

International Atomic Energy Agency

Plant Standardization, Simplification and Constructability

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Standardization (1 of 5)

“**NPP Standardization** is a life-cycle commitment to uniformity in the design, construction and operation of a family of nuclear power plants”

US. NPOC Standardization Policy Statement (1991)

Standardization (2 of 5)

- Today, Utilities and Vendors are committed to plant standardization as opposite to customized designs in the past
- Four main steps to standardization of Advanced Reactors:
 1. EUR (EU) and URD (USA) specify NPP requirements consensuated by Owners and Operators. They provide the basis for Standard Plant designs.
 2. Design Certification/prelicensing of Standard Plants by Regulatory Authorities.
 3. Detail design developed to a level well beyond to what is necessary for Design Certification (Goal: 80% detail design completion).
 4. Standardization beyond design: Standardized approach on construction practices, operation, maintenance and procurement practices.

Standardization (3 of 5)

- Most Reactor Vendors have developed a Standard Plant design
- Future GIII and III+ NPPs will be families of Standardized Plant designs
- **Benefits:**
 - Early definition of requirements (EUR or URD) ensures regulatory stability and eliminates unnecessary changes
 - Design optimization to improve constructability, operability and maintainability
 - More simple and uniform designs easier to construct and operate
 - Maximize experience feedback from units in each family of standard plants
 - Standard plants designed to comply with an envelope of site conditions
 - Plant design will be transferable without major changes, to any site with design conditions within the envelope of design parameters
 - Design drawings identical except for changes due to equipment sourcing and site-unique conditions



Standardization (4 of 5)

◆ Issues:

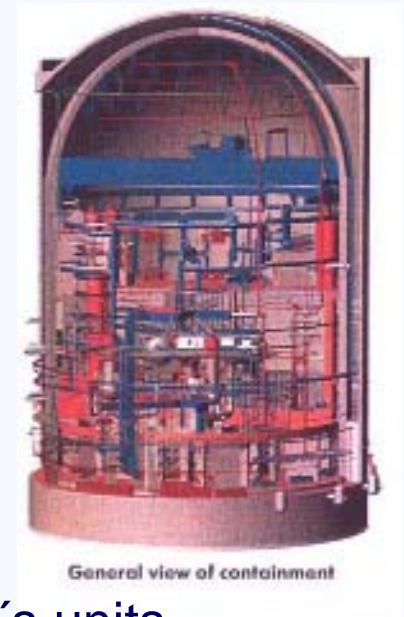
- Licensability of Standard Plant design in countries different from the country of origin where it was certified
- Construction in different sites without changes
- Minimizing changes to the Standard Plant design minimizes costs to the Investor and facilitates licensing
- The Standard Plant concept should provide confidence to the Investors
- Standardization should allow equipment sourcing from different suppliers and allow local participation



Standardisation (5/5)

◆ System design and equipment specification shall consider:

- Minimizing system diversity
- Same design solution for same functions
- Use of standard component sizes and types for the complete plant
- Employ repeated detail engineering solutions and installation details
- Develop design and engineering standards and the same project documentation for series of NPP's units



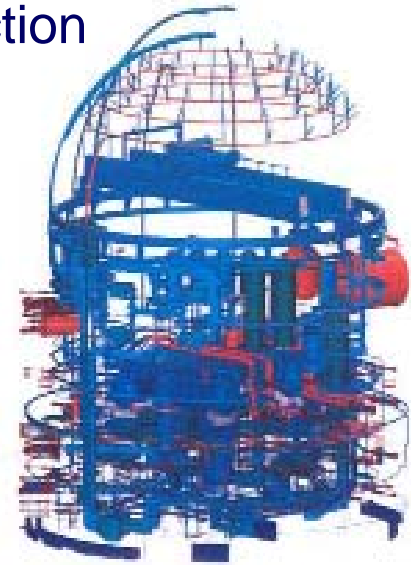
Simplification (1/4)

- ◆ Design complexity and “tailor made“ / “one-of-a-kind” designs have been a source of problems in past NPP projects
- ◆ Past experience shows that design simplification is a high priority for next NPP’s projects
- ◆ **Main design considerations for simplification are:**
 - Use minimum number of system and components for the function
 - Simplicity in the design reduce the number of components, site work and cost (less pipes and valves, fewer pumps, less cables, etc.)
 - Facilitate construction by design
 - Design for easy maintenance and operation



Simplification (2/4)

- ◆ Main design simplification issues to implement in the project:
 - Develop a efficient equipment layout and arrangement
 - Design to accommodate an easy construction sequencing
 - Minimize labour intensive activities during construction
 - Larger slab/foundation to minimize construction and schedule constrains
 - Develop a computer Plant 3D model to optimize and simplify design and construction



3-dimensional model of main systems of the reactor building

Simplification (3/4)

- ◆ Main design simplification issues to implement in the project (cont.)
 - Simplicity in construction by the use of modularization
 - Modularization of steel structures
 - Utilization of skid mounted equipment assemblies as much as possible
 - Consideration of prefabrication of complete pipe and support structures.
 - Optimize site prefabrication and assembly of large components

Simplification (4/4)

- ◆ Main design simplification issues to implement in the project (cont.)
 - Utilization of standard materials, items and components to facilitate stocks
 - Simple and standard design for BOP underground works
 - Standardization of electrical cable trays/conduits/support and materials
 - Use of latest I&C standard system technologies (already licensed), the same system for the complete Plant (NI+TI+BOP)

Constructability (1/12)

“**Constructability** policy is to be implemented in NPP projects to achieve a substantially improved construction schedule compared to what was the experience with existing plants”

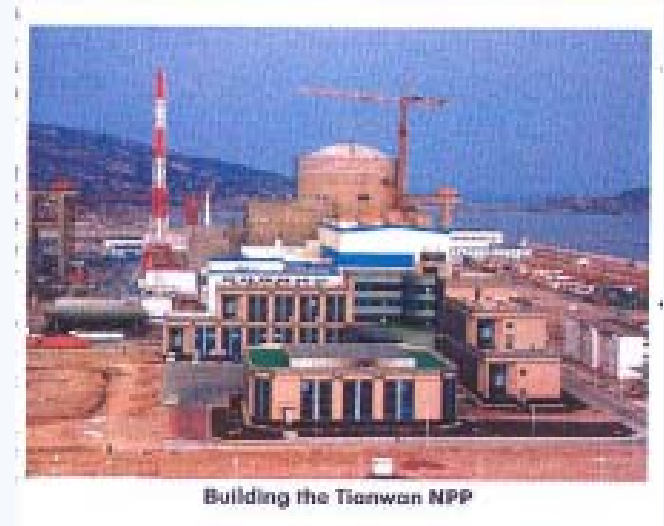
EPRI URD



Constructability (2/12)

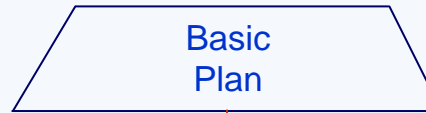
1. Construction organization, planning and scheduling is essential to constructability

- Project organization chart and Supplier/Owner responsibilities defined
- Site management: Owner and Plant Supplier organizations and interfaces shall be clear
- Project schedule
 - Contractual schedule and Milestones: Basic Plan (Level 1)
 - Planning Levels 1 / 2 / 3 / 4 in accordance number of activities
 - See Typical Project Scheduling System in next slide



Constructability (3/12)

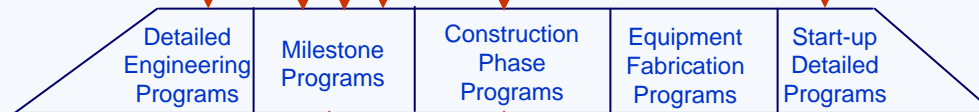
1st Level



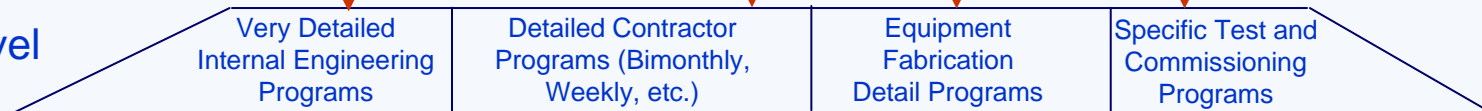
2nd Level



3rd Level



4th Level



Typical Project Scheduling System

(SOURCE: EPRI URD)



Constructability (5/12)

2. Construction considerations to implement during design:

- Provisions to facilitate construction shall be introduced at design stage
- Design shall be “complete”, before placement of structural concrete
- Large margins between engineering and construction. On time information from equipment suppliers is critical
- Construction methodologies shall be considered in, and integrated with, the design. Use of advanced technologies
- Replication of standard design in series of NPP’s units –Opportunity to benefit from a learning process

Constructability (4/12)

3. Subcontractor selection and procurement site control

- Equipment site delivery complying with schedule and quality critical
- Define the Plant Supplier responsibilities to control Subcontractor and equipment procurement
- Develop a List of Approved Subcontractors
- Owner right to have access to Subcontractors information, QA and QC programs
- Owner right to access Subcontractor works and inspection



Constructability (6/12)

4. Advanced construction technologies

- Most of existing NPP's were constructed in 70's up to 90's
- Latest constructed NPP's have use some advanced construction technologies resulting in:
 - Improved constructability by new and proven technologies
 - Reduced construction schedule
 - Cost optimization
- Future NPP's will use new construction technologies
 - Already applied in recent NPP projects
 - Successfully proved in other industrial sectors
 - Promoted by Vendors and large civil contractors based on their expertise

Constructability (7/12)

4. Advanced construction technologies (cont.)

- Utilities, Vendors and Construction Companies are evaluating and implementing these new construction technologies for future NPP projects
- Some relevant new construction Technologies:
 - Excavation and rock removal by precision blasting
 - Advanced concrete mixtures
 - Built in place large frames of concrete reinforced bars
 - Use of concrete structure reinforced by steel plate
 - Use of GPS and laser for positioning and as-built control

Constructability (8/12)

4. Advanced construction technologies (cont.)

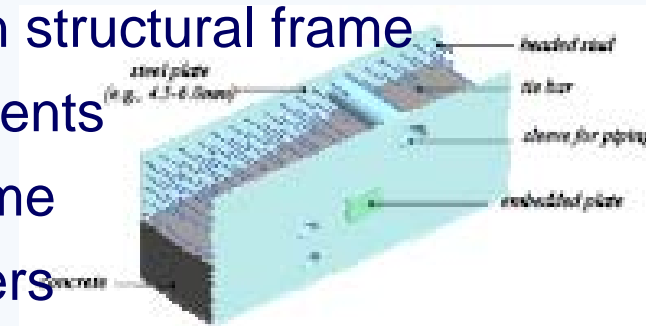
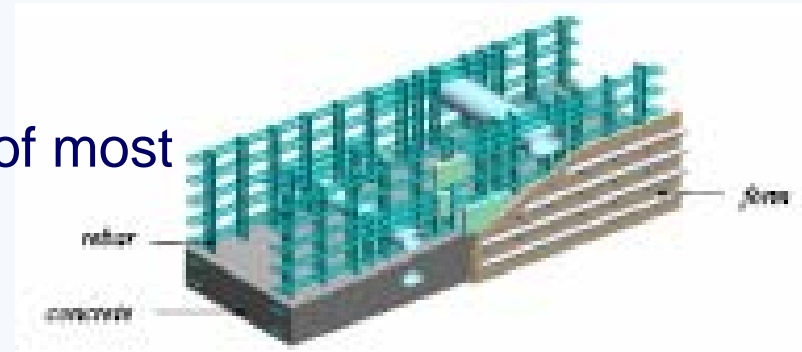
- Open Top installation
- Use of fiber - reinforced polymer concrete panels
- Use of pipe bends instead elbows
- Automatic and Robotic Welding
- All - weather construction
- Modularization



Constructability (9/12)

5. Modular construction

- Modules are currently on integral part of most of current NPP Vendor's designs
- In general, modules include:
 - Wall and forms rebar, pedestals, floor reinforces and liners
 - Structural steel and frames, platforms and foundations
 - Mechanical equipment including piping, valves, instruments and cable trays in a common structural frame
 - Piping modules including valves, instruments and supports in a common structural frame
 - Electrical equipment modules in containers or common structural frames



Constructability (10/12)

5. Benefits of modular construction

- Allows parallel working, reducing construction schedule
- Reduction of manpower at site and construction costs
- Better quality by constructing in a controlled environment.
- Facilitates quality control
- Substantial pre-testing and qualification can be carried out
- Requires additional and early planning of engineering, design and procurement
- Avoidance of congested working areas
- Safer construction
- Capitalize on repeat design

◆ Site layout / space and transportation shall be carefully considered

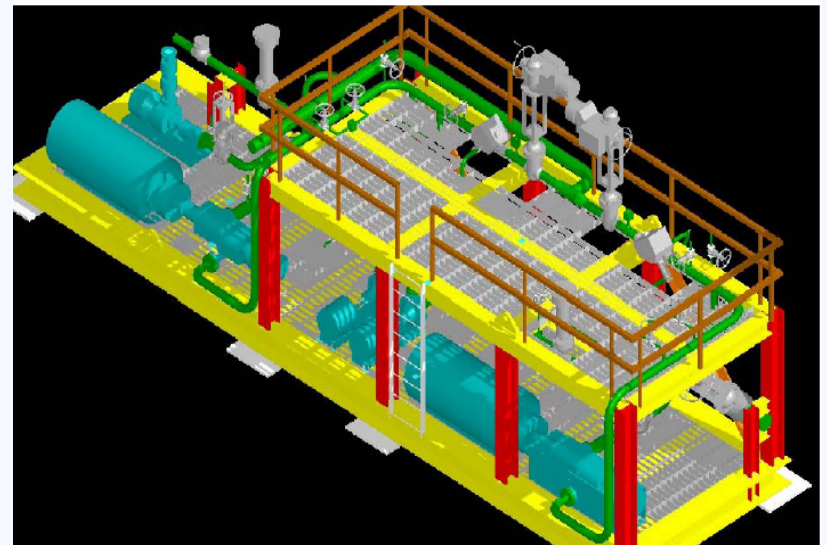
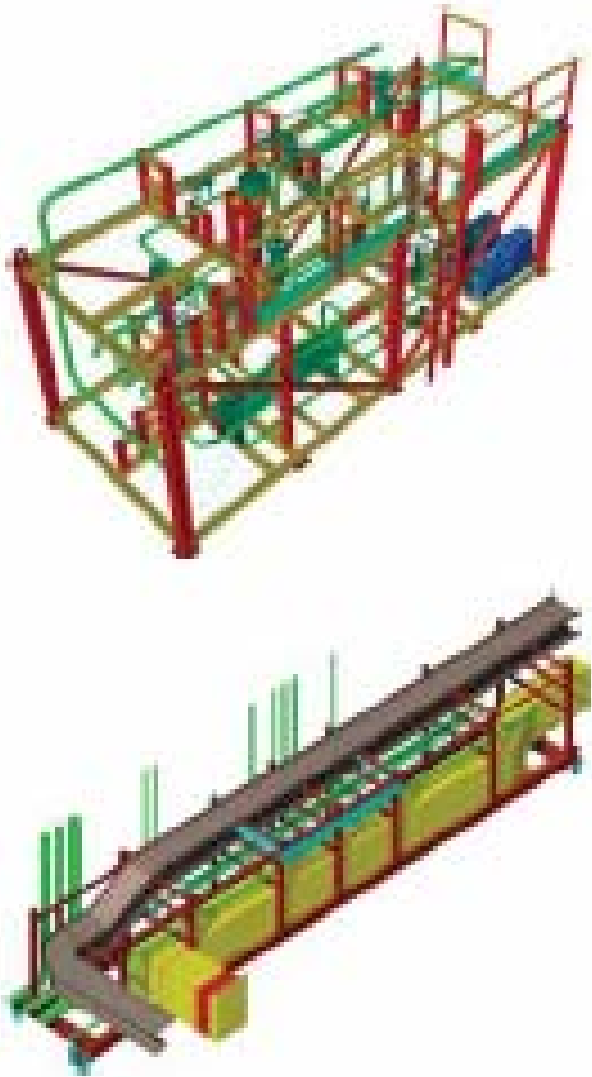
◆ Code and regulations allow modularization but QA and design documentation requirements are affected



Constructability (11/12)

Equipment Modules

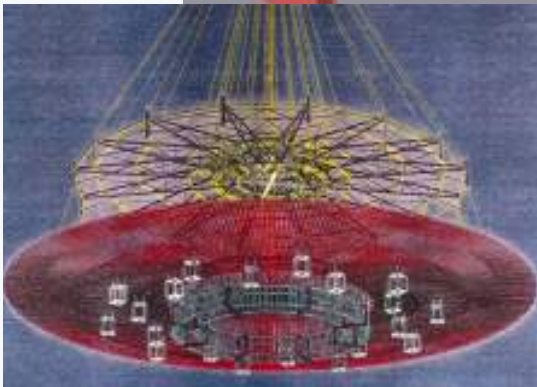
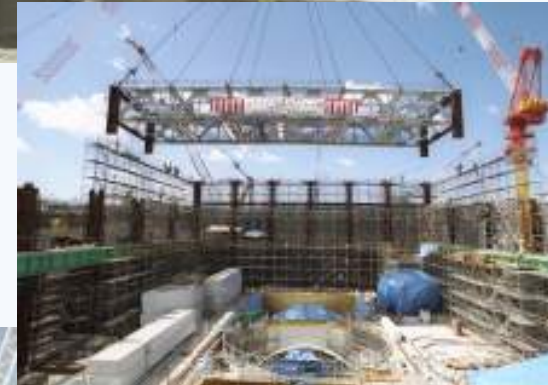
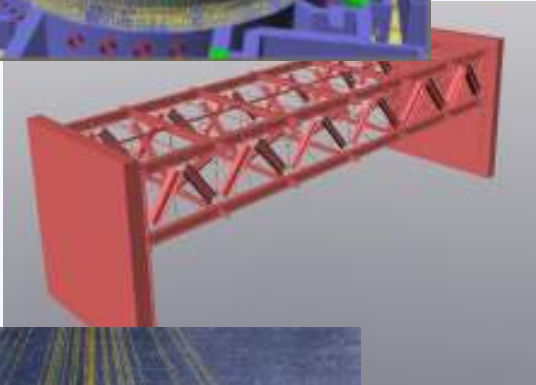
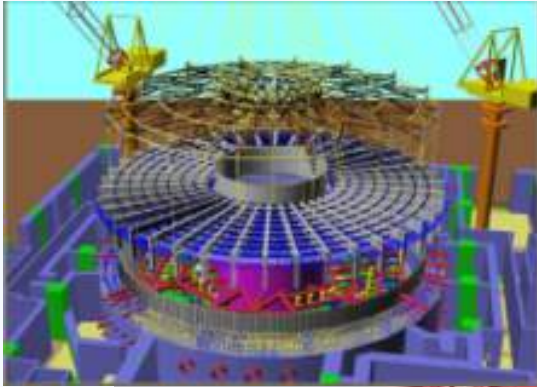
(Built at shops outside the site)



SOURCE: GEH

Constructability (12/12)

Construction Modules (Built at site)



SOURCE: GEH