UK contributions to the decommissioning of the BN-350 reactor in Kazakhstan: 2002 – 2011

David Wells
September 2011
BN-350 Assistance Programme overview
Rationale and objectives of UK assistance programme

• Objectives of the overall UK Global Threat Reduction Programme:
  • Countering the threat arising from Terrorist or state acquisition of chemical, biological, radiological and nuclear weapons of mass destruction through upstream preventative work;
  • Delivering the UK’s commitments to the Global Partnership against the spread of Weapons and Materials of Mass Destruction

• Assistance with decommissioning of BN-350 is part of the UK’s Global Threat Reduction Programme and aims to:
  • Achieve safe and irreversible shutdown of BN-350
  • Address proliferation issues associated with the presence of nuclear materials and radioactive materials
  • Provide continuity of employment for personnel with weapons-related expertise
Key operational parameters for BN-350

- BN-350 is a large, loop-type sodium-cooled fast reactor
- Designed in the Soviet era and operated successfully from 1973 to 1999, supplying electricity and steam for desalination
- Max achieved output: 750 MWth
- Core fuel – High Enriched Uranium oxide with some mixed Plutonium/Uranium oxide assemblies
- Decommissioning is being undertaken by the Republic of Kazakhstan, with International assistance
Application of UK fast reactor experience to BN-350 decommissioning

• Decommissioning challenges for BN-350 and the UK’s fast reactors, particularly the Dounreay Prototype Fast Reactor (PFR), are similar:
  • Oxide fuel
  • Sodium coolant in main circuits, with NaK used in special heat rejection circuits
  • On-site spent fuel cleaning and storage facilities
• BN-350 and PFR had similar power output and operational lifetimes
• BN-350, DFR & PFR were unaffected by major, unplanned events during operation
• Hence, exchange of decommissioning experience is likely to be beneficial
Collaboration arrangements

- Kazakhstan – NTSC, MAEC Kazatomprom, NNC; KAEC & MINT
- USA – INL & other National Laboratories; USDOE and USDOS, NNSA
- UK – Nuvia Limited; DECC

Joint Kz-US-UK progress meeting at BN-350
Annual UK funding for BN-350 assistance

Includes SNF Storage Project operations funding

UK Financial Years

Annual funding £k


Budget for 2011/12
BN-350 Decommissioning Assistance Programme

- **Task 1 Programme Management**
  - Decommissioning Plan
  - Technical assistance
  - Collaboration with US

- **Task 2 Training**

- **Task 3 ISTC Projects**
  - K-512 Cs Trap disposition
  - K-970/K-1199 Sodium Processing support
  - K-1345 Residual sodium processing
  - K-1583 Fuel route surveys

- **Task 4 Semipalatinsk Test Site Projects**

- **Task 5 SNF Projects**

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Individual Tasks
Overview of individual Tasks

• Editing of Decommissioning Plan – 2002/2003
• Technical assistance – 2003 to 2010
• Training – 2003 to 2009
• ISTC Projects – 2004 to 2011
  • Caesium Trap disposition
  • Sodium Process Facility product immobilisation
  • Alternative options to sodium processing
  • Residual sodium processing
  • Hot Cell waste vault and spent fuel discharge route surveys
• STS Survey Projects – 2005 to 2008
• SNF Projects – 2006 to 2010
Task 2: Training

• Decommissioning Project Management Workshops:
  • Introduction to Project Management
  • Planning software/Optioneering/Risk management
  • Compression/acceleration of project schedules
  • Cost estimating and procurement processes
  • Project review and closeout

• Technical/Safety Workshops
  • Decommissioning technology
  • Alkali Metal handling, treatment and disposal
  • Cementation of liquid radioactive waste
  • Radiation Protection
  • Decommissioning and retrieval & immobilisation of stored radioactive wastes

• Other
  • International Financial Accounting Systems training
  • English language training
### Task 3: Shutdown/decommissioning projects listing

<table>
<thead>
<tr>
<th>Number</th>
<th>Project Title</th>
<th>Period</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-970</td>
<td>Geocement stone facility</td>
<td>2005-7</td>
<td>$300k</td>
</tr>
<tr>
<td>K-1199</td>
<td>Alternatives to geocement &amp; formulation development</td>
<td>2005-8</td>
<td>$125k</td>
</tr>
<tr>
<td>K-1323</td>
<td>Characterisation surveys of selected areas of STS</td>
<td>2006-7</td>
<td>$162k</td>
</tr>
<tr>
<td>K-1345</td>
<td>Residual sodium processing</td>
<td>2006-10</td>
<td>$590k</td>
</tr>
<tr>
<td>K-1583</td>
<td>Survey of Hot Cell waste repository, fuel transfer route and storage pond</td>
<td>2007-11</td>
<td>$707k*</td>
</tr>
</tbody>
</table>

ISTC Project Funding Total: $3,329k

* Including extension to fuel storage pond

Note: US funding of K-970 $300k; K-512 investigations $50k
Project K-512: Immobilisation of Caesium Traps

- Caesium traps arose from a successful sodium decontamination exercise undertaken between 1999 and 2003.
- The traps are concentrated sources of radioactivity, which require immobilisation on safety and physical security grounds.
- An extension to ISTC Project K-512, funded by the UK is immobilising the traps to allow them to be stored as solid, conditioned radioactive waste.
- Technique used is draining of sodium following by filling with lead.

BN-350 Caesium Trap prior to assembly

Caesium Trap in shielding following lead fill
Projects K-970 & K-1199: Sodium processing support

- Processing of ~600 metric tons of primary sodium coolant generates large amounts of radioactive liquid sodium hydroxide
- Aim of joint US- and UK- funded K-970 project was to develop an efficient solid wasteform for this effluent – geocement
- Process development, product testing and plant design all included
- K-1199 considered alternative options, in particular for low activity secondary sodium
- K-1199 also extended full-scale testing and investigation of the process envelope

Despatch of BN-350 secondary sodium for industrial re-use
Geocement development: full scale trials

Mixing of one of the geocement full-scale trials specimens in a 200 litre drum
Residual sodium is the term for the undrainable pockets, deposits, films and droplets of sodium left on wetted internal surfaces once the bulk coolant has been drained.

Target amounts for BN-350 residual sodium were:
- ~ 1 metric ton in reactor vessel and primary loops
- ~ 2 metric tons in secondary circuit loops

During normal operation of liquid metal circuits, an argon or nitrogen cover gas is used to prevent reaction with air or water ingress. For Safestore, the chemically reactive sodium metal needs to be treated to change it to a form compatible with atmospheric air.

ISTC Project K-1345, funded by the UK, was undertaken between 2006 - 2010 to react the residual sodium with moist carbon dioxide, producing unreactive sodium bicarbonate/carbonate which can remain in situ throughout Safestore.

Processing also promotes irreversible shutdown of the reactor.
Project K-1583: Fuel route surveys

- Remote visual and radiation surveys of:
  - Hot Cell waste vault
  - Spent fuel transfer cells
  - Spent fuel storage pond

- Objective – to establish the absence of significant amounts of nuclear material which might require ongoing safeguards actions

βγ-active debris field on waste vault floor
Task 4: Semipalatinsk Test Site investigations
Task 5: SNF Project overview

- US-Kazakhstan SNF Storage Project aimed to remove some 3,000 spent fuel assemblies from BN-350 for remote secure storage in dual-use transfer/storage casks

- $200 million, 7 year project (2003 to 2010)

- Project manager: NNSA with in-country support from KATEP

- UK contribution of approximately $3 million for operations:
  - Recover fuel assembly storage canisters from pond and load into casks
  - Assemble casks into overpacks and despatch from BN-350 by rail
  - Transfer overpacked casks onto road trailers for journey to storage site
  - Offload, remove overpacks and store casks at secure storage site
  - Provision of task lead for operations, interfacing with PM team

- Project completed November 2010 with 60 casks consigned to secure long term storage
Cask loading operations
Cask despatch and receipt operations

Fit overpack & despatch by rail

Tranship to road trailer and emplace at storage site
Summary
Lessons learned (1) – working effectively

- **Add value by collaborating:**
  - Avoid overlaps and potential conflicts in approach
  - Identify synergies
  - Be clear on who leads and who supports on individual tasks
- **Develop strategy away from contact with the beneficiary**
- **Allow adequate “gestation” time – the preparatory work always takes longer than you think!**
- **Select appropriate funding mechanism (eg via ISTC)**
- **Break project into stages**
- **Feedback to UK projects:**
  - Use of carbonation process for passivating residual alkali metal on Dounreay reactors
  - Remote surveys & analysis methodology
  - Plans for PFR spent fuel
Lessons learned (2) – understand the Beneficiary

- Excellent technical knowledge of Kazakhstani staff
- Low cost rates partly offset by low productivity levels:
  - UK management costs > Funds paid to Kazakhstani staff
  - UK management mandays < 1/5 of Kazakhstani mandays
- Project management accepted in principle by Kazakhstanis – there are many practical reasons why implementing these principles is much harder
  - Management support
  - Permissions/Bureaucratic obstacles to making progress
  - Industrial context and Procurement
- Understanding cultural differences
  - What is meant by “fixed price”
  - The need to deliver to target
  - Knowledge/experience vs Youth/cleverness
- “Knowledge is power” – keep on asking questions
Conclusions

• UK assistance with the decommissioning of BN-350 has cost ~£8.9 million over ten years, ~£4 million spent directly in Kazakhstan
• The Programme has immobilised key wastes, contributed to irreversible shutdown of the reactor and addressed issues associated with sodium coolant processing
• The Programme funded the operations to load spent fuel canisters into casks at BN-350, together with their despatch from site and receipt at the secure storage facility
• The Programme also delivered technical and project management training, assisted in the production of the BN-350 Decommissioning Plan and contributed to the radiation survey effort in the STS
This presentation summarises the work of many individuals in Kazakhstan, the United States, Great Britain and elsewhere. In particular, funding from the British Government Department for Energy and Climate Change (DECC) is gratefully acknowledged.