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BASELAYER CONTROL APPLICATIONS

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies rules, policies and guidelines for configuration of process control loops.

Implementation of the control logic in this DEP will be different on each DCS system. Hence, the descriptions in this DEP are written to be independent of the DCS system Manufacturer/Supplier.

This DEP applies to the control system design, narratives, functional logic diagrams and PEFS for the application for which it has been specified by the Principal.

This is a revision of the DEP of the same number dated September 2010; see (1.6) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Abbreviations

Term	Definition
AUTO	AUTOMatic mode
CAS	Remote control mode in which a PID controller receives its setpoint from a second "master controller"
CASC	Compressor Anti Surge Calculations
DCS	Distributed Control System
DEP	Design and Engineering Practice
HIC	Hand Controller or Manual Loader Station.
IPS	Instrument Protective System (The safeguarding system)
MAC	MANual Mode
MCB	Motor Control Block
OP	Out Put
PC	Pressure Controller
PI	Proportional Integral
PID	Proportional Integral Derivative
PEFS	Process Engineering Flow Scheme
PV	Process Value
SMOCPro	Shell Multivariable Optimising Controller
SP	Set Point
SSVCPro	Shell Surge Volume Controller
SRL	Surge Reference Line
SRV	Surge Reference Value
SCL	Surge Control Line
TC	Temperature Controller
VPC	Valve Position Controller
VSD	Variable Speed Drive

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets (). Other documents referenced by this DEP are listed in (4).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated September 2010. The following are the main, non-editorial changes.

Old section	New section	Change
2.2	3.2	Made corrections for engineering units and minor changes for clarity.
2.9	3.9	Updated compressor ant-surge control for clarity.
2.12	3.12	Switched philosophy for pH control from characterizing gains to characterizing PV to make the controller response linear.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of “DEPs on the Web”, available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

2. CONFIGURATION OF PROCESS CONTROL LOOPS

2.1 GENERAL

This DEP shall be used as the basis for control system design, narratives, functional logic diagrams and PEFS for the application for which it has been specified by the Principal.

The control narratives shall include all details required for flawless installation and commissioning. Guidelines for authoring control narratives are provided in the report OG.00.20489.

2.2 STANDARD DCS TOOLKITS

For capital projects, the MAC shall implement the configuration of process control loops using its own DCS toolkit, if one exists, as the basis for the loops implemented. It is the intention that all schemes listed in (3) shall be implemented within each MAC's DCS toolkit.

For each capital project, the MAC shall ensure that the control scheme functional specification is implemented using toolkit typicals wherever possible. The toolkit includes more loop typicals than those specified in this DEP. For the loops specified in this DEP, section (3) is the basis from which the MAC toolkit typicals are developed.

During P&ID development, the MAC, Contractor and the Principal's Control Systems Engineer shall agree on the toolkit typical to be utilized, or agree that a prototype complex control loop will need to be developed.

2.3 PROTOTYPE DCS TOOLKITS

If a loop typical does not exist in the DCS toolkit, the guidance in (3) shall be used to develop a prototype complex loop for the project. The prototype complex loop shall be approved by the Principal prior to implementation on the project.

This project prototype should then be considered for inclusion in the MAC's toolkit as a typical.

Each MAC's established procedure shall be followed in making updates to its toolkit.

2.4 COMPLEX CONTROLS

For complex controls which are not described in (3), nor included within the MAC's existing toolkit, the MAC shall consult the Principal for implementation guidance.

The MAC shall implement the narratives, configuration, and testing in accordance with the toolkits and other general and project-specific standards as agreed with the Principal.

3. MEASUREMENT / SIGNAL CONDITIONING / CONTROL SCHEMES**3.1 DUAL RANGE TRANSMITTERS****3.1.1 General**

Often two transmitters with different ranges are used to increase the rangeability of the measurement. The measured value is determined automatically, depending on the readings of the lower and upper range transmitters. The switching algorithm is designed to maximise the measurement accuracy over the entire operating range. When the flow is above the full scale of the low-range transmitter span, the PV from the high-range transmitter is selected. When the flow rate is below the minimum value that can be accurately measured by the high-range transmitter, the PV from the low-range transmitter is selected.

For the intermediate points between the two intervals, a weighted average is calculated, based on the flow measured by the low-range transmitter. The weighting is proportional to the distance through the overlap range, so that at the lower end of the overlap the weighting is 1 for the low range transmitter PV and at the top of the overlap the values are 0 for the low-range and 1 for the high-range transmitters. The transition range should be chosen so that the low value is equal to the minimum reliable value of the high range transmitter and the high value is equal to the full-scale value of the low range transmitter.

If density compensation is being applied to the measurement, it shall be applied to the individual flows unless the calibration conditions of the two flows are identical. In the latter case, the compensation may be applied to the calculated flow instead.

3.1.2 Calculations

The flow is determined with reference to Figure 1 as follows:

$$F001 = Y1 \quad (0.1)$$

$$Y1 = (1 - k) \times F001A + k \times F001B \quad (0.2)$$

$$k = \text{Min} \left\{ \text{Max} \left(0, \frac{F001A - F_{\text{Min}}}{F_{\text{Max}} - F_{\text{Min}}} \right), 1 \right\} \quad (0.3)$$

Where:

k weighting factor

F_{min} Transition range minimum

F_{max} Transition range maximum (< maximum range transmitter F001A)

Thus, k=0 when the flow is lower than the transition range minimum and the low range transmitter then determines the flow. When the flow measured by the low range transmitter is higher than the transition range maximum, k=1 and the high range transmitter determines the flow. When the flow is in the transition range, the weighted average of both flows is used to determine the flow.

3.1.3 Initialisation

No initialisation required.

3.1.4 Operational modes

The calculation for flow is always enabled. The calculated flow status shall be determined from the table below if either of the two transmitters is manually forced or has a bad value.

Mode of Operation	Scenario	Automatic Action	Operator Action
Startup	No special requirement		
Normal Operation	No special requirement		
Crippled Mode	Low range transmitter (F001A) failure	Use value from high range transmitter if flow value (F001B) is greater than F_{min} , else set status of F001 to 'BadPV'.	-
Crippled Mode	High range transmitter (F001B) failure	Use value from low range transmitter if flow value (F001A) is less than F_{max} , else set status of F001 to 'BadPV'.	-

3.1.5 Operator interface

Both flow transmitters should be shown on the schematic. An additional symbol should be used to indicate which of the transmitters has been selected. Where the calculated flow is used, this should be indicated on the schematic.

3.1.6 Startup/shutdown

No special provision required.

3.2 PRESSURE COMPENSATED TEMPERATURE

3.2.1 General

Temperature is often used as a quality indicator to determine a cutpoint in distillation operations. Since the cutpoint temperature is a function of pressure, it may be compensated for fluctuations in pressure.

By preference, the relationship between pressure and temperature is assumed to be linear. The coefficients are obtained either from experimental data, from design data over the operating range or from an online optimizer.

Where this is impossible and the relationship is not linear over the operating range, the Clausius-Clapyron (C-C) equation may be used. Coefficients may, as before, be obtained from experimental data or from design data. If design data is used, a common approach is to specify the key distillation components and to use the Antoine coefficient for the more valuable of these two components as the coefficients for the C-C equation. Thus, if the overhead column of a distillation column is to be controlled and if this temperature is to be pressure-compensated, the Antoine coefficients of the lighter of the two key components should be used. Conversely, for bottom temperature control, the Antoine coefficients of the heavier of the two components should be used.

The pressure compensation is only valid within certain limits. These limits shall be specified and used to clamp the pressure compensation. If the pressure moves outside of these limits, the limit closest to the pressure is used to perform the pressure compensation. Under these circumstances, the status of the compensated pressure should be set to "uncertain", where the DCS permits this.

If the pressure used in the pressure compensation calculation goes bad, the pressure-compensated temperature (PCT) calculation should use the normal operating pressure specified for this application, or the last good pressure measurement if this is available. The last good measurement should be selected only if the transmitter reports this value reliably. Under these circumstances, the status of the compensated pressure should be set to "uncertain".

There should be an option to filter the pressure measurement used by the compensation algorithm to avoid interactions with the column (or vessel) pressure controller.

If the measured temperature status becomes “uncertain” or “bad” the status of the compensated temperature shall assume the same status.

The pressure compensation is always active and cannot be switched off by the operator.

3.2.2 Calculations

There are two types of pressure compensation that may be used.

Type I Linear

This compensation has the form:

$$T_{\text{Compensated}} = T_{\text{measured}} + k \times (P_{\text{reference}} - P_{\text{measured}}) \quad (00.1)$$

k = Linear compensation factor based on steady state simulation or step response data.

The parameter k may be determined experimentally or from a plot of vapour pressure versus temperature for the material of interest. Make a step change to the column pressure PI1 at constant heat input with the temperature controller in manual mode. The compensation factor is the gain between the measured pressure and the temperature. Any dynamics between the pressure and temperature should be applied as a filter to the measured pressure (P_{measured}) in the calculation.

Thus, with reference to Figure 2:

$$Y1 = TI1 + k \times (Pref - PI1) \quad (00.2)$$

$$TC1 = Y1 \quad (0.3)$$

Type II Clausius Clapeyron Compensation

Pressure compensation is based on the premise that the relative volatility of the key distillation component should be constant. Assuming that the vapour and liquid are both ideal, using Raoult's law the relative volatility of component 'i' may be written as:

$$\frac{y_i}{x_i} = \frac{P_{\text{isat}}}{P} \quad (0.4)$$

Where:

y_i = mole fraction of component i in the vapour phase

x_i = mole fraction of component i in the liquid phase

P_{isat} = Saturation pressure of component i (bara)

P = operating pressure (bara)

Using the Antoine equation, the saturation pressure may be estimated as follows:

$$\ln P_{isat} = A - \frac{B}{T + C} \quad (00.5)$$

Where:

A = Coefficient A of the Antoine equation. This is dependent on component i.

B = Coefficient B of the Antoine equation. This is dependent on component i.

C = Coefficient C of Antoine equation. This is dependent on component i, In the Clausius-Clapeyron simplification, this is set to 0.

The coefficient B can be determined from tables of Antoine coefficients for pure components, while the coefficient 'A' is eliminated by cancellation and is not required, and C is assumed to be 0.

Thus if:

$$\left(\frac{y_i}{x_i} \right)_P = \left(\frac{y_i}{x_i} \right)_{Pref} \quad (0.6)$$

The temperature corresponding to the reference pressure may be estimated:

$$T_{\text{compensated}} = \left(\frac{B}{\frac{B}{T_{\text{Measured}}} - \ln \left(\frac{P_{\text{reference}} + P_{\text{Atmospheric}}}{P_{\text{Measured}} + P_{\text{Atmospheric}} + \Delta P} \right)} \right) \quad (0.7)$$

Where:

T_{Measured} = Measured temperature (absolute – Rankine or Kelvin).

$T_{\text{compensated}}$ = Compensated temperature referenced back to P_{ref}

P_{Measured} = Measured pressure (gauge).

$P_{\text{reference}}$ = Reference pressure (gauge).

$P_{\text{Atmospheric}}$ = Atmospheric pressure (absolute).

ΔP = (fixed) pressure drop from pressure measurement to temperature point.

Thus with reference to Figure 2:

$$Y1 = \left(\frac{B}{\frac{B}{T1} - \ln \left(\frac{P_{\text{reference}} + P1}{P1 + P_{\text{Atmospheric}} + \Delta P} \right)} \right) \quad (0.8)$$

$$TC1 = Y1 \quad (0.9)$$

B can be determined by experiment using two operating points and rearranging equation 0.7:

$$B = \frac{\ln \left(\frac{P_2 + \Delta P + P_{Atmospheric}}{P_1 + \Delta P + P_{Atmospheric}} \right)}{\frac{1}{T_1} - \frac{1}{T_2}} \quad (1.0)$$

3.2.3 Initialisation

None.

3.2.4 Operational modes

Mode of Operation	Scenario	Automatic Action	Operator Action
Startup	No special requirement		
Normal Operation	No special requirement		
Crippled Mode	Failure of Temperature transmitter	The compensated temperature calculation shall return a bad value.	-
Crippled Mode	Failure of Pressure transmitter	The compensation calculation should use the vessel operating design pressure or last good measured temperature depending on selection. The compensated temperature quality should be uncertain.	-
Crippled Mode	Pressure outside validity limits	The limit closest to the pressure shall be used to calculate the compensated temperature. The compensated temperature quality should be uncertain.	-

3.2.5 Operator interface

The raw temperature value and the compensated temperature should be available to the operator. The operator should have read only access to all parameters.

3.2.6 Startup/shutdown

No special requirements.

3.3 MOTOR OPERATED VALVE (MOV)

The open/closed limit switches and valve positioner (if available) should be used to indicate valve position. The open/close command to the MOV should be a pulse and MOV should be switchable to fully opened or fully closed position. A separate digital output should be

used to stop the valve movement before the fully open or fully closed position has been reached. In areas where local control is likely, such as offsites, a remote/local flag should be configured.

If an MOV is used for closed loop control (i.e., driven from a PID controller output), it shall be possible to set the position of the valve. In order to prolong the life of the MOV, the valve shall be moved only if the required change in output is greater than a prescribed threshold value. MOVs are not commonly used for control type applications because of the excessive wear and tear such an application imposes on the valve. The Principal's approval is required to use MOVs in this application.

If the PID output change is less than this prescribed amount, it is accumulated (i.e., added to the current PID output change) but is not sent to the MOV. Only once the cumulative change exceeds the threshold value is it sent to the MOV, and the cumulative amount is reset to zero.

Any MOV requiring an inching facility (that is the ability to stop the motor before the valve has reached full travel, and set the valve position around the position at which it was stopped) should be treated as an MOV used for closed loop control. In this case, a hand controller, rather than a PID controller, should be used to specify the position of the MOV.

3.4 SURGE VOLUME CONTROL

Surge volume control is a principle that allows vessel holdup to vary between predefined upper and lower limits to smooth the outlet flow from the vessel. The requirement to implement surge volume control using SMOC^{Pro}, SSVC^{Pro} or PID Gap shall be specified by the Principal. Where a single level is to be allowed to vary to provide surge volume control, a PID Gap controller should be used. Where this principle is to be applied to several (2 or more) levels in series, the Shell Multivariable Optimising Controller (SMOC^{Pro}) should be used if it is available. If it is not available, the Shell non-linear control package SSVC^{Pro} should be used if available.

SSVC^{Pro} is implemented on the DCS. For implementation details, refer to the functional specification for SSVC2 (OP.01.20020).

3.5 FIN FAN CAPACITY CONTROL

3.5.1 General

Banks of air coolers are frequently employed to condense and sub-cool the overhead vapour stream from a distillation column. Cooler banks are normally configured in rows of three fans with two of the three fan motors driven by fixed speed motors and the remaining fan driven by a variable speed fan. Temperature control is then achieved by regulating the speed of the variable speed fans. Distillation columns equipped with total condensers for the overheads, frequently employ air coolers in this service. The rundown temperature from the coolers is controlled by regulating the speed of the variable fans as a group. To increase the control range of the variable speed fans, the motors of the fixed speed fans are switched off sequentially when the temperature controller output falls below a minimum (nominally 10 %) and are switched on sequentially when the temperature controller output rises above a maximum (nominally 90 %). Once a fan has been switched, automatic switching is disabled for a period of time (typically around 2 minutes) to ensure that multiple switches do not occur in response to the same trigger.

Switching fixed speed fans on and off has an immediate effect on the overall cooling duty, and to prevent disturbances, whenever a fan is switched, the output of the temperature controller is adjusted so that the overall duty remains constant. The control system is shown in Figure 3.

This scheme should not be used for all temperature controllers of this type. The scheme should only be implemented if required, and shall be subject to approval of the Principal.

The control system consists of three main components:

1. Feedback temperature controller cascaded onto the fin fan speed controllers.
2. Feed-forward control which adjusts the output of the temperature controller to compensate for the effect on cooling duty that switching fin-fan motors on /off has. The duty of a fixed speed fin fan is expressed as a fraction of the duty range of the variable speed fin fan. The feed-forward feature may not always be required, and shall be subject to approval of the Principal.
3. Switching control. Fin fans are switched on and off sequentially whenever the temperature controller moves outside its operating limits. A simple algorithm is employed to determine which fan to switch on and which fan to switch off. The switching principle is that all banks should have a similar number of fans in operation. This reduces the chance of bypassing. Often, the bank with the fewest number of fans running has its fan switched on when TC001.OP exceeds Max, and the bank with the greatest number of fans has its fan switched off when TC001.OP falls below Min (Min and Max are the lower and upper outputs of TC001, beyond which switching occurs). If the above selection criterion does not identify which fan to switch, the fan runhours may be used as the secondary criterion. A number of strategies for determining which fan to switch on or off are possible, and the appropriate strategy should only be decided on after consultation with the Principal. Typically the strategy will be linked to the maintenance schedule of the fan motors. Often a strategy designed to stagger the maintenance schedule of the fan motors is employed. In this case, of the possible fans available for switching, the one with the greatest number of runhours is switched on and the one with the least number of runhours is switched off. This strategy ensures that the maintenance plan for the motors can be staggered.

Run hours should be calculated by the algorithm, which should provide a mechanism for resetting the runhours after motor maintenance has been carried out. If possible, the reset should be performed automatically.

The operator shall have the ability to remove fans from the selection scheme. This does not affect the state of the fan (running or stopped) but prevents the fan from being started or stopped by the controller.

Some schemes exist with more than one VSD per bank. In this case the two fans are operated in a split-range fashion, with the first fan moving from 0 – 100 % over the 0-50 % range of the controller and the second fan moving from 0 – 100 % over the 50 – 100 % range of the controller. The VSDs are then configured as simple split range controllers. This approach means the controller tuning is unaffected when one VSD is not available for control. An alternative would be to run both fans at the same speed. In this case, from a control point of view they may be treated as a single fan.

The block 'Y1' calculates the number of fin fans currently in operation. The output of Y1 is the difference between the number of fans in operation during the current cycle and the number in operation during the previous cycle. Thus, if a fan is started, the output of Y1 has a value of 1 for one cycle and thereafter a value of zero. Similarly, if a fan is stopped, the output of Y1 has a value of -1 for one cycle and thereafter a value of zero. This change represents the change in cooling duty, expressed as a fraction of the duty of a VSD fan, running at 100 %.

Block Y3 scales the output of Y1 based on the number of VSD drives that are currently controlled by TC1.

The output of Y3 is used as the input to lead-lag block Y6. The block Y6 has two functions: the first is to simulate the dynamics of switching a fan on or off, and the second is to convert the scaled and normalised output of block Y3 into an equivalent output change in the temperature controller TC1 to prevent FSD fan switching from disturbing the process temperature. The principle of operation of Y6 is that it adjusts the feed forward contribution to the VSD output fast enough to match the process disturbance and then decreases the output back to zero at a rate slow enough to allow the feedback controller to respond without noticeable effect.

Temperature controller TC1 is configured as a feed-forward PID controller as described in DEP 32.30.20.15-Gen. Y4 represents the feed-forward component of the loop. Block Y2 determines the feed-forward value, based on the assumption that all VSD fans are controlled by TC1. Block Y3 scales the feed forward signal based on the number of VSD drives that are currently controlled by TC1.

The duty calculation is performed on the basis of the comparative duties of fixed speed and variable speed fans. Thus, assuming a fixed speed fan, when it is running, has 70 % of the duty of a variable speed fan running at 100% speed, and has 40 % of the duty of a VSD when stopped, stopping a fixed speed fan reduces the cooling capacity by 30 % of one VSD. Assuming there are 3 VSDs running, these should be increased by 10 % each to compensate.

The Block Y5 monitors the output of temperature controller TC1. If the controller is in automatic mode and its output falls below a prescribed minimum (typically 10 %), Y5 instructs one of the fixed speed fans to start. Similarly, if its output rises above a prescribed maximum (typically 90 %), Y5 instructs one of the fixed speed fans to stop. The fan to be started or stopped is determined on the basis of the rules defined above.

3.5.2 Specific configuration considerations

Normally, the fan speed is not available on the DCS, so speed controllers (SciA, SciB) are configured as auto-manual stations. When a VSD motor is stopped the auto manual station output is set to MANUAL 0 % output. This is repeated when the motor is started. An auto manual station has two modes of operation: manual mode where the operator sets the VSD speed, and automatic mode where TC1 sets the VSD speed. The transition between the modes shall be bumpless.

3.5.3 Calculations

$$Y1 = \text{No of fans running this cycle} - \text{No of fans running previous cycle} \quad (0.1)$$

$$Y2 = \text{Number of VSDs controlled by TC1} \quad (0.2)$$

Y2 scales the feed-forward requirement based on the number of VSDs under the control of TC1.

$$Y3.OP = \frac{Y1}{Y2} \quad (00.3)$$

$$Y6 = k \times k_{LL}(t) \times Y3 \quad (00.4)$$

where

$$k = \frac{(\text{Fixed speed duty running} - \text{Fixed speed duty stopped})}{\text{VSD duty at 100\%}} \quad (00.5)$$

3.5.4 Initialisations

The output of the temperature controller is initialised based on the output of the first variable speed fan speed controller (SCiA/SCiB) to be set in cascade mode. Subsequent speed controllers shall move from manual mode to automatic mode to cascade mode in a bumpless fashion.

3.5.5 Operational modes

During normal operation, the temperature controller (TC1) is in AUTO/CAS mode and all the variable speed fan speed controllers SCiA/SCiB are in automatic mode.

The system has the following major modes of operation:

Mode of Operation	Scenario	Automatic Action	Operator Action
Startup	All speed controllers SciA/SCiB in automatic mode and temperature controller TC1 is in automatic mode		
Crippled Mode	Speed controller SciA in MAN	Update feed-forward estimate	
	TC1.PV to BAD	TC1 mode to MAN	
Crippled Mode	Temp controller TC1 in MAN		

3.5.6 Operator interface

Apart from the standard faceplate for controlling each device (fans / temperature controller), the operator interface should have the following functionality:

- Ability to select fixed speed fans which will be switched by the scheme. At any point of timer operator may add/remove fans from the scheme and control them manually.
- A display of the next fans to be started and stopped by the capacity controller logic.
- A display showing which fixed speed fans are switched by the logic and which are switched manually.
- A display showing the Local/Remote status of the VFDs if available.

3.5.7 Startup/shutdown

To start up the scheme, based on the duty needed, the required number of fixed speed fans is started by the operator from the operator interface. With TC1 in manual mode, the required number of variable speed fans is manually started at a speed pre-determined by the operator. The operator then specifies which fixed speed fans may be started by the control scheme. Thereafter the temperature control is set to AUTO mode and all the running variable speed fan speed controllers are set to CASCADE mode. Once the temperature is steady, the operator enables the feed-forward action for temperature controller.

To shutdown the capacity control scheme, the temperature controller is put into MAN mode.

3.6 THREE ELEMENT LEVEL CONTROL

3.6.1 General

The objective of the three term level control scheme is to improve the controllability of the steam drum level by predictively adjusting the boiler feed water flow to match the steam flow generated. This approach reduces the instability of level controller feedback and provides more robust level control. The basic problem with attempting to control the boiler feed water flow on level only is that as the steam consumption increases, the steam fraction in the risers increases as well, leading to a level surge in the steam drum. Similarly, as the steam consumption decreases, the steam in the risers collapses, causing a level drop in the steam drum. If only level control is used, the controller should be tuned tightly and the controller will then respond incorrectly to the level change in the steam drum. The feed-forward approach allows much slower tuning of the level controller. The control scheme is shown in Figure 4.

Changes in the steam flow FI2 are added to the output of the level controller LC1, to provide the setpoint to the boiler feed water controller FC1. Note that, in line with the feed-forward standard, the absolute steam flow is not used. Instead the incremental difference in the steam flow since the previous cycle is added to the level controller output. The feed forward is implemented as described in DEP 32.30.20.15-Gen.