CHAPTER VI

FURNACE DRAFT CONTROLS

Most large utility boilers used to be designed with pressurized furnaces. The justification for such designs was the lower installed equipment cost (one set of forced draft fans) and reduced fan maintenance since the FD fans handle clean air. However, problems with maintaining casing-pressure integrity, and concern for personnel safety have made the industry return to use of balanced draft units. Concurrently, clean air standards requiring use of scrubbers, etc., introduce higher draft losses and the need for higher-head induced draft fans.

While the problem of regulating the fans to supply the required airflow and, at the same time, maintain the desired furnace draft during normal operation is elementary, special control requirements are associated with limiting transient pressure excursions during major upsets such as main fuel trips. A discussion of the factors involved will be based on studies of a 600 MW oil-fired unit reported in reference (6.1). Although this unit has unusual requirements, the example serves to illustrate the nature of control and override logic involved in furnace draft controls.

As shown in Figure 6.1, combustion air is supplied to the boiler by two constant speed motor driven forced draft fans, with inlet vanes control. There are two sets of Induced Draft fan trains; each train consisting of a primary I.D. fan discharging to a secondary I.D. fan inlet. The secondary I.D. fans discharge through a scrubber system to the stack. The primary I.D. fans are constant speed, motor driven, with control on inlet vanes. The secondary I.D. fans are speed controlled through hydraulic couplings. Because of the head loss requirements created by high draft loss boiler design, particulate scrubbers and future sulphur removal scrubber, these Induced Draft fans are considerably oversized for a unit of this capacity. Each of the fans are driven by 7000 HP motors and each set can develop a total head of 76 inches W.C.

Combustion air flow measurements are made by piezometer rings located in the inlet of the two forced draft fans. Furnace draft taps are just below the furnace roof, with each of three transmitters connected to its own dedicated tap.

This oil-fired high-draft loss boiler design has created severe problems for the electric operating companies. Of initial concern was the large induced draft fans, with their high inertia and a long coast-down time, continuing to pull a significant draft after the forced draft fans had stopped rotating following the tripping of all fans.
On further consideration, the boiler implosion potential from sudden loss of fire appeared even more critical; especially because of the use of series sets of two (2) induced draft fans discharging to four (4) flue gas scrubbers.

The most critical element in minimizing an implosion potential was found to be that of time. Studies disclosed that maximum negative pressure occurred approximately 1.7 seconds after loss of flame and loss of flame occurs at an estimated one second after loss of fuel. This allows approximately 2.7 seconds to take corrective control action to counter the anticipated high negative pressure unless the time could be extended.

PROCESS CHARACTERISTICS

The dynamic behavior of the boiler air-gas path was simulated by a digital computer. The simulation study had two objectives:

First, to indicate the pressure excursion profiles that could be expected following a master fuel trip disturbance.

Second, to indicate the relative merits of alternative F. D. and I. D. automatic control arrangements.

The simulation model accounts for the following effects:

- gas flow head loss according to the square law, \( P = C_p V^2 \).

- variation of gas temperature through the boiler due to combustion heat release and to convective and radiative heat transfer.

- variation of gas specific volume according to the gas law, \( P = pRT \).

- variations in the mass of gas residing in furnace sections.

- variations in fan characteristics with gas density, fan speed, and damper position.

Before discussing model results, it is useful to review the fundamental requirements of furnace air flow control.
AIR FLOW CONTROL REQUIREMENTS

For the furnace and fan configuration shown schematically in Figure 6.1, air and gas flow through the furnace and ducting is maintained by the combined action of forced draft and induced draft fans. Opposition to this flow is contributed by air heaters, tube sections, furnace dampers, duct losses, and scrubbers, and is distributed along the entire length of the flow path.

It is useful to visualize the pressure distribution along the boiler air gas path as shown in Figure 6.2a. This shows positive pressure upstream of the furnace, negative pressure downstream of the furnace and then positive pressure again to force the flue gases through the scrubber to the stack.

The scrubber is an adjustable orifice device designed to hold a constant head loss in steady operation, but the head losses through the remainder of the flow path vary as the square of air/gas flow. Thus, if Figure 6.2a applies for full load, the pressure profile at part load should be as shown in Figure 6.2b. Note that, to maintain balanced pressure in the furnace, the net head developed by both F.D. and I.D. fans must be reduced.

Now consider the case where the F.D. and I.D. fan controls are imperfectly manipulated to reduce air flow to a part load value. The pressure profile will be as shown in Figure 6.2c; the slope of the pressure profile and the total head loss will be essentially unchanged from Figure 6.2b, but the whole profile will be biased up or down.

Examination of Figure 6.2 shows that:

- The net head of F.D. and I.D. fans must be adjusted in unison to regulate air flow while maintaining furnace pressure at a given value.

- The net head of the F.D. and I.D. fans must be adjusted in opposition to regulate furnace draft while holding a given air flow.

In accordance with these characteristics, reduction of unit load under normal operating conditions involves simultaneous gradual reduction of the net head of both F.D. and I.D. fans. This is achieved by closing inlet vanes on the F.D. fans, closing inlet dampers on the primary I.D. fans, and reducing the speed of the secondary I.D. fans.
It is to be noted now that the above control rules apply for normal operation where the system is undergoing relatively gradual changes. The control requirements following sudden loss of fire are significantly different. The nature of these different requirements is best illustrated by reference to simulations of fuel trip disturbances as presented in the next section.

**FIGURE 6.2a Full Load, Air Flow**

**FIGURE 6.2b Reduced Load and Air Flow, Properly Coordinated Fan Adjustment**

**FIGURE 6.2c Reduced Air Flow, Improperly Coordinated Fan Adjustment**
S U D D E N  D I S T U R B A N C E  B E H A V I O R

Figure 6.3 shows a simulation of the boiler's response to a sudden complete shut-off of fuel flow in the condition where all air flow and furnace draft controls are locked. There is an immediate and rapid decline in the temperature of the gas within the furnace. The pressure in the furnace is governed by the gas law: \( P_v = mRT \) where volume, \( v \), and the gas constant, \( R \), are constant. The rate of change of the furnace mass inventory is dependent on the air and gas flows which are governed by fan and head loss characteristics. The mass inventory adjustment rate does not immediately match the rate of decay of temperature and there is, following from the gas law, a rapid fall in pressure inside the furnace.

Figure 6.3 shows an increase in furnace air inflow as furnace pressure and temperature fall. There is a corresponding decrease in gas outflow. Both of these flow changes aggravate the disturbance since they create decreased net F.D. head and increased net I.D. head, hence depressing the already low furnace pressure. The furnace inventory adjustment "catches up" with the temperature change process after about 2 seconds and the furnace pressure then commences its return to nominal value.

This behavior shows that initial movement of the I.D. fan controls in the closing direction will ultimately be needed to regulate air flow at the desired post-disturbance value, and will tend to counteract the transient dip in furnace pressure. More importantly it shows that, although they will ultimately be required to close in correspondence with the I.D. fan controls to maintain the new air flow, the F.D. fan controls should be moved in the opposite (opening) direction during the initial transient following a sudden firing rate reduction.

This requirement for different directions of motion of the F.D. fan controls during sudden firing rate transients, as opposed to gradual load changes, is a key factor in selecting between the two commonly used control arrangements described below.
Rapid fuel shut-off, fan dampers locked.

FIGURE 6.3
AIR FLOW CONTROL ALTERNATIVES

Two feedback control arrangements that have commonly been used to meet the control objectives are shown in Figure 6.4. Both achieve the desired coordination of fan control actions by assigning one set of fans to regulate air flow and the other to regulate furnace draft. The difference is that they have reversed responsibilities for the F.D. and I.D. fan control loops. Simulation runs covering several different boilers have shown that both arrangements can give satisfactory regulation of air flow and furnace draft when following load ramps as rapid as 100% per minute.

The behavior of the two control arrangements following sudden disturbances of the load reference is quite different, however. Scheme A, which makes the F.D. fan control sensitive to load reference, will tend to close the F.D. fan inlet vanes immediately following a sudden downward disturbance of load reference and fuel flow, hence aggravating the negative furnace pressure excursion. In contrast, Scheme B will respond to the sudden reduction of load reference by closing the I.D. fan dampers, but the associated negative furnace pressure caused by the fuel flow reduction will cause it to initially open the F.D. fan inlet vanes. It will close the F.D. vanes only after the negative furnace pressure excursion has passed.

Thus, Scheme B is regarded as being preferable to Scheme A because it inherently gives the correct initial response to potentially damaging fuel trip disturbances while Scheme A would have to depend on override logic to prevent inappropriate closure of the F.D. fan vanes.

The other factor affecting the selection of Scheme B is that the F.D. fan control, usually has the more direct effect on furnace pressure since there is less buffering volume and head loss in the ductwork between the F.D. fan and the furnace than between the furnace and the I.D. fans. Now, furnace pressure control is the highest priority requirement; it should be assigned to a fast-acting inner control loop, with the air flow control being handled by an outer control loop. Since stable control design requires the inner loop to be faster acting than the outer loop, it is desirable to assign the more direct control means, the F.D. fan vanes in this case, to furnace pressure control.

The recommended control arrangement incorporates the essential features of Scheme B for the regulation of furnace draft and air flow, together with high gain overrides to drive both F.D. and I.D. fan controls in the compensating directions indicated by Figure 6.2 whenever the deviation of furnace draft from setpoint exceeds preset emergency limits.
Scheme A, I.D. Fan controls Furnace Pressure

Scheme B, F.D. Fan controls Furnace Pressure

Figure 6.4
ORIGINAL CONTROL SYSTEM

The original control system configuration as it was installed, before any specific requirements for coping with furnace implosion were imposed on it, is shown on Figures 6.5 and 6.6.

The original air flow and furnace draft controls on this unit were implemented with pneumatic control hardware throughout. The forced draft inlet dampers are each powered by one 10" x 16" pneumatic piston drive. The two primary I.D. fan inlet vanes required, for each fan, two 10" x 16" piston drives, set up in a master/slave configuration. Operation of each of the secondary I.D. fans hydraulic coupling control levers was accomplished with one 8" x 16" piston drive to each lever.

The original system assigned the duty of maintaining air flow to its required set point to all three sets of fans in parallel (the forced draft H/A stations could be considered air flow master stations). The furnace draft controller had plus/minus trim adjustment on the primary I.D. fan inlet dampers available to it to maintain balance between fans. No specific provisions were made in this system to cope with the implosion possibilities inherent with a main fuel trip. With no F.D. fan running, an automatically set maximum I.D. inlet vane position equivalent to about 30% air flow is established.

Initial checks on the original pneumatic draft control system disclosed that there was a time lapse of eighteen (18) seconds from the time the furnace pressure transmitter felt a change until the primary induced draft fans inlet vanes, used for furnace draft control, began to move. The vane drives required thirty (30) seconds to go full travel.

Booster relays were installed in the inlet vanes drives and the time for full travel, without load, was reduced to approximately 5-6 seconds. Installation of electronic transmitters and electric transmission to the pneumatic control system and from the control system to the drives reduced the overall loop time to 3.5 seconds. To gain more time, sequential elevation tripping of fuel was utilized as recommended in Reference 6.2.
REVISED CONTROL SYSTEM

Based on computer model studies, it was found advisable to do most of the control using primary induced draft fans and to use the secondary I.D. fans to supply the additional head to push the exhaust gases through the scrubber to the stack. The studies led to the control revisions described below:

a) Primary I.D. Fans Control (Figure 6.7)

The air flow demand and the air flow measurement, with $O_2$ correction, are developed just as in the original system to index the air flow controller. However, in this revision, the air flow demand is also fed-forward as a demand for total primary I.D. fans inlet damper position. This reduces the duty of the integral component of the air flow controller to a calibrating trim adjustment, since the load matching duty in positioning the vanes is carried by the feed-forward demand. Utilizing average vane position demand (from below the H/A stations) as a negative feedback against this demand, a much faster and more accurately timed system linearization for one-two fan operation is obtained.

This same averaged primary I.D. vanes signal acts as the feed-forward demand to the F.D. fans control. Separately, each primary I.D. fan position demand indexes its corresponding secondary I.D. fan speed control. Thus, air flow control is applied, in parallel to all three pairs of fans.

Back-up safety features, and special action taken specifically to help contain furnace pressure within bounds on a M.F.T., come into the system below the primary I.D. fans H/A stations, so they will be effective even if the fan loops are on manual.

If furnace pressure increases to a value higher than the normal control range (set at +3"), an increasing signal from the furnace pressure deadband controller (discussed later in the F.D. fan control sub-loop) will take over and increase the opening of the vanes at the high signal auctioneers. On an out-of-range low furnace pressure (set at -4") a runback takeover at the low signal auctioneers will close the vanes.

Entering the summers below the auctioneers, is a transient negative signal that is triggered by the same logic that initiates a M.F.T. This negative signal, promptly reduces the primary I.D. fan vanes position by 35%, and then wipes itself out over a 30 second period.
b) Secondary I.D. Fans Control (Figure 6.8)

Since the primary and secondary I.D. fans form physically, and operationally, series pairs, the control system is set up on that basis. The "A" primary I.D. fan vanes positioning signal becomes the feedforward, through a function generator, to the "A" secondary fan hydraulic coupling control. The pair of "B" fans are treated in the same way. Empirically determined from operational data, a load referenced set point for the duct pressure between the two fans is compared with the actual duct pressure to provide a balancing trim to keep the two fans working together properly. This duct pressure corrective action also provides the desirable feature of a self-timing derivative type action to the high inertia, slow responding secondary fan speed loop. "Out-of-range" furnace pressure overrides are applied to the secondary I.D. fans also.

c) Forced Draft Fan Control (Figure 6.9)

The averaged primary I.D. fan vane positioning signal acts as the feedforward to the F.D. fan vane position control. Calibration of this feedforward based on the steady state relationship between I.D. and F.D. vanes is provided.

Because of the importance of the furnace pressure measurement, it was decided to use three transmitters feeding into a median selecting circuit. In this way, the loss of any one transmitter can be accepted without loss of automatic control. This verified furnace pressure signal from the selecting circuit is used to index the furnace pressure controller. Because of the load related feedforward from the primary I.D. fan vane positions the furnace draft controller has only a trim duty to perform under normal conditions.

In the deadband controller, furnace pressure is compared against both high and low pressure set points. Should a sufficient upset occur to drive furnace pressure to one or the other of these limits, the appropriate override action will be taken at the low and high signal selectors below the F.D. fans H/A station. These same signals, inverted, are used in the primary and secondary I.D. fan circuits, as previously discussed.

This "out-of-range" furnace draft controller is of prime importance as a safety backup to the normal control. For this reason it comes into the system below the Hand/Automatic stations. Introducing this backup control loop below the H/A stations, however, forces an evaluation of failure modes that could occur. The two extremes would be failures that create 100% positive or 100% negative outputs from the "backup" controller. Either case would be disastrous, since the I.D. and F.D. controls would be driven inversely to extreme positions.
FIGURE 6.8
FURNACE PRESSURE

P  P  P

MEDIAN SELECT

FURN. PRES. CONTROLLER

PRL D. VANES POSITION

f(x)

Σ

SYSTEM LINEARIZER

- K

Σ/n

FURNACE PRESSURE HIGH

#1

DEAD BAND CONTROLLER

FURNACE PRESSURE LOW

#2

DEAD BAND CONTROLLER

#3

DEAD BAND CONTROLLER

Δ T

Δ T

<

<

>

>

"A" F.D. FAN INLET VANES

"B" F.D. FAN INLET VANES

- K

- K

- K

TO F.L. FANS

FIGURE 6.9
To protect against such a catastrophic failure situation, the deadbanded furnace draft controllers are triplicated and the three controller outputs are auctioneered in a median signal selecting circuit.

In this manner a failure in any one control loop, or furnace pressure transmitter, can be accepted without system upset. Monitors alarm to the operator any such failure, and alert him to the fact that one of the channels of control is faulty.

d) Operational Characteristics

In terms of the overall control philosophy, the major change made in this revision is to assign furnace pressure supervisory control to the F.D. vanes, instead of to the primary I.D. fan vanes as originally designed. Air flow control is still assigned in parallel, to all three sets of fans. The operational characteristics of this revision under normal operating conditions are apparent from the system's description just discussed. We can postulate a M.F.T. and follow, qualitatively, the control actions of the system.

Two immediate actions are triggered from, and coincident with, the M.F.T. contact:

1. The master demand (and thus the air flow demand) is locked up at its existing value.

2. The transient negative signal is inserted in the primary I.D. fan vanes positioning signal, closing these vanes, at their fastest rate, about 35% to offset the anticipated furnace negative pressure.

In spite of this kicker action to the primary I.D. fans, the furnace pressure will start going strongly negative as the furnace temperature collapses. This starts the forced draft dampers opening by normal furnace pressure control action.

The combination of lower furnace pressure and further open F.D. fan vanes increases the air flow as measured on the suction side of the F.D. fans.

The increase in air flow starts the air flow controller driving all fans downward.

The feedforward action to the F.D. fan loops in the reducing direction starts countering the opening action of the furnace draft controller, and continues as the reduction in the furnace draft requires progressively less F.D. fan.
When measured air flow has been reduced to match the "locked-in" demand, all I.D. fans will be operating at a lower level and the forced draft fan dampers will be back at essentially the same position they started from at the time M.E.T. was triggered.

CONTROL RESPONSE SIMULATIONS

A simulation study was made with controller models and logical statements added to the basic furnace model to represent the proposed control system in detail. The controls were tuned by making an initial series of small disturbance runs and adjusting the controller proportional and integral gains for good damping and response in normal operation. Simulations of major boiler trip disturbances were then made by suddenly stepping the load reference to zero and reducing fuel flow according to the desired shut-off sequence.

One representative set of runs showed the effect of controls on furnace pressure transients. All runs shown here used the initial operating condition where the flue gas scrubbers are fully opened to give minimum head loss; both fan trains are operating, the secondary I.D. fan motors are in operation, and the primary I.D. fan motors are de-energized.

A simulation of a full load trip from this initial operating condition where all fuel flow is shut off in two seconds with all controls locked showed a maximum furnace draft excursion of 20 inches of water. One typical series of simulation runs was made to show the extent to which control action could reduce this excursion.

Figures 6.10a and b show the response to this disturbance when the F.D. (draft) control is active in its normal mode and the I.D. control is in manual at fixed damper position. The negative furnace pressure excursion of 18 inches w.g. is slightly less than that observed with no control action and the initial negative pressure excursion is followed by a significant positive excursion.

A limitation of the basic control scheme as used to yield the results in Fig. 6.10 is that it relies on the regulating controller whose gain settings are optimized for normal operation, and does not provide the strongest possible control action in emergency situations. Gain values that would give maximum rate control action in boiler trip transients would result in poorly damped response to normal small disturbances.
Rapid fuel shut-off F.D. vanes-auto I.D. vaneslocked

FIGURE 6.10a
Rapid fuel shut-off F.D. vanes-auto I.D. vanes-locked

FIGURE 6.10b
This limitation of the normal regulating control is overcome by the use of high gain overrides which become active when the furnace pressure deviates from set point by more than 4 inches w.g. The effect of these overriding controls is evident from Figure 11 which shows the response to the same transient as in Figure 10 but with the high gain overrides set to drive the F.D. fan vanes strongly in the opening direction and I.D. fan dampers strongly in the closing direction when the furnace pressure falls below -4 inches w.g. The overriding controls give a significant reduction of the initial transient, and are able to return the furnace pressure rapidly to the -4 inch w.g. value. As the rate of change of furnace temperature decreases the normal regulating loop is able to regain control and return the furnace draft smoothly to its set point value.

Figure 6.11a and b showed that the use of fast acting override control action provides a strong reduction of the furnace draft excursion, but that the first very rapid fall in furnace temperature following complete fuel shutoff in two seconds cannot be compensated by control action because of the stroking speed limitation of the damper and vane actuators. If the primary I.D. fans had been in operation, giving a greater maximum available I.D. head, the initial negative furnace pressure excursion shown in Figure 11 would have been significantly greater.

The most effective method of limiting the first downward swing of furnace pressure has been found to be the use of programmed reduction of fuel flow to reduce the initial rate of fall of furnace temperature.

Figures 6.12a and b shows the response to a Master Fuel Trip when both F.D. and I.D. controls are in automatic mode and the emergency overrides are activated. In this case the "hydromotor" fuel valves on the four levels of No. 6 oil guns were closed in succession at 0, 2, 4, and 6 seconds after receipt of the MFT signal. The staged fuel shutoff is shown to reduce the rate of fall of furnace temperature to a value where the overriding controls can hold the initial furnace pressure excursion very close to the -4 inch w.g. level.
Rapid fuel shut-off over-ride controls active

FIGURE 6.11a
Rapid fuel shut-off over-ride controls active

FIGURE 6.11b
Staged fuel shut-off full automatic fan controls

FIGURE 6.12a
Staged fuel shut-off full automatic fan controls

FIGURE 6.12b
IMPROSION/EXPLOSION

It might be argued that the control system, advocated here could increase the possibility of boiler explosions. The rationale for this argument seems to be grounded in N.F.P.A. standards for prevention of furnace explosions; specifically in the statements contained in paragraph 563 of standard 850 quoting directly:

563, Recommended Procedure For Purging After an Emergency Trip:

"If the fans are operating after the trip, continue in service. Do not immediately increase the air flow by deliberate manual or automatic control action. If the air flow is above 25% of full load air flow, it may gradually be decreased to this value for a post firing purge of at least five minutes. If the air flow is below 25% of full load volumetric air flow at the time of trip, it shall be continued at the existing rate for five minutes and then gradually increased to 25% of full load air flow and held at this value for a post firing purge of five minutes."

This paragraph has been widely interpreted and implemented as a requirement to lock the forced draft dampers in the position existing at the time of trip, and allow the induced draft dampers (or speed) to go toward shut on furnace pressure control. Some interpretations have called for locking the I.D. fan actuation also. To us, this seems completely at odds with the problem to be solved. The overall intent of this paragraph, as stated in its heading and several times in the body of the text, is to establish a procedure for post firing purge. Earlier, in this same NFPA publication, "purge" is defined in Chapter 3 by:

"A flow of air through the furnace, boiler gas passages and associated flues and ducts which will effectively remove any gaseous combustibles and replace with air."

And on page 33 by:

"Purge air flow shall be equal to or greater than 25 percent of full load volumetric air flow for a period of 5 minutes."
Studying these direct quotations raises the question: Just what "air flow" does paragraph 563 recommend not be increased? In the control system, when we refer to "air flow", we mean the air delivered by the forced draft fans to the burner windbox. After a fuel trip, "purge air flow" is not equal to this "forced draft air flow" until furnace draft is very nearly restored to its set value. Referring to Reference 2 we find reported on page 10 the situation after a fuel trip, with all dampers locked. The plots of furnace pressure and I.D. suction pressure following the trip show that from about 2 seconds to 12 seconds after the trip, furnace pressure was reduced to very nearly equal I.D. fan suction pressure. In other words, for about 10 critical seconds there was no purge air flow. The "forced draft air flow" entering the furnace during this time was all used to restore volumetric inventory lost when the fuel was tripped off. An additional piece of information illustrated by this same set of response curves is that, even with all fan dampers locked, the "forced draft air flow" increases as the furnace pressure plunges to its minimum value. This is recognized in paragraph 563 by the phrase "deliberate automatic or manual control action." While the suggested control system temporarily increases "forced draft air flow" on a controlled basis following a fuel trip, a control philosophy that locks up the forced draft damper differs from this only in degree, since both approaches result in a temporary increase in "forced draft air flow" while lost inventory is being restored. Only when the volumetric unbalance is restored can "forced draft air flow" be considered as "purge air flow". The only control action that would result in no change in F.D. air flow would be a closure of the FD dampers. This appears to be a sure invitation for a boiler implosion. Another reason sometimes stated for not increasing air flow is that an increase in air flow will pick up combustible material that has settled out in low-velocity areas, and that this can create an explosive mixture. Our proposed solution increases, transiently, only "forced draft air flow" in an effort to restore air flow through the furnace boiler gas passes, flues and ducts (the defined "purge air flow"). There is no sudden increase in flow rate through those parts of the boiler where combustible material could collect; the increase occurs only in the clean air side of the boiler. In fact, if we do not take the steps we do to keep the furnace pressure from plunging to minus 15 to 17 inches w.c., we can visualize more combustibles being stirred up by the inrush of air through observation doors and any other points of leakage. These paths are not the normal flow path, and there would be more tendency for accumulation pickup by these random air flow paths.

In summary, the suggested control configuration and override logic will reduce the probability of implosion following M.F.T., without increasing the possibility of a furnace explosion. The actions taken positively account for the temporary imbalance created by the rapid inventory upset in the
furnace, giving optimum short-term protection. Control action quickly returns the forced draft dampers to the position they were in prior to the trip, thus restoring and assuring the continuous post-trip surge air flow as required.

CONCLUSIONS

A careful review of furnace control and performance by both simulation and test has shown that large furnace draft excursions can be contained by:

a) Timed fuel shutoff over a period of 6 to 8 seconds following initiation of boiler trip.

b) Fast-acting actuators for all fan control vanes.

c) Assigning the furnace draft control duty to the fans (FD or ID) having the prompter impact on furnace draft; in most boilers this will be the forced draft fans.

d) Direct acting override controls responding to out-of-range furnace pressure, applied to both F.D. and I.D. fans, combined with a transient closing bias of I.D. damper position initiated by master fuel trip.

The control system, properly designed and tuned to handle master fuel trip situations, also provided improved control under normal operation.

REFERENCES


6.2 "Recommendations for Furnace Enclosure Damage Prevention" - Combustion Engineering Co. position paper.