Reactor Control Interface Design

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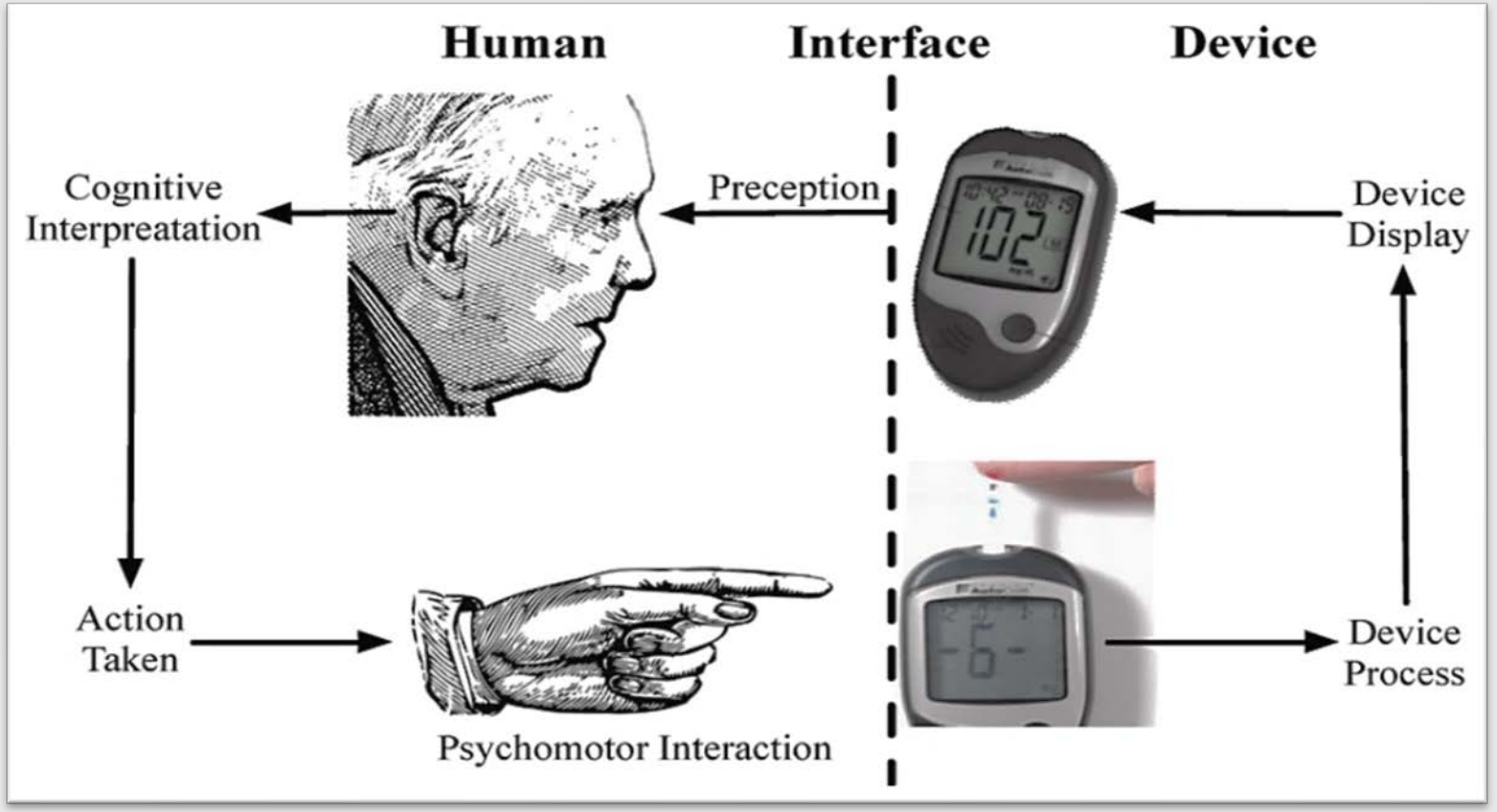
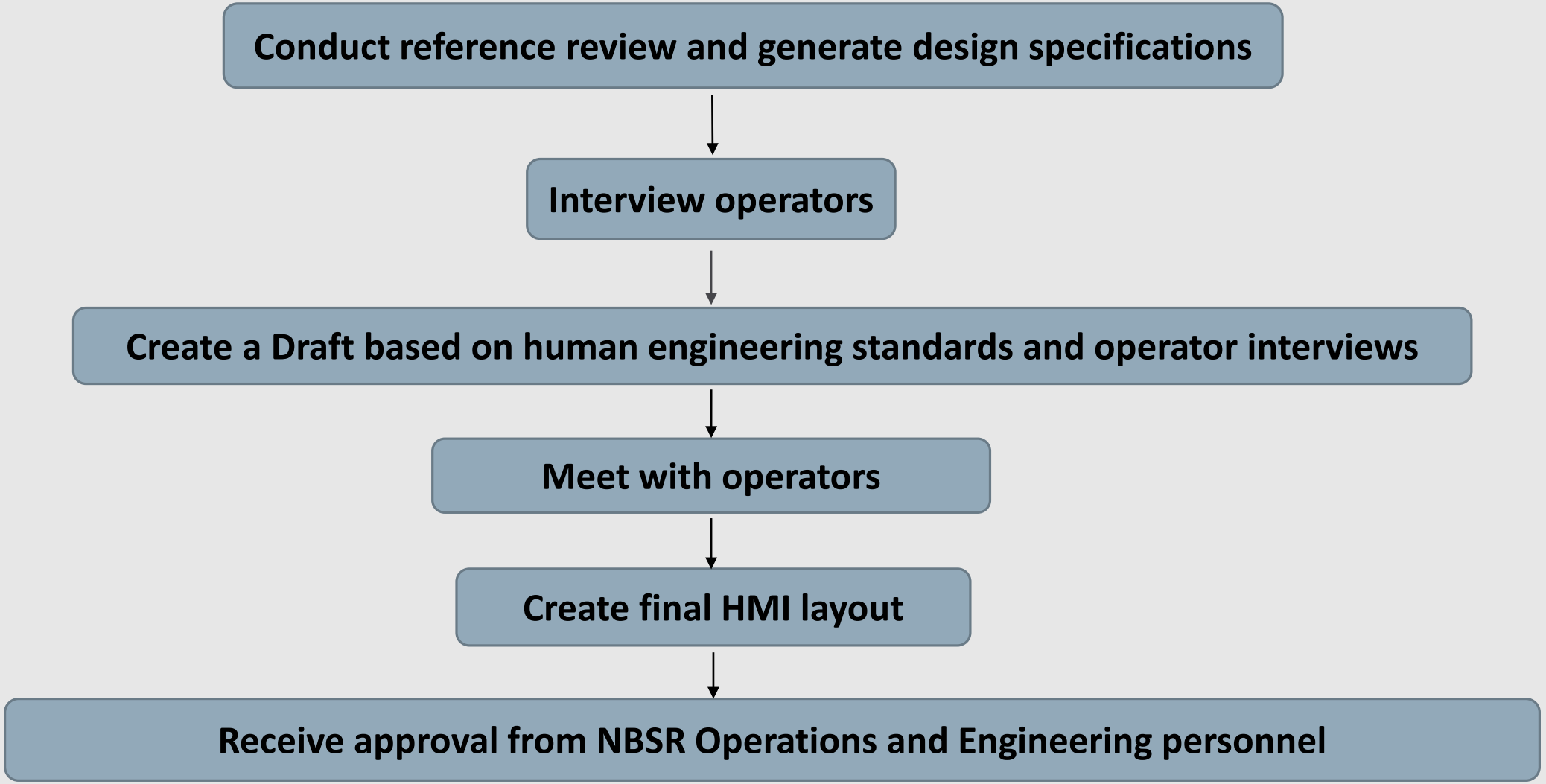
Goals

- Design a Human Machine Interface layout for the NBSR Control System
- Use 3D CAD software (SolidWorks) to generate a design
- Collectively apply reactor operator feedback and standards

Human Machine Interface



Design Approach



Guidance

- Human Factors Engineering Review Model **(NUREG-0711)**
- Department of Defense Standard Practice Human Engineering Requirements for Military Systems, Equipment, and Facilities **(MIL-STD-46855A)**
- Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria **(NUREG-1537, Part 2)**

Design Specifications

Redundant

a) Must consider redundancy in digital systems
b) Design should be able to avoid single failures

Simple

a) Use analog representations when needed since it reduces cognitive load of operator
b) Make sure displays are readily available and easy to read

Safe

a) Must go beyond guidelines to make sure design is safe
b) Design should promote less-stressful work environment and minimize operator fatigue

Design Specifications

Reliable

a) Must work with operators to understand their responsibilities and feedback

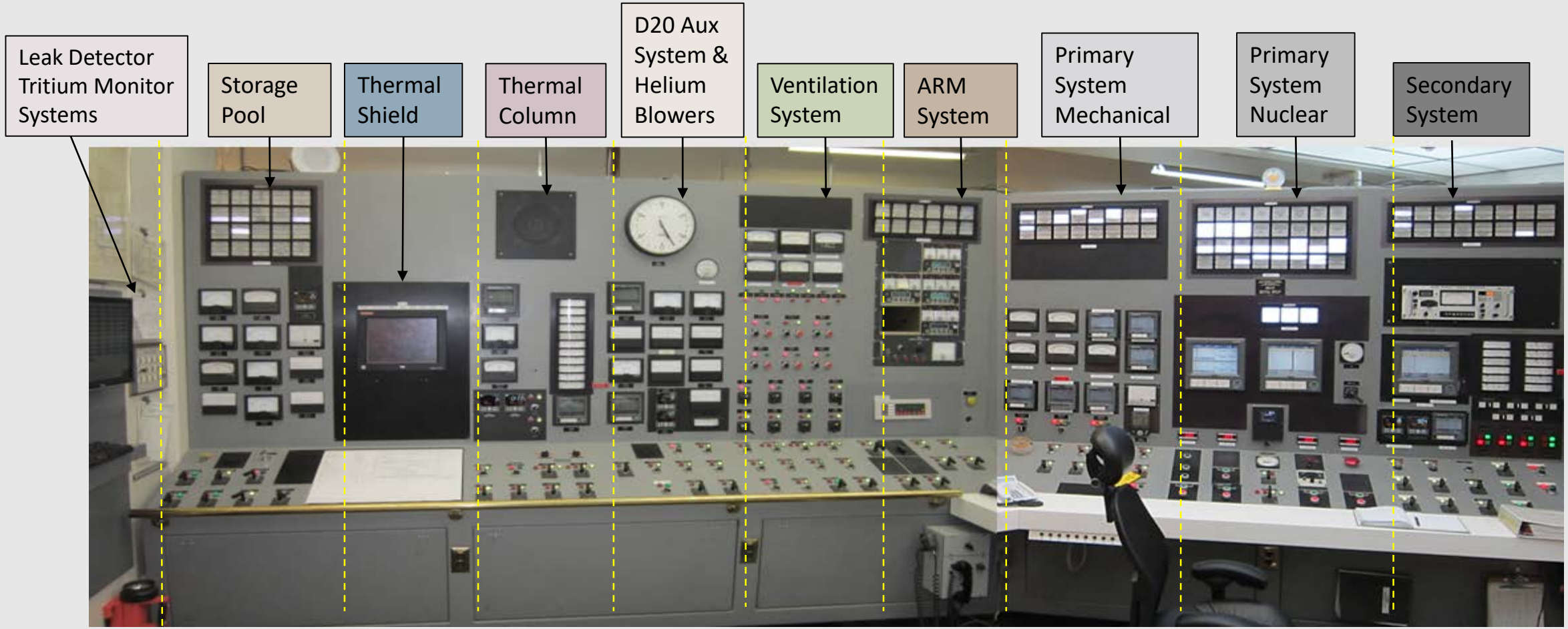
b) Must consider ways the design addresses HMI problems

Adequate

a) Must follow proper code, standards, and regulations needed for design

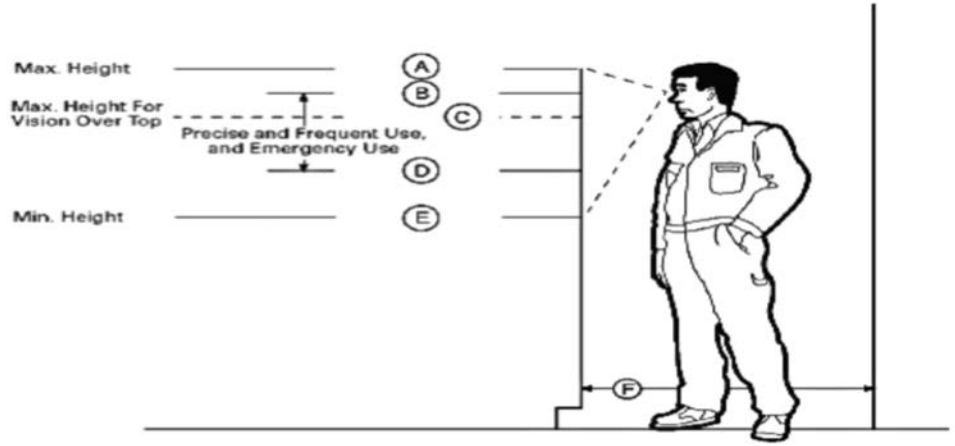
b) Must guard against common design errors

Sections


Leak Detector Tritium Monitor Systems
Storage Pool
Thermal Shield
Thermal Column
D20 Aux System & Helium Blowers
Ventilation System
ARM System
Primary System Mechanical
Primary System Nuclear
Secondary System

The Department of Defense Design Criteria Standard for Human Engineering (MIL-STD-1472G)

- Establishes general human engineering criteria for design and development of military systems , equipment, and facilities
- Control interference, spacing, consistency, grouping, control mounting height, are examples of MIL-STD 1472G details used for HMI design



Dimension	Value
Maximum height (A)	177.8 cm (70 in)
Preferred max. height 1/ (B)	165.1 cm (65 in)
Maximum lookover height 1/ (C)	150.1 cm (59 in)
Preferred min. height 1/ (D)	139.7 cm (55 in)
Minimum height (E)	104 cm (41 in)
Preferred min. depth (F)	104 cm (41 in)
Minimum depth (F)	94 cm (37 in)

NOTES:
1/ Preferred dimensions are for those controls that require precise, frequent, or emergency use.

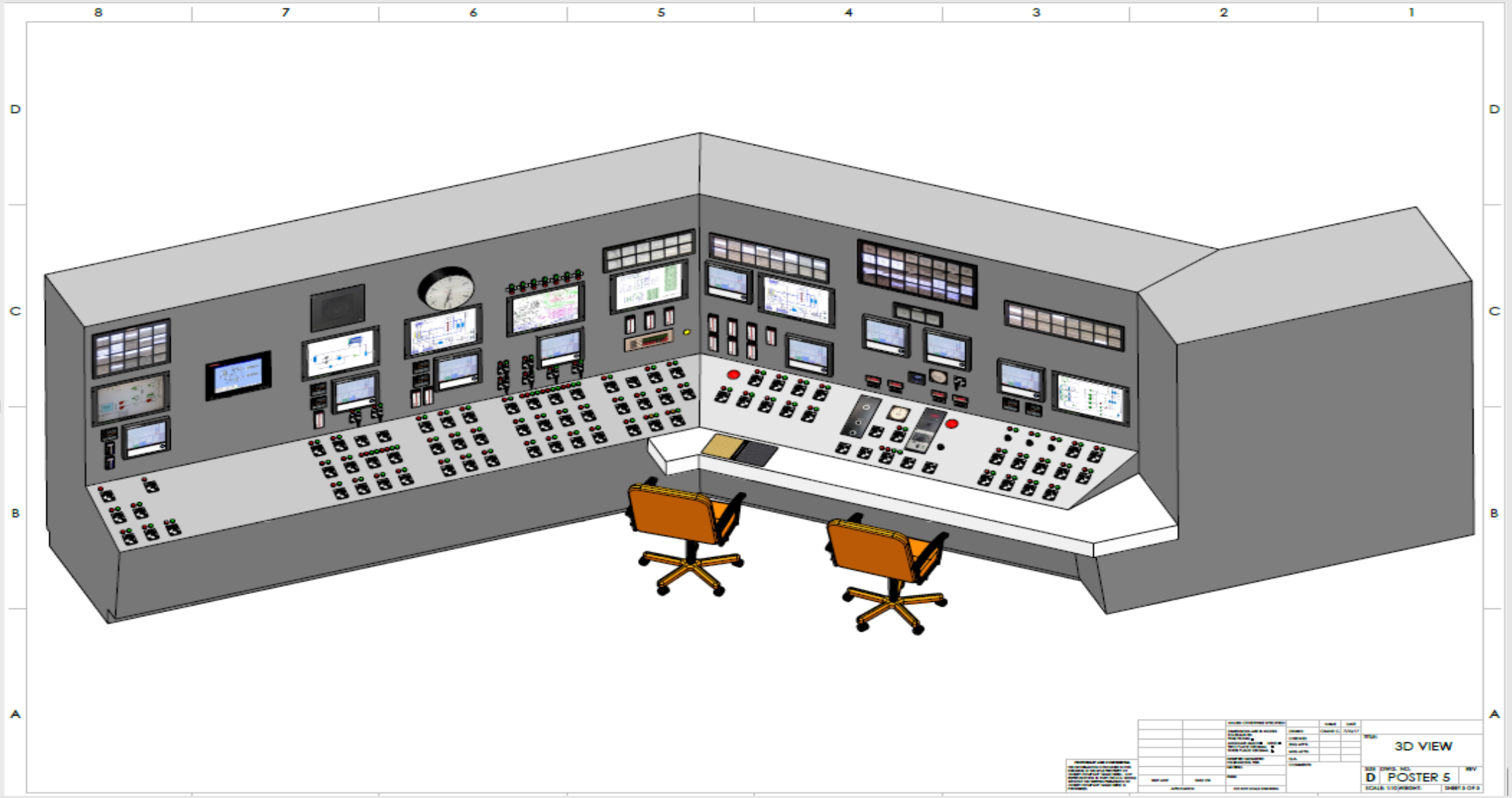
FIGURE 61. Display mounting height.

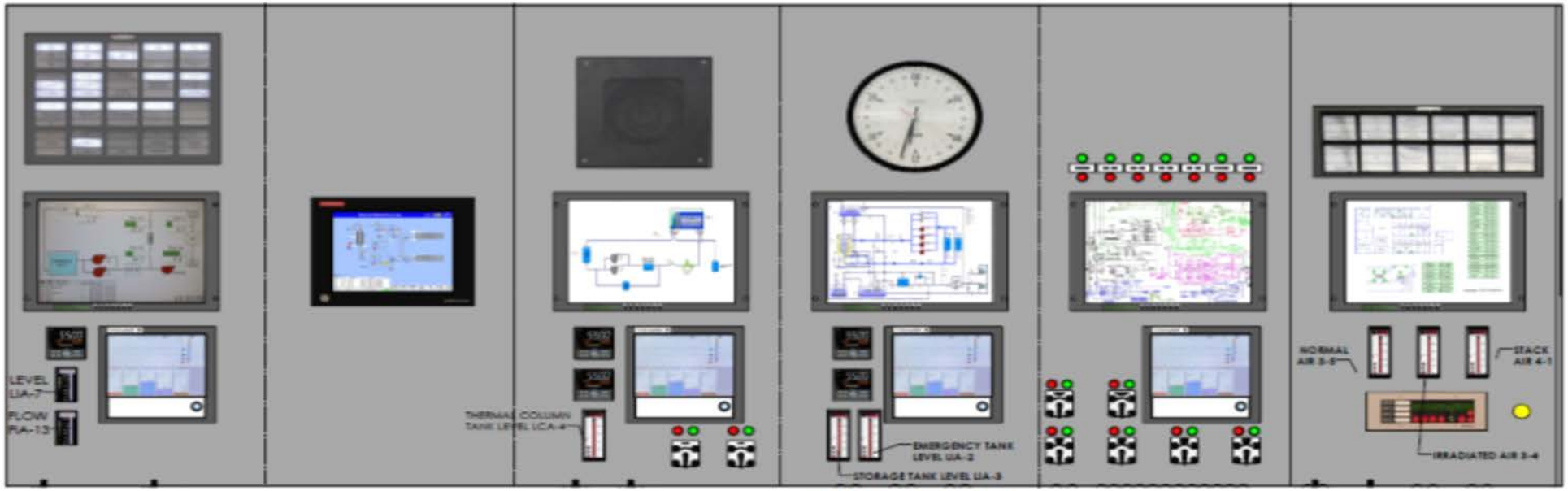
Reactor Operator Interaction

- Feedback provided early in the design ensured that errors in the HMI are addressed
- The HMI design will be used by the operators
- Crucial to Human performance Evaluation/Analysis as required from the Human Factors Engineering Program Review Model (NUREG-0711)

Current Control Console

Posters

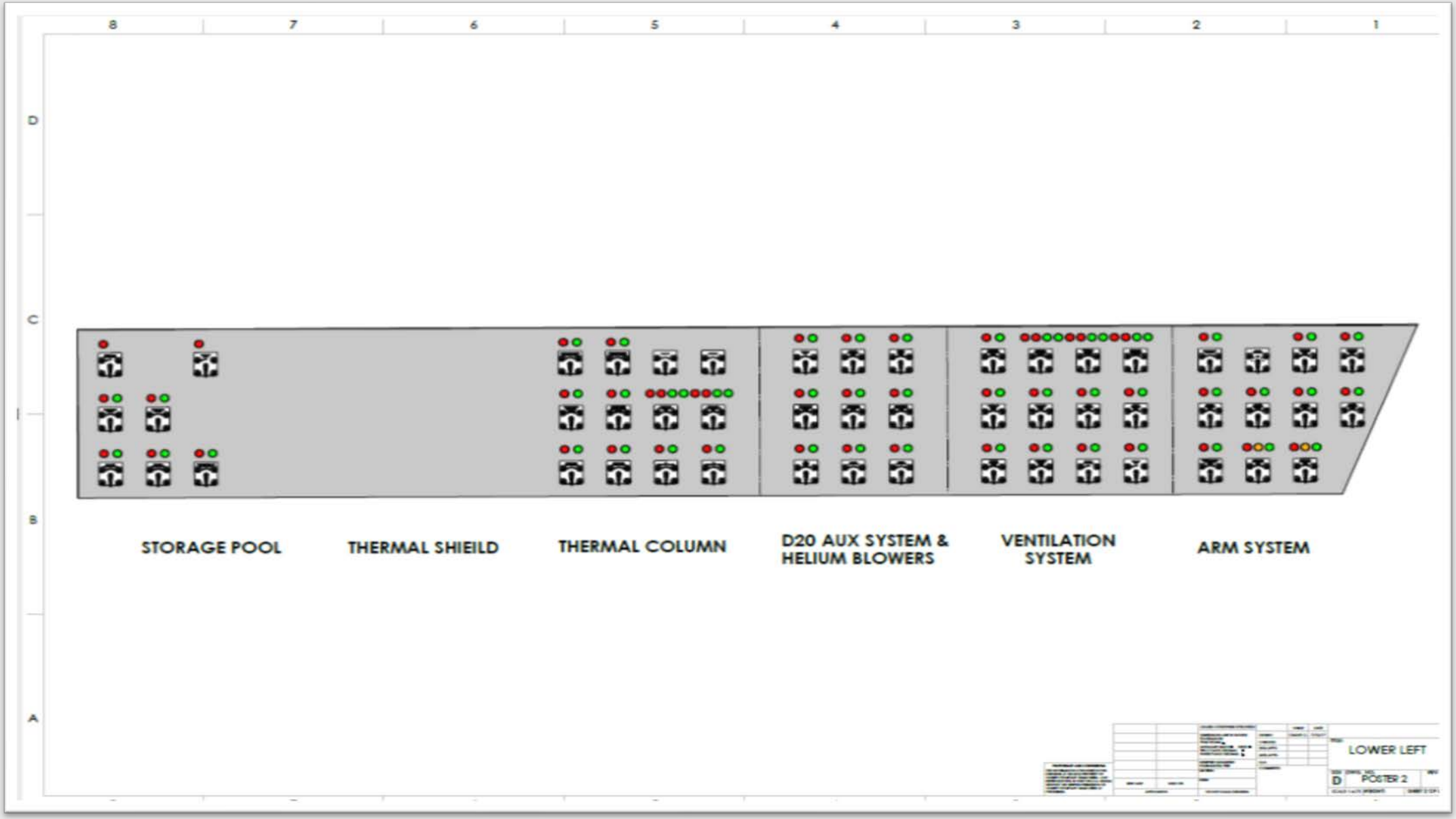




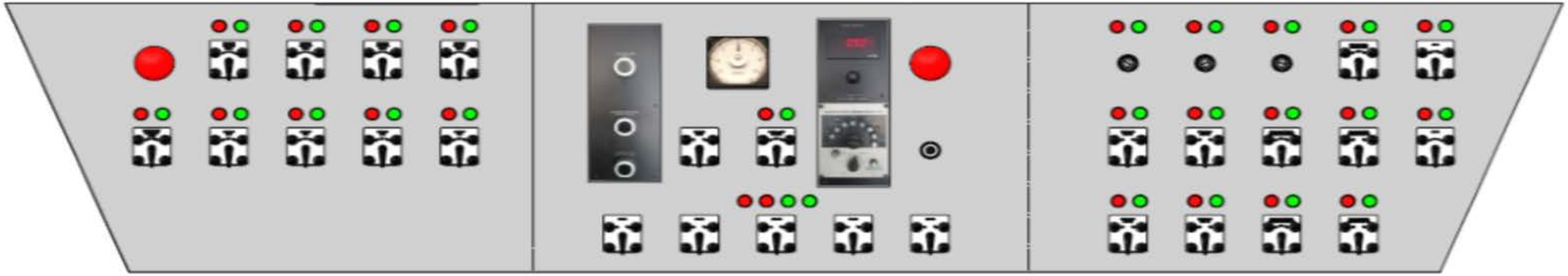
STORAGE POOL | THERMAL SHIEILD | THERMAL COLUMN | D20 AUX SYSTEM & HELIUM BLOWERS | VENTILATION SYSTEM | ARM SYSTEM

UPPER LEFT

D POSTER 1


8
7
6
5
4
3
2
1
D
C
B
A
STORAGE POOL
THERMAL SHIEILD
THERMAL COLUMN
D20 AUX SYSTEM & HELIUM BLOWERS
VENTILATION SYSTEM
ARM SYSTEM
LOWER LEFT
D
POSTER 2


OUTLET T1A-40
OUTER PLENUM FRC-3
INNER PLENUM FRC-20
REACTOR OUTLET TEMP TR-2
T1A-40A
T1A-40B
VESSEL LEVEL LOW L1A-40
PRIMARY SYSTEM MECHANICAL
PRIMARY SYSTEM NUCLEAR
SECONDARY SYSTEM
UPPER RIGHT
D
POSTER 3



PRIMARY SYSTEM MECHANICAL

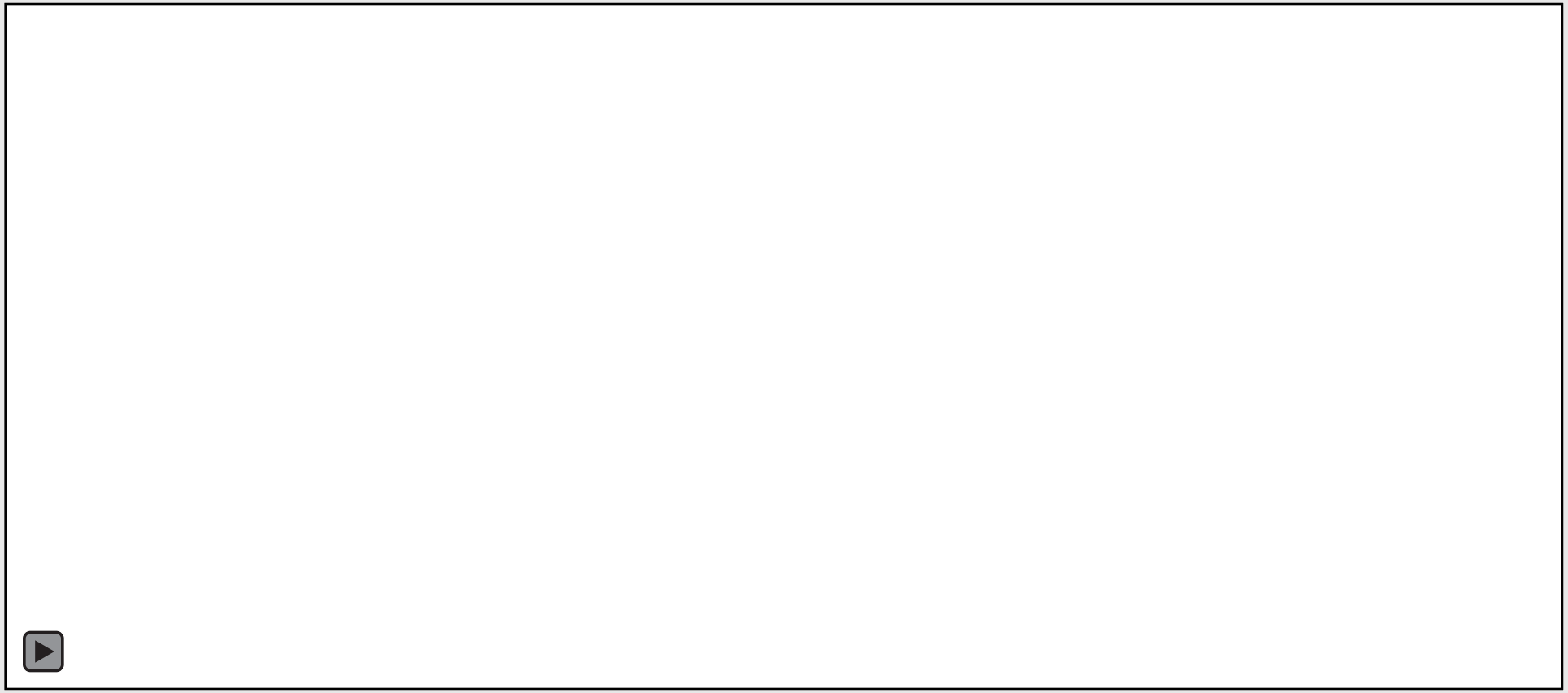
PRIMARY SYSTEM NUCLEAR

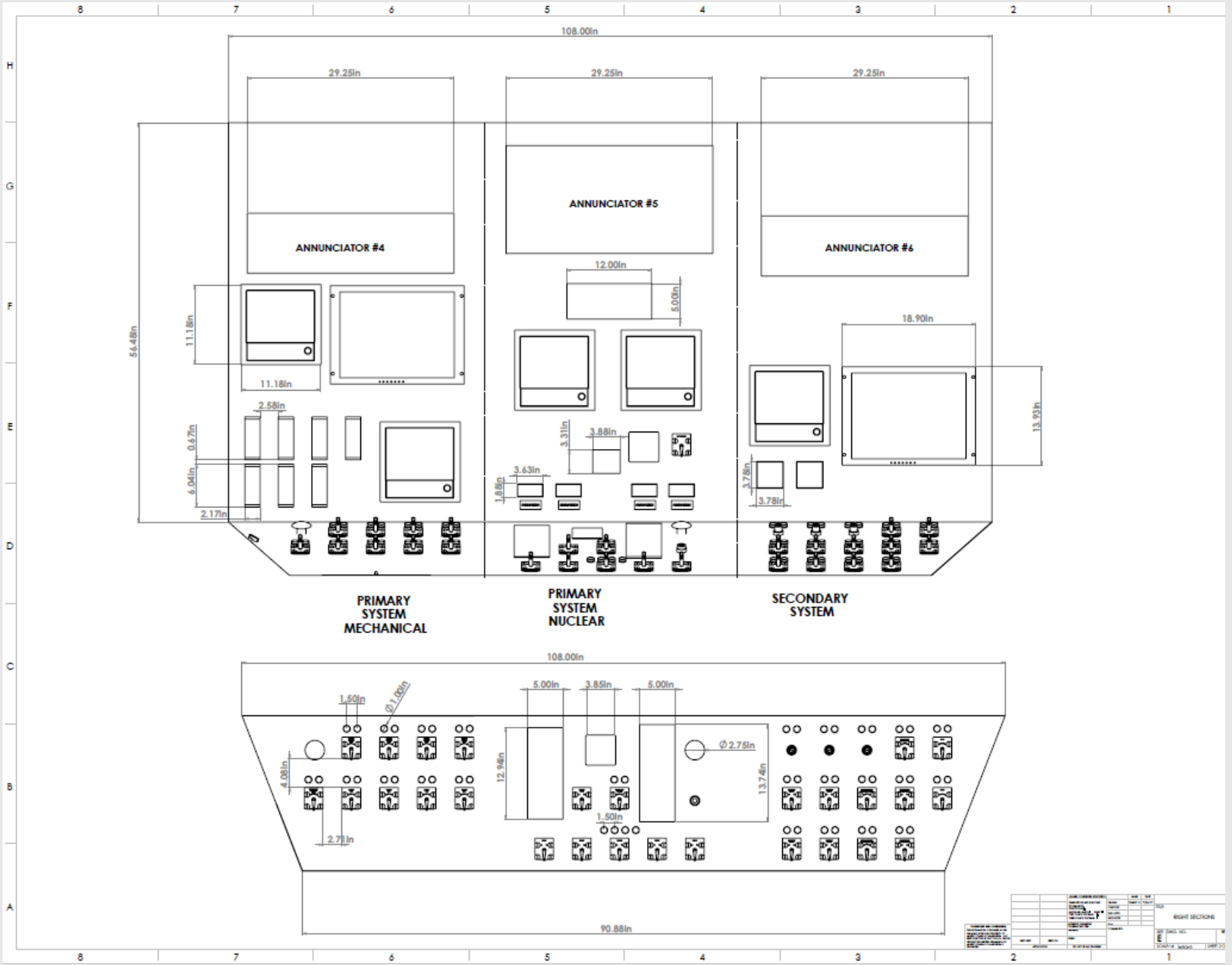
SECONDARY SYSTEM

LOWER RIGHT

D POSTER 4

Final Design (SolidWorks)



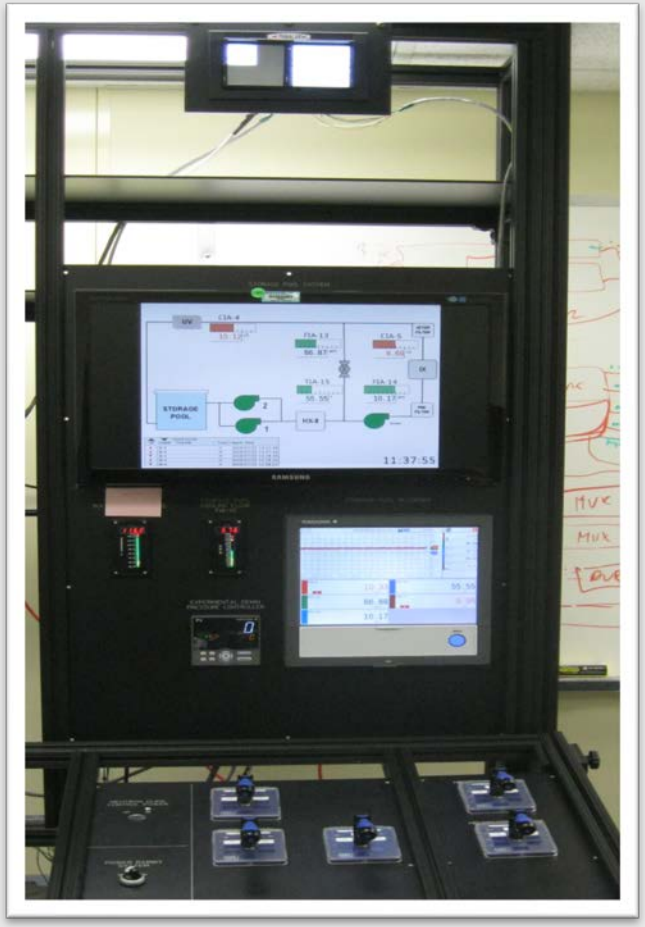

108.00In
29.25In
29.25In
29.25In
ANNUNCIATOR #4
ANNUNCIATOR #5
ANNUNCIATOR #6
12.00In
5.00In
18.90In
54.48In
11.18In
11.18In
2.58In
0.67In
6.04In
2.17In
3.31In
3.88In
3.63In
1.88In
3.78In
3.78In
13.93In
PRIMARY SYSTEM MECHANICAL
PRIMARY SYSTEM NUCLEAR
SECONDARY SYSTEM
108.00In
1.50In
Ø1.00In
5.00In
3.85In
5.00In
Ø2.75In
4.08In
12.94In
13.74In
1.50In
2.71In
90.88In

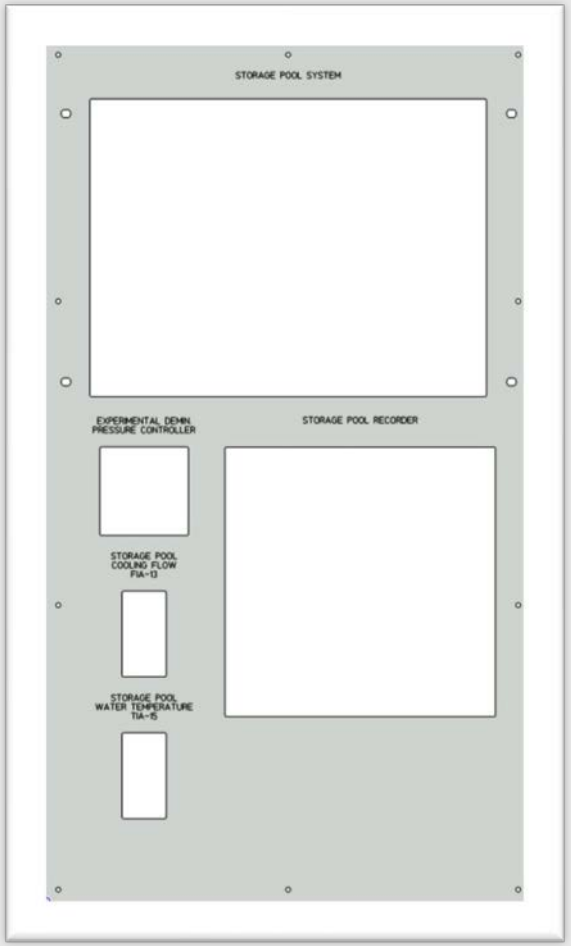
Human Performance Analysis

- Includes design specifications
- Describes the details about how the design met design specifications
- Includes standards and guidance applied
- Describes the reactor operator interaction

Future Work

- Continue on electric layout behind console
- Install new storage pool control panel on mock-up
- Human performance testing on mock-up





Conclusion

- After participating in the 2017 Surf Program, reactor operator feedback and The Department of Defense Design Criteria Standard for Human Engineering (MIL-STD-1472G) was applied to design a HMI for the NBSR Control Console.

Acknowledgements

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