GENERAL DISPLAY REQUIREMENTS
- FEATURES & CONSIDERATIONS

- considerations that could be factored into a display guideline

I. ***What needs to be done*** - requirements for the system

Display Hierarchy & Controls

- types of displays (overview, system status, equipment status, point data, utility function displays, etc.)
- interaction/coordination of the displays - hierarchy organization and navigation
- formats of the displays (layout, headings, dedicated space, navigation aids)
- display call-up methods
- display call-up rates
- display update rates
- display standards (colours, organization, text size, flash, etc.) and guidance
- Operation context (warm-up, cool-down, at power, etc.), when should the display be used?
- Maintenance, Test and Inspection considerations
- Commissioning considerations

Display Features

- have any ***display standards*** been identified for compliance (text size, colours, layout, font,etc)
- system information adequately & completely described? (for example, **system ID,** ***engineering units provided, etc)***
- adequate system ***flow chart***/mimic with ***embedded labeling*** and ***state/status***
- ***simplified*** (as practicable) for understandability
- is ***colour & text*** used appropriately and in a standard manner - and is the ***readable, brightness & contrast*** acceptable
- can ***gross inflows/outflows*** (energy, material) be easily assessed and compared - does it give a ***summary*** indication? Is there unnecessary cognitive overhead, could relationships be calculated rather than deduced?
- adequate system ***separation/grouping*** indication provided, boundaries shown and all necessary ***other display interfaces*** shown
  (pressure sources/sinks or flows from/to)
- is it clearly shown ***which system*** display (or part of) is being presented
- is it clearly shown how to ***navigate*** from this display to other displays (action points, dedicated keys), relationship between overview, system & device displays
- can ***gross energy inputs/outputs*** be considered for balance summary indication
- any important ***margins*** to be noted (operating margin, margin to trip)
- is ***plant state, system operating mode*** and/or ***system control scheme*** indicated (power, normal mode, special shutdown, 3-e control) and is the ***computer that is in control*** indicated as such?
- ***annunciation linkage*** to the display parameters (colour change or flash for an alarm condition) also to distinguish for ***stale*** or ***irrational*** values)

Display Features.....continued

- can user ***cross checks*** be initiated (say flow, inlet pressure, differential pressure across valve, valve position, electronic control signal, typical previous, valve position at this power, reactor power level, flowing temperature, any like-parameters)

- all user ***access points*** from this display clearly shown (menu, last display, summary, etc.) and easy to use (no overlap, visual cues)
- any ***controllable points*** on the display (show access to manual entry - setpoints or control values)

Details Accessible from the Display

- ***computerized tags*** (AI, AO, DI, DO) available as a detail
- unique ***instrument tag*** available as a detail
- annunciation information and ***alarm S/W jumper*** state details
- is ***source of power*** (Class, Group or Division) & ***state of this power*** (available - healthy) indicated or available as a selectable display detail
- is ***location*** of the device available (or as a detail) for elevation, quadrant, room, panel, row, card?)
- ***status of equipment*** shown (isolated, in-service, bypassed, maintenance) and any cross reference to station documentation (jumpers, work authorizations)

Control Related Display Features

- ***indicate*** if the displaying computer is ***in control***
- indicate the ***measured variable***(s)
- indicate the ***controlled variable***(s)
- indicate the ***automatic setpoint*** value
- indicate the ***manual setpoint*** value
- indicate the ***mode*** (automatic or manual)
- indicate any ***bumpless transfer*** related parameters
- require a ***two-key entry sequence*** to initiate a ***control action***
- ***indicate the two-key sequence*** required for data entry
- indicate the state and adequacy of any ***related margins***
- indicate control ***entry ranges*** allowed
- indicate the ***controlled rates*** available
- indicate any special information required to ***ensure operator success***

ANTICIPATED USER INTERACTIONS

- list the ***types of interactions*** that users will perform
- are there any special user requirements or considerations

Operators, Maintenance and Technical Staff

- Call up displays, navigate
- monitor system conditions
- monitor computer conditions
- log data in historical summary for future reference
- printout display information for future reference, documentation
- cross check information from one system to another
- confirm suspected condition, diagnose
- revise allowed display limits (scales)
- enter numeric data (setpoints, trend limits, manual signals)
- execute requests
- cancel requests
- prepare reports
- printout reports

FAILURE CONSIDERATIONS

- failure annunciation and display indication
- stale data indication
- irrational data indication
- invalid data (failed cross checks) indication
- computer equipment failures (lack of indication?)
- communication failures (no data refresh?)

GENERAL DISPLAY REVIEW CHECKLIST

- **Here are some points you could consider when reviewing a display to decide if it is adequate/acceptable.**

- **You need some consistent method to assess something as subjective as a display in order to be able to develop rules that can then be followed to ensure consistent display features and functions are provided.**

- **Note that you could assign numeric values to each attribute so that a quantified score for the display could be obtained - this may be useful for a large project to be able to say that each display must have an overall assessment rating of xx points before being integrated into the display system.**

- **This example is presented in class to promote discussion and could be used to form the basis of an internal assessment for general displays to see if they should be modified or documented acceptable and left unchanged.**

- **Once you have assessed a few displays, you should see if you can summarize the key features and qualities that you think are essential for a functional display.**

- **The display review attributes that are useful to assess for review purposes were:**

1. ACCESS - Was the display easy to find and invoke

2. DISPLAY RATE - once called up, was the display presented within an acceptable time period (i.e. fast enough?)

3. IDENTIFICATION - was the display suitably titled so that the intended function (i.e. system display) and focus (i.e. boiler level control) was obvious

4. INFORMATION - does the actual information provided satisfy the design mission or goal for this display. (is the information complete and correct). Can you fully understand the system condition from reading this display?

5. PRESENTATION - is the display readable (good size text & symbols), is the use of colour appropriate (not colour for the sake of colour - good contrast, good attention attraction and can it still be used by a colour blind person?) and not too cluttered (i.e. can a simpler display be provided)

6. COMPREHENSION - is the display understandable by the intended user, does it make sense, is enough data provided, do conclusions need to be drawn or is the extrapolated information provided

Display review attributes continued....

7. USER - is the information correct for the intended user (does the user need this information, is it appropriate? is there some information shown that this user does not need, should this display information always be displayed (i.e. is another display appropriate here or perhaps a pop-up window) - i.e. don't show the operator some maintence or tuning information

8. OPERATING STATE - is the gross unit operating state shown (i.e. power operation, hot shutdown), the date & time provided (necessary?), identification of which computer information is being provided. Can you tell where this system fits in the overall application

9. EXIT INFORMATION - are the ways to leave from this display clearly shown (i.e. next, previous, menu, system icon) to facilitate user navigation, and once there is it easy to get back?

10. COORDINATION & INTEGRATION - does this display facilitate the information integration with the rest of the application - system boundary data?, display parameters in-alarm shown?, -energy transfers in or out for this display?

11. STANDARDIZATION - is this display compatible with other displays provided for this project (i.e. is there a similar look & function for all the displays) so the user will know where to look, how to interact and how to understand the data presented)

Typical Display Review and Assessment Summary Table

Display Attribute	Comments	Assessment (1-10)
ACCESS	easy to find & invoke	1 to 4 - poor
DISPLAY RATE	did it come up fast enough	5 to 7 - average
IDENTIFICATION	suitably titled?	8-10 - very good
INFORMATION	data correct & complete	
PRESENTATION	readable, colour, clutter	
COMPREHENSION	understandable?	
USER	who uses it for what?	
OPERATING STATE	gross state, time, computer	
EXIT INFORMATION	navigation aids	
INTEGRATION	links to rest of system?	
STANDARDIZATION	same approach used?	
	Display Gross Score	

You could assign an arbitrary value for an acceptable display (say greater than 77) to have a documented subjective 'good average' display or better in the opinion of the assessor.

You may find it worthwhile to develop your own display assessment table to facilitate the review and documentation of the relative merits of a display interface.

Simple Display Features Example Review

- Consider a display which represents a pump installation, the discharge from which provides the process fluid flow to a control valve.

- The devices in the diagram are the ***pump***, ***piping***, the ***control valve*** and an ***orifice plate*** downstream of the valve. The control valve has a ***positioner*** and an ***I/P transducer***.

- The possible ***parameters***, the ***intended measurement role*** and their ***scale values*** used for display and cross comparison purposes could be tabled and the means of best utilizing this data can then easily be reviewed.

No.	Parameter Name	Parameter Scale
1.	Pump Suction Temperature	0 - 300 C
2.	Pump Suction Pressure	0 - 5 MPa
3.	Pump Discharge Pressure	0 - 5 MPa
4.	Valve Outlet Pressure	0 - 5 MPa
5.	Process CV Fow	0 - 300 Kg/s
6.	Control Signal	0 - 100 %
7.	I/P output signal	4 - 20 mA
8.	Positioner Output Signal	40 - 200 kPa
9.	Valve Travel Position	0 - 100 %
10.	Valve Open Limit Switch	Open = 1, Not Open = 0
11.	Valve Closed Limit Switch	Closed = 1, Not Closed = 0
12.	Plant Power Level	0 - 100 %FP
13.	I/P Pneumatic Supply	0 - 140 kPa
14.	Positioner Pneumatic Supply	0 - 250 kPa

Parameter Operating Display Priority Ranking

- It would be useful to have a way to decide the ***relative importance*** for the need ***to display*** a ***certain parameter*** under ***certain conditions***. This can be achieved in part by applying a display parameter priority ranking system (very important, not important, etc.) to generally decide the most appropriate relative display plan for different parameters.

Priority #1: (Pri-1)

- most important, should be displayed all the time

Priority #2: (Pri-2)

-important, very helpful to operator in determining present operating conditions, could be displayed all the time or could be displayed on demand

Priority #3: (Pri-3)

- useful to diagnose problematic conditions or confirm performance characteristics, could be displayed on demand or on a special console

Priority #4: (Pri-4)

- predictive maintenance data, not frequently displayed and would only be displayed upon demand.

Purpose of the individual Parameter Indication

1. **Pump Suction Temperature** - with parameter #2 (*Pump Suction Pressure*), allows the determination of the Pump Suction ***Margin to Saturation*** to avoid pump cavitation conditions. (**Pri - 2**)

2. **Pump Suction Pressure** - with parameter #1 (*Pump Suction Temperature*), allows the determination of the Pump Suction ***Margin to Saturation*** to avoid pump cavitation conditions. (**Pri - 2**)

As well the pump suction pressure can be monitored with the pump discharge pressure to verify continued expected pump performance (without this measurement, the suction pressure may decrease due to some external problem which could be misconstrued as a pump discharge problem). (**Pri - 2**)

3. **Pump Discharge Pressure** - with parameter #2 (*Pump Suction Pressure*) and parameter #5 (*Process CV Flow*) , allows the confirmation of ***Expected Pump Head vs Flow Characteristics***. This parameter (supply head to the valve) is also of use to confirm the performance of the control valve. (**Pri - 1**)

4. **Control Valve Outlet Pressure** - with parameter #3 (*pump discharge pressure*), parameter #5 (*process flow*) and parameter #9 (*valve position*), allows the confirmation of expected ***Control Valve Flow Characteristics***. (**Pri - 3**)

5. **Process CV Flow** - to determine the ***Process Flow*** provided by the pump and allowed by the control valve.

Also to confirm the expected pump head vs flow performance (with parameters #2 (*pump suction pressure*), #3 (*pump discharge pressure*) and #5 (*Process flow*)) and the control flow characteristics (with parameters # 3 (*pump discharge pressure*) , #4 (*valve outlet pressure*) and #5 (*process flow*)) and as a gross cross check against Plant Power Level (parameter #12). (**Pri - 1**)

6. **Control Signal** - to indicate the ***Requested Control Valve Position***, important to understand if the control system is performing correctly.

Also to allow cross comparison with Parameter #7 (*I/P output signal*) with #13 satisfactory (*I/P pneumatic supply*) to check the I/P calibration, and gross cross check of the actual valve position (parameter #9) as well as gross cross check with Parameter # 12 (plant power level) **(Pri - 1)**

7. **I/P Pneumatic Output Signal** - allows monitoring of the ***Performance of the I/P*** (by cross checking with parameter #6 (*control signal*) with #13 satisfactory(*I/P pneumatic supply*)) and the performance of the Positioner (by cross checking parameter #8 (*positioner output signal*) with #14 satisfactory (*positioner pneumatic supply*) **(Pri - 3)**

8. **Positioner Pneumatic Output Signal** - allows monitoring the ***Performance of the Positioner*** (by cross checking with parameter #7 (*I/P output signal*) with #14 satisfactory (*positioner pneumatic supply*)) and the performance of the control valve (by cross checking with parameter #9 (*valve travel position*) **(Pri - 3)**

9. **Control Valve Travel Position** - allows monitoring of the ***Control Valve Final Position***

Is a means of confirming the control valve flow characteristics in conjunction with parameters #3 (*pump discharge pressure*) and #4 (*valve outlet pressure*), provides a point check against parameter #10 (the *valve open*) and parameter #11 (*valve closed*) limit switches.

As well as to check for ***not closed*** for any signal beyond the closed threshold via parameter #11 (*valve closed limit switch*) or not fully open for any signal beyond the open threshold via parameter #10 (*valve open limit switch*) and provides a gross check against requested parameter #6 (*valve position*) , parameter #5 (*process flow*) and parameter #12 (*plant power level*) **(Pri - 1)**

10. **Valve Open Limit Switch** - allows monitoring that the valve has moved to the ***Fully Open Position*** and as well provides a point check against the fully open travel position from parameter #9. **(Pri - 1)**

11. **Valve Closed Limit Switch** - allows monitoring that the valve has moved to the ***Fully Closed Position*** and as well provides a point check against the fully closed travel position from parameter #9 (*valve travel position*). **(Pri - 1)**

12. **Plant Power Operating Level** - provides an indication of the operating ***Plant Power Level*** ,if this system is dependent upon power level for operation, to facilitate energy balance recognition.

As well, this parameter can be used as a gross cross check against parameter #6 (*the control signal*), parameter #9 (*the control valve position*) and parameter #5 (*process flow*). **(Pri - 1)**

13. **I/P Instrument Air Supply Pressure** - provides an indication of the available ***I/P Air Supply Pressure*** . This would only be needed to be checked when the calibration performance of the I/P is verified (parameter # 7 (*I/P output signal*) against #6 (*control signal*) with #13 satisfactory (*I/P pneumatic supply*) or if troubleshooting the loop operation. **(Pri-4)**

14. **Positioner Instrument Air Supply Pressure** - provides an indication of the available ***Positioner Air Supply Pressure***. This would only be needed to be checked when the calibration performance of the Positioner is verified (parameter # 8 (*positioner output signal*) against #7 (*I/P output signal*) with #14 satisfactory (*positioner pneumatic supply*)) or if troubleshooting the loop operation. **(Pri-4)**

Man - Machine Interface Display Development Assignment

Question #1.

Provide a system layout sketch (NOT a proposed CRT Display) to show the system key components and measured parameters for the following application (called MAIN CHILLER).

Please label the following parameters, as a minimum: Hot Process Flow, Cold Coolant Flow, Valve Position, and Pump Status. This system's operation is dependent upon the overall unit operating state and power level.

Application Description: The application is a heat exchanger which accepts hot process fluid from the discharge of a pump through the tube side of the exchanger while colder cooling water is passed through the heat exchanger shell side. The cooling water control valve is located on the inlet side of the heat exchanger (i.e. not on the outflow discharge bay side of the HX). An orifice flow metering plate is provided in both the hot process and the cold coolant lines to allow flow measurements to be made.

Question #2.

Suggest a more complete display parameter set for this MAIN CHILLER application from Question #1. Include some additional parameters (as well as those already requested to be labeled - but no more than 10 total). Provide a simple display prioritization (say 1 to 3 - but state your prioritization strategy - why is it Pri 1 etc.) strategy for operator use and apply this to the parameters you have proposed. Identify & list the parameters that you think could be displayed and indicate if they should be displayed all the time for an operator based on your prioritization scheme.

#	Tag	Function	Pri	Oper Display?

Question #3.
Are there any margin type displays or cross reference comparisons that you would recommend for this application (that is - can you state a possible use for some of the remaining parameters or combinations of parameters that are not priority #1 for operators but may be useful for other users or other missions).List and explain two examples here (hint - consider pump head vs. flow manufacturer performance, pump cavitation or control valve installed characteristics issues):

Question #4.

Give a mission statement for an operator display for this system. From the information provided in questions #1 to #3 , sketch your recommendation for a typical CRT operator display for this application (based largely on your findings from Question #2). Sketch and label this display as you would like it to appear on the application CRT.

Use the Display Review Table given below to numerically assess your display for those applicable attributes (use the rankings of Poor 1-4, Average 5-7 and Very Good 8-10 to quantify your answer).

Mission Statement: =

Display Attribute	Comments	Assessment (1-10)
IDENTIFICATION	suitably titled?	
INFORMATION	data correct & complete	
PRESENTATION	readable, colour, clutter	
COMPREHENSION	understandable?	
USER	who uses it for what?	
OPERATING STATE	gross state, time, computer	
EXIT INFORMATION	navigation aids	
	Display Gross Score	