



RECOMMENDED GOOD PRACTICE
EMERGENCY SHUTDOWN PROCEDURE (ESP)
AND
PROCEDURE FOR TESTING ESP SYSTEM
FOR BLACK LIQUOR RECOVERY BOILERS

THE BLACK LIQUOR RECOVERY BOILER ADVISORY COMMITTEE

October 2012

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CHANGES

October 2012

Chapter 1:

- Clarified requirements of the Emergency Shutdown Procedure (ESP) System.
- Deleted requirement for “dedicated, stand alone”.
- Added DCE dilution water as a specific exception to “stopping all water and steam supplies”.

Chapter 3:

- Section 3.8, *Shut Off All Water and Steam Sources*: Added DCE Dilution water as a specific exception to “stopping all water and steam sources”.
- Section 3.11, *Fans and Dampers*:
 - Deleted phrase “or allowing them to seek full flow” from Sentence starting with “Restarting the fans, or allowing...”
 - Added allowance for DCE Fire Protection System to override ESP logic.
- Deleted definition for “Dedicated Stand Alone”.

For a summary of prior changes to this document refer to Appendix A, Document Revision History.

CHAPTER 1 EMERGENCY SHUTDOWN PROCEDURE (ESP) FOR BLACK LIQUOR BOILERS

An immediate emergency shutdown must be performed whenever water in any amount is known or suspected to be entering the furnace and cannot be stopped immediately.

Upon initiation of the Emergency Shutdown Procedure, the system shall perform the following automated actions:

- Activate Alarms**

Immediately activate audible and visible alarms to clear the recovery boiler area of all personnel.

- Stop All Fuels**

Immediately stop firing all fuels and ensure positive isolation of fuels from boiler. Shut off the auxiliary fuel supply at a remote location, manually or automatically.

- Stop All Water and Steam Supplies**

Immediately shut off feedwater and all other water and steam sources to the boiler except smelt shatter steam, **dilution water for direct contact evaporators**, and smelt spout cooling water. (For spout water leaks, see Section 3.19.)

- Set Air Flows to Stop Combustion and Smelting**

Immediately shut off all primary air flow. Immediately set other air flows to essentially stop combustion and smelting in the bed while maintaining some level of purge air flow. Regulate the induced-draft fan(s) speed or damper(s) to maintain a balanced draft in the furnace.

- Drain the Boiler to an 8-Foot Level**

Immediately start draining the boiler in accordance with manufacturer's recommendations to a level eight feet above the low point of the furnace floor. Simultaneously start to drain the economizer.

- Reduce Boiler Pressure**

After the boiler has drained to the eight-foot level, reduce steam pressure as rapidly as possible.

The Emergency Shutdown Procedure functions must be “energized to activate” and executed either by means of relay technology and hard-wiring or other Recovery Boiler Safety System as defined in Chapter 4 of the *Checklist and Classification Guide for Instruments and Control Systems*.

It must not be possible to alter the system unintentionally or to alter the system during operation of the boiler. Any time maintenance is done or modifications are made to the

*Recommended Emergency Shutdown Procedure (ESP) & Procedure for Testing ESP
System for Black Liquor Recovery Boilers*

system, the system shall be functionally tested prior to putting the unit back on line. Whatever technology is utilized, the BMS or DCS systems can be used to monitor operation of the functions.

It is critical that proper and complete execution of the Emergency Shutdown Procedure should not depend on the performance of a single system. Alternate means to accomplish all intended functions of the Procedure should be provided. Trained personnel should remain in the safe recovery boiler control room or other designated safe area to monitor and ensure completion of the ESP.

CHAPTER 2 RECOMMENDED PROCEDURE FOR TESTING EMERGENCY SHUTDOWN SYSTEM

2.1 Initial System Checks

The entire ESP system, including the rapid drain portion, should be put through an initial operational check to assure that the ESP logic system will function properly and safely. This initial operational check will determine drain time, confirm that rapid drain valves open, drain lines are clear, emergency feedwater stop valve closes, blowdown system is adequate, determine blowdown tank pressure, etc. This check should be made prior to firing black liquor in the kraft recovery unit. If liquor has been fired in the unit prior to ESP tests, make sure the bed has been burned down completely and the furnace hearth is free of molten smelt. Considerable experience has shown that the initial system check will not damage the recovery boiler.

The following test procedure is recommended:

1. Check out the complete ESP logic system electrically to assure each component is wired to operate as intended.
2. Bring the boiler to operating pressure, firing auxiliary fuel.
3. Stop all auxiliary firing. Check drain lines, one at a time, by manually opening the motor-operated drain valves fully. If two motor-operated valves are used, open the one closest to the boiler first and close it last. Maintain drum level during these tests and only keep the valve(s) open long enough to be sure that the line is clear and adequately supported.
4. Be sure all motor-operated valves are returned to the closed position and selector switches are returned to “remote” or “remote/manual” position.
5. Bring the unit back to operating pressure firing auxiliary fuel. Push the emergency shutdown button(s) to initiate a complete ESP. The first item in the ESP is activating alarms to clear the recovery area of unnecessary personnel. Abide by this - only those people necessary to monitor the test from a safe distance should be in the area! From this initial test, establish the actual drain time curve to the eight-foot level by plotting drum pressure vs. time. In particular, make note of the time taken to get to the eight-foot level. This time may be marked by a “knee” in the curve or a distinctive sound change. Use this value to establish the required time delay in the ESP logic before the remaining pressure is automatically relieved.
6. Following completion of the ESP test, open the superheater vent valves to take pressure off the unit and facilitate cooling. Do not refill the boiler until the temperature

differential between feedwater and drum shell is less than 100°F. A hydrostatic test to at least the operating pressure of the unit should be performed prior to restarting the unit.

2.2 Routine Operational Checks

It is recommended that the motor-operated drain valves be checked at least once per month to assure that they are still in working order. This can be done by going to each station, closing the hand-operated valve and individually energizing the motor-operated drain valves to be sure they will open and close, and the indicator lamps read correctly. Following the check, and after closing the motor-operated valves, be certain the hand-operated valves are locked open. Only one drain line at a time should be isolated for the monthly motor-operated valve tests; this will allow the remaining drain lines to function as designed if an ESP is required during the testing period.

It is recommended that the entire ESP sequence, except for draining the boiler, be checked as opportunity arises, but at least once per year. This may be done from a reduced pressure. With the hand-operated valves closed, use the ESP buttons to shut the unit down. This will assure that the rapid drain valves operate properly and are not stuck, all fuel to the furnace shuts off, the correct dampers close, the preset fan conditions are achieved, the emergency feedwater stop valve closes, floor and steam drum thermocouple recorder prints correctly, etc. Also, at least annually verify that the “alternate means” to actuate individual ESP elements will transmit a signal to the intended ESP element. Physical actuation of the ESP element by the alternate means is not necessary during the test, only verification that a signal is transmitted to the device. Similarly, for those locations with any “remote” means to initiate the ESP or actuate individual ESP elements, verify the remote means will transmit a signal to the intended ESP element(s).

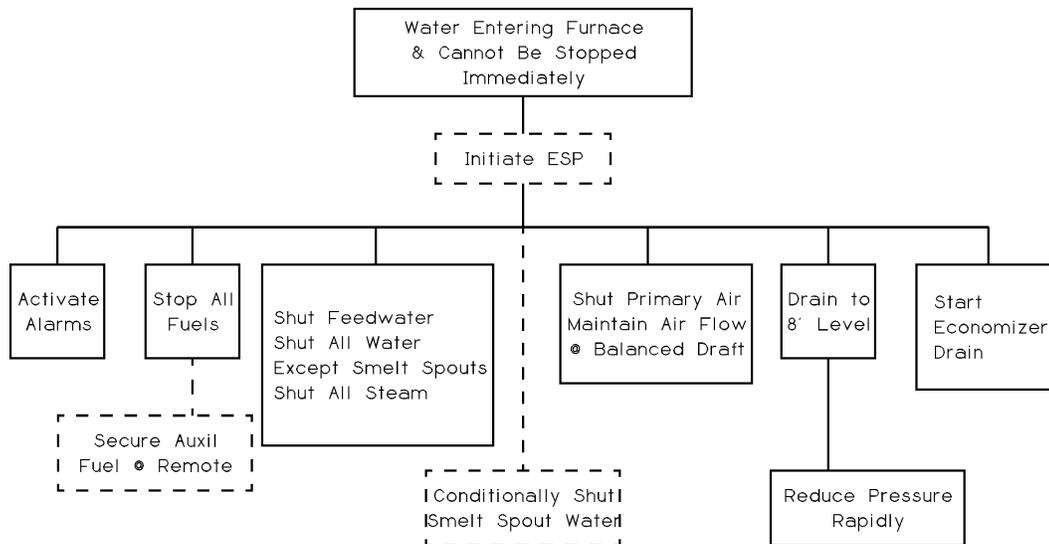
CHAPTER 3 BACKGROUND AND INSTALLATION NOTES REGARDING THE EMERGENCY SHUTDOWN PROCEDURE (ESP)

3.1 Endorsement

The ESP write-up should be endorsed by policy-making mill management, giving the operators the authority to perform an ESP as per BLRBAC guidelines. A signed and dated copy should be permanently posted at each recovery unit control station.

3.2 Logic

The ESP wording is intended to be implemented according to the following logic diagram:



(Dashed Lines = Operator Action)

(The Words in the Blocks are Abbreviations See Actual ESP Writeup for Complete Explanations)

Fig. 1. ESP logic diagram.

3.3 Permissives

It is important that all ESP functions be completed in a timely manner upon initiation. No permissives whose failure could prevent the successful implementation of an ESP should be incorporated into the system.

3.4 Initiation

The recommended embodiment for initiation requires only one operator action to initiate the entire ESP (such as pushing two buttons simultaneously), rather than individual steps.

3.5 Monitoring

Those monitoring the ESP must utilize proper follow-up procedures. Properly trained operators should be standing by in the safe control room or other designated safe areas, monitoring the ESP against a check list, and using available alternate means (in most cases these are normal operating controls) to operate individual steps of the procedure if they fail to perform automatically.

The general goal is to allow remote-from-unit backup options to make the unit safe. Under no condition should anyone go out to the boiler to perform a back-up option.

3.6 All Fuel

The system should prove that all fuels, including black liquor, auxiliary fuel, NCG, and other waste fuels have stopped entering the furnace. Stop all black liquor firing pumps and any other pumps that tie directly into the liquor firing system such as the indirect black liquor heater recirculation pump(s) and any macerator (gorator) in the black liquor firing system. Stop any black liquor pump supplying flush liquor to boiler bank or economizer hoppers. Divert liquor. Liquor firing systems that recirculate to a pressurized tank require an automated shutoff valve in the recirculation line.

Obtain positive feedback from motor starters and valve proof-of-closure or position indicator switches.

3.7 Remote Auxiliary Fuel Shut-Off

The purpose of shutting off auxiliary fuel at a remote location is to protect against fuel line rupture hazards in the event of an explosion; not just to stop fuel entry into the furnace. It is not necessary for the remote auxiliary fuel valve to be automated into the ESP logic, as long as it can be reached by a safe path and is in a designated safe area.

3.8 Shut Off All Water and Steam Sources

These include, but are not limited to:

- Feedwater Stop Valve (Do not rely upon closure of the feedwater control valve.)
- Desuperheater Water Stop Valve except from sweet water condenser (Do not rely upon closure of the desuperheater control valve.)
- Chemical Feed Pump and any Flush Lines connected to unit
- Steam Coil Air Heater (prevents condensate leaks into unit; allows cooler air to unit)
- Soot Blowers (Steam off, automatically retract)
- Steam to Direct Liquor Heaters
- Auxiliary Fuel Atomizing Steam (if not closed automatically with fuel trip)

This does NOT include Spout Shatter Steam, Dilution Water for Direct Contact Evaporators, and Spout Cooling Water.

3.9 Optional Items to Consider

- Steam to Indirect Liquor Heaters (so as not to bake the residual liquor)
- Isolating soot blower condensate system (as precaution against water backup)
- Automatic shut-off of power to precipitator (as precaution against igniting possible combustible gas mixture)
- For boilers with a motorized main steam stop valve, it is considered Good Practice to close the motorized valve when an ESP is initiated. (Can be through the DCS.)

3.10 Feed Water Coil Air Heater Leaks

Some configurations may allow water from a ruptured air heater tube to enter the furnace through combustion air ductwork. The potential for leakage to enter the furnace may be mitigated by the location of the feed water air heater coil and design of the ductwork. The configuration may include a system of air duct low points and drains, water detection alarms, and if necessary air heater waterside isolation or a boiler ESP.

3.11 Fans and Dampers

The shutdown strategy for the FD fans and dampers will depend upon the number of fans and the number of elevations of combustion air. The preferred (but not the required) embodiment of this requirement is to shut off all air below the liquor guns as per logic diagram, except in the case of low load operation described below. Air blowing on the bed will prolong combustion and smelting, extending cool-down time and increasing the potential to damage the floor and wall tubes. Purge air should be provided through the combustion air ports located at elevations above the liquor guns. The appropriate FD

fan(s) should remain running to provide purging and cooling air through the upper furnace zones following an ESP.

Units with alternate operating scenarios, such as extended low load operation with no tertiary air, may devise alternate air shutdown strategies provided the BLRBAC ESP intent of minimizing extended heat production and subsequent smelting is addressed. Units burning NCGs must meet these requirements when NCGs are tripped.

If any fans, including the ID fan(s), trip immediately prior to initiating an ESP or during an ESP, leave them tripped. Restarting the fans can cause excessive heat release, or cause a combustibles explosion. The system should be checked to make sure that other control logic could not override ESP logic **except in the event of an actuation of the DCE Fire Protection System**.

3.12 Drain Time to 8-Foot Level

The drain system should be designed to drain to the 8-foot level in approximately 20 minutes starting at normal operating pressure. The actual time should be recorded during the “Initial System Checks” described in “Recommended Procedure for Testing Emergency Shutdown System”. A nominal acceptable range is from 15 to 25 minutes. If over 30 minutes, additional drain capacity should be installed. Twenty five years of experience confirm that the 8-foot level provides sufficient water to protect the lower furnace tubes while the smelt bed cools. Granted, if a leak existed in that region, water would still be behind it, but the pressure would be greatly reduced and decreasing rapidly because of the pressure-relieving step.

3.13 Valves

3.13.1 Valve Local Selector Switch

The actuators on the rapid drain valves and all other valves that operate during an ESP should be wired to move the valves to the ESP position upon initiation of the ESP system regardless of the position of the local selector switch on the valve actuators.

3.13.2 Alternative Actuation

The following are acceptable means for complying with the requirement for an alternative means of actuating rapid drain valves:

- A switch or group of switches in the control room;
- A boiler control PLC (independent of the ESP system) providing an independent signal to each rapid drain control relay;
- Manual actuation of the individual rapid drain relays; or
- Manual actuation of the individual valve operator motor starters.

When individual switches are provided in the control room, they can serve the dual function of testing rapid drain valves as well as the alternate means of actuation. When manual actuation of the relays or motor starters is chosen, the relays or starters must be in a location that is designated safe and accessible during an ESP and the boiler operators must be trained to locate and actuate them.

3.13.3 Alternate Power

Historically, power supply to rapid drain valve operators has been sufficiently reliable that an alternate power supply is not a recommendation. Care should be taken in selecting and protecting the reliability of the power source to these valve operators.

3.13.4 Torque Limits

The torque limits should not be included in the motor control open circuit for the rapid drain valves so that the motor will exert maximum effort to open the valves until the open position limit is reached. The torque limits may be used in the valve test mode if desired.

3.14 Number of ESP Drain Valves

The ASME code allows the ESP drain valves to be installed with one root valve and one electric-operated valve in any given series path leaving the boiler. The rapid drain piping is not considered “blowoff piping”, per December 6, 1989 ASME finding BC86-316. The reasons that two electric valves became the industry standard were: the critical and severe duty required that the stations have minimum out-of-service valves due to maintenance; valve seat cutting and therefore leakage of such critical valves be minimized (by properly sequencing the openings); and associated maintenance costs be minimized. Experience has shown that the valves are not exercised so frequently as to make them vulnerable to valve seat cutting. The entire system may be more reliable if only half the number of electric valves are being depended upon to open. Maintenance replacement by change-out of a single electric valve can be easily accomplished by using the manual root valve for isolation. If leakage is a concern, a number-one mill-wide priority could be established to ensure rapid response. The boiler manufacturers’ current recommendations are to use only one electric valve. THEREFORE, a design using one manual and one electric valve on a given path is acceptable. New installations and retrofits may consider this. There is no intent to “require” a retrofit to eliminate valves already installed which are satisfactory. Consideration should be given to permanently locking open one of the motor-operated drain valves. If an existing system incorporates a time delay between opening of the two valves, the time delay should be eliminated.

Since there is no longer a “blowoff piping” requirement, individual valves could be made larger than 2½", with corresponding decrease in number of valve locations required to meet the drain time. It is recommended that the valve size NOT be increased beyond 3".

3.15 Atmospheric Vent

Experience in North America has demonstrated flash tank systems permit draining of the boiler even if the ESP is initiated after boiler pressure has been significantly or completely lost. Provision of a flash tank rapid drain system is recommended for all new installations. Atmospheric vent (flash-to-the-sky) rapid drain systems may not drain the boiler as quickly as flash tank systems under reduced pressure conditions and may not permit any draining in some cases. Existing atmospheric vent systems should have some means to drain the boiler to the 8 ft. level under low or no pressure conditions (no specific drain time). This alternate drain does not have to be a part of the automated ESP system and may be an operator-initiated action.

3.16 Final Pressure Reduction

In order to implement the last (pressure-reducing) step of the ESP, it is intended that only automated, remote-actuating valves such as Electromatic relief valves, superheater vent valves, etc., be used. It is not intended nor acceptable for personnel to enter unprotected areas to operate valves or other equipment.

3.17 Economizer Drains

At least the hot economizer bank should have emergency drain valve(s) to start the economizer draining. This will help prevent flow of water into the steam drum or furnace in the event of a feedwater valve leak-by or failure. It will also handle swelling and burping of water over to the drum as the pressure falls. This is to avoid feeding a furnace leak any longer than necessary and to prevent undue thermal shock to the drum. It is not necessary to drain the economizer as fast or as completely as the furnace, as long as the economizer water level is heading downward during the ESP. This condition is also favorable if a leak occurs in the upper, hot (front) economizer, facing forward toward the furnace, as discussed below.

3.18 Economizer Leaks

Some economizer configurations allow certain economizer tube ruptures to direct a water leak forward into the furnace cavity through the generating bank. This has been verified by critical incident reports. Also, some hopper sluice systems and refractometer liquor divert system failures could allow economizer leaks to send water to the furnace via the black liquor piping. ESP's should be performed except when it is known at that time to be impossible for water to get to the furnace. If an economizer leak occurs, where water is known not to be entering the furnace, cease firing liquor and initiate an orderly shutdown immediately. One can NOT rely on the theoretical installation based on drawings of baffles to make this determination. One must KNOW that such baffles are in place and functioning with no damage or disrepair. Case histories exist where leaks have entered the forward furnace through voids in a baffle less than six months old.

3.19 Spout Leaks

Known smelt spout water leaks do not require an ESP. Shut off the cooling water to the leaking spout and plug the spout. If the spout is required for operation, conduct an orderly shutdown to replace the spout.

3.20 Alarm Silencing

There should be a method of silencing/acknowledging the audible alarms (after sounding a minimum of 15 minutes) that is COMPLETELY independent of the ESP system resets. Visual alarms are to remain in effect until the ESP system is reset.

3.21 System Reset

The ESP system should not be reset until reentry to the area is permitted. The ESP system reset logic/procedures may result in automatic movement of controls to undesired positions. Proper caution should be taken to position controls where intended. Examples of valves that may need isolation or manual positioning prior to reset include the feedwater to economizer and the steam to steam coil air heater(s).

3.22 Testing ESP System

When conducting ESP system checks in the Recommended Procedure for Testing, the ESP is done while firing auxiliary fuel. Added attention must be given to assure that black liquor functions perform as expected.

When manually opening the motor-operated valves for line blowdown in Step 3 of the Initial testing, initially open the valves quickly to avoid wire-draw or damage to the seat.

3.23 Thermocouples

Recovery boilers should be equipped with floor thermocouples. The thermocouple readings should be monitored and recorded during an ESP as a means for evaluating the potential of floor tube overheating damage.

3.24 Definitions

Designated safe area: means that the mill has responsibly determined that the area is blast-safe, and therefore has defined it as such for purposes of ESP.

3.25 References

For further information, refer to BLRBAC “Recommended Good Practice” publications:

Safe Firing of Black Liquor in Black Liquor Recovery Boilers; Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers; and Installation Check List and Classification Guide for Instruments and Control Systems Used in Operation of Black Liquor Recovery Boilers.

APPENDIX A DOCUMENT REVISION HISTORY

Summary of the February 2012 changes

“Notice of Disclaimer of Liability” has been added to page 2.

Summary of the October 2009 Changes

Guidance added to Section 2.2, Routine Operational Checks, to recommend only one drain line be tested at a time.

Summary of the April 2009 Changes

Guidance added to Section 2.2, Routine Operational Checks, to recommend at least annual testing of the alternative and/or remote means of actuating ESP elements.

Summary of the October 2006 Changes

Chapter 1,

- Clarified smelt spout cooling water is not to be isolated as a normal part of an ESP.

Chapter 3,

- Revised section 3.6 to conform with the Safe Firing of Black Liquor Recommended Practice. Also in section 3.9 deleted shutting down the black liquor pumps and macerators as an optional item to consider.
- Revised section 3.8 to clarify smelt spout cooling water is not to be isolated as a normal part of an ESP.
- Revised section 3.9 to add closing the main steam stop valve as an optional good practice to consider where practical when these valves are present.

Summary of the October 2004 Changes

- Chapter 1 reworded the Stop All Fuels section
- Chapter 3,
 - Reworded the 3.6 All Fuel section
 - Changed title from 3.13 Rapid Drain Valves to 3.13 Valves
 - Changed title from 3.13.1 Local Selector Switch to 3.13.1 Valve Local Selector Switch
 - Reworded the 3.13.1 Valve Local Selector Switch section
 - Changed title from 3.21 ESP System Reset to 3.21 System Reset
 - Reworded the 1st sentence of section 3.21 System Reset
 - Reworded the 3.23 Thermocouples section

Summary of the October 2003 Changes

- Added a new section 3.13.4 Torque Limits

Summary of the October 2002 Changes

- This document has been revised to provide a consistent format.
- Chapter 3,
 - Changed the heading for section 3.9 from “Additional Items to Consider” to “Optional Items to Consider.”
 - Added paragraph on “Feed Water Coil Air Heater Leaks” as Section 3.10 and renumbered section numbers that follow.
 - Reformatted section 3.13, Rapid Drain Valves, to create section 3.13.1, Local Selector Switch, and added a new section 3.13.2, Alternative Actuation, and 3.13.3, Alternative Power.
 - Provided new guidance in section 3.15, Atmospheric Vent.

Summary of the October 2000 Changes

- Chapter 1 reworded the Emergency Shutdown Procedure entire 4th bullet on Air Flows.
- Chapter 3, Section 3.10 “Fans and Dampers” reworded the entire paragraph.

Summary of the October 1993 Major Changes

- Combined “Emergency Shutdown Procedure (ESP) for Black Liquor Boilers” with “Recommended Procedure for Testing Emergency Shutdown System” into one document and added Chapter 3 “Background and Installation Notes Regarding the Emergency Shutdown Procedure (ESP)”
- Chapter 1 “Emergency Shutdown Procedure (ESP) for Black Liquor Recovery Boilers” reworded to include the following:
 - Elimination of reference to “external” leaks
 - Addition of visible alarms
 - Addition of black liquor divert
 - Clarification of spout cooling water leaks action
 - Restriction of total air entering furnace and portion below liquor guns
 - Addition of economizer drain valves
 - Requirement for alternate means to be provided
 - Requirement that personnel monitor and complete the ESP

Recommended Emergency Shutdown Procedure (ESP) & Procedure for Testing ESP System for Black Liquor Recovery Boilers

- Chapter 2 “Recommended Procedure for Testing Emergency Shutdown System” reworded to include the following:
 - Clarification of conditions for Initial System Checks
 - Clarified steps in the initial test procedure
 - Identified method to determine time to reach 8-foot level
 - Changed routine test interval to yearly minimum

- Chapter 3 “Background and Installation Notes Regarding the Emergency Shutdown Procedure (ESP)” added this new chapter to include the following:
 - Diagram of intended logic
 - Clarification of alternative logics requirements
 - Acknowledgment of some water and steam sources
 - Suggested drain times
 - Elimination of requirement for two electric drain valves in series
 - Discussion of atmospheric vent systems
 - Specific economizer drain and leak background
 - Handling of reset