

I: Recommended Procedure for Forced Shutdown

Pulverized coal, oil, gas

1. Shut off the fire immediately
2. Shut down the forced draft
3. Close off the steam output
4. Stop the flow of feedwater to boiler
5. Reduce air flow as low as possible to a point consistent with safety from water or steam blowing into boiler room

Stoker firing

1. Shut down the fuel feed
2. Cut off the combustion-air supply
3. In extreme emergency, smother fire. Take care not to cause gas explosion
4. Close off the steam output
5. Keep the feedwater flowing to maintain the water level

II: Procedure for Feed Loss

Stoker firing

1. Cut fires when the water level drops out of sight
2. Close all blowdown and drain valves to conserve H₂O
3. Reduce load on steam turbines, etc
4. Trip out turbine if the boiler pressure falls below 20% of normal

a boiler on the line from purely operating causes are (1) sudden cooling following the loss of a boiler tube (2) a large pressure drop produced by extinguishing the fires without immediately shutting off steam outlet to the plant load.

Thermal stress from chemical feed connections or cold-water inlets to the drum are problems of design that require thermal sleeves for their correction.

Operating Precaution. Now that we know just how temperature stress can develop in a boiler drum we appreciate the value of an operating procedure that will prevent any stress from developing. Briefly, abnormal stress does not develop if temperature differences between various sections of the drum are limited to (1) 100 F during pressure-raising (2) 70 F during pressure-reducing. These limits apply to drums of any thickness. In filling a boiler hold feedwater to 50 F above or below drum temperature to reduce chances of tube seat leakage.

Temperature difference can be measured by thermocouples, preferably spotted as follows: (1) on the thickest part of the drum, top and bottom (2) about 18 in. from the top on the drum circumference (3) on a boiler tube or circulating tube that is always at saturation temperature. An approximate check method for drums up to 10 in. thick is to hold the rate of increase of saturation temperature to 100 F per hr so the drum parts will remain well within the temperature-difference limitation. For drums up to 4-in. thickness the restrictions on heating rates imposed by superheaters and other boiler elements hold drum temperature differentials within the recommended limits. Similarly on shutdown, unless it is accelerated by blowing down and feeding water, normal cooling rates at natural pressure drops lie well within the 70-F-per-hr limit. For a thick-drum high-pressure installation, where steam

can discharge into a lower-pressure system, allow the pressure to drop with a reduced-firing rate, but hold to the 70-F-per-hr temperature differential. This may involve intermittent firing and completely filling the drum with feedwater, using thermocouples as a guide.

Forced Shutdowns. Now let's look at forced shutdowns. A drum empty of water, but still under steam pressure, experiences serious stresses if relatively cold feedwater comes in contact with the drum surface. Any drum, thick or thin, can withstand a certain number of temperature shocks without damage. But no one can predict just how many.

Damage from such a shock far outweighs any temperature shock that could develop from the low heat given off by accumulated slag in a furnace setting. Because of this possibility, an operator's primary consideration should be safe-guarding the drum. Here is how he can do that. Tables I, II.

A boiler fired with pulverized coal, oil or gas and experiencing a tube rupture, say, should have its fire cut off immediately, the forced draft shut down, and steam output closed off completely. In addition, stop the feedwater flow to the boiler. With this procedure, by the time water within the drum has dropped to where furnace-wall tubes are dry, heat emission from slag or refractory will be so low that no damage will result.

Air flow should be reduced as low as possible: to a point where water or steam escaping from the tube rupture does not blow into the boiler room.

Once pressure in the unit has dropped to zero follow the procedure for a normal shutdown. Do not empty the boiler system of water until the furnace is cool enough to permit a man to enter.

Fuel-Bed Firing. With stoker or other fuel-burning methods where the fire can't be killed instantly, other steps must be taken. The problem resolves itself into a choice between risking

damage to (1) drum by continuing the flow of feedwater (2) furnace tubes and boiler structure by shutting off this flow. A majority of stoker-fired units are of lower pressure, and thus danger from quenching drum shells is not as prevalent.

For emergency, shut down the supply of fuel and combustion air. Smother the fire by whatever means have been predetermined or are available without causing a gas explosion. Shut off steam output completely to prevent a sudden drop in pressure and temperature within the boiler.

Keep feedwater flowing to the crippled boiler and try to maintain water level. Do not rob other boilers. Shut off supply entirely after fuel combustion drops to where overheating of pressure parts will not develop—about 15 minutes after the rupture has been detected. From then on, the cooling procedure follows that outlined for pulverized coal, oil or gas-fired units.

But suppose feedwater supply is lost. If pressure parts remain intact, cut the fires out as soon as water level drops out of sight. Conserve all water in the boiler by closing off blowdown and drain valves. Reduce the load on the turbines. This procedure prepares the way before pressure drop makes complete shutdown necessary. In addition this method keeps safety valves from blowing, and if feedwater is restored saves restarting the turbine.

If boiler pressure falls 20% below normal, trip out the turbine. It saves stress from temperature reduction throughout the boiler and turbine unit which could develop from abnormal pressure drop. Once feedwater supply is restored deliver water slowly into the drum.

No reference has been made to operating pressures on this shutdown procedure. It has been worked up primarily for high-pressure thick-drum installations but applies equally to low-pressure thin drums.



AUTOMATIC RELEASE, heat-operated, sends carbon dioxide from above cylinders to discharge nozzles in vault on floor below



DISCHARGE NOZZLES are placed at intervals along the pipeline, encircling room. Fire causes carbon dioxide to flood room

Automatic Electrical-Fire Protection

Textile-plant circuit breaker and battery room protected against fire by a carbon-dioxide extinguishing system

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► CONTINUOUS MANUFACTURING at the Garfield, N. J. plant of the Forstmann Woolen Co is totally dependent on uninterrupted electrical output from its power house, which has a capacity of 7300 kw. Recently the company installed an automatic carbon-dioxide fire-protection system, which prevents serious damage and costly electrical-power interruption by safeguarding the circuit breaker and emergency lighting battery vault on the station's ground floor.

The room containing the breakers and battery is the supply center for hundreds of circuits in the many plant buildings. It is 107x15 ft, and has steel

fire doors—one at each end and two along one side.

Fire-Protection Equipment. Directly above the breaker room, on the operating floor of the power plant, are 28 steel cylinders, each containing 50 lb of liquid carbon dioxide. They are manifolded together for simultaneous discharge in case of fire. The cylinder manifold is connected by simple piping to a series of 20 wide-dispersal discharge nozzles, strategically located along the inside walls of the circuit-breaker vault.

Near the ceiling of the enclosed vault and directly over the breaker units are three heat actuators for detection of excessive temperature rise. They would quickly detect fire in any of the breakers. Automatically operating the cylinder manifold valves, the heat actuators release carbon dioxide through the piping network via discharge nozzles into the vault.

How Equipment Operates. The carbon dioxide provides its own propellant power, as it is stored in cylinders under 850-psi pressure. When this liquid reaches the discharge nozzles and hits the air, it turns into a gas expanding to 450 times its stored volume. Slightly heavier than air, this cloud of gas and

dry-ice snow floods the entire fire space, penetrating to every nook and corner of the circuit-breaker vault. This reduces the air's normal oxygen content to below the point where combustion can be supported. Elapsed time between outbreak of fire in the vault and complete extinguishment is only a matter of seconds. In fact, the fire might be out before power-plant attendants even detect it.

At the main door to the circuit-breaker room, which would be closed automatically by a release valve actuated by the discharging gas, are two remote-control break-glass boxes for fire-emergency use. One is for manual cylinder release, used when the system is taken off automatic operation. Manual operation of the fire-protection system is used when maintenance men are working in the vault. Thus they have a chance to leave during a fire before carbon-dioxide gas is released. The other remote-control box sets off the power-house fire alarm, ringing four gongs at various points on the floor.

After the fire is extinguished, there is little clean-up to be done since carbon dioxide leaves no messy residue. CO₂ will not damage delicate electrical equipment or machinery.