facility and a great deal of research progress has been achieved. The VTR program is considered to have been a great success over the first two years of operation and has proved to be an extremely valuable research asset. Some examples of key achievements to date are included below.

Successful operation of the vitrification equipment at an overall increase in waste oxide throughput of 50% has been demonstrated on the VTR compared to WVP operation in 2005, and operating envelopes for the calciner, off-gas and melter have been established and recommended to WVP up to this new level of plant challenge. On the VTR experimental program this significant potential increase in HA liquor processing has been achieved through incremental steps, which will accommodate phased implementation of improvements onto the active facilities progressing to the full demonstrated throughput level.

Work performed on the VTR has confirmed that a good quality product (from the perspective of characteristics including leachability, homogeneity and crystalline content) is generated when producing vitrified glass containing 12% more waste oxides than standard WVP glass with 25 wt% waste oxide incorporation. This confirms that more waste can be stored per product container thus reducing the total vitrified waste container inventory generated during the lifetime of WVP.
Experiments have been undertaken to establish the upper throughput limit for the calciner in terms of the evaporative load. The calciner was found to be capable of generating acceptable calcine up to the maximum feed rate possible using the current plant feed system at typical liquor concentrations.

In addition to the delivery of specific throughput improvement targets, the development of Nexia Solution's and British Nuclear Group's technical expertise in the field of vitrification is a further successful outcome of the program, with a significant increase in the number of staff in both organisations with vitrification process and research experience.

INITIATIVES TESTED

As the throughput level operated on the vitrification equipment was increased, new challenges to the calciner, melter and off gas system were expected. To counteract difficulties related to the increased level of throughput challenge, many innovative operating regimes have been tested during VTR experimental campaigns. Some examples of areas investigated on the VTR are included below.

Optimisation of Calcination Additives

As a tool to counteract the effect of increased material carryover into the off gas system, the effects of calcination additives such as sugar have been assessed in detail. Optimum sugar addition levels were derived and recommended to WVP based on a trade-off between maximising the ruthenium retention within the calcine whilst preventing an excessive degree of dust carryover. The figure below demonstrates the variation in ruthenium carried over to the dust scrubber as a function of sugar addition to the calciner.

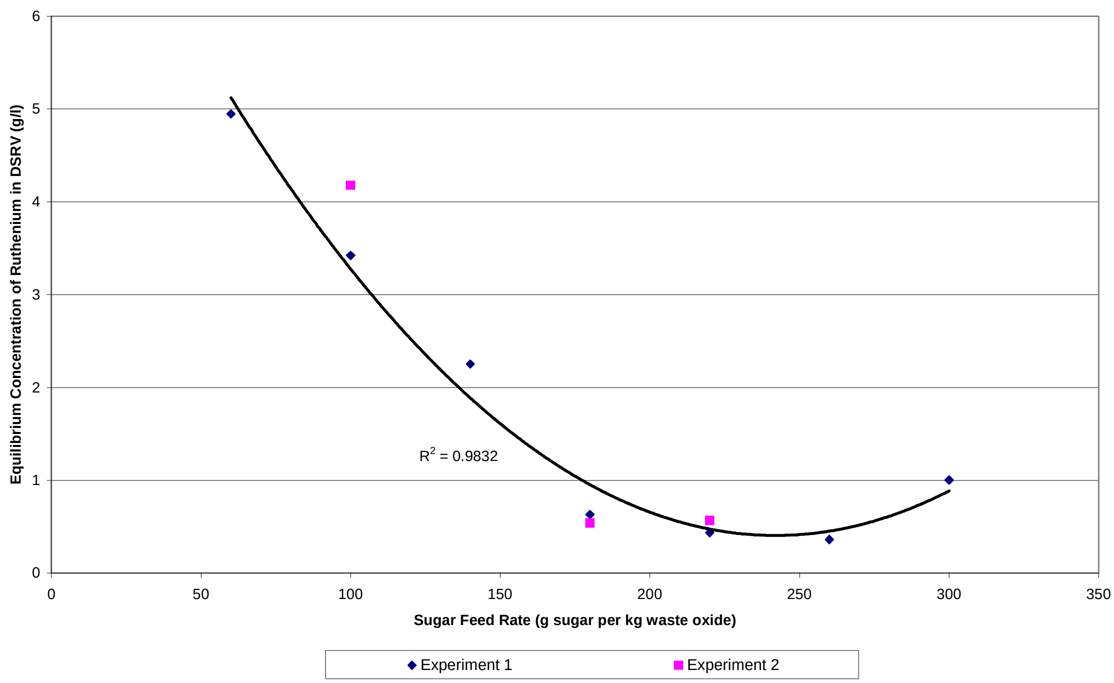

Figure 2: Ruthenium in the Dust Scrubber versus Sugar Concentration

Expansion of Process Feed Envelope.

The VTR has derived baseline settings for the processing of historic Magnox HAL containing high amounts of materials such as chromium. Work has also been performed on higher blend ratios and incorporation rates. This work has underpinned expanding the process envelope of feeds suitable for vitrification.

Asymmetric Glass Frit Addition

Glass is typically added into the melter over the same time period as the calcine charge from the calciner. Experiments were performed to test the effects of fully charging glass into the melter system prior to completing the charge of calcine. This type of operation can improve average melt temperatures at the completion of feeds by around 20°C.

Addition of Multiple Melt Spargers

In order to attempt to improve heat and mixing characteristics beyond the capabilities of the current single sparged melter system, additional sparge pipes were added inside the melter and tests performed. Multiple sparging provided benefits over the single sparged system from the perspective of melt temperatures achieved for a given melter wall control setpoint configuration. When operating certain multiple sparge configurations, melt temperatures over 20°C higher can be achieved compared to single sparging.

Control of Melter Heating Systems

Induction heating systems are used to provide heat for the melter system, and new methods of controlling and operating these heaters to improve efficiency and optimise product glass temperatures in the melter were tested. The potential benefits of melter operational initiatives tested on the VTR compared to operating a single melter sparge and standard glass frit addition are summarised in Table II.

Table II. Summary of Potential Improvements to Melt Temperatures

Melter Operating Regime	**Potential Improvement in Internal Temperatures**
Optimisation of Heating System Software Control	~10°C
Multiple Sparging	~20°C
Asymmetric Glass Frit Addition	~20°C
Multiple Sparging + Asymmetric Glass Frit Addition	~40°C

*Benefit achieved through ability to reduce wall setpoints

CATALYSTS TO SUCCESS

When considering the success of the facility to date a number of key areas are thought to contribute to the positive results obtained from the facility. British Nuclear Group as an intelligent customer can clearly describe their requirements of the VTR facility, and these requirements can then be translated into contract deliverables, which helps to focus the experimental work, reduce the possibility of scope creep and ensure Nexia Solutions delivery satisfies requirements exactly.

The level of investment in technical training for all staff levels has assisted the success of the project to date. Personnel on the project undergo detailed technical written and verbal assessments before being appointed as suitably qualified for the position they occupy. The operations team are highly motivated, and are trained to monitor the facility and experiments from a technical perspective in the absence of the experimental team, such as during silent hours. This enables continuous operation of the VTR rig during experimental campaigns analogous to the operation of the WVP process.

The safe operation of the VTR facility is of maximum importance, and the commitment to safety has been demonstrated by the investment in the fail-safe design of the equipment along with significant time investment into job planning. Considered as important as the technical training investment, VTR staff undergo relevant safety training courses and actively participate in behavioural safety monitoring.

A policy of shared learning is adopted, the whole team including Operations, Experimental and support teams regularly meet to discuss the outcome of work and to generate ideas on how to overcome difficulties. This encourages contribution from individuals of numerous disciplines and backgrounds and tends to enrich the work performed on the VTR. This along with the significant investment in training and safety helps to encourage motivation and commitment from the staff.

IMPLEMENTATION AND USE OF RESEARCH LEARNING

Data from work performed on the VTR has already provided significant benefits to the UK's vitrification facilities. The vitrified product quality has been confirmed when pouring at relatively low temperatures from the melter system. If at the completion of feeds melt temperatures are lower than target, previously feeds were stopped to allow melt temperatures to rise to meet existing pour temperature criteria. The plant now has the option to initiate a pour provided the reduced pour temperature criteria are met thus avoiding lost production time whilst waiting for glass temperatures to increase.

Whilst benefits have already been achieved, implementation of further significant learning is planned or underway. Nexia Solutions have demonstrated that vitrification equipment used in the UK can potentially operate at significantly higher HA liquor throughput levels than those currently operated on WVP.

The VTR experimental program represents a significant research investment for British Nuclear Group, and obtaining the maximum benefit from this investment is essential. The realisation of this benefit is a priority for British Nuclear Group on behalf of their customers, and is realised through the implementation of VTR findings onto the active Vitrification facilities. The most significant use of VTR research onto WVP to date involved a recent trial on Blended feeds generating vitrified product with increased waste oxide incorporation, thus increasing the amount of high level waste material stored in each product container by 12%. This trial was performed successfully in autumn 2006 with WVP producing 40 containers at increased incorporation; the HAL vitrified would have resulted in the generation of 5 additional containers under standard incorporation operations.

The increased incorporation trial came to an end due to the planned change from Blended to Magnox HAL feeds in November 2006. Additionally, increased incorporation operations on Magnox feeds are also under consideration on WVP. Whilst the blend trial was relatively short, the plant responded successfully and confidence in operations at this level of challenge was achieved. Operating blended HA liquor at increased incorporation is likely to be resumed for the next Blended feed campaign around March 2007, and will potentially become standard plant operation on WVP for this feed type. If increased incorporation operations are continued, there is the potential to reduce the total container inventory generated over the lifetime of WVP by around 200.

Methods of Implementing Research Learning

The increased incorporation plant trial described above represents one of the most significant initiatives derived from the VTR to be implemented onto WVP. In order to ensure efficient transfer of research learning from VTR to WVP, Nexia Solutions and WVP’s Technical Department developed methods and a plan for information transfer. The approach adopted was successful for the increased incorporation trial and will form the basis for future implementation of VTR learning onto WVP; this approach is briefly described below.

Experimental work on the VTR is always formally reported in detail, although there is a requirement for the generation of technical documents summarising information specifically relevant to a proposed plant trial. The aim of these documents is to provide a succinct overview of VTR learning and the active trial proposal for dissemination amongst senior plant management and decision makers. These documents include VTR experience when operating at the new challenge level, required WVP operational configuration, expected outcomes, success criteria and fall back positions.

Briefing sessions are provided to all plant operations personnel with the goal of information sharing in relation to the proposed trial and to provide a direct communication route allowing input from staff at the front end of operating plants. Occasionally new issues are highlighted by WVP operators on the basis of very detailed and specific plant knowledge and these comments are then investigated further and addressed appropriately.

The final stage of support to the operational plants whilst the trial is in progress involves Nexia Solutions representatives being present at daily plant review meetings, and being available to provide technical assistance and data analysis were required. Additionally, at key stages of the trial, during plant reconfiguration for example, Nexia Solutions provide 24-hour cover to WVP Operations and are utilised as an on demand information source and for assistance with plant monitoring during crucial periods.

Relationships Strengthened

The increased incorporation trial was certainly successful from the perspective of increasing the amount of waste oxide in each product container, and additional to this strengthened links were generated between the research community and the active facilities funding this research. The continued development of relationships between Nexia Solutions and British Nuclear Group staff on WVP including plant management, operators, manufacturing teams and technical teams has ensured additional and constant informal transfer of research learning and experience onto the active facilities. This has resulted in a general industry wide increase in understanding of the vitrification process and research developments.

Following the success of the increased incorporation trial of autumn 2006, which was performed on Oxide/Magnox blended feeds, similar work on Magnox only feeds is planned. Nexia Solutions and British Nuclear Group are again working closely together to prepare for this trial which has the potential to reduce the lifetime WVP container inventory much further than the 200 potentially saved by high incorporation operation on Blend feeds.

FUTURE WORK

Work performed during the first two years of operation (through to 2006) on the VTR facility was primarily for British Nuclear Group in support of UK vitrification facilities considering throughput, incorporation and availability issues. Though not finalised, British Nuclear Group along with Nexia Solutions are developing a continued programme of work covering 2007 including:

- The investigation of more dilute feed stocks, which would represent a change in emphasis from increasing the glass production rate of WVP to dealing with an increased liquor throughput of low concentration.
- Very high incorporation product for UK wastes to maximise the waste oxide loading per storage container utilising improved base glass formulation.
- Decontamination and decommissioning waste streams or wastes without a current management route.
- Design changes to vitrification process equipment including new melter design.

Even when considering these options, beyond 2007 there may potentially be some spare experimental time on the VTR facility not utilised by British Nuclear Group or the NDA. In that scenario it would be conceivable that the VTR could be applied to the requirements of alternative customers. Whilst the facility currently represents a full-scale replica of WVP, the VTR is an excellent platform for the development of vitrification technology. Systems such as the calciner or melter could potentially be replaced or upgraded should a requirement for development of new vitrification systems, such as Cold Crucibles or new off-gas systems, arise.

The VTR has proven to be an effective development project which has already delivered demonstrable improvements to the performance vitrification plants at Sellafield and realised tangible benefits to both customers and external stakeholders.

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