Control Systems of NPP-2

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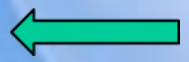
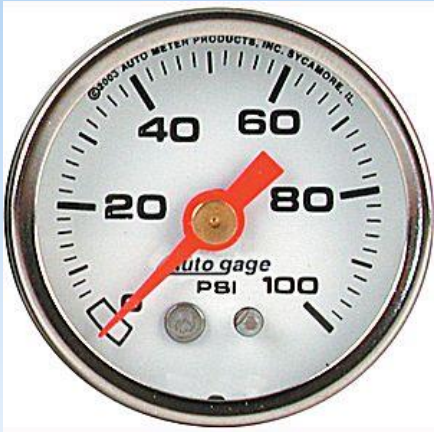
- Fundamentals of I&C Systems
- Overview of Plant Control Systems
- **Control Systems Design**
  - NSSS Control Systems
  - **Pressurizer Pressure Control System** 
  - Pressurizer Level Control System
- IAEA Safety Standard for Plant Control Systems

Pressurizer Pressure Control System

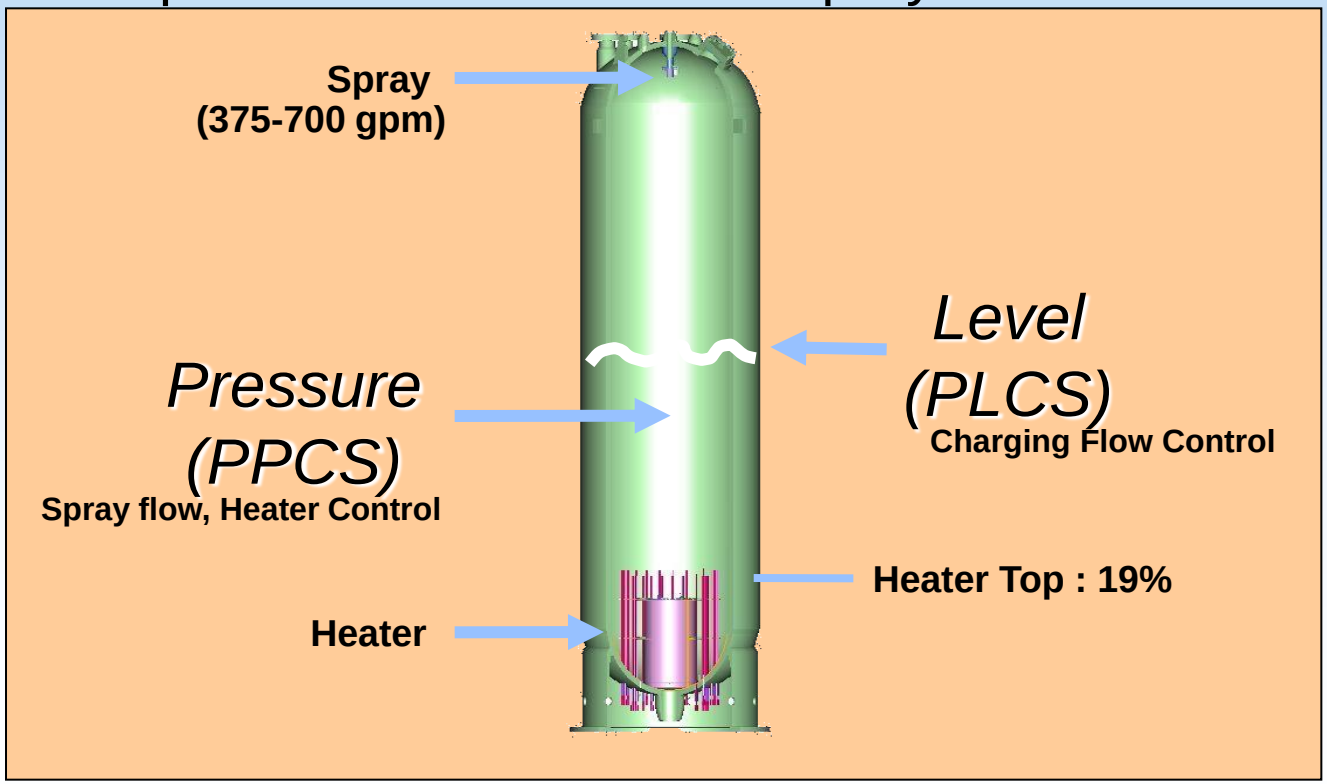
- PPCS
  - What makes to change the pressure?
    - decreased / increased Tavg of RCS
    - decreased / increased RCS inventory
    - Decreased / increased pressurizer level
    - …
  - What happened?
    - ..
    - Reactor Trip by RCS high / low pressure



  - Well, I want to maintain the pressure within specified limit for normal operation.

Pressurizer Pressure Control System

- PPCS
  - Maintains the reactor coolant system pressure within specified limits
    - by the use of pressurizer heaters and spray valves



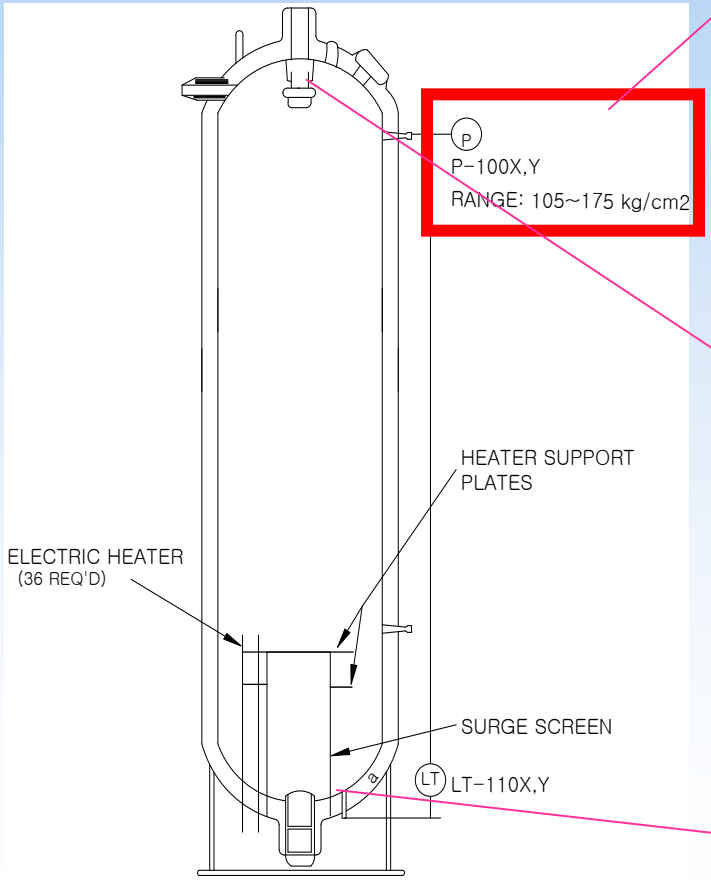
Pressurizer Pressure Control System

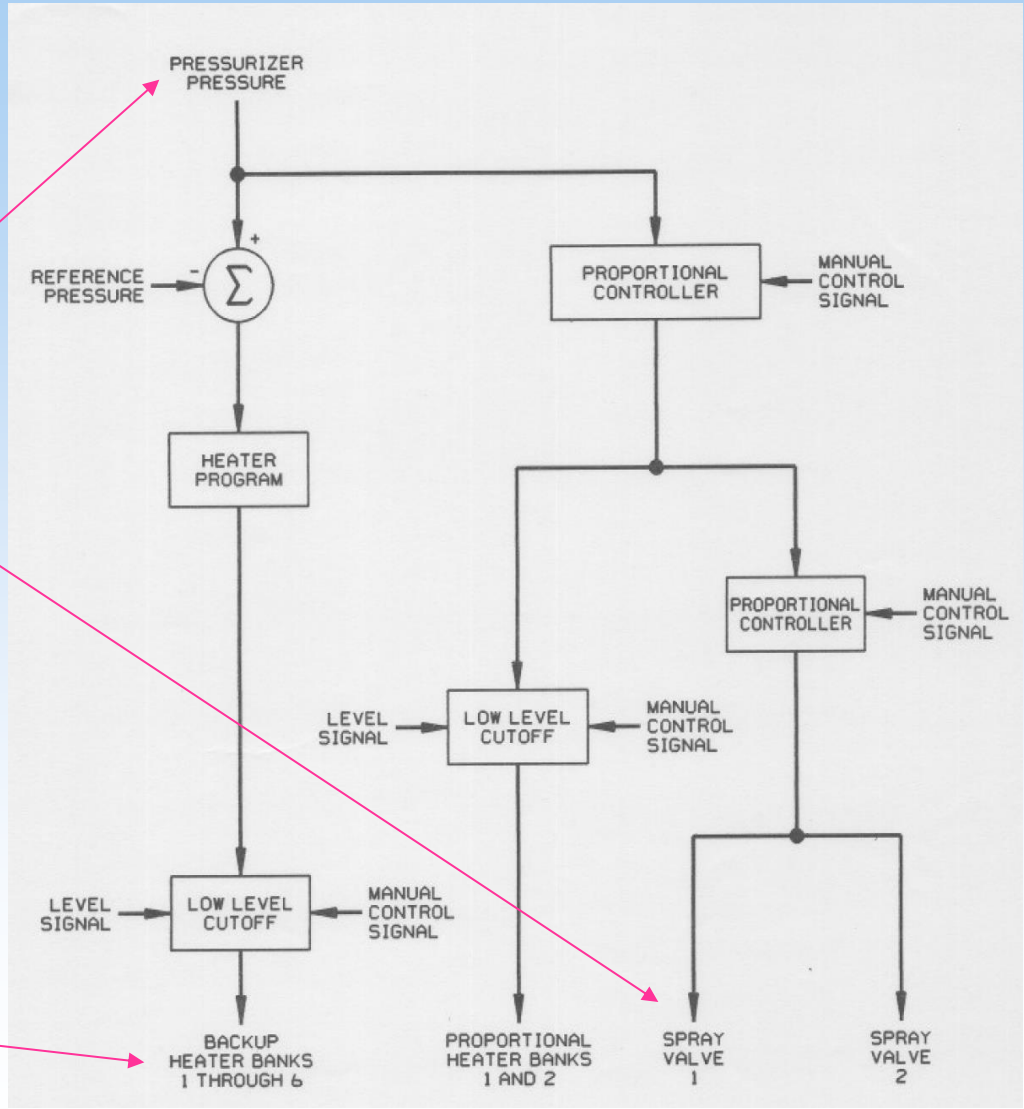
□ Design requirements

- Provides Auto/Manual controls to maintain RCS pressure within specified limits
- Operator can select one of two channels for automatic control
- Interlock signals : PZR Level-Low & Pressure-High
- Input : PZR Pressure (2)

Pressurizer Pressure Control System

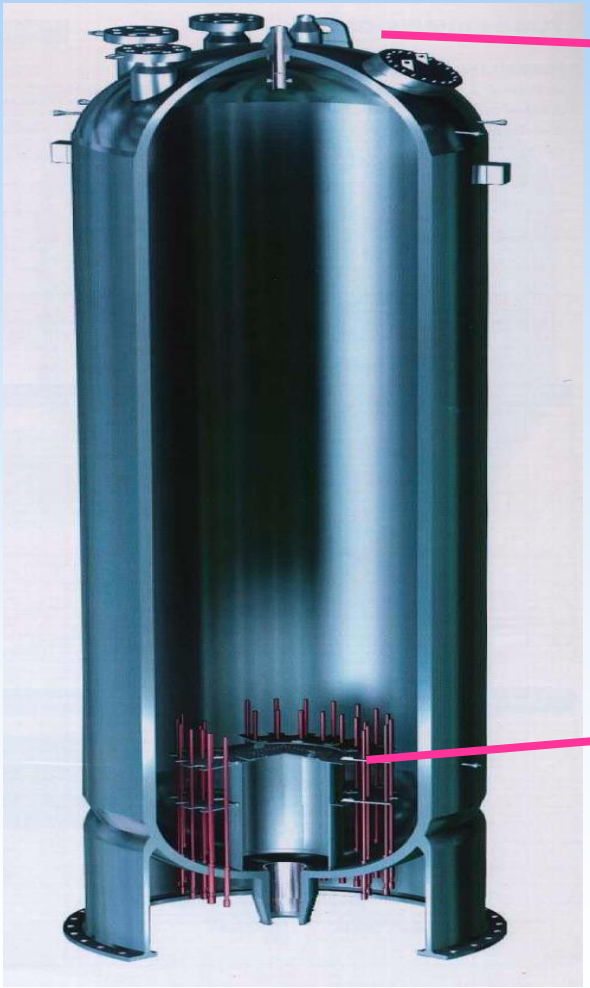
□ PPCS





Pressurizer Pressure Control System

□ PPCS

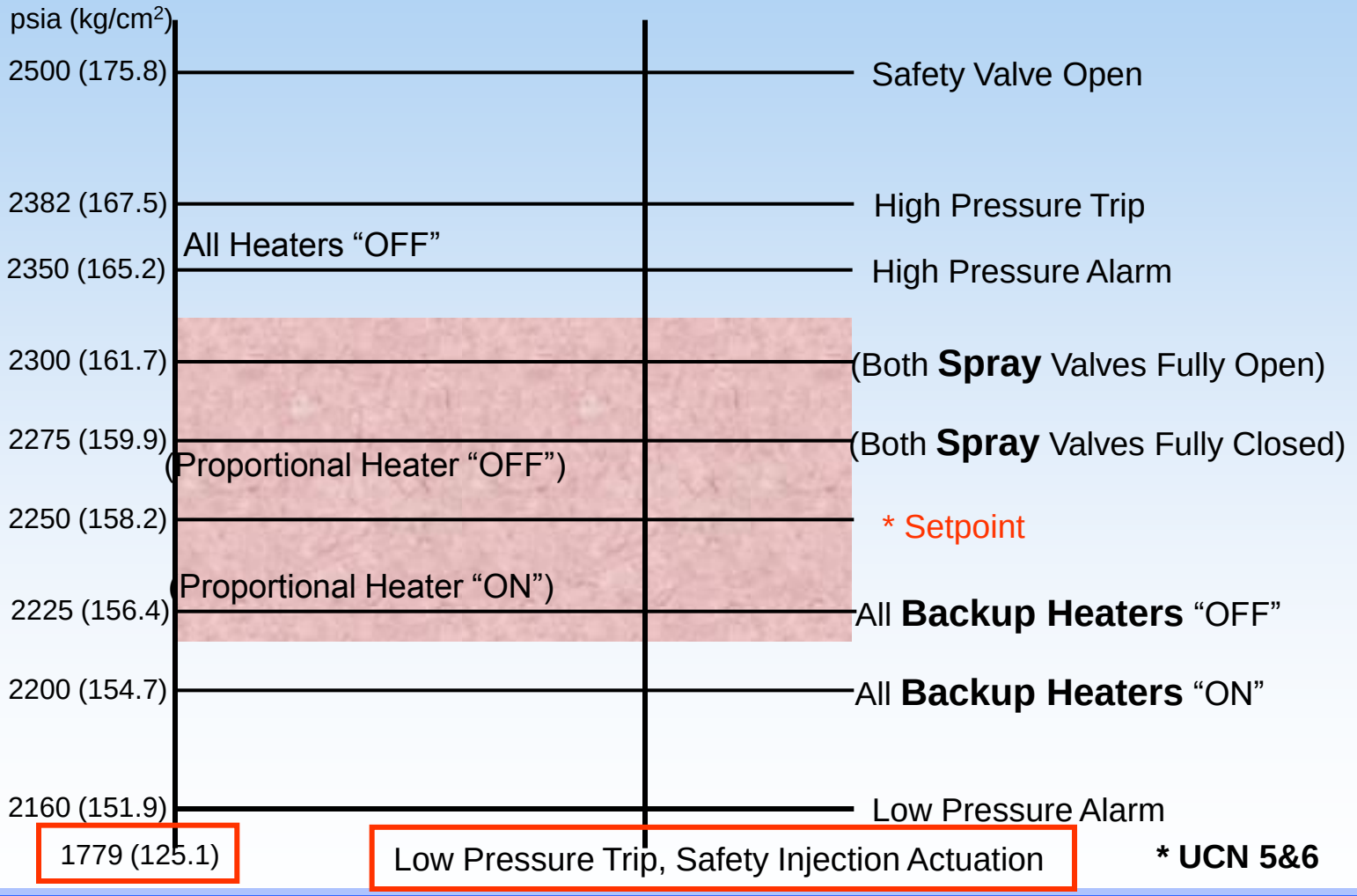


Spray

Heater

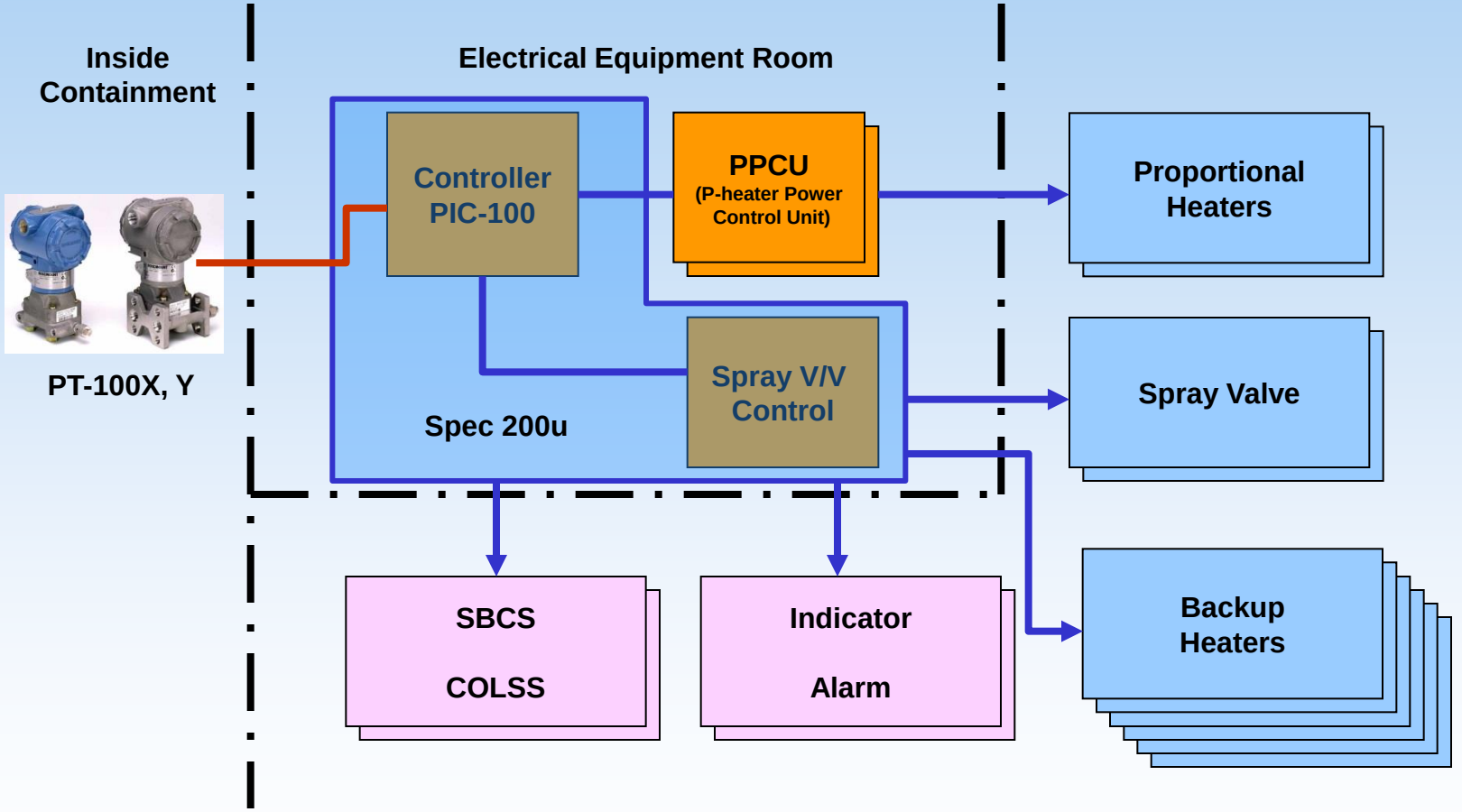
Pressurizer Pressure Control System

□ PPCS setpoint



Pressurizer Pressure Control System

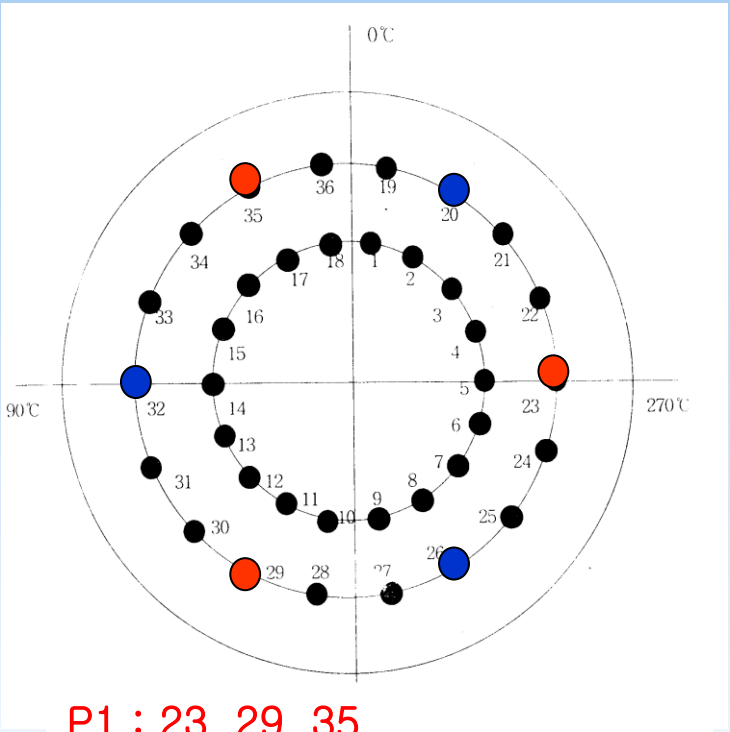
□ PPCS



Pressurizer Pressure Control System

□ PPCS - heaters

Bank	Element	Capa.	Power Supply
P-1	3	150 kw	Non-1E
P-2	3	150 kw	Non-1E
B-1	3	150 kw	1E
B-2	3	150 kw	1E
B-3	6	300 kw	Non-1E
B-4	6	300 kw	Non-1E
B-5	6	300 kw	Non-1E
B-6	6	300 kw	Non-1E



P1 : 23, 29, 35
P2 : 20, 26, 32
B1 : 5, 28, 36
B2 : 14, 27, 19
B3 : 31, 7, 4, 9, 2, 34
B4 : 6, 33, 3, 8, 1, 30
B5 : 25, 11, 18, 22, 16,13
B6 : 21, 10, 17, 15, 24,12

1800kw to maintain sub-cooled margin just with RCP

1E : to maintain PZR P in case of LOV

P-1,2 : Proportional Control

B : On-Off

Pressurizer Pressure Control System

□ Operations

- Automatic Mode
  - Normal condition
    - Proportional heater : approximately 50% energized
    - Backup heater : OFF
    - Spray control valve : CLOSE
    - Bypass spray flow : approximately 3 gpm, continuous spray flow
  - When Pressure decreased,
    - Proportional heater power increase
    - If the full power of proportional heaters is not sufficient, energizes the backup heaters to provide additional heat input

Pressurizer Pressure Control System

- Operations
  - Automatic Mode
    - When pressure increased,
      - Proportional heater power decreases
      - If the pressure continuous to increase after the heaters are completely OFF, opens the proportionally controlled spray valves (maximum flow : 375 gpm)
    - All heaters are protected against operating while not fully submerged in liquid coolant by means of the low level interlock
  - Manual Mode
    - Plant startup/shutdown
    - Automatic controller failure

- Fundamentals of I&C Systems
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  - **Pressurizer Level Control System**
- IAEA Safety Standard for Plant Control Systems

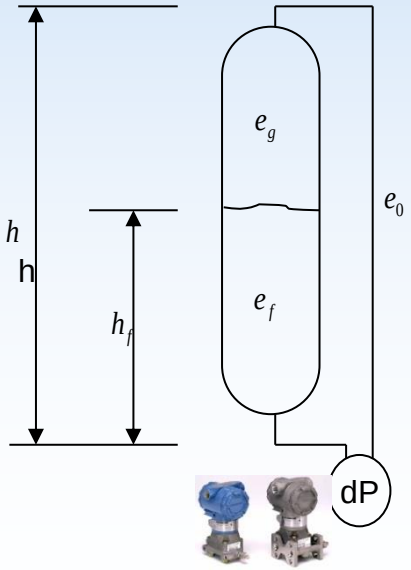
Pressurizer Level Control System

□ PLCS

- Minimizes changes in RCS coolant inventory
  - by using the charging pumps and letdown control valves in the chemical and volume control system (CVCS)

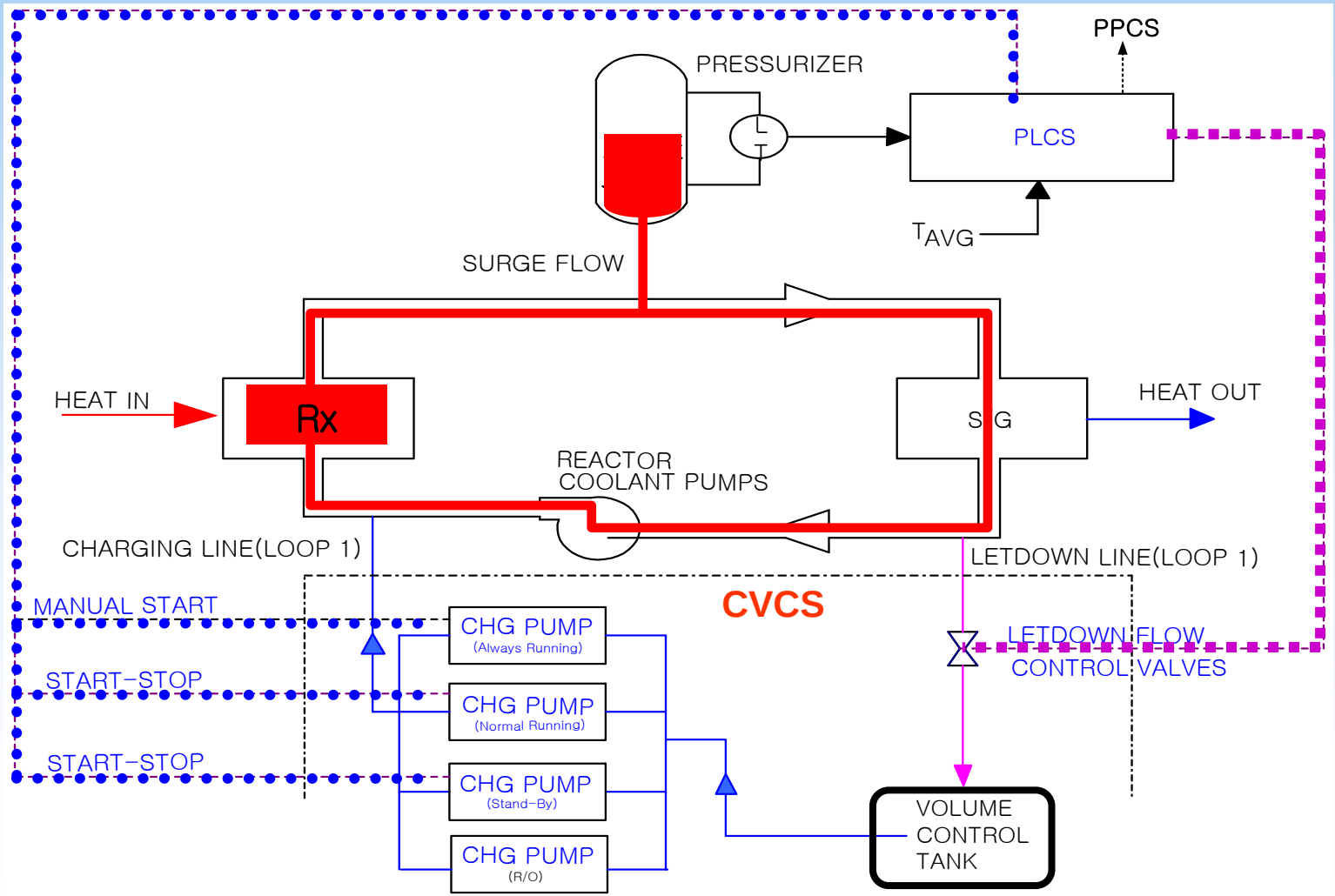
- Maintaining a vapor volume in the pressurizer to accommodate surges during transients

$$h_f = \frac{\rho_0 h - \rho_g - \Delta P}{\rho_f - \rho_g}$$



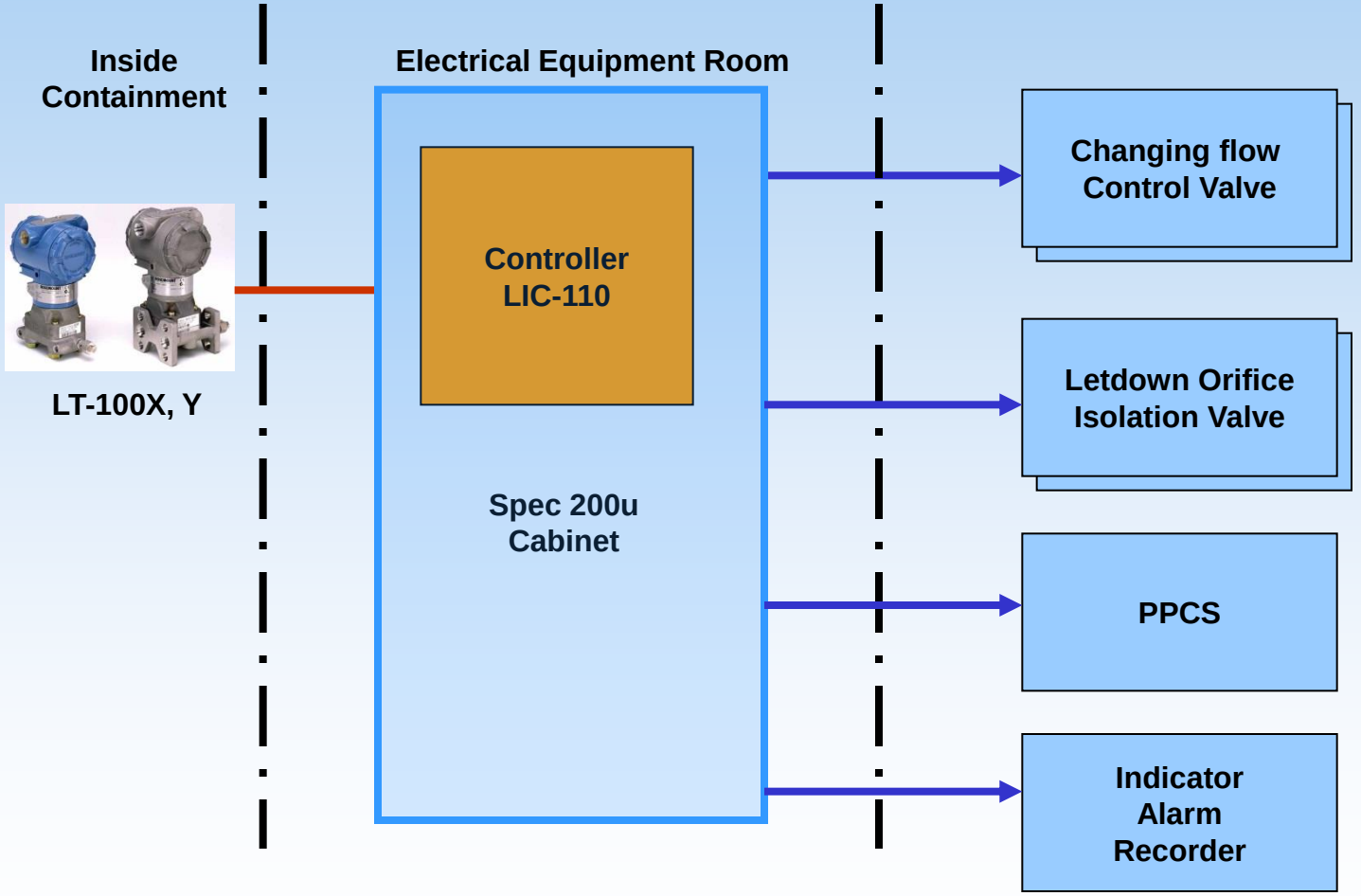
Pressurizer Level Control System

□ PLCS



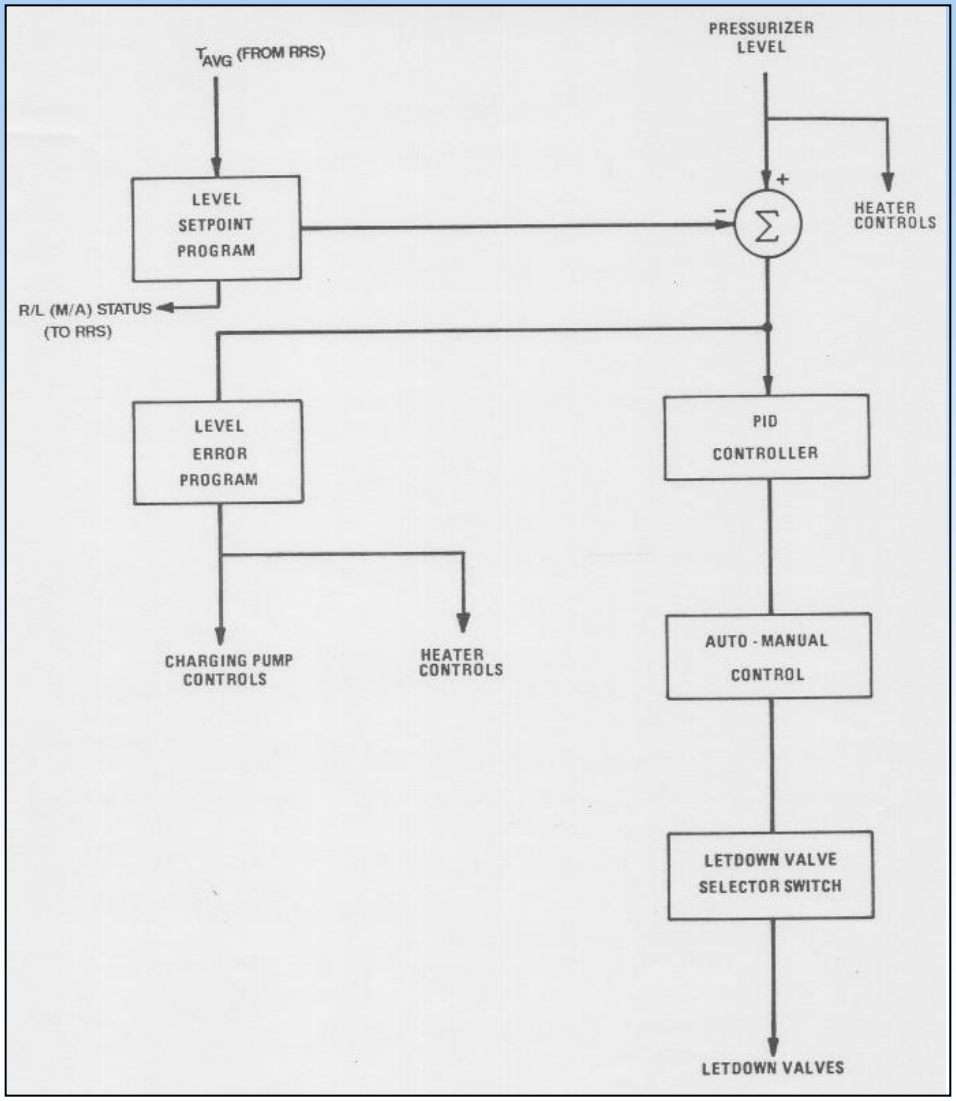
Pressurizer Level Control System

□ PLCS



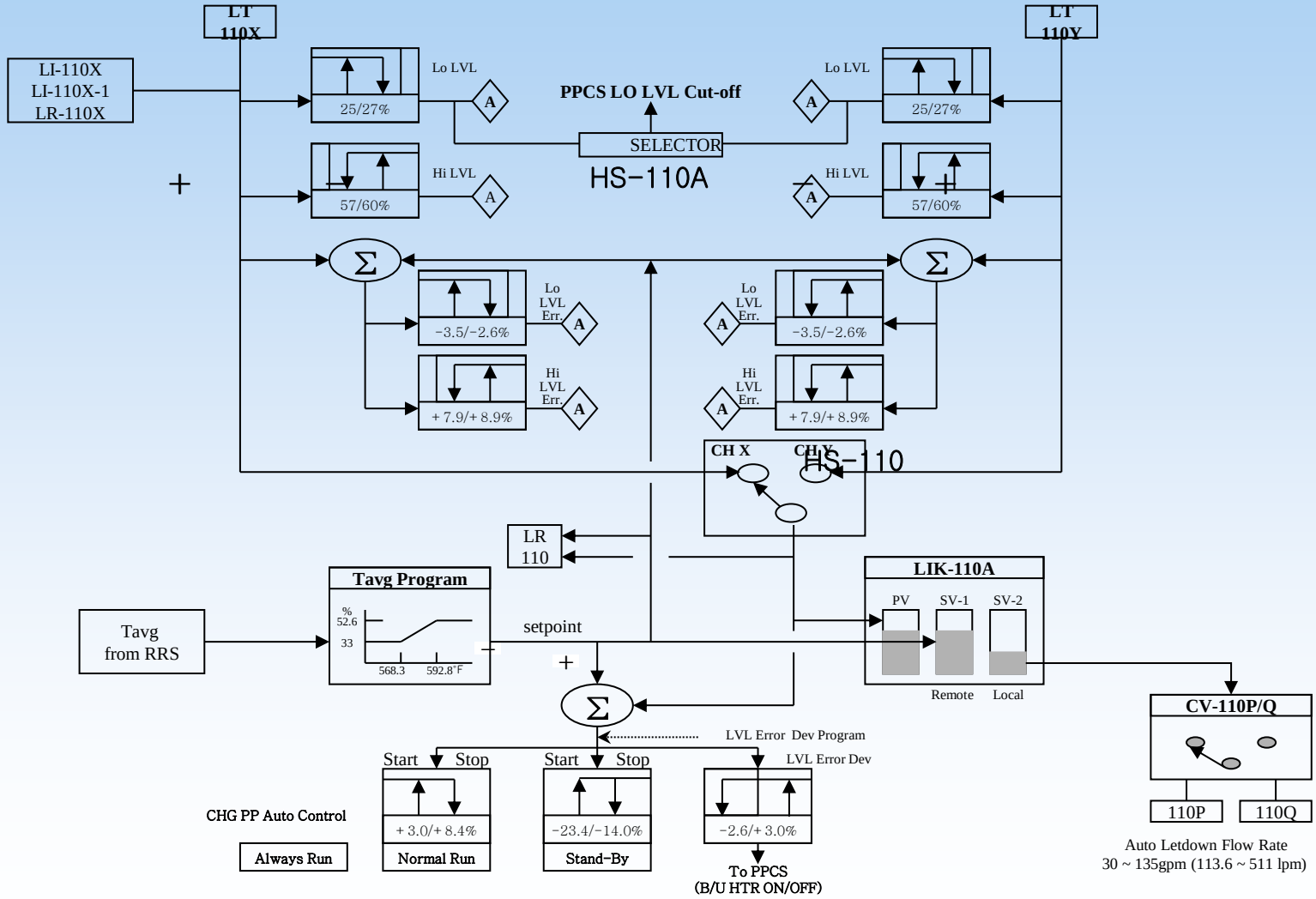
Pressurizer Level Control System

- PLCS



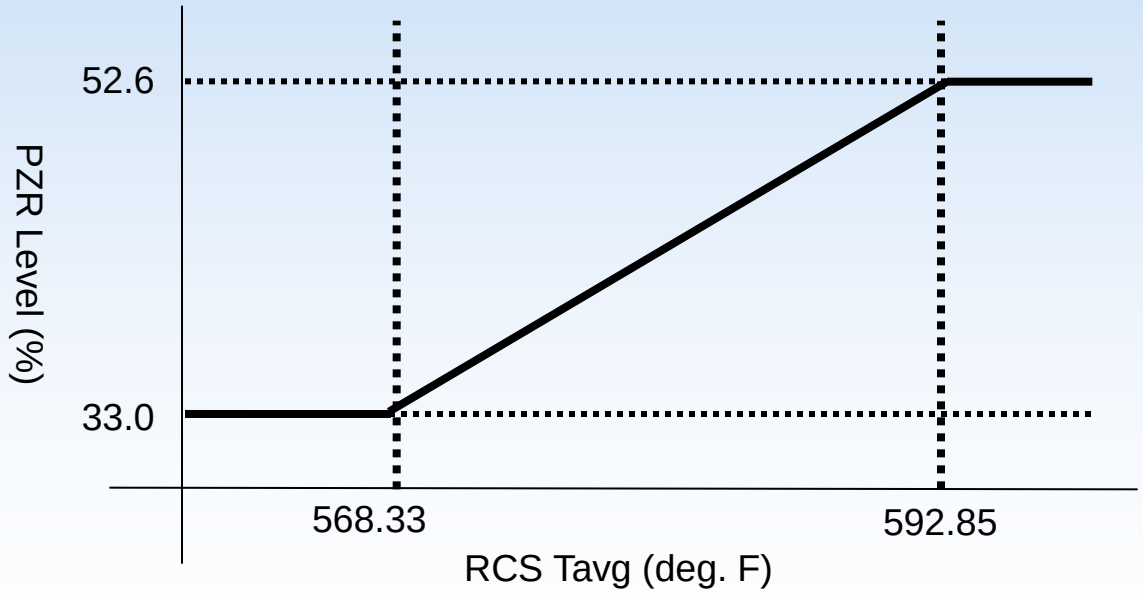
Pressurizer Level Control System

□ PLCS



Pressurizer Level Control System

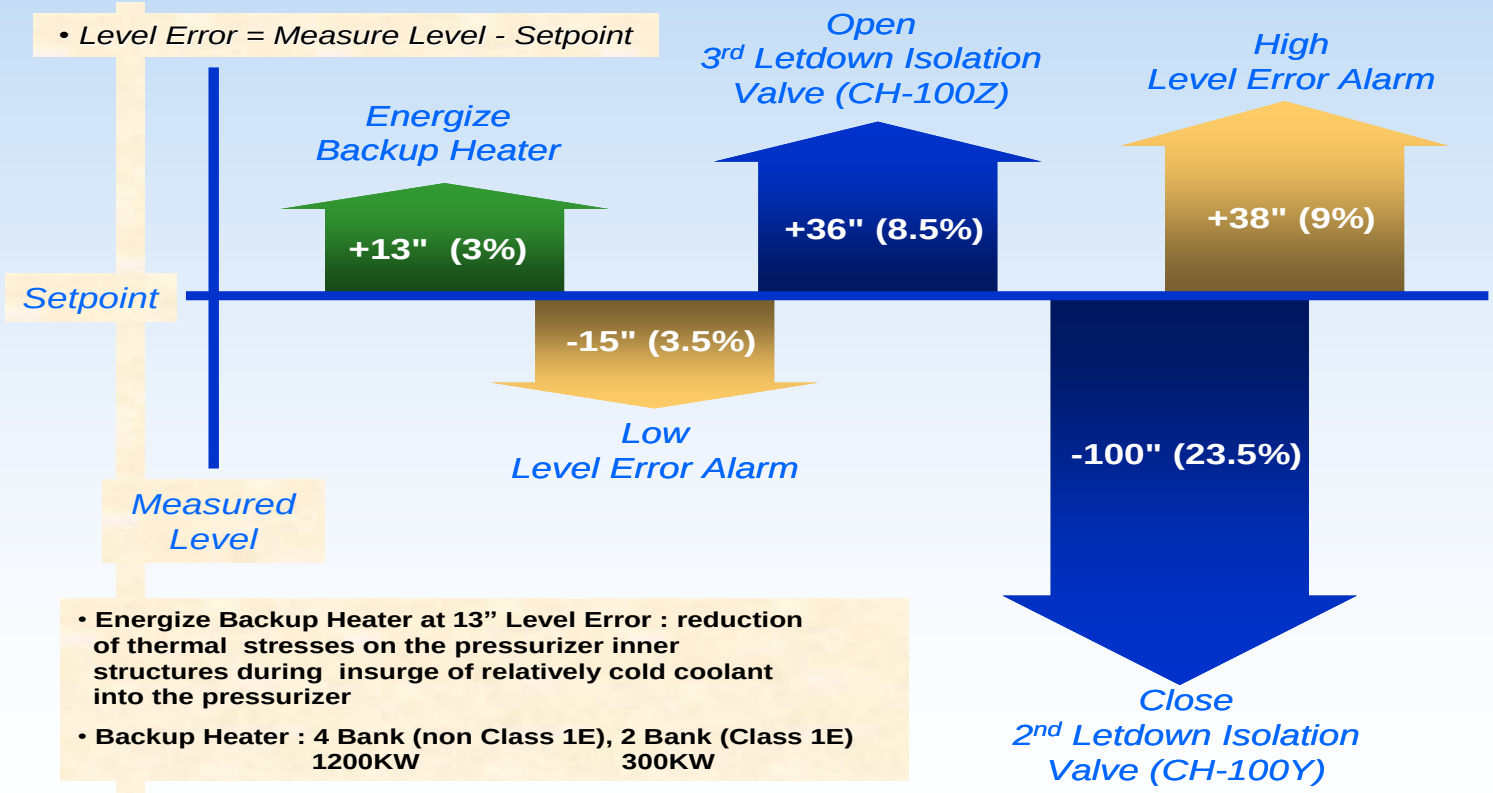
- PLCS
  - Level Setpoint
    - Manually setting or,
    - Generated by function generator
      - RCS Tavg



Pressurizer Level Control System

□ PLCS

- Level Error Program
  - Controls charging pump and heater
  - To PID controller to control letdown valve



Pressurizer Level Control System

- PLCS
  - Design requirements
    - Maintain PZR level within specified limits (33 – 52.6%) during normal operation
    - Two PZR level signals
    - Operator can select one channel for automatic control
    - Provides PZR level-low signal to PPCS to protect heaters

Pressurizer Level Control System

- PLCS
  - Operations
    - Automatic Mode
      - Two charging pumps operation : Always Running Pump / Normally Running Pump
      - Only one letdown valve is operable in automatic mode
      - If PZR level decreases, letdown valve closed
      - If PZR level continuous decrease after letdown valve close, start Standby pump
      - When the level error reaches 0(zero), then stop Standby Pump and open letdown valve until charging flow is equal to letdown flow
    - Manual Mode
      - Letdown valve manual operation
        - » When the controller is not operable, operate letdown valve manually
      - Charging pump manual operation
        - » Manual switching station for charging pump
        - » Ignore control signals except interlock signal for equipment protection

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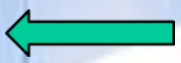
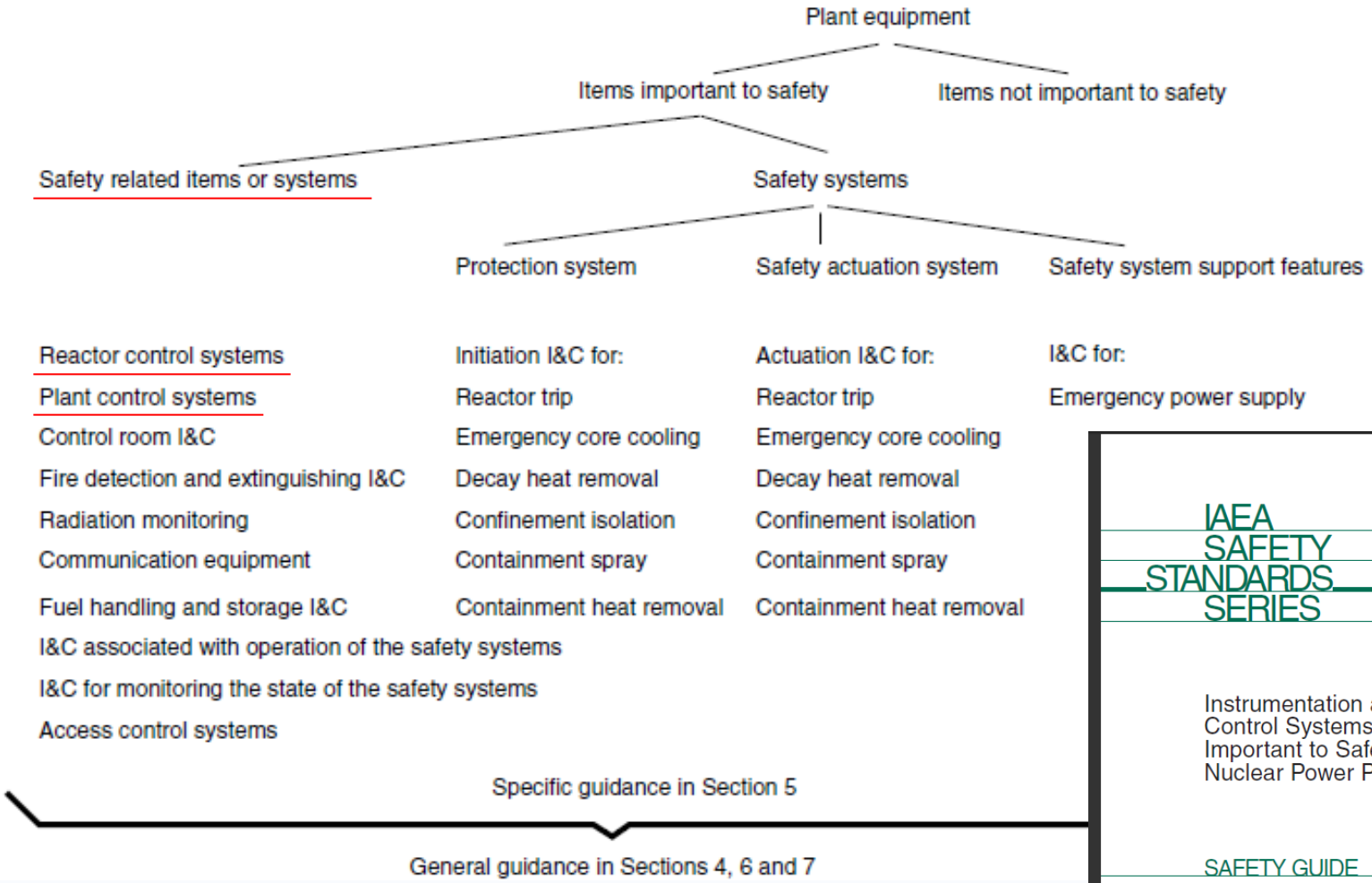


Classification of Control System_ NS-G-1.3



*** In this context, an 'Item' is a structure, system or component**

Requirements related with Control Systems

- **Requirement 7: Application of defence in depth**
  design of a nuclear power plant shall incorporate defence in depth. The levels of defence in depth shall be independent as far as practicable.

- **Requirement 14: Design basis for items important to safety**

  The design basis for items important to safety shall specify the necessary capability, reliability and functionality for the relevant operational states, for accident conditions and for conditions arising from internal and external hazards, to meet the specific acceptance criteria over the lifetime of the nuclear power plant.

Requirements related with Control Systems

- **Requirement 22: Safety classification**

  All items important to safety shall be identified and shall be classified on the basis of their function and their safety significance.

- **Requirement 23: Reliability of items important to safety**

  The reliability of items important to safety shall be commensurate with their safety significance.

- **Requirement 24: Common cause failures**

  The design of equipment shall take due account of the potential for common cause failures of items important to safety, to determine how the concepts of diversity, redundancy, physical separation and functional independence have to be applied to achieve the necessary reliability.

Requirements related with Control Systems

- **Requirement 26: Fail-safe design**

  The concept of fail-safe design shall be incorporated, as appropriate, into the design of systems and components important to safety.

- **Requirement 29: Calibration, testing, maintenance, repair, replacement, inspection and monitoring of items important to safety**

  Items important to safety for a nuclear power plant shall be designed to be calibrated, tested, maintained, repaired or replaced, inspected and monitored as required to ensure their capability of performing their functions and to maintain their integrity in all conditions specified in their design basis.

- **Requirement 30: Qualification of items important to safety**

  A qualification programme for items important to safety shall be implemented to verify that items important to safety at a nuclear power plant are capable of performing their intended functions when necessary, and in the prevailing environmental conditions, throughout their design life, with due account taken of plant conditions during maintenance and testing.

Requirements related with Control Systems

- **Requirement 39: Prevention of unauthorized access to, or interference with, items important to safety**

  Unauthorized access to, or interference with, items important to safety, including computer hardware and software, shall be prevented.

- **Requirement 59: Provision of instrumentation**

  Instrumentation shall be provided for determining the values of all the main variables that can affect the fission process, the integrity of the reactor core, the reactor coolant systems and the containment at the nuclear power plant, for obtaining essential information on the plant that is necessary for its safe and reliable operation, for determining the status of the plant in accident conditions and for making decisions for the purposes of accident management.

Requirements related with Control Systems

- **Requirement 60: Control systems**

  Appropriate and reliable control systems shall be provided at the nuclear power plant to maintain and limit the relevant process variables within the specified operational ranges.

- **Requirement 62: Reliability and testability of instrumentation and control systems**

  Instrumentation and control systems for items important to safety at the nuclear power plant shall be designed for high functional reliability and periodic testability commensurate with the safety function(s) to be performed.

- **Requirement 63: Use of computer based equipment in systems important to safety**

  If a system important to safety at the nuclear power plant is dependent upon computer based equipment, appropriate standards and practices for the development and testing of computer hardware and software shall be established and implemented throughout the service life of the system, and in particular throughout the software development cycle. The entire development shall be subject to a quality management system.

Requirements related I&C

- **Requirement 64: Separation of protection systems and control systems**

  Interference between protection systems and control systems at the nuclear power plant shall be prevented by means of separation, by avoiding interconnections or by suitable functional independence.

- **Requirement 65: Control room**

  A control room shall be provided at the nuclear power plant from which the plant can be safely operated in all operational states, either automatically or manually, and from which measures can be taken to maintain the plant in a safe state or to bring it back into a safe state after anticipated operational occurrences and accident conditions.

Requirements related I&C

- **Requirement 66: Supplementary control room**

Instrumentation and control equipment shall be kept available, preferably at a single location (a supplementary control room) that is physically, electrically and functionally separate from the control room at the nuclear power plant. The supplementary control room shall be so equipped that the reactor can be placed and maintained in a shutdown state, residual heat can be removed, and essential plant variables can be monitored if there is a loss of ability to perform these essential safety functions in the control room.

- **Requirement 67: Emergency control centre**

An on-site emergency control centre, separate from both the plant control room and the supplementary control room, shall be provided from which an Emergency response can be directed at the nuclear power plant.

Conclusion

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- Overview of Plant Control Systems
- Control Systems Design and Requirements;
  - NSSS Control Systems
  - Pressurizer Pressure Control System
  - Pressurizer Level Control System
- IAEA Safety Standard for Plant Control Systems

All had be done.
The rest is to raise the safety of NPPs by your head, hands, and heart.
The NPPs' safety is up to you !!!

Always we keep watching
our Atomic Power

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Thank You

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