CONSIDERATION OF THE AIR VENTILATION AND CLEANING SYSTEM FOR A RESEARCH REACTOR

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Characteristics of HANARO

http://www.mest.go.kr

Specification of the Reactor

- Type: Open Tank-in-Pool
- Thermal Power: 30 MW
- Max Thermal Flux: 4.5E14 n/cm^2-s
- Fuel: LEU(19.75% w/o ^{235}U) U_3Si-Al Meat, Al Clad
- Coolant/Moderator/Reflector: H_2O/(H_2O,D_2O)/D_2O
- Absorber: Hafnium

Reactor Building HVAC System(1/2)

- Design Requirement
  - At all time, negative pressure relative to the atmosphere to be maintained
  - Positive air flow from low contamination area to highly contaminated area(Once-through system)
  - To maintain the temperature and humidity within the operating limit in the reactor hall and controlled area
  - Confinement Isolation Valves to isolate the airflow in and out from the reactor hall
    - Isolation valve: safety class 3, seismic category 1
  - Non Safety, Non seismic category

Reactor Building HVAC System(2/2)

- Classification of Radiation Zone

Classification	Dose Rate	Area	Pressure
6000	≤6.25 uSv/hr	Uncontrolled Area	Atm.
8000	≤ 500 uSv/hr	Reactor Hall & Support Area	– 3.8mmWg or more
9000	≥500 uSv/hr	RCI Equipment Room	– 6.5mmWg or more

- Temperature & Relative Humidity
  - 20~27 ° C, 50±10% RH
- AIR EXCHANGE RATE
  - 1(one)/hour

Requirements of Engineered Safety Feature(1/2)

- Reactor Building of HANARO
  - Confinement & Safety grade Confinement Isolation Damper
    - Leakage Rate: ≤600m³/hr @25mmWg ΔP
  - Emergency Ventilation System
- Code Requirements of emergency Ventilation system
  - Power Reactor
    - Korea: Nuclear Safety Act (Decree Article 5.3.6)
      - Engineered Safety Features
      - Containment
    - U.S.A.
      - 10 CFR Part 50, Appendix A, Nuclear Power Plants GDC 41, 42, 43: Atmosphere Cleanup System
      - Reg. Guide 1.52

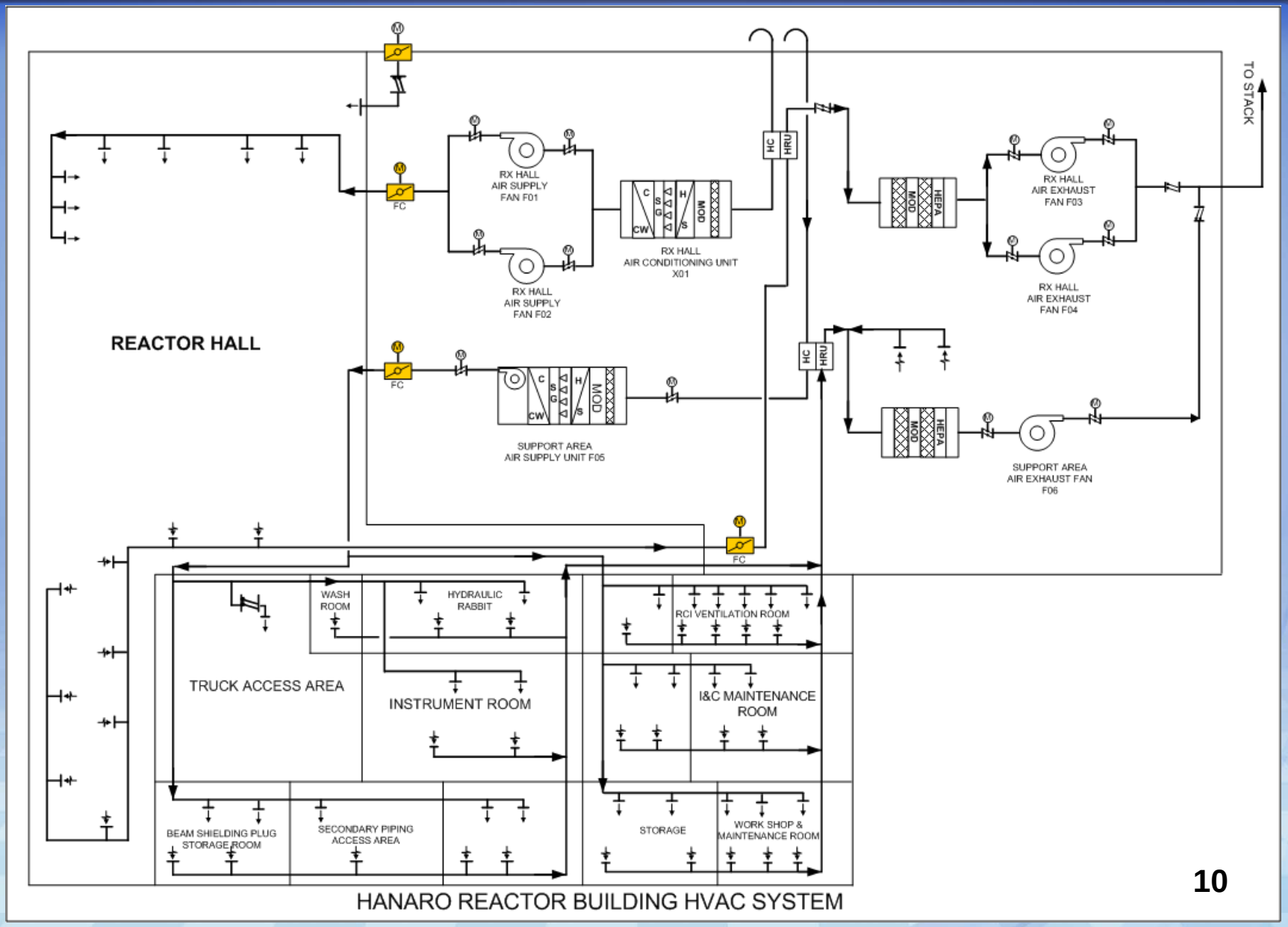
Requirements of Engineered Safety Feature(1/2)

- Code Requirements (Continued)
  - Research Reactor
    - Korea
      - Nuclear Safety Act 30.2 & Decree Article 29.4 (Application of Construction Permit & Operating License of Research Reactor)
        - Radiological Environmental Impact Analysis, Technical Specification, Safety Analysis Report, and Quality Assurance Program.
        - Decree Article 5.3.6 (Preliminary Safety Analysis Report)
          - ✓ Engineered Safety Feature
          - ✓ Containment/Confinement
          - ✓ Emergency Core Cooling
          - ✓ …
    - U.S.A
      - 10CFR Appendix A to Part 50, GDC 41,42, 43
        - Containment Atmosphere Cleanup System for Production and Utilization Facility

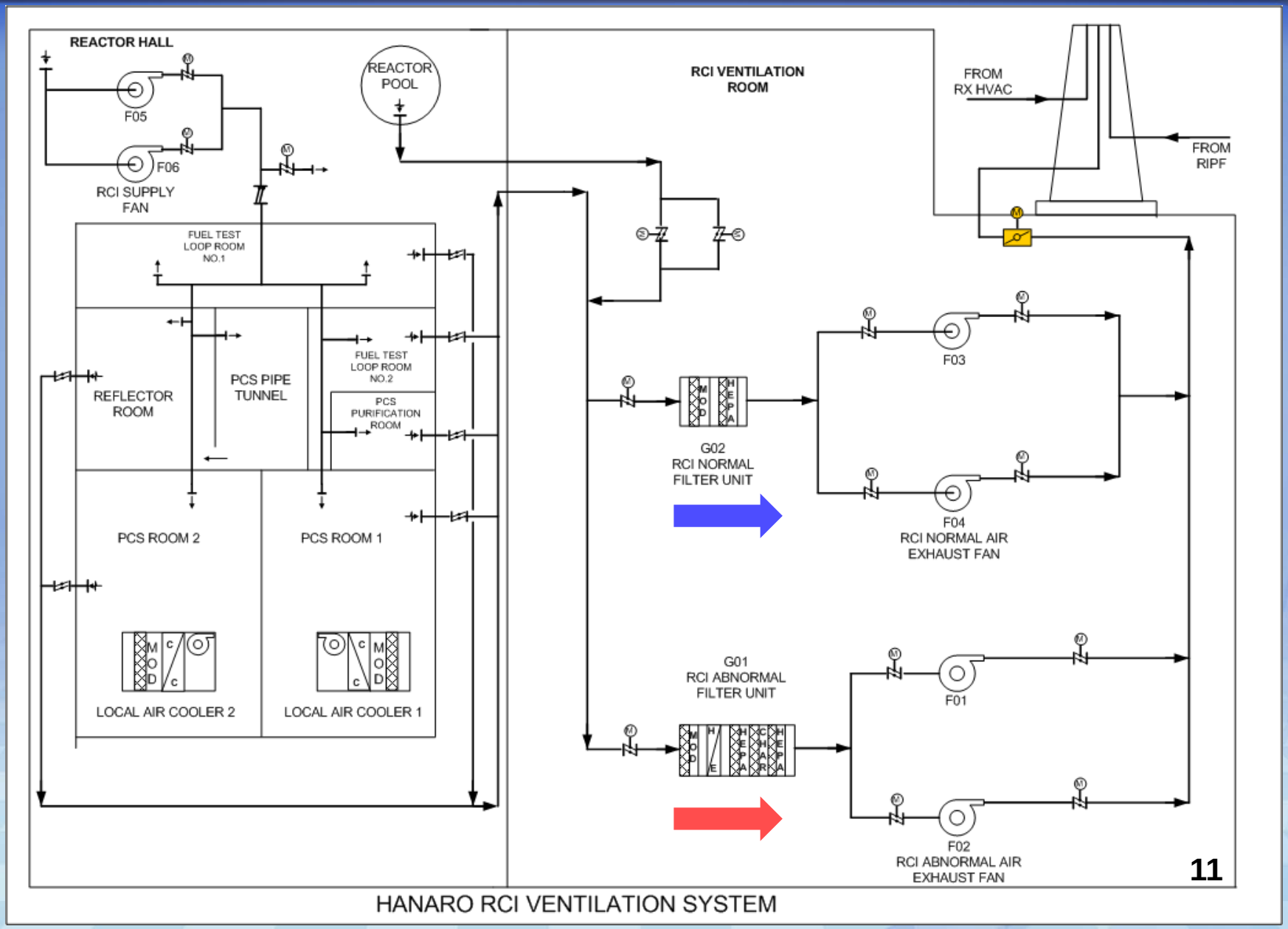
Emergency Ventilation System

- Design Requirements
  - Reactor Building inside Vacuum(P_s) ≥ 25mmwg relative to the confinement outside when EVS is operating
  - Air exhaust through the HEPA/Charcoal Filter Bank on detection of high radiation
  - Standby Exhaust Fan for Redundancy
    - Duplication of actuation signal detecting instrument
  - Prohibition of reverse flow caused by single component failure
    - Back draft damper & isolation damper on fan inlet/outlet
  - Controlled Release through the stack → Mitigation of radioactivity by diffusion
  - Electric Power back up by EDG

HANARO REACTOR BUILDING HVAC SYSTEM



HANARO RCI VENTILATION SYSTEM



HANARO RCI VENTILATION SYSTEM

Operation of Emergency Ventilation System(1/2)

- Initiating events
  - Pool Surface Radiation High
  - Failed Fuel Detection
  - RCI Exhaust Duct Radiation High
- Operation
  - Normal: Reactor Building Ventilation ON & RCI Normal Ventilation ON
  - Abnormal: Reactor Building Ventilation OFF & RCI Abnormal Ventilation ON (Controlled Release to Atmosphere thru Charcoal Filter & Stack)
  - In case of exceeding Derived Release Limit
    - Isolation of air inside confinement by closing the confinement isolation damper and shutting down the emergency ventilation system

Operation of Emergency Ventilation System(2/2)

- Surveillance Test
  - period: every 18 months
  - Procedure
    - Operation of EVS for 10 hrs
    - Electric Heater Test in Filter Housing
    - Testing of Confinement Isolation Dampers
    - Measurement of Confinement Internal Pressure
      - Vacuum 25mmWg or greater
    - In-place Leakage Test for Adsorber
      - Removal efficiency: Halide 99.95% or greater
    - In-place Leakage Test for HEPA filter
      - Aerosol removal efficiency: 99.95% or greater
    - Lab Testing of sample of activated carbon (by ASTM D3803-89)

Characteristics of JRTR

http://www.mest.go.kr

Specification of the Reactor

- Type: Open Tank–in–Pool
- Thermal Power: 5 MW
- Max. Thermal Neutron Flux :
  - $1.5 \times 10^{14} n/cm^2 \cdot s$ (Core area)
  - $0.4 \times 10^{14} n/cm^2 \cdot s$ (Reflector area)
- Fuel Element Type and Material :
  - Plate Type
  - $U_3Si_2 - Al$, (19.75% enrichment)
- Reflector: Be/Graphite

JRTR Reactor Building HVAC System (1/2)

- Design Requirements
  - Positive air flow from low contamination area to high contamination area (Flow & Negative Pressure Control)
  - Once-through system
  - To maintain comfortable environmental conditions such as temperature, humidity and cleanliness, and to prevent overheating of equipment and control panel
  - Non Safety Grade & Non Seismic Category
  - Only Confinement Isolation Damper is Safety Class 3, Seismic Category 1, Quality Class Q
    - To isolate the confinement during Design Basis Accident (keeping the airborne contaminants inside confinement)

JRTR Reactor Building HVAC System (2/2)

- **Outside Air** (by ASHRAE Fundamental 2009)

	Summer	Winter
Temperature	34.3 ℃ DB	2.0 ℃ DB
Humidity	22% RH	99% RH

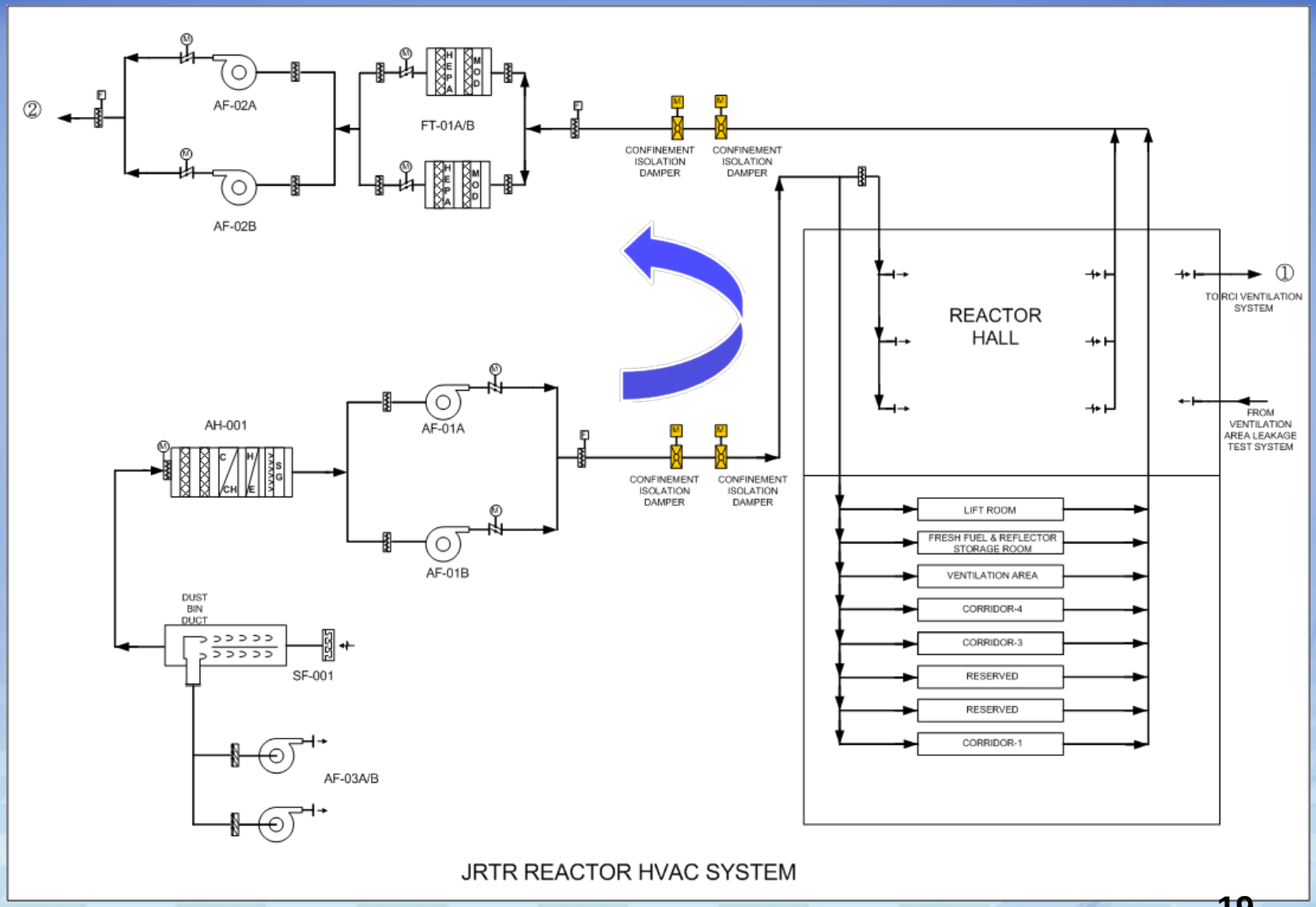
- **Design Requirement of Reactor Building Inside**

	Summer	Winter
Temperature	26 ℃ DB	21 ℃ DB
Humidity	40% RH	40% RH

JRTR RCI Ventilation System

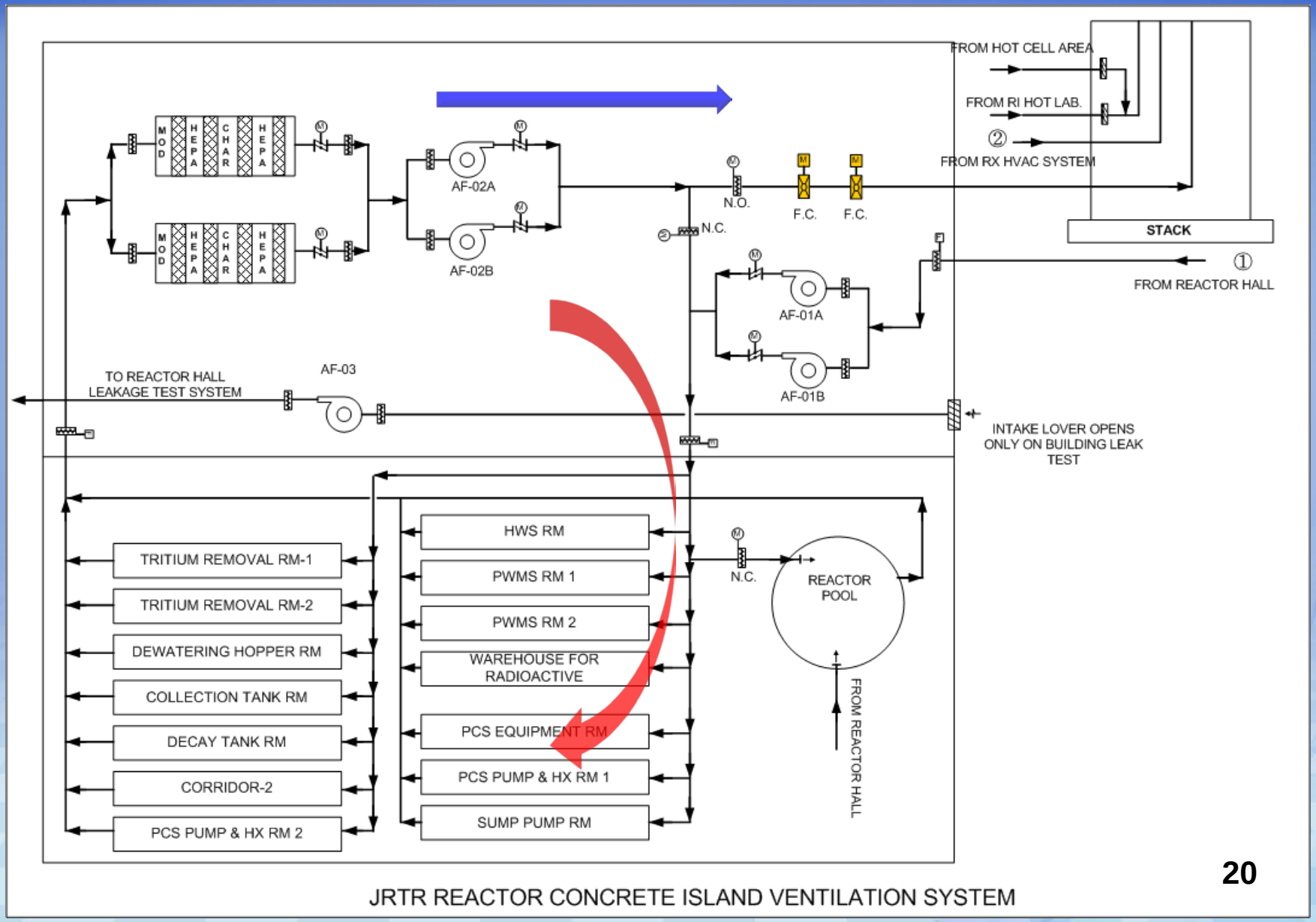
- Design Requirements
  - Negative Pressure Control between RCI & Reactor Hall
    - To maintain positive air flow from Reactor Hall to RCI at all time
  - Once-through system
  - Reactor pool top air to be exhausted through RCI ventilation system
  - 2x100% Supply Air Fan, 2x100% Exhaust Air Fan, 2x100% Filtration Unit(w/Charcoal Adsorber)
  - Non Safety, Non Seismic Class
  - Only Confinement Isolation Dampers are Safety Class 3, Seismic Category 1, Quality Class Q
    - Isolation of the confinement from environment during DBA (keeping the effluent inside the confinement)

JRTR REACTOR BUILDING HVAC SYSTEM



JRTR REACTOR HVAC SYSTEM

JRTR RCI VENTILATION SYSTEM



JRTR REACTOR CONCRETE ISLAND VENTILATION SYSTEM

Operation (1/2)

- Emergency Ventilation System: Not designed*
- Operation of ventilation system
  - Normal: Reactor Building Ventilation ON & RCI Ventilation ON
  - Abnormal: Reactor Building Ventilation OFF & RCI Ventilation OFF
    - Confinement Isolation Damper closed
  - Initiating Event of Confinement Isolation Damper Closure
    - Reactor Hall Fire Alarm
    - Reactor Pool Top High Radiation (RPS trip signal)
    - Failed Fuel Monitoring System High Alarm (RPS trip signal)

- Recently Jordan regulatory body decided to add EVS. So the design change is underway.

Operation (2/2)

- RCI Ventilation System
  - Not required to operate during DBA
    - Confinement Isolation Dampers are closed to isolate the reactor building
    - As an option, it can be operated to filter the contaminated air by recirculation mode.(TBD)

- Controlled release of the contaminated air during DBA may be allowed thru filtration system, when EVS is installed.

Proposed Design for KJRR

http://www.mest.go.kr

Specification of the Reactor

- Type: Open Tank-in-Pool
- Thermal Power: 15 MW
- Max Thermal Flux: ≥3E14 n/cm^2-s
- Fuel: LEU(≤20% enrichment) U-Mo Plate
- Coolant/Moderator: H_2O/Be
- Production of RI, Silicon Doping by NTD , Fast Neutron Irradiation for Silicon Doping

Code & Standard for KJRR Ventilation System

- ASHRAE
- U.S. NRC Reg. Guide 1.52
- U.S. NRC Reg. Guide 1.140
- ANSI/ASME N509
- ANSI/ASME N510
- KEPIC MH & ASME AG-1
- AMCA
- SMACNA

Reactor Building HVAC System (1/2)

- Design Requirements
  - Positive air flow from low to highly contaminated area (Flow & Negative Pressure Control)
  - Once-through system
  - To maintain comfortable environmental conditions such as temperature, humidity and cleanliness, and to prevent overheating of equipment and control panel
  - Non Safety Grade & Non Seismic Category
  - Only Isolation Damper is Safety Class 3, Seismic Category 1, Quality Class Q
    - To isolate the confinement from the environment during Design Basis Accident (keeping the effluent from leaking out of confinement)
    - Redundancy to avoid complete functional loss by single failure

Reactor Building HVAC System (2/2)

- **Outside Air** (Pusan,1981-2010, 30 years average data by KMA)

	Summer	Winter
Temp.	29.4 ℃ DB	- 0.6 ℃ DB
Humidity	79.9% RH	48.3% RH

- **Design Temperature for Reactor Building (TBD)**
  - To meet the guideline imposed by government regarding Energy Saving
  - To meet the New and Renewable Energy Deployment Guideline

RCI Ventilation System (1/2)

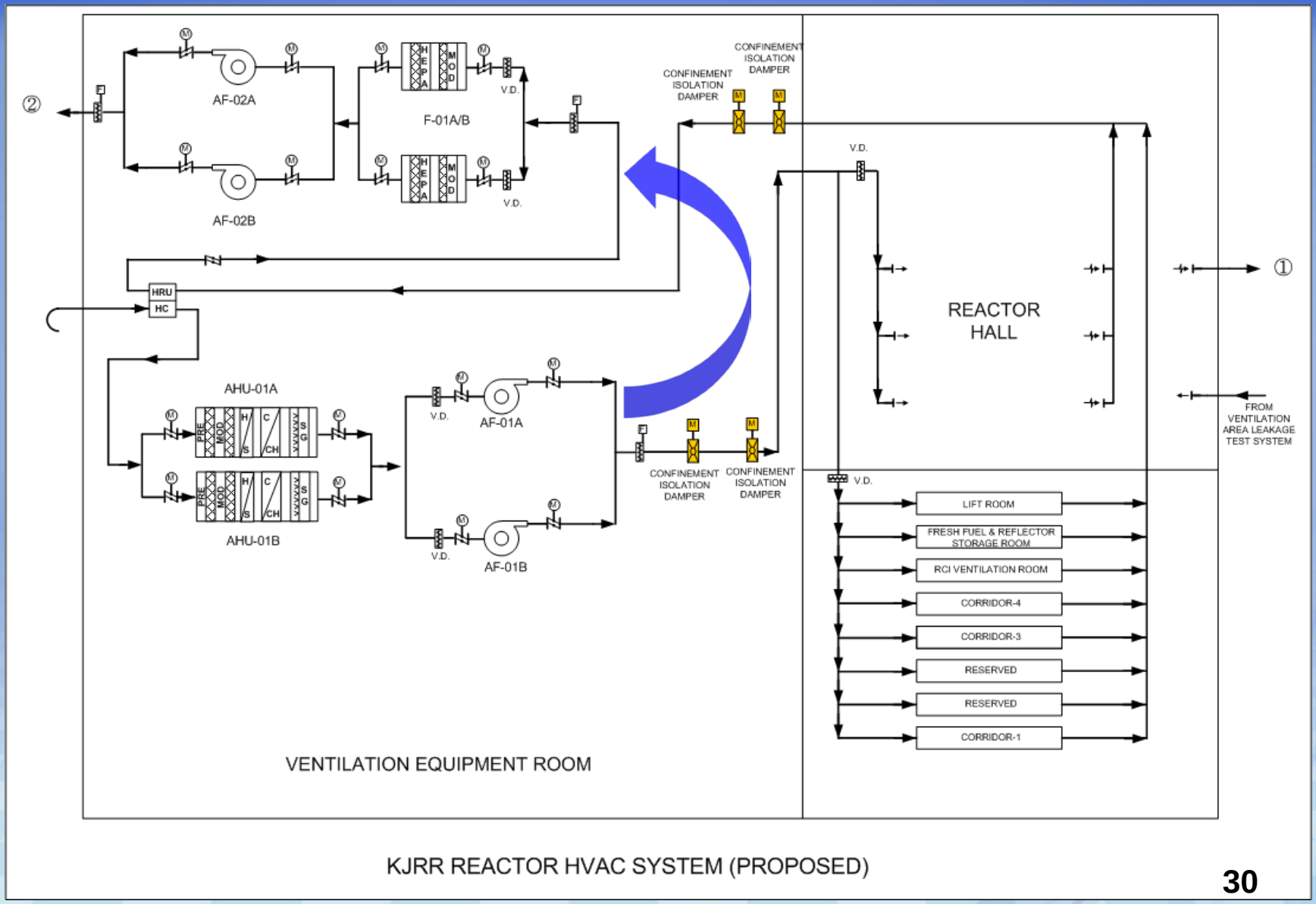
- Design Requirements
  - RCI Normal Ventilation System
    - Positive air flow from Reactor Hall to RCI area(Once-through system) by maintaining differential pressure
    - Air from RCI & Reactor Pool Top to be filtered by HEPA filter and exhausted to atmosphere thru stack
    - Redundant Intake/Exhaust fan and Filter train to avoid complete functional loss by single failure

RCI Ventilation System (2/2)

- RCI Abnormal Ventilation System (Emergency Ventilation System)
  - Redundancy
    - 2x100% Exhaust and/or Recirculation Fans, 2x100% HEPA/CHARCOAL Filtration Units
  - Non Safety, Non Seismic Category
  - Confinement Isolation Damper: Safety Class 3, Seismic Category 1, Quality Class Q
    - To prevent the leakage of contaminated air to the environment during DBA
  - In case of emergency, the contaminated air will be released thru charcoal filter train and stack
  - When DRL is exceeded, Confinement Isolation Dampers are closed and the contaminated air can be purified by recirculation mode if required.

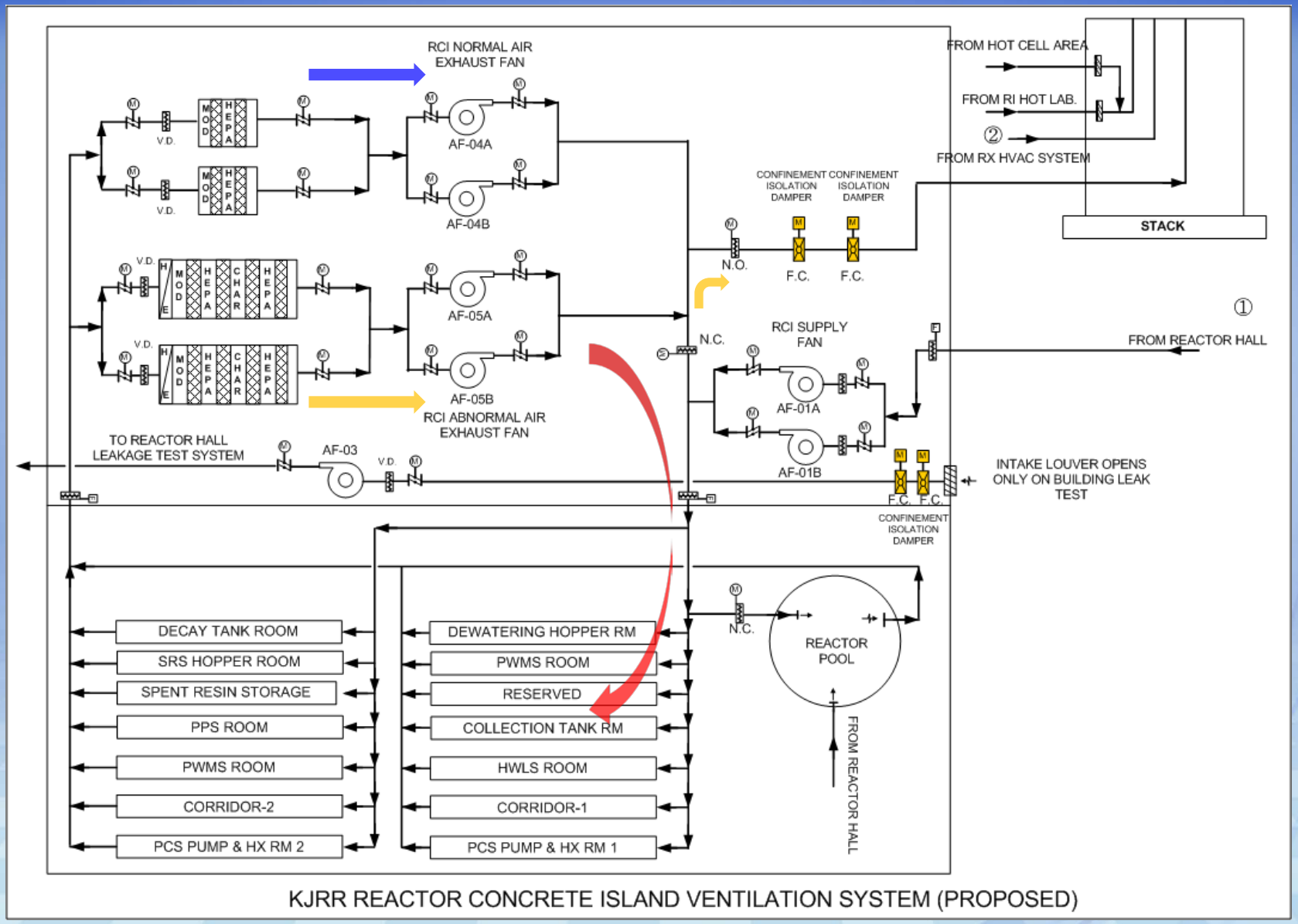
- DRL: Derived Release Limit

KJRR REACTOR BUILDING HVAC SYSTEM



KJRR REACTOR HVAC SYSTEM (PROPOSED)

KJRR RCI VENTILATION SYSTEM



KJRR REACTOR CONCRETE ISLAND VENTILATION SYSTEM (PROPOSED)

Operation of Ventilation System

- Operation of Ventilation System
  - Normal: Reactor Building Ventilation ON & RCI Normal Ventilation ON
  - Abnormal: Reactor Building Ventilation OFF & RCI Normal Ventilation OFF
    - Initial Stage: RCI Abnormal Ventilation Fan ON & Exhaust thru Charcoal Filter Train
    - When DRL is exceeded at stack: CID closed
      - Recirculation Mode ON (Contaminated air is filtered thru charcoal adsorber) if required
  - Initiating Events of RCI Abnormal Ventilation (EVS)
    - Reactor Pool Top Radiation High
    - Fuel Failure detection
    - RCI Exhaust Duct High Radiation
  - Confinement Isolation Damper is either automatically or manually closed when DRL is exceeded at stack.

Conclusion

- Emergency Ventilation System of Research Reactor
  - Not mandatory to constitute Engineered Safety Feature in Korea
  - In HANARO, EVS & CID were adopted as ESF
  - In JRTR, safety grade CID was chosen as ESF.
    - No EVS was adopted initially (Just isolation of the contaminated air in the reactor building during DBA)
    - Recently addition of EVS was decided and design change is underway
- In KJRR, safety grade CID & Non Safety Grade EVS are considered as ESF.
  - Controlled Release to Atmosphere
  - Isolation of contaminated air when DRL at stack is exceeded
  - Purification by Recirculation if required


Thank You