Technologies & Management Systems that Work: Current Best Practice in Nuclear New Build

John H. Moore
Nuclear Power Division
j.h.moore@iaea.org

Paris, France March 11, 2014
(OECD Workshop)
Exciting Times!
The United Arab Emirates is the first country to start the construction of its first nuclear power plant in 27 years, since construction was started on China's first plant in 1985.

July 20 2012
Concrete pouring after approval of PSAR.

Unit 2 followed
May 2013.
Sanmen, China

Jan 29, 2013
AP-1000
Containment vessel top head placement;
Sanmen, China
VC Summer Unit 2, USA

March 10/11, 2013
First concrete pour of a new NPP in North America in three decades.

- Followed closely followed by concrete pours at Vogtle Unit 3 (and later by Summer 3 and Vogtle4)
Other recent starts (2013 and 2014)

- Belarus;
- China (3);
- South Korea;
- Argentina.
Current status

Construction Starts

Under Construction

Source: IAEA PRIS 05-Mar-2014
IAEA MANAGEMENT SYSTEM GUIDANCE
“Things to do:”
• Define roles and interfaces;
• Grade requirements based on safety significance;
• Have well defined processes;
• Define handover and responsibility transfer processes;
• Plan activities;
“Things to do” (continued):

- Have kick off meetings;
- Control design information;
- Maintain cleanliness;
- Maintain control of material;
- Prevent damage during storage and handling;
- Verify construction work.
Verification of Construction Work

Need to have:

• Methods/schedules for verification that specify levels of inspection & verification required;
• Suppliers must verify all procurement requirements have been satisfied;
• Construction activities should follow inspection and test plans (ITPs) approved by organization (Owner);
Verification of Construction Work

• ITPs should have appropriate hold / witness points for owner to verify acceptability;
• Plan to be prepared to ensure design and regulatory requirements met;
• Process required to verify construction activities;
• Verification normally documented via check sheets or similar means to record that SSCs have been constructed and installed to specified requirements.
Example quality issues (Sanman, China)

- RCP impeller: Irregularities welded without documentation;
- Squib Valve: Manufacturer used components and subcontractor without proper equipment qualification.
Project Management in NPP Construction

• Construction management
  • Preparatory phase;
  • Construction phase (after concrete pouring);
  • Commissioning phase;

• Main issues and lessons learned
  • Selection of local suppliers;
  • Bulk material management;
  • Worker turnover;
  • Construction equipment;
  • Massive movements of people and material;
  • Public perception;
  • Construction phase closure activities;

• Country specific lessons learned
Construction Technologies for New NPPs

- **Goal:** Achieving optimum construction schedule for future NPP construction projects.
- **Content:**
  - Comprehensive descriptions of all construction methods;
  - Advantages / disadvantages;
  - Best practices;
  - Lessons learned.
Some sample beneficial technologies

• Early engineering / front end planning;
• Site construction management support systems
• Modularization and open top construction;
• Advanced welding;
• 4 season construction.
Early Engineering

Reduce Site Manpower by 40%

Previous Design Process

Basic Design

Detailed Design

Construction

Construction Engineering

Front-Loaded Construction Engineering

Basic Design

Detailed Design

Construction

Construction Engineering

Requirements from Construction Engineering

Inputs from Plant Design (BOQ, Composite Design, etc.)

Source: From Hitachi construction experience
Issues with a Gen 3+ project

• 18000 design changes by end of 2013;
• Lead time for nuclear side design change approvals from one month to six months;
• Engineering completion behind schedule;
• Insufficient support for regulatory review from off-shore team.

*Should improve for “nth of a kind”*
Site construction management support

3D-model linked to schedule
“6D” construction schedules

3D model + Quantities + Resources + Time = 6D database

- Develop detailed construction schedule by area based on quantities and labour resources;
- Simulate schedule with 3D-model.
Modularization

- Upper Drywell Module: 650 ton
- RPV: 900 ton
- RCCV Top Slab: 550 ton
- Stator: 420 ton
- RCCV Lower Liner Module: 630 ton
- Upper Condenser Module: 270 ton
- RPV Pedestal Module: 410 ton
- Base Mat Module: 460 ton
- HPU Module: 270 ton
- Lower Condenser Unit: 260 ton
Sep 27, 2010 Unit 1 CA01 lifting.
Manpower Peak Reduction Effort
- Construction & Module Experience-

Based on previous ABWR (Conventional Method)

Level-off Manpower Peak

Manpower Distribution

Based on Latest ABWR
Advanced Welding Techniques

- Quality welding is crucial and time consuming;

- Advanced Techniques
  - Metal Arc Welding;
  - Gas Tungsten Arc Welding;
  - Submerged Arc Welding;

- Automatic welding equipment is very effective;
  - Maintains high quality;
  - Improves work environment in narrow spaces.
Automatic Welding Machine for RCCV Liner

Automatic Welding for Large Bore Piping

Automatic Welding for Small Bore Piping (CRD piping)
Four season construction

• Provides “factory-like” environment for construction during winter;
• Secures environment for:
  • Welding;
  • Concrete pouring & curing;
  • Protection from equipment;
• Allows around the clock work.
Four season construction

Buildings with the All-Weather Structure (Steel and Temporary cover)

Movable Temporary Roof

Improvement of Work Productivity during winter
CONSTRUCTION READINESS REVIEW SERVICE
IAEA REVIEW SERVICES

Phase 1
- NPP site review mission
- INIR mission

Phase 2
- IPPAS mission
- INSSERV mission
- ISSAS mission

Phase 3
- Pre-OSART mission
- SCART mission
- EPREV mission
- NPP construction review mission
- INIR mission

Milestone 1
Milestone 2
Milestone 3
Construction Readiness Reviews

• Focus is on a specific NPP construction project (new build or refurbishment), not the overall programme.
• Must have design chosen and construction preparations underway at a very detailed level.
• Guidelines finalized and published. Service available now!
Construction readiness reviews

• **Areas Reviewed:**
  
  • Project Management;
  • Engineering Readiness;
  • Procurement / Material / Supply Chain Readiness;
  • Quality Management and Records;
  • Human Resources and Training;
  • Construction Readiness;
  • Construction Installation Completion Assurance;
  • Targeted Reviews (as requested by customer).
Project management area

- Scope control;
- Front end planning;
- Project scheduling;
- Estimating;
- Metrics;
- Alignment;
- Community support;
- Roles & responsibilities;
- Risk management;
- Project oversight;
- Contract & procurement strategies;
- Change control;
- Delay/suspension provisions.
Engineering readiness area

- Documentation;
- Feedback incorporation;
- Design change process;
- Planning;
- Configuration mgmt, controlled docs & records;
- Computer & cyber security;
- Review of previous work (if delayed project);
- Eng. Programmes;
- Eng. quality (Ph2 review).
Procurement / material / supply chain readiness

- Equip./material availability;
- Procurement procedures and plans;
- Packaging, warehousing, & transport;
- Material inspection;
- Risk management;
- Quality assurance / quality surveillance.
Quality management and records

- Quality assurance & controls;
- Independent assessments;
- Non-conformance / corrective action programmes;
- Construction experience;
- Quality surveillance and construction inspection;
- Controlled documentation and records.
Human resources and training

- Hiring, development, and training;
- Personnel qualification;
- Human performance;
- Health and safety training;
- Personnel availability;
- First line supervision and management.
Construction readiness

- Site infrastructure requirements;
- Regulatory requirements;
- Tools availability;
- Construction sequencing;
- Security and safeguards requirements;
- Construction execution plans and procedures;
- Safety management;
- Environmental management;
- New construction practices / technologies.
Construction completion assurance

- Process defined;
- Walkdown processes;
- Hold points;
- Open item tracking;
- Labelling and control of boundaries;
- Inaccessible items;
- Interim maintenance during construction.
Targeted reviews (upon request)

- Completed activities and expenditures;
- Detailed as-experienced schedule review;
- Variance review;
- Significant events of interest;
- Corrective action review;
- Other areas.
E-LEARNING
Construction e-learning module

- Part of a series targeted at newcomer countries, at both senior leader and project team member levels.

- Topics covered in Construction Module:
  - What makes nuclear construction unique;
  - Important considerations for projects and programmes;
  - How to achieve excellence;
  - Key site considerations.

- Now available!
SOME LESSONS LEARNED
Elements needed for successful NPP

• Health, environment and safety
  • Communicate with regulator and public as early as possible and as much as possible;

• Quality
  • Quality surveillance of sub-contractors (engineering, construction etc.) should start early;
  • Cover both domestic and foreign vendors;

• Schedule
  • Level 2 for management; monitor at level 3;
  • Ensure sufficient resources, support contractors;

• Financial
  • Risk funding needed. Only 25 % NPP projects in China were completed with planned budget.
Project management lessons

- Clearly define roles of Owner and EPC contractor;
- Set up PM organization early;
- Ensure Owner has appropriate contingency funding and risk allocated for unforeseens;
- Perform surveillance of quality during manufacturing;
- Need strong site centred PM for EPC and Suppliers;
• Off-site team should support fully, but not manage site team;
• Include incentives for on/off site team;
• Authorized to proceed (ATP) for long lead items equally important with first concrete pour date (FCD);
  • Lead time typically 3 years between ATP and FCD in recommended (China).
Thank you for your attention!

Follow IAEA Nuclear Energy on Twitter @IAEANE