



HSI Technology Evolution and Effects on Operators

August 26, 2008

Overview



- HSI technology evolution in new control rooms will change some operator tasks
- This presentation highlights a few key areas for the US-APWR

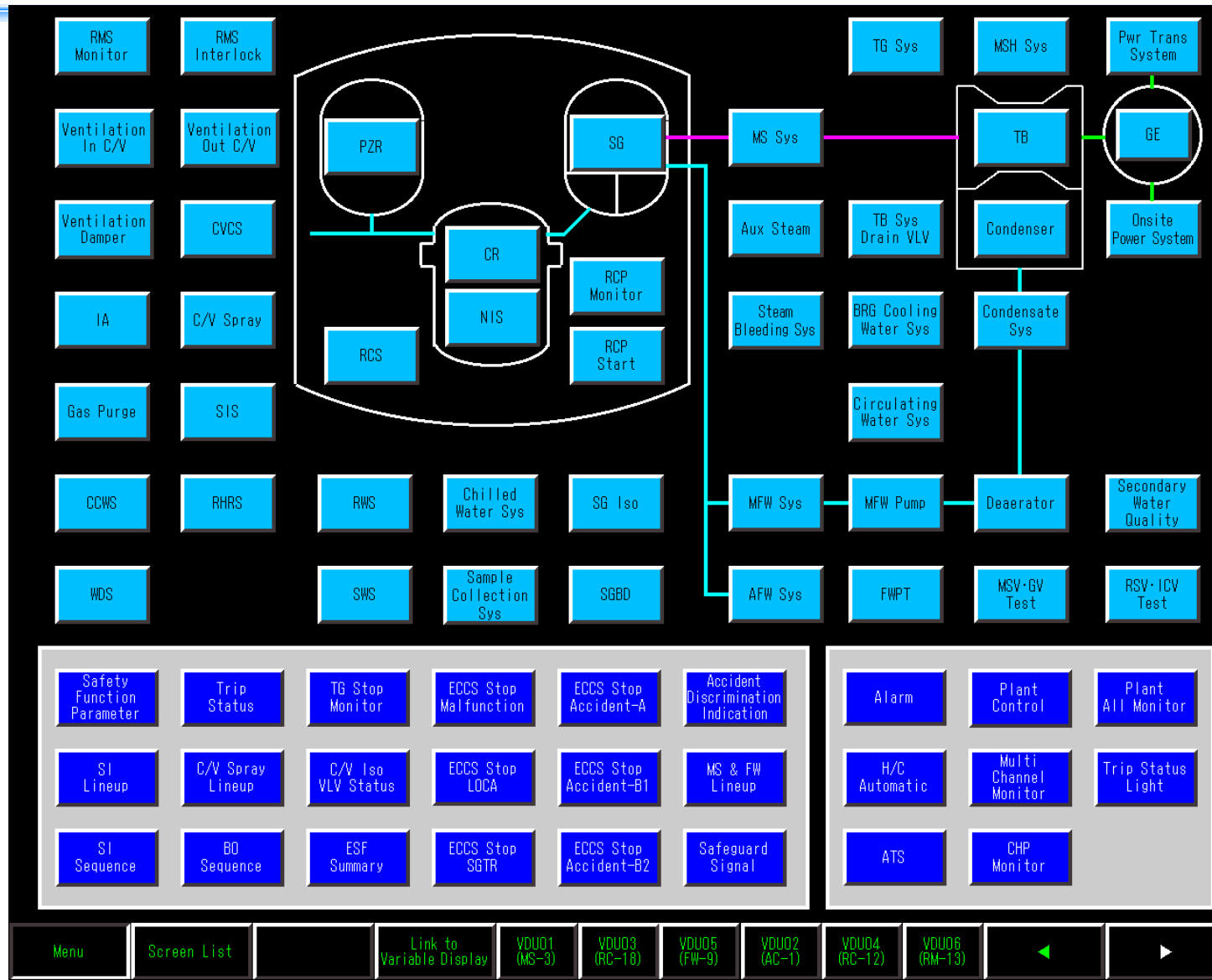
Information & Controls Accessibility



- **All information and controls are easily accessible to each operator**
 - ✓ Video Display Units with hundreds of display pages
 - Menu selectable
 - ✓ Multi-division VDUs
 - Control all safety divisions and non-safety from same VDU

- **Very different than the geographic distribution of instrumentation and controls on conventional panels**
 - ✓ One RO can monitor and control all plant functions
 - ✓ With two ROs, the division of responsibility between ROs can be function based rather than system based
 - For example, one RO can be responsible for all systems (safety and non-safety) for controlling the same function (eg. RCS inventory).

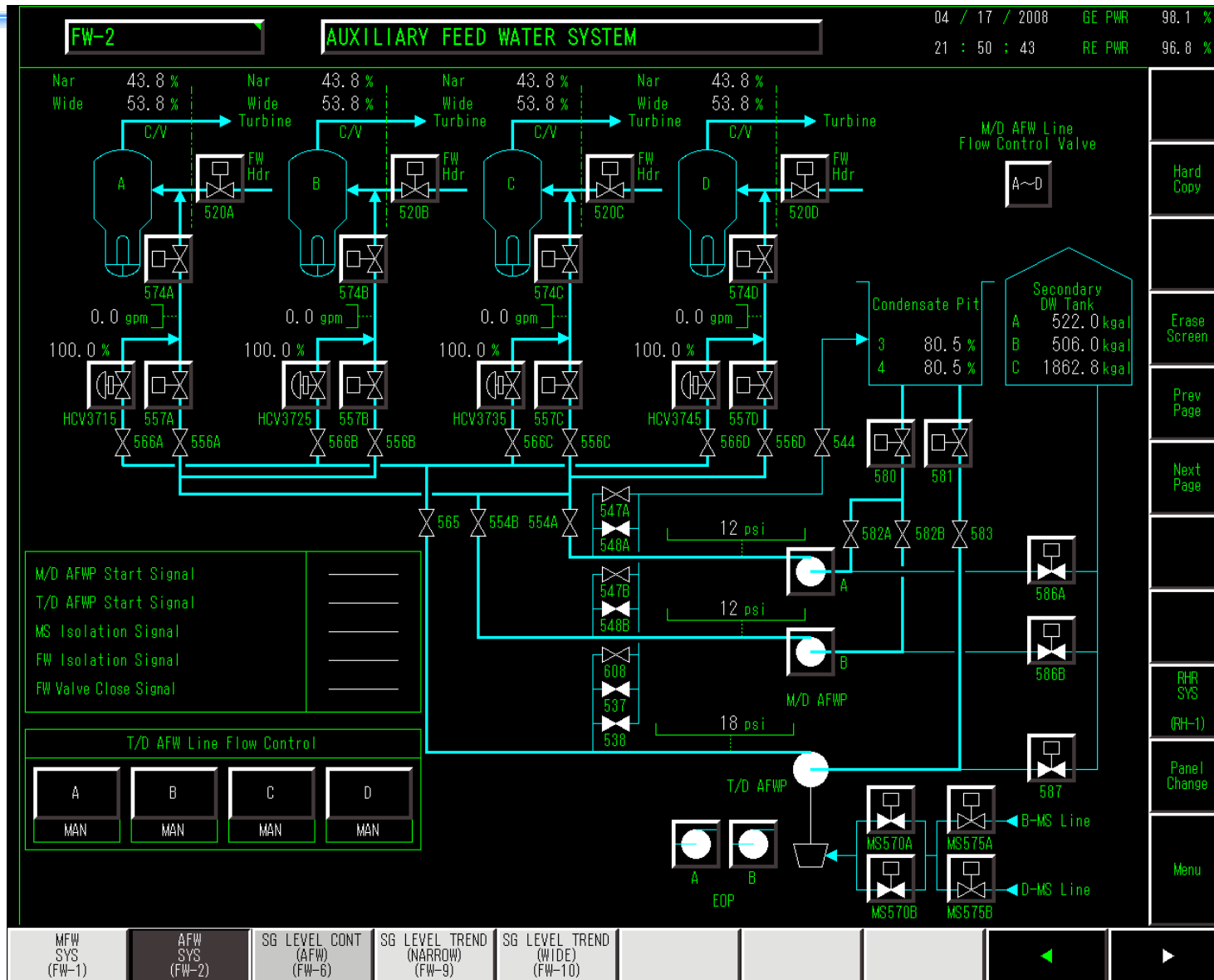
Operational VDU - Screen Menu



System display request area

Emer display request area

Operational VDU - Monitoring



Operational VDU - Control



FW-3

SG LEVEL CONTROL (MAIN FEED WATER VALVE)

04 / 19 / 2008 GE PWR 100.0 %

05 : 41 : 02 RE PWR 98.5 %

| | | | | |
|--|---|---|---|---|
| | A-SG L Hi Main FW V Close (C-14A DN) | B-SG L Hi Main FW V Close (C-14B DN) | C-SG L Hi Main FW V Close (C-14C DN) | D-SG L Hi Main FW V Close (C-14D DN) |
|--|---|---|---|---|

| | A | B | C | D |
|----------------------------|------|------|------|------|
| 1 SG Level (Nar) (Mid) (%) | 44.0 | 44.0 | 44.0 | 44.0 |
| 2 SG Reference Level (%) | 44.0 | 44.0 | 44.0 | 44.0 |
| 3 FW Flow (Mid) (klb/h) | 3699 | 3699 | 3698 | 3699 |
| 4 MS Flow (Mid) (klb/h) | 3679 | 3679 | 3678 | 3679 |

| A-FW Flow | B-FW Flow | C-FW Flow | D-FW Flow |
|----------------------|----------------------|----------------------|----------------------|
| FK-468B | FK-478B | FK-488B | FK-498B |
| AUTO MAN-MV | AUTO MAN-MV | AUTO MAN-MV | AUTO MAN-MV |
| MV 72.8% LV 72.8% | MV 72.8% LV 72.8% | MV 72.8% LV 72.8% | MV 72.8% LV 72.8% |
| FAST SLOW MV LV | FAST SLOW MV LV | FAST SLOW MV LV | FAST SLOW MV LV |
| 100 50 0 | 100 50 0 | 100 50 0 | 100 50 0 |
| 1 2 3 4 5 6 M | 1 2 3 4 5 6 M | 1 2 3 4 5 6 M | 1 2 3 4 5 6 M |

MFW SYS (FW-1)

SG LEVEL CONT (MFW VLV) (FW-3)

SG LEVEL CONT (POS CHANGE) (FW-4)

SG LEVEL CONT (MAKEUP) (FW-5)

SG LEVEL CONT (AFW) (FW-6)

SG LEVEL CONT (BYPASS VLV) (FW-7)

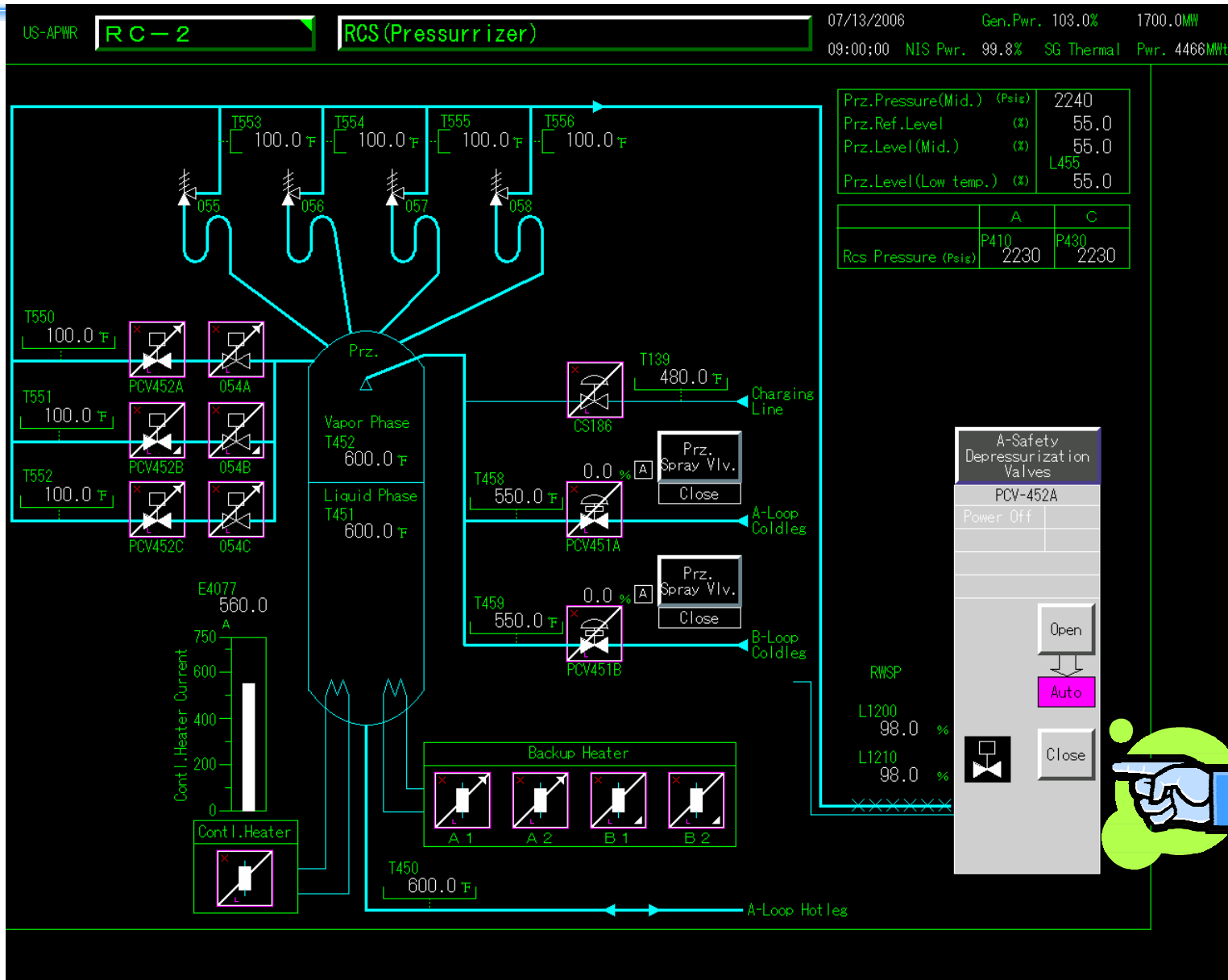
SG LEVEL CONT (A-LOOP) (FW-8.1)

SG LEVEL CONT (B-LOOP) (FW-8.2)

Panel Change

Menu

Operational VDU - Multi-Division



Automated Cross Channel Checks



- **Computers continuously perform cross channel checks**
 - ✓ Operators don't need to do this anymore
- **Monitoring and control displays show one parameter, not four**
 - ✓ Four are available on diagnostic level displays
- **Control systems use all channels**
 - ✓ No effect from single channel failures
- **Operators respond to channel deviation alarms**
 - ✓ Check system level effect (usually none, Partial Trip)
 - ✓ Confirm deviation
 - ✓ Check Tech Spec LCOs
 - ✓ Longer term action
 - Maintenance work order

Automated Actuation Checks

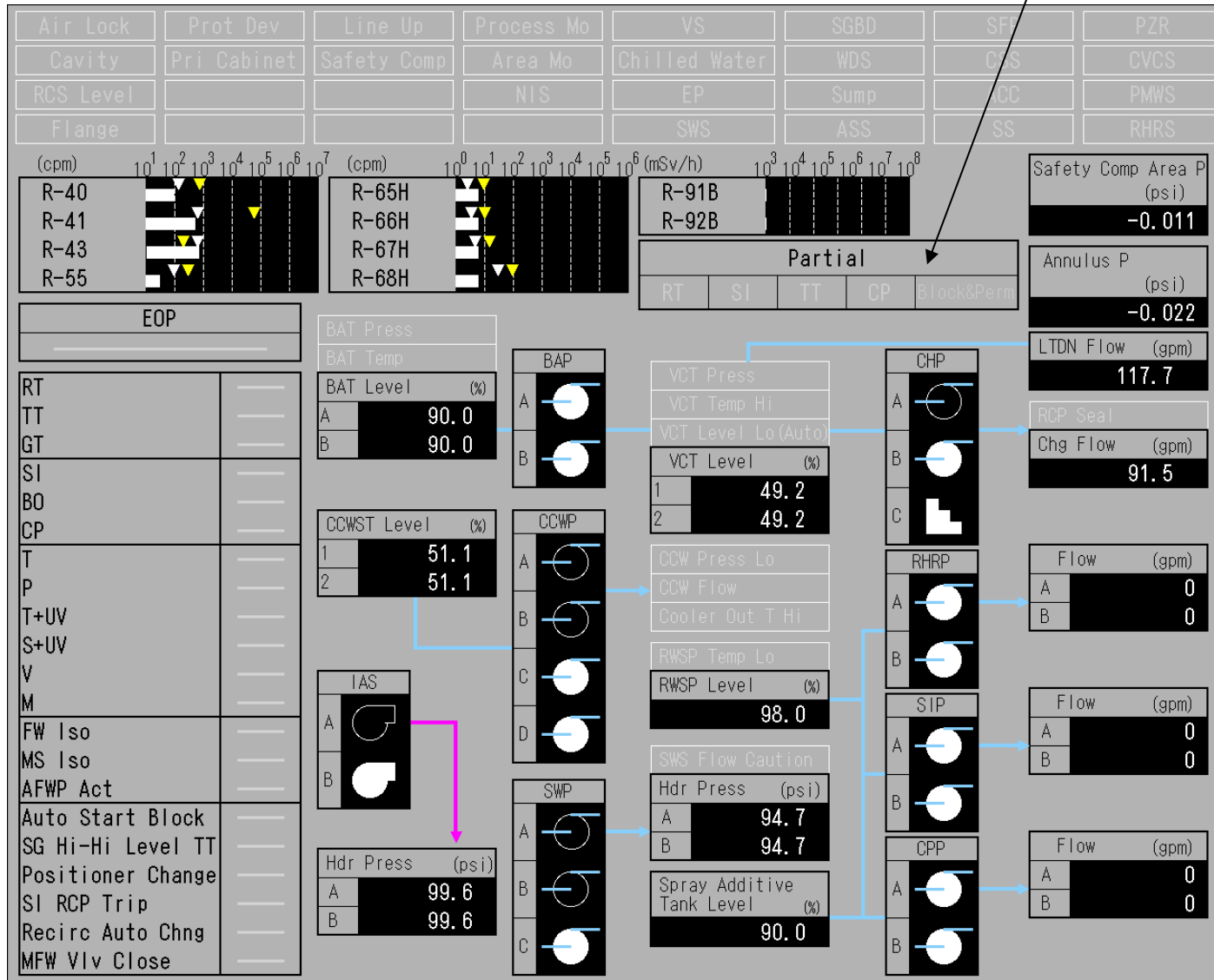


- **Computers check correct actuation of all ESF system components**
 - Pump start, valve line-up
 - ✓ Operators don't need to do this anymore
- **Operators respond to "Not OK" alarms**
 - ✓ Confirm alternate train is "OK", including performance
 - ✓ Longer term action
 - Confirm "Not OK" status
 - Restore to "OK" status
 - Maintenance work order

Large Display Panel



Partial Trip Monitor



OK Monitor

Automated BISI



Bypassed or Inoperable Status Indication

- **Computers monitor components for inoperable or misalignment conditions**
 - ✓ While in standby mode
- **Computers determine and display effects at train level**
 - ✓ Operators don't need to do this anymore
- **Operators respond to "Not Ok" alarms**
 - ✓ Confirm "Not Ok"
 - ✓ Check Tech Spec LCOs
 - ✓ Longer term action
 - Restore to "OK" status
 - Maintenance order

Alarm Management

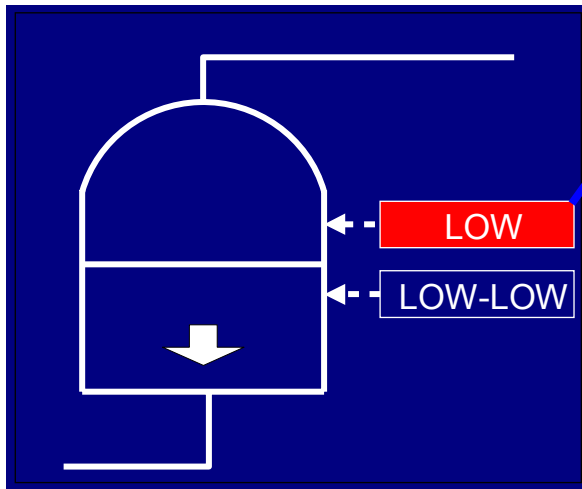


- **Alarm avalanche conditions are common in current alarm systems**
 - ✓ EOPs and training do not credit the alarm system
- **Alarm avalanche conditions are significantly reduced by**
 - ✓ Signal validation
 - based on automated cross channel checks
 - One process alarm, not one for each division
 - ✓ Cause-consequence dependency logic
 - Plant mode
 - Equipment mode
 - ✓ Prioritization logic
 - Highlights degrading conditions
- **Allows the alarm system to be credited**

Dynamic Alarm Priority Rules (1/3)



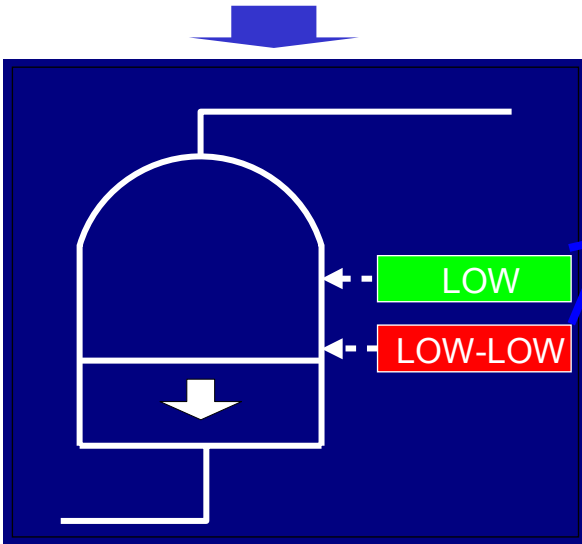
Higher prioritization rule



| | Primary(1) X/A | Primary(2) X/A | Secondary X/A | Electrical X/A |
|---------------|----------------|----------------|---------------|----------------|
| Priority | 1 | 1 | 3 | 3 |
| Color | Red | Red | Green | Green |
| Alarm Group | 1 | 1 | 0 | 0 |
| Page Select | 1 | 2/4 | 3/4 | 4/4 |
| Alarm Control | FD | Admck | Admck | Silence |

| | Primary(1) X/A | Primary(2) X/A | Secondary X/A | Electrical X/A |
|---------------|----------------|----------------|---------------|----------------|
| Priority | 3 | 3 | 1 | 1 |
| Color | Green | Green | Red | Red |
| Alarm Group | 0 | 0 | 1 | 1 |
| Page Select | 1 | 2/4 | 3/4 | 4/4 |
| Alarm Control | FD | Admck | Admck | Silence |

Low alarm is displayed as Priority 1 (alarm information) until the tank level reduces to the Low-Low alarm setpoint.



| | Primary(1) X/A | Primary(2) X/A | Secondary X/A | Electrical X/A |
|---------------|----------------|----------------|---------------|----------------|
| Priority | 3 | 3 | 1 | 1 |
| Color | Green | Green | Red | Red |
| Alarm Group | 0 | 0 | 1 | 1 |
| Page Select | 1 | 2/4 | 3/4 | 4/4 |
| Alarm Control | FD | Admck | Admck | Silence |

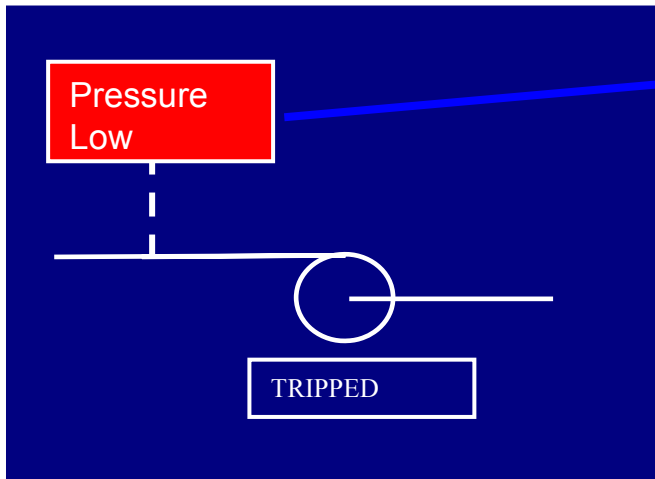
| | Primary(1) X/A | Primary(2) X/A | Secondary X/A | Electrical X/A |
|---------------|----------------|----------------|---------------|----------------|
| Priority | 1 | 1 | 3 | 3 |
| Color | Red | Red | Green | Green |
| Alarm Group | 1 | 1 | 0 | 0 |
| Page Select | 1 | 2/4 | 3/4 | 4/4 |
| Alarm Control | FD | Admck | Admck | Silence |

When the level reaches the Low-Low alarm setpoint, the Low-Low alarm is displayed as Priority 1 and the Low alarm is changed to Priority 3 (status information).

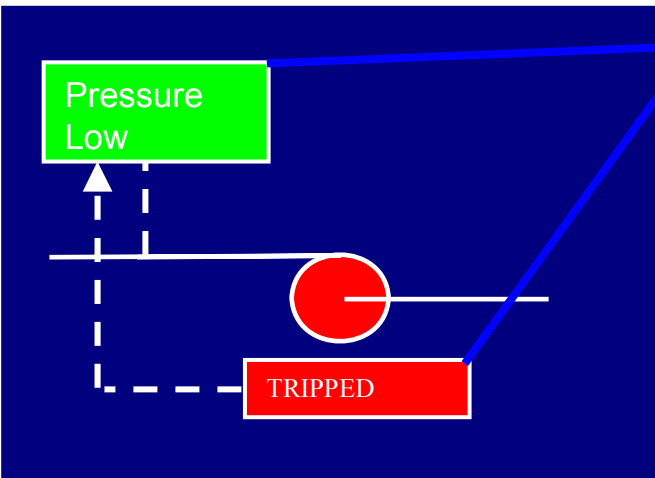
Dynamic Alarm Priority Rules (2/3)



Cause-consequence equipment rule



A low discharge pressure alarm is displayed at priority 1 if there is no cause for the alarm.

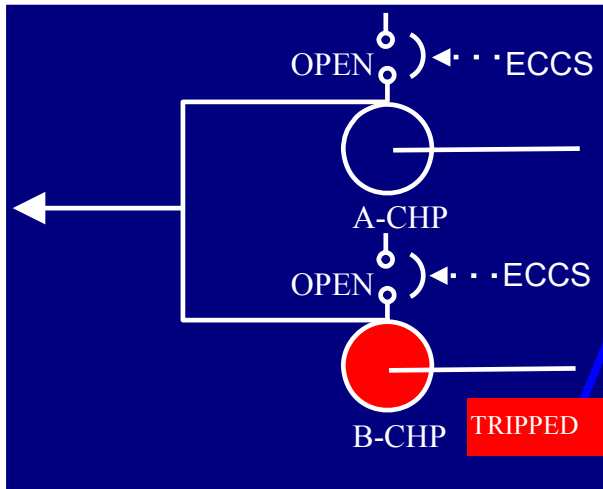


However, the low pressure alarm (“result” alarm) is regarded as Priority 3 when the pump is stopped by the interlock alarm (“cause” alarm) which is displayed as Priority 1.

Dynamic Alarm Priority Rules (3/3)



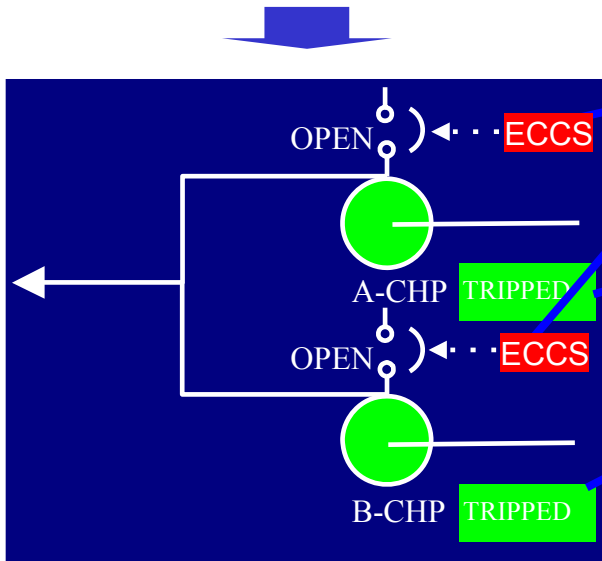
Cause-consequence mode rule



| Priority | Primary(1) XX | Primary(2) XX | Secondary XX | Electrical XX |
|----------|--------------------|---------------|--------------|---------------|
| 1 | Charging Pump Trip | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

| Priority | Primary(1) XX | Primary(2) XX | Secondary XX | Electrical XX |
|----------|--------------------|---------------|--------------|---------------|
| 1 | | | | |
| 2 | | | | |
| 3 | Charging Pump Trip | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

A charging pump trip is displayed at priority 1 if there is no cause for the alarm.



| Priority | Primary(1) XX | Primary(2) XX | Secondary XX | Electrical XX |
|----------|--------------------|---------------|--------------|---------------|
| 1 | | | | |
| 2 | | | | |
| 3 | Charging Pump Trip | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

| Priority | Primary(1) XX | Primary(2) XX | Secondary XX | Electrical XX |
|----------|--------------------|---------------|--------------|---------------|
| 1 | | | | |
| 2 | | | | |
| 3 | Charging Pump Trip | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

Charging pump trip alarms are regarded as Priority 3 (status information) when an ECCS signal is actuated.

Degraded HSI Conditions



➤ Current control rooms

- ✓ HSI is an integral part of the plant systems and components (eg. pumps, valves, instruments)
- ✓ Operators train to cope with plant component failures, not HSI failures

➤ New control room

- ✓ HSI redundancy to minimize the potential for failures
- ✓ If an unusual failure occurs, the effect can be much more global (eg. complete VDU freeze)
 - In addition to training operators for plant component/system failures, we must also train them for HSI failures
 - This is further complicated by NRC criteria for consideration of common cause failure
 - Adds even more training for beyond design basis events
- ✓ Degraded HSI may be the most significant operator training challenge

Degraded HSI Conditions



Diverse
HSI Panel

Safety
VDU

Summary



- **HSI technology evolution in new control rooms will reduce routine operator task burden**
- **Digital technology has proven highly reliable**
- **Regardless, operators must be well trained for degraded HSI conditions**