ASME | PLANT SYSTEMS DESIGN

SETTING THE STANDARD

New ASME Standard on Plant Systems Design

Technical Meeting on Codes and Standards, Design Engineering and Manufacturing of Components for Small Modular Reactors, 10-13 May 2022

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Plant Systems Design Standards Committee
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Agenda

- Innovations
- Description, Purpose & Objective
- General Overview
- Design Process Overview
- Key Points

Innovations

- Addresses Design Processes
- System Based
- Using MBSE Tool
  - To plan and write the standard
  - Case Study on MBSE approach:

https://www.innoslate.com/resource/plant-systems-design-systems-an-mbse-approach-case-study/

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Description

- Design of facilities with the potential for significant hazards to the health and safety of the public, the worker, and the environment, includes:
  - nuclear facilities; fossil power generation facilities (e.g., coal, natural gas); oil refining; oil and natural gas production; petrochemical; chemical; and hazardous waste plants and facilities

Purpose & Objective

- Purpose: provide enhancements to current industry design practices

- Objective: reduce design errors or omissions that increase the cost of design, construction, operation, maintenance, decontamination, decommissioning, and disposal.

General Overview

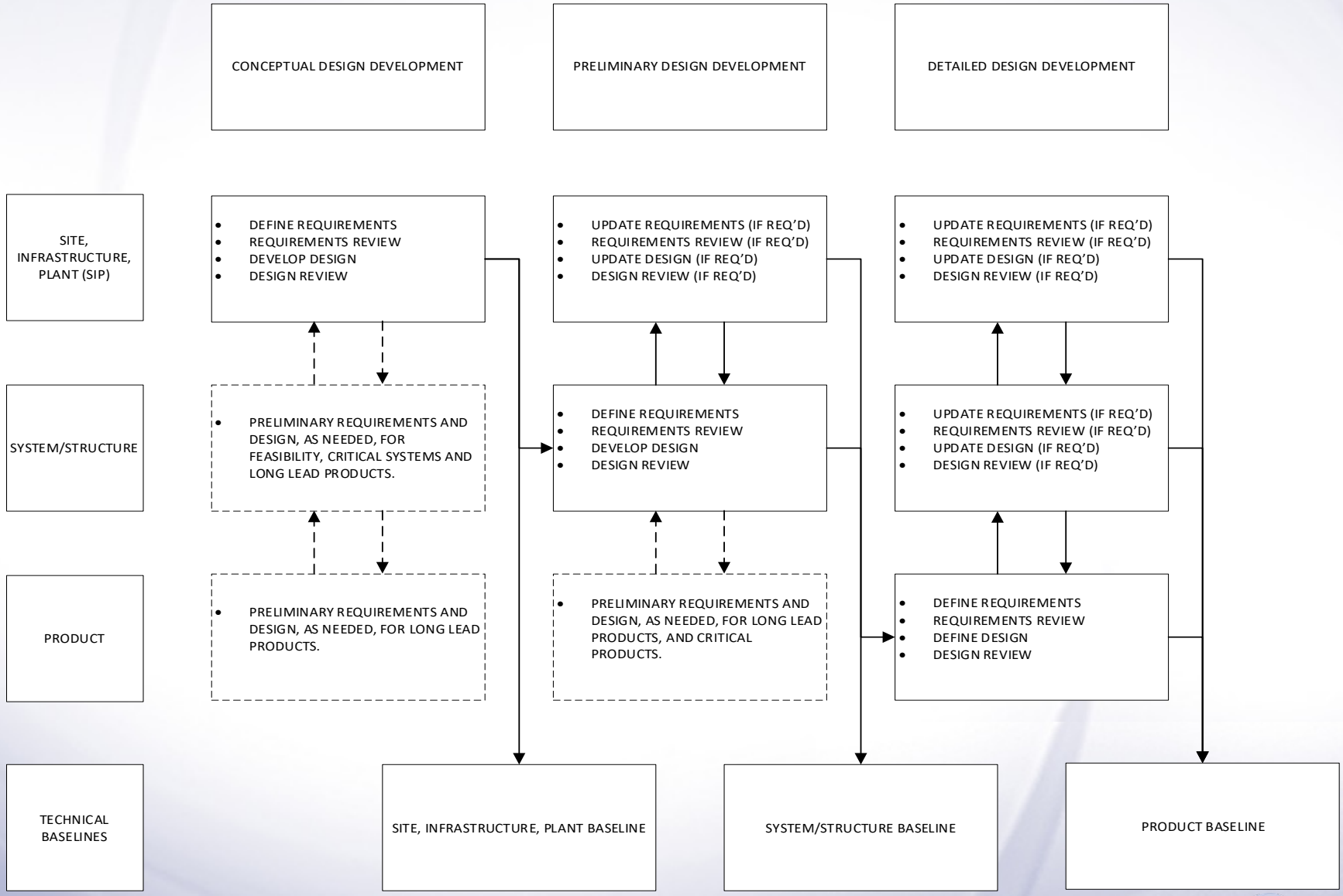
A technology neutral standard that provides a framework, including requirements and guidance, for **design organizations** to:

- Conduct plant **process hazard evaluations** and analysis in the early stages of design that:
  - advance as the design matures and
  - provide structure to the development of a quantitative risk assessment.
- Integrate **systems engineering** design processes, practices, and tools with traditional architect engineering design processes, practices, and tools.
- Integrate **risk informed probabilistic design** processes, practices, and tools with traditional deterministic design processes using reliability and availability targets.

Four Subobjectives

1. **Safer** and **more efficient** system designs and design alternatives with **quantified safety levels**
2. **More effective requirements management**
   - including assumptions, TBDs and TBVs
3. Cover the **entire life cycle** of a plant (design, construction, operation, decontamination and decommissioning)
4. Be **system based**, vs. component based, **and cover multiple disciplines** (mechanical, electrical, instrumentation & control, HVAC, etc.)

PSD-1 Design Process Overview



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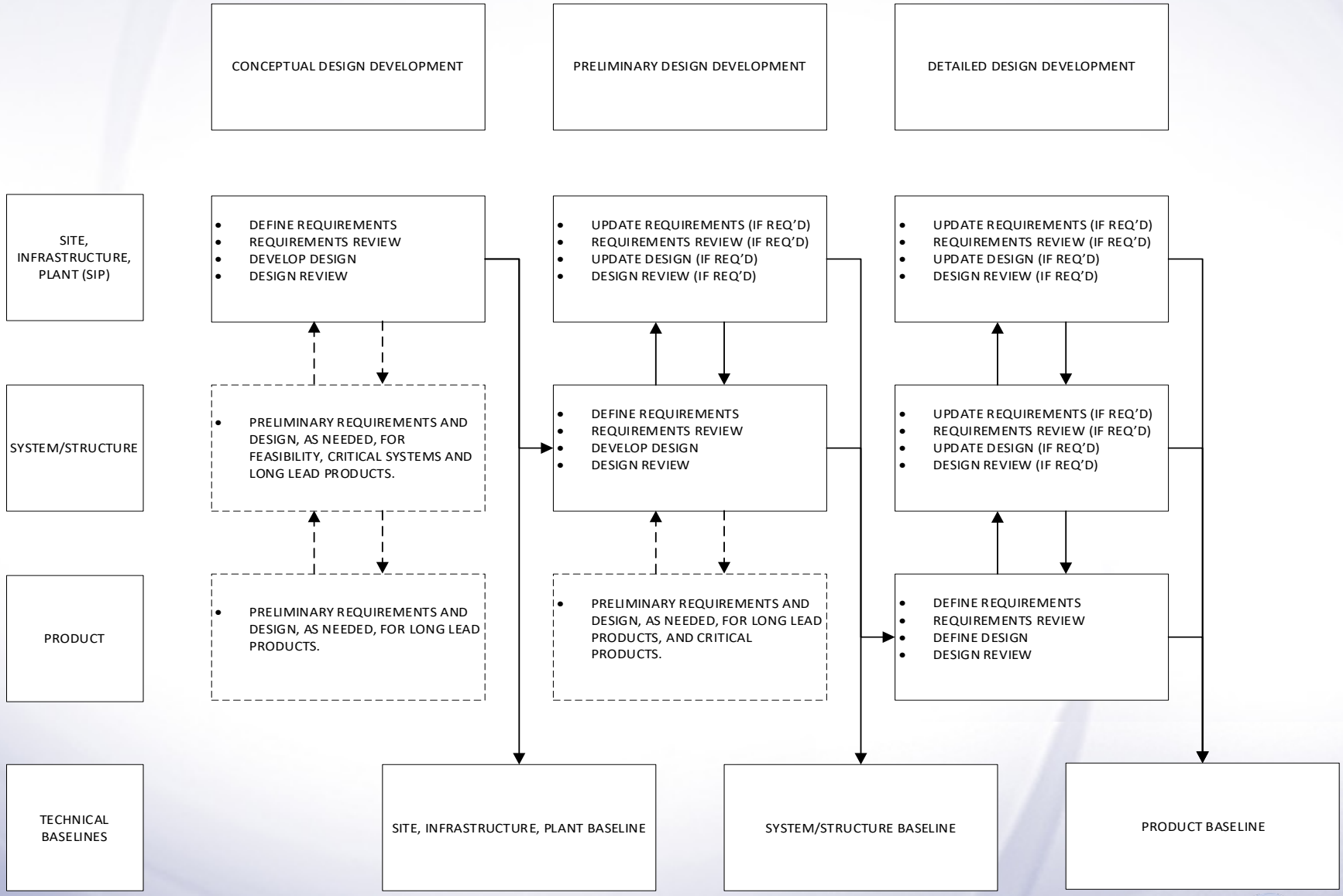
Key Terms

1. **Design development activities**
   - establishing technical requirements
   - allocating requirements
   - functional design
   - engineering design
   - verification
2. **Conformed Contract**
   - Customer requirements
   - Site conditions
   - Regulations
   - Design constraints
   - Stakeholder needs
   - External interfaces
   - Industry codes & standards

Key Terms

3. Product

- Material
- Hardware
- Firmware and Software
- Device
- Assembly and Subassembly



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Conceptual Design Development

Inputs

Contract technical requirements

Site conditions

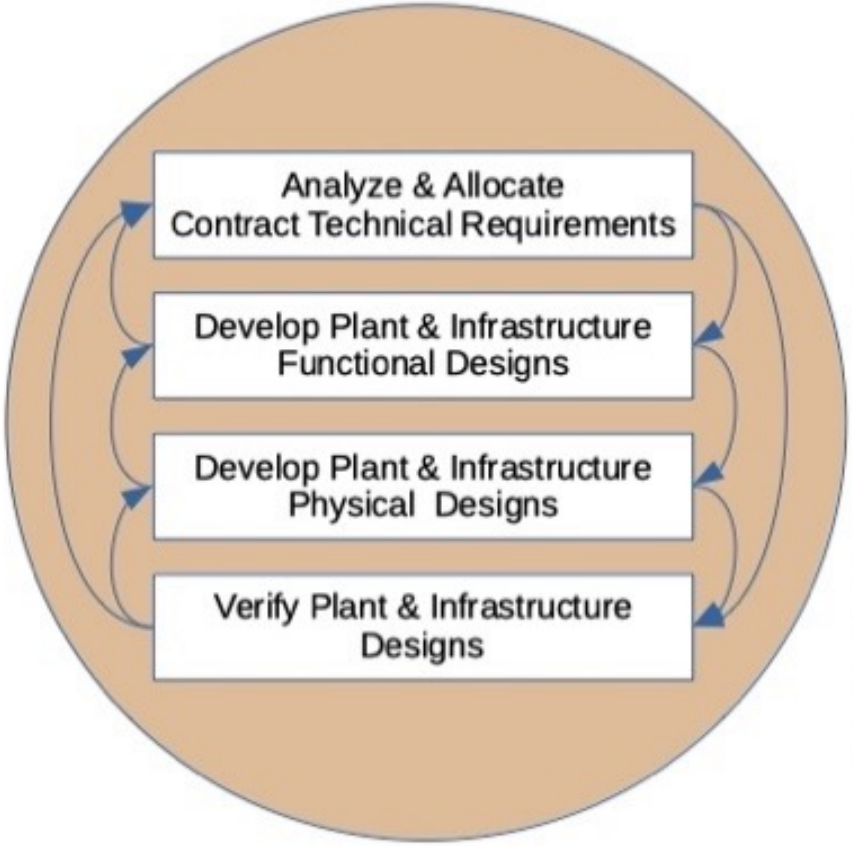
Regulations

Design criteria

Stakeholder needs

External interfaces

Industry codes & standards



Outputs

SIP Functional requirements

SIP Performance requirements

Site layout drawings

SIP Functional diagrams

SIP Interface requirements

SIP Design constraints

SIP Environmental requirements

SIP Health & Safety requirements

SIP Production requirements

Preliminary Design Development

Inputs

SIP Functional requirements

SIP Performance requirements

Site layout drawings

SIP Functional diagrams

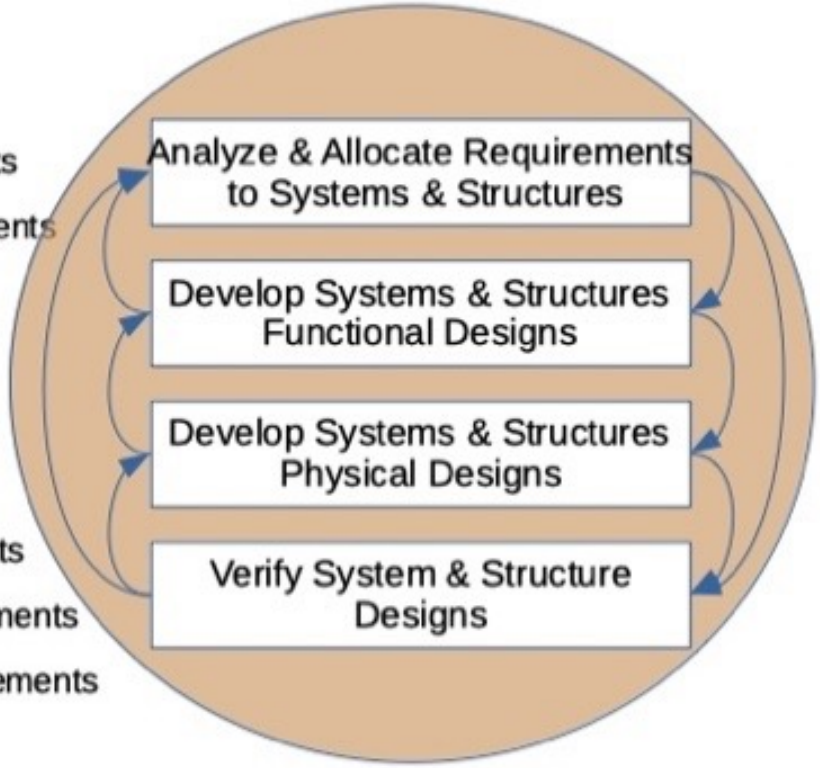
SIP Interface requirements

SIP Design constraints

SIP Production requirements

SIP Environmental requirements

SIP Health & Safety requirements



Outputs

SS Functional requirements

SS Performance requirements

SS Derived requirements

SS Interface requirements

SS Functional diagrams

System design documents (P&IDs)

Structural plans and elevation drawings

SS Production requirements

SS Health & Safety requirements

SS Environmental requirements

Detail Design Development

Inputs

SS Functional requirements

SS Performance requirements

SS Derived requirements

SS Interface requirements

SS Functional diagrams

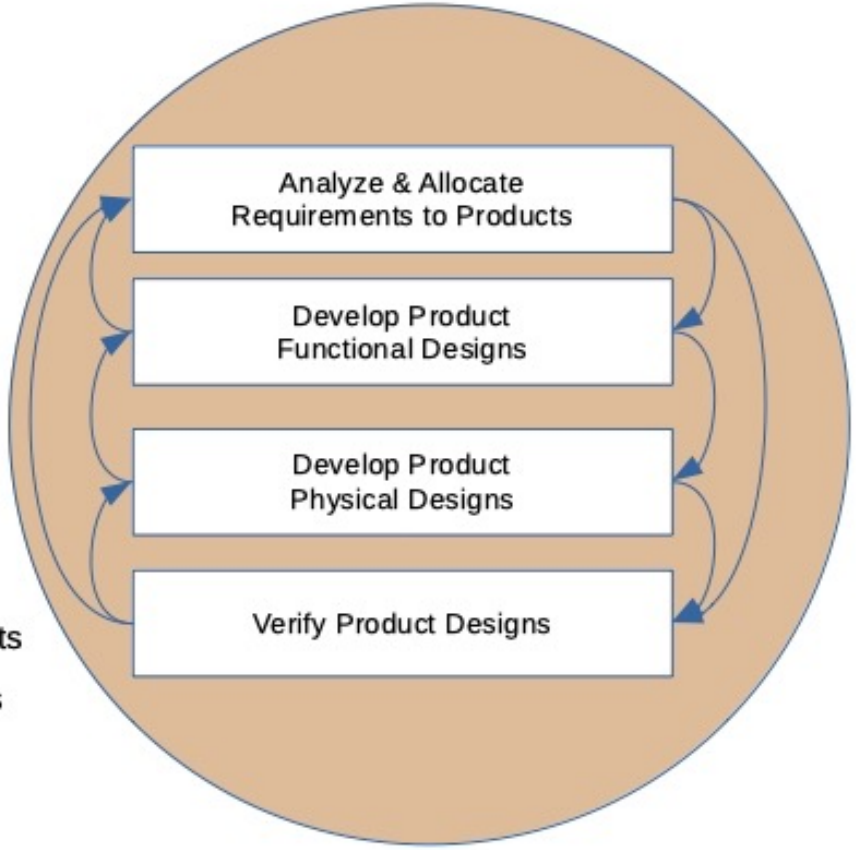
System design doc's (P&IDs)

Structural plans and elevation drawings

SS Production requirements

SS Health & Safety requirements

SS Environmental requirements



Outputs

"Build to" specifications

Engineering design documents

Engineering drawings

Construction drawings

Hardware lists

Software design documents

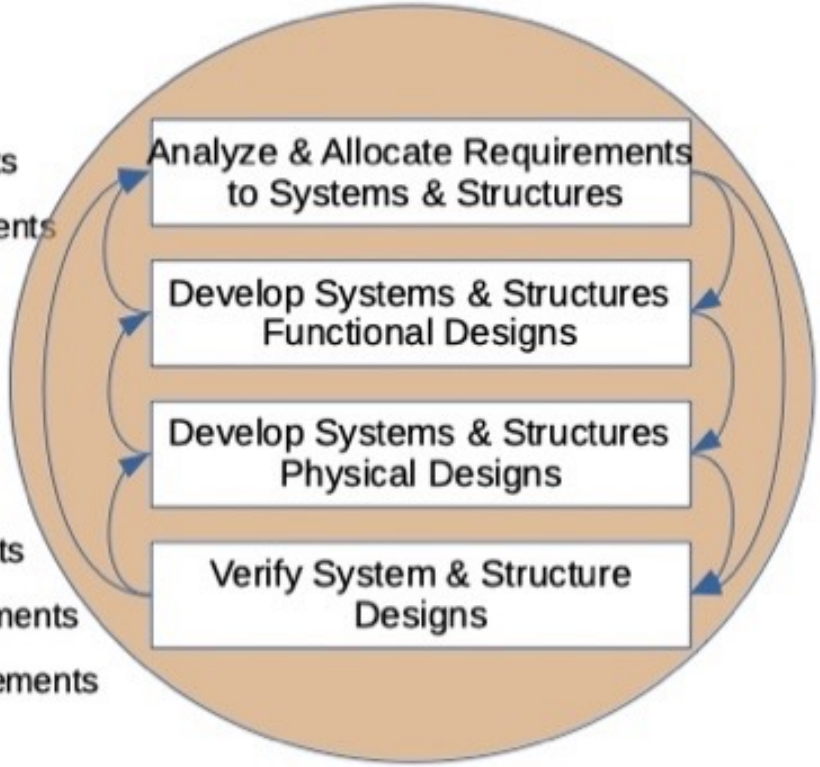
Software code

Physical form, fit & function characteristics

Testing requirements

Purchase specifications

Preliminary Design Development



Inputs

- SIP Functional requirements
- SIP Performance requirements
- Site layout drawings
- SIP Functional diagrams
- SIP Interface requirements
- SIP Design constraints
- SIP Production requirements
- SIP Environmental requirements
- SIP Health & Safety requirements

Outputs

- SS Functional requirements
- SS Performance requirements
- SS Derived requirements
- SS Interface requirements
- SS Functional diagrams
- System design documents (P&IDs)
- Structural plans and elevation drawings
- SS Production requirements
- SS Health & Safety requirements
- SS Environmental requirements

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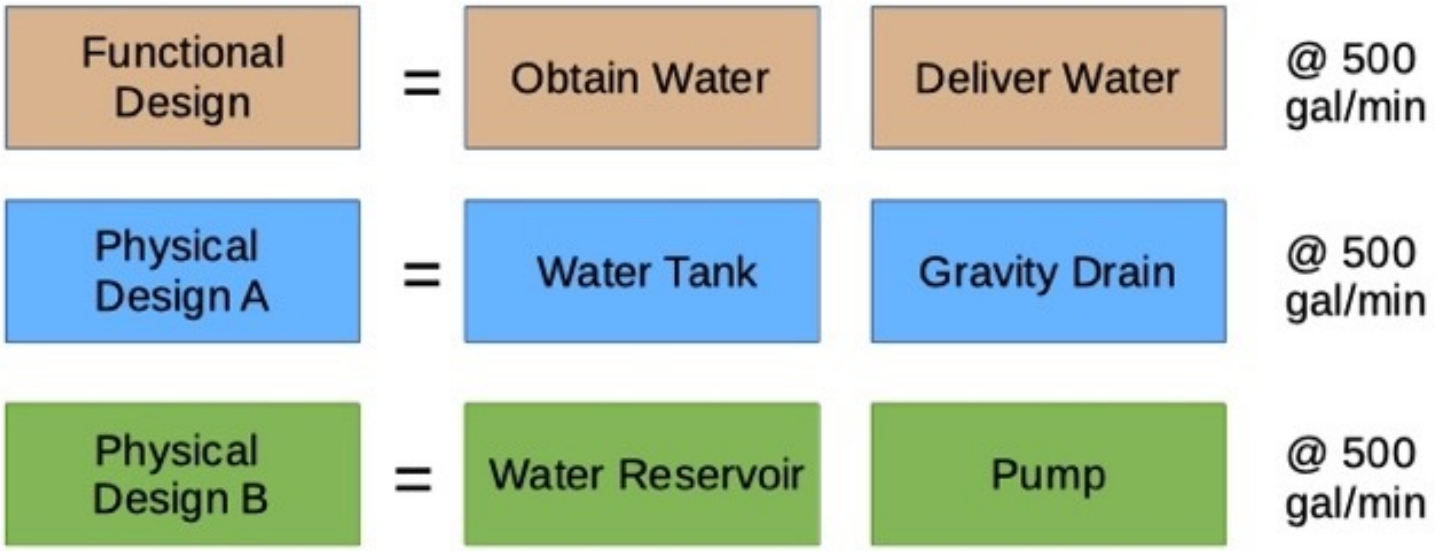
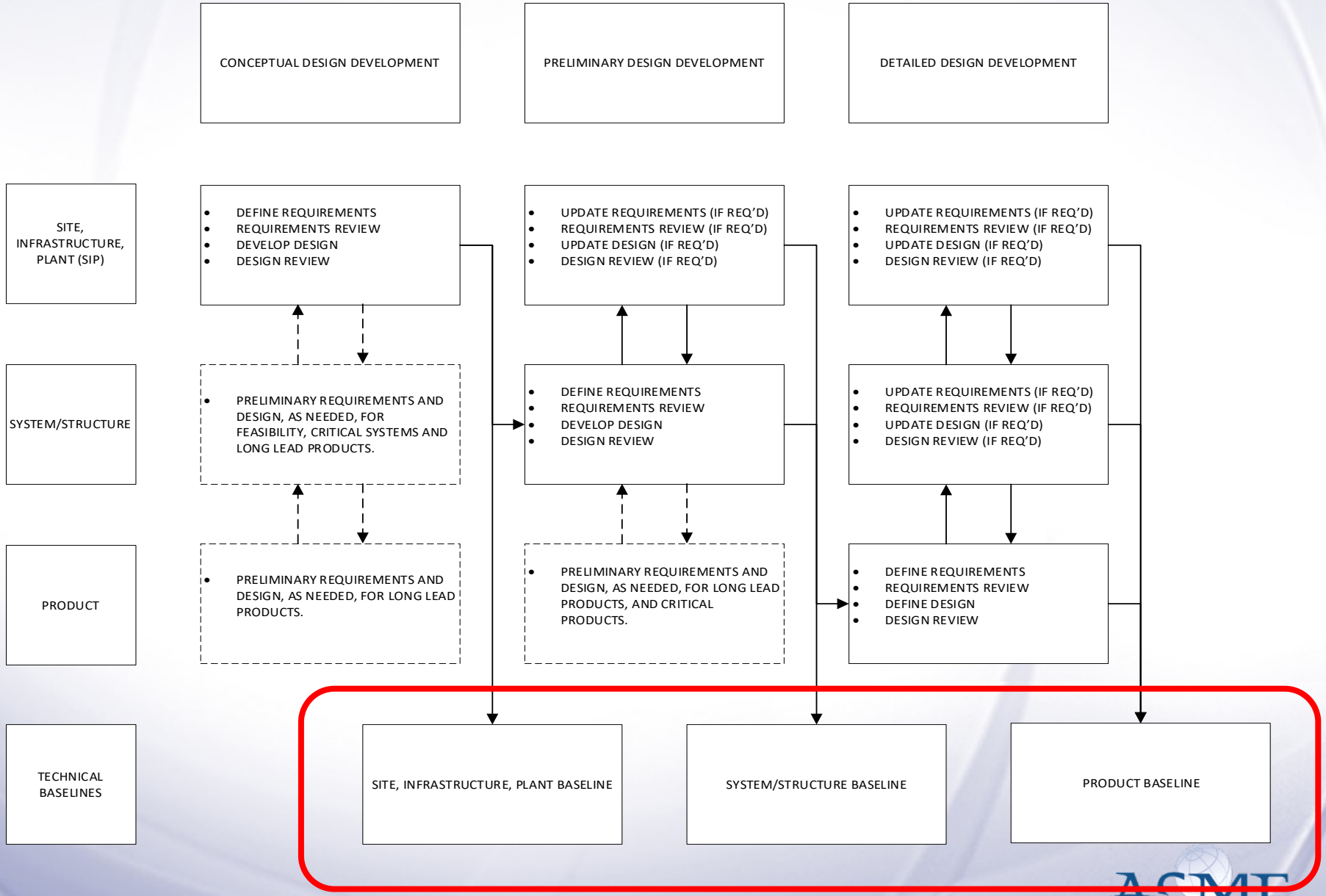
COOLING WATER EXAMPLE

Functional Requirement: provide cooling water to process system
Performance Requirement: 500 gallons per minute





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Technical Requirements Definition

Technical Requirements

Technical requirements definition activities:

- transform customer and other relevant stakeholder needs, goals, and objectives into a technical definition of the problem
- and then into a complete set of technical requirements expressed as “shall” statements
- used for defining a design and related products

Technical Requirements

- Improve development and traceability of technical requirements.
- Define before beginning design
- Failure to identify and manage requirements has caused about half of all projects to:
  - not meet original goals and objectives
  - have significant cost and schedule overruns and
  - result in inadequate facility capabilities.

Technical Requirements

- Form basis for architecture definition, design, integration, and verification activities
- Enable the description of inputs to and outputs from activities, as well as required relationships between inputs and outputs
- Include constraints, and system interactions with operators, maintainers, and other systems

Technical Requirements

Typically, technical requirements include:

- Functional requirements – ***what*** functions need to be performed
- Performance requirements –***how well*** the functions need to be performed
- Verification requirements – show proof of **compliance** with other technical requirements

Technical Requirements

Typically, technical requirements also include:

- Design constraints
- Internal interface requirements.
- External interface requirements
- Health, safety, and environmental requirements
- Environmental requirements
- Codes and standards requirements

Technical Requirements

Typically, technical requirements also include:

- Regulatory requirements
- Availability and reliability requirements
- Physical and cyber security requirements
- Constructability requirements
- Requirements to support plant operations
- D&D requirements

Key Points

- Define technical requirements before beginning design
- Verification and validation requirements are important part of technical requirements definition
- Integration of the required activities and guidance from this Standard into design processes and procedures will reduce design and operational risks and costs

References

- ISO/IEC/IEEE 15288, Systems and software engineering — System life cycle processes, 1st edition 2015-05
- [1] NASA Systems Engineering Handbook, NASA SP-2016-6105, Rev 2, National Aeronautics and Space Administration, NASA Headquarters, Washington, DC, USA, January 27, 2020, also available at:

  https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook
- [2] "Requirements Management - A Core Competency for Project and Program Success", Project Management Institute, August 2014
- [3] "The Impact of Rework on Construction & Some Practical Remedies", Navigent Construction Forum, August 2012