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The information in this manual is supplied for guidance purposes only and is not a substitute for the customer consulting professional engineers and installing contractors as each installation has its own particular issues that cannot be covered in this manual. Although the information inside these pages is sound engineering and boiler room practice, we recommend making absolutely sure before starting up this equipment.

As this equipment is a pressure containing vessel, operation must be done by personnel adequately trained in and capable of the use of this equipment. When operated incorrectly, problems may occur that could result in injury or death.

ECONOMIZER

I. GENERAL

A. **Boiler Types:**

These instructions are applicable for economizers installed on fire tube or water tube boilers firing natural gas and /or all grades of fuel. Also, the boiler must be equipped with modulating combustion controls.

B. **Feedwater System:**

Additionally, these instructions are applicable for economizers using only treated deaerated feedwater unless the pressure parts are stainless and the feedwater flow rate control system must be modulating type.

C. **Codes:**

The economizer installation in the boiler flue gas stream, including all ductwork, piping, structural supports, thermal insulation, and electrical wiring and equipment must conform to all applicable national, state, and local codes, using suitable materials for specific installation conditions.

D. **Operator and Installer Qualification:**

This manual has been prepared for the use of competent and knowledgeable personnel; those responsible for the operation and maintenance of the equipment. It is imperative that such personnel thoroughly familiarize themselves with the entire manual before attempting to install, operate, or maintain the equipment.

II. RECEIVING

A. **Inspection and Damage Claims:**

At the time of delivery, a thorough visual inspection of the economizer should be made for evidence of damage during shipment. In the event any damage is noted, the CARRIER MAKING THE DELIVERY should be notified at once so they can start claims procedure for repairs or replacements. Do not contact E-Tech, Inc. for shipping damage claims.

III. INSTALLATION

A. **Inspection, Clean-Up and Interim Storage:**

Prior to installation, a through visual inspection of the economizer should be made and all foreign objects such as packing/shipping materials, protectors, tags, debris, etc. removed. It recommended that both the water and gas sides of the heat transfer surfaces be blown clear with clean, dry, compressed air. In the event the unit must be stored for an extended period before installation, fill and maintain waterside with clean, DRY, compressed air or N₂

air or N₂ at about 10 PSIG. Cover the flue gas inlet/outlet with a weatherproof covering such as a sheet of plastic or marine plywood.

B. Attitude:

Install the economizer so that the flue gas and feedwater stream flow directions will be in accordance with design intent, as shown on the general arrangement drawings.

C. Hoisting and Handling:

Use the lifting beams provided for hoisting. Use "spreader bars" and/or lifting beams so the hoisting forces are essentially vertical to the hoisting points. Avoid "uneven" lifting which may cause excessive distortion and possible failure of welded joints or casing seams not intended for such flexure. Handle insulated/lagged units so outer casing is not punctured or damaged, fix outer casing damage as soon as possible & do not allow insulation to become wet.

D. Structural Supports and Clearances:

Provide structural supports as shown on the E-Tech shop drawings. If support is by "others", be certain the unit is supported uniformly on the channel members that also serve as flue gas connection flanges. When designing structural supports, take into account stack and guying static and dynamic loads. Provide ladders, catwalks, and platforms to allow easy approach to all access openings, instrument connections, valves and sootblower equipment. Be certain the economizer is installed level so complete drainage and venting is accommodated.

Provide sufficient clearance around the unit to allow easy removal of tubes, sootblower lance, and access opening covers. Clearance requirements are shown on shop drawings.

E. Transitions, Ductwork, Stacks and Expansion:

Flue gas inlet/outlet faces of the economizer are always larger than the corresponding ductwork. It is recommended that flue gas stream cross-section changes, from duct to economizer to stack, occur gradually. Provide an inlet transition piece for a smooth, even distribution of gas flow over the face area. An outlet transition piece should be designed with an angle never greater than 45°. For installations where inlet/outlet ductwork is horizontal, provide access panels so accumulated solids may be removed easily.

Installations having relatively short, large diameter stacks which are directly over the unit, or economizer which are subject to prolonged shutdowns should be equipped with stack outlet rain caps of either the "Coolie Hat" or "flap gate" type.

F. Flue Gas Connections:

Flue gas connections must be gas-tight and sized to match the transition piece of economizer inlet/outlet as detailed on the E-Tech shop drawings. The installation contractor shall provide gasketing and bolting as required. For bolted connections, use a heavy, non-asbestos sheet gasket material. Connections may also be seal welded.

G. Feedwater Piping:

Feedwater pressure losses expected through the economizer for maximum flow rate conditions, in a new unit, are shown in the E-Tech proposal specification sheet.

Feedwater piping to and from the economizer should be sized to accommodate all the friction and head losses at maximum feedwater flow rate with enough residual pressure to deliver water to the boiler at its maximum steaming capacity. Additionally, there should be enough pressure in the system to exceed the pressure corresponding to the maximum normal operating water temperatures likely to occur at the highest point in the economizer, in order to prevent steaming in the economizer at high feedwater flow rates.

The feedwater piping should be arranged and anchored so stresses due to thermal expansion are isolated from the economizer.

The boiler drum level control valve must be a modulating type. The valve may be located either upstream or downstream of the economizer in systems which serve boilers with slow to moderate pressure fluctuations, (load swing rates). Where load swings occur rapidly, the drum level control valve should be in the downstream (outlet) piping of the economizer.

Piping, to allow bypassing of the economizer, should be installed.

H. Valves, Including Safety-Relief:

The economizer may be equipped with the following valves in the feedwater lines:

1. *Inlet and outlet shutoff valves:* These must be "line-size" gate valves having the same body/connection rating as the economizer flanges. Rising stem valves are recommended.
2. *By-pass valve:* This valve should be a "line-size" globe valve, having the same body/connection rating as the economizer flanges. This valve should be located so it is easily accessible during normal operations. This valve should be equipped with a stem position indicator.
3. *Vent and Drain connections:* Your E-Tech economizer comes equipped with 3/4" vent and drain connections.
4. *Safety-relief valve(s):* This valve should be installed in the highest physical location in the feedwater system, as near the economizer as possible, and BETWEEN the inlet/outlet shutoff valves. The valve must have body/inlet connection ratings the same as the economizer flanges. The valve outlet must be piped to a safe relief area. The outlet piping should be sized and arranged like conventional boiler safety valve installations, plus provisions should be made for draining

relief water. The safety relief valve should be sized to accommodate the economizers maximum heat transfer capability equivalent, in pounds of steam per hour, at the 3% accumulation above set pressure. Set pressure should be above feed pump relief pressure but at or below the economizer maximum allowable working pressure as listed in the E-Tech proposal.

I. Sootblower Piping:

Sootblower piping and valves should be installed in accordance with sootblower manufacturer instructions included with this manual. Sootblowing media must be dry.

J. Insulation:

Thermal insulation should be installed on the economizer and all inlet duct work. It is strongly recommended that economizer outlet duct work and stack be insulated to prevent condensation of combustion products. In some installations, stack lining may be desirable. All feedwater lines and sootblower steam lines should also be insulated in accordance with standard practice for such services. Provide weatherproofing protection for all parts of the system that are outdoors.

K. Instrumentation:

E-Tech recommends monitoring the following variables as basic to every economizer installation.

Simple, local indicators, mounted in conveniently observable locations are usually adequate for monitoring operations and performance.

Where load swings are rapid, local or remote recording is recommended so data may be easily correlated with steam-flow and fuel consumption, to yield economizer operating and efficiency data.

Instrument ranges should be selected so the maximum operating temperatures and differential pressures listed in the E-Tech proposal coincide with the β point of instrument full scales.

IV. STARTUP

A. Washout:

The procedure and materials used in boiler washout may be used for cleaning the waterside of the economizer. A piping arrangement should be provided to allow high velocity re-circulation through the unit and proper disposal of wash water.

- B. Filling:**
Before exposure to hot flue gases, the economizer should be filled with treated deaerated boiler feedwater. Air and non-condensable gases should be simultaneously vented through the vent valve provided.
- C. Testing:**
The completed installation should be hydrostatically tested. Test pressure must not exceed the test pressure listed in the E-Tech proposal specification sheet. Test pressure should be maintained while all joints and valves are checked for leaks. The safety relief valve may be checked for proper setting at this time. The boiler feed pump may be used for pressurizing.
- D. Putting on Stream:**
With the economizer filled, vented, and tested, the boiler may be lighted and carried at low fire to warm up and bring the system to pressure. The economizer shutoff and by-pass valves should be in the full open position. As the boiler begins to pick up load, the economizer by-pass valves should be closed proportionately. Observe economizer outlet water and gas temperatures. Do not allow economizer water outlet temperature to rise beyond the saturation temperature corresponding to the feedwater pressure, so boiling in the unit will be prevented. Do not allow the economizer flue gas outlet temperature to fall below the minimum gas outlet temperature listed in E-Tech proposal specification sheet. Manually "modulating" the economizer by-pass globe valve will serve to regulate flow through the unit so the limits mentioned above are not exceeded. When the boiler load is at approximately 25% to 30% of full capacity, the by-pass valve may be closed and the economizer becomes self-regulating as boiler load varies.

V. OPERATION

- A. Normal Operation:**
Normal operation may be considered as a load condition from about 25% to 30% of capacity on upward and, as stated earlier, the economizer is self-regulating. Temperatures and differential pressures will be as pre-calculated and shown in the E-Tech proposal specification sheets.
- During these load periods, it is necessary only to monitor indicating instruments and periodically open the vent valve to eliminate non-condensable which may have accumulated in the high point of the system. Venting frequency may be reduced as trapped gases are purged from the system. The soot blowing routine as described in Paragraphs VI,A,1 and VI,A,2 should be maintained.
- B. "No Load" Operation:**
No load operation of an economizer equipped boiler is not recommended for more than a few minutes, unless means are provided for diverting flue gas flow and/or feed water flow, so prescribed temperature limits mentioned in Paragraph IV,D above are not exceeded. E-Tech is prepared to offer engineering services and equipment to allow no load operation such as may

be required for an "active stand-by" situation.

C. Dry Operation:

Dry operation is not recommended except under extreme circumstances, and may be accomplished by opening the economizer by-pass valve, vent and drain valves and, closing the shutoff valves, thereby isolating the economizer from the feedwater supply. Reduce firing rate and allow residual water to boil off and/or drain out completely before closing the vent and drain valves. A DRY economizer may be exposed to flue gas temperatures of 650°F without damage. Higher tube metal temperatures will not damage the fin-to-tube bond but may cause tube sagging or distortion of the entire unit.

NOTE: The following procedure is to be used only when other, more sound techniques, are not possible.

Putting a hot, dry economizer back into "wet" service is not recommended as a general operating practice, however, should it become necessary to do so, we suggest the following procedure. Reduce firing rate to the lowest tolerable level. Check safety-relief valve operability. Open the vent and drain valves be certain personnel stand clear of discharge line openings. Make certain the economizer by-pass valve is wide open. Open the economizer inlet valves slightly, allowing steaming from vent and drain. Continue opening the inlet valve slowly (safety-relief valve may operate for a short period). When the safety-relief valve closes and water appears at the vent and drain valve line ends, the inlet valve may be opened wide. Allow the vent and drain to discharge until scale and non-condensable are purged from the system. Slowly open the economizer outlet valve wide. Close drain and vent valves. Close economizer by-pass valve, following the procedure described in Paragraph IV,D, "Putting On Stream". Raise firing rate to meet demand.

D. Performance Evaluation:

Your E-Tech Economizer will perform within or better than the heat recovery and operational parameters stated in the E-Tech proposal specification sheets. In the event you observe data contrary to that contained in your unit specification sheet, please notify E-Tech. An E-Tech engineer will review your data and make recommendations.

E. Cold End Corrosion:

When analyzing requirements for installation of an E-Tech Economizer, or a similar heat recovery device, there are two important items that must be considered, namely:

- The sulfur content of the fuel being burned;
- The temperature of the inlet feedwater; (If not maintained at proper levels, certain byproducts of the fuel being burned have the potential to cause low temperature corrosion.)

1. **The corrosive byproducts of combustion:** Oil, natural gas, and coal all contain the elements carbon and hydrogen. They may also contain amounts of sulfur. During the combustion process, these elements rapidly oxidize. If sulfur is present in the fuel, it will combine with

oxygen to form sulfur dioxide (SO_2) and sulfur trioxide (SO_3). It is the presence of these sulfur oxides in the flue gas that represents the largest potential cause for corrosion.

Sulfur dioxide, for example, will dissolve in any free moisture that may be present in the flue gas to form sulphurous acid (H_2SO_3) - a powerful corrosive.

Depending on the sulfur content of the fuel, the amount of excess air in combustion, and the flame temperature, approximately 1% to 2% of the sulfur dioxide is further oxidized into sulfur trioxide. When combined with superheated water vapor, sulfur trioxide forms sulfuric acid vapor (H_2SO_4). Vanadium pentoxide V_2O_5 can elevate this conversion several times the normal levels. In fact the main use of vanadium is for the production of sulfuric acid.

2. **SO_2 and SO_3 Dew Points:** Determining the dew point, or temperature at which moisture begins to condense out of a gas, makes it possible to predict when SO_2 and SO_3 gases in the flue gas form the acids that cause corrosion. The following graph illustrates the acid dew point of SO_3 as well as the minimum recommended feedwater temperature base on various sulfur contents.

When SO_3 combines with superheated water vapor to form sulfuric acid vapor, the formation of sulfuric acid (H_2SO_4) begins to occur at what is known as the "acid dew point". There are many variables that influence this including excess air rates, the sulfur content of the fuel, moisture content and Vanadium. These temperatures range between 240° F. and 280° F.

3. **Inlet Feedwater Temperature vs. Corrosion Potential:** As flue gases contact the tubes, it is the metal temperature of the metal heating surface that most affects condensation. The gas temperature approaches these metal temperatures to the point of being within a few degrees of the temperature of the metal which, in turn, will be within a few degrees of the feedwater flowing through the tubing.

So it's the temperature of the metal surfaces that will determine whether or not corrosive acids will condense out of the gas as it passes through the economizer.

Note that because of this fact, bypassing gas or feedwater is NOT a solution to cold-end corrosion and might, under certain circumstances, cause steaming in the economizer.

You will notice that the minimum recommended feedwater temperature is lower than the acid dew point. This is because maximum condensation does not take place until temperatures much lower than the acid dew point (80°F. or more).

The minimum safe metal temperatures, is also lowered as the temperature of the flue gas surrounding the tube increases. Hence, a co-current parallel flow pattern of gas and water flow can minimize many potentially corrosive situations.

VI. MAINTENANCE

A. Flue Gas Side Care:

Flue gas side care and cleaning is one of the most important factors contributing to efficient economizer operation and extended service life. An effective sootblowing routine should be established and followed so solids will not accumulate on the heat transfer surface, and every effort should be made to keep gas side surfaces dry at all times.

1. Immediately after the economizer has been placed in service, when gas side surfaces are still clean, gas side differential pressures and inlet/outlet temperatures difference relative to boiler loads, should be read and noted.

Any decrease of temperature difference coupled with an increase in differential pressure, for related steam loads, is a positive indication that gas side surfaces are fouling and should be cleaned with the sootblower(s). (For sootblower operation instructions, see manufacturer's data enclosed herein.)

2. Maintaining a practice of sootblowing on the basis of instrument readings, as described above, rather than a mere "timed" sootblowing schedule, will assure not only cleaner tube surfaces but a most economical use of blowing media and prolonged economizer service life.
3. Not less than every six (6) months and at every opportunity, the economizer gas side surfaces, duct interiors, and where supplied with covers, end boxes, should be inspected for and cleared of all solids accumulations. Steam lancing and/or wash-down using a moderate pressure water lance and a mild detergent will be found helpful with removing stubborn deposits.
4. If the unit is not scheduled for startup soon after wash down, transfer surfaces should be dried and kept dry. Draft fan(s) may be utilized for drying.

B. Feedwater Side Care and Cleaning:

Feedwater side care and cleaning is relatively simple since the procedures and materials are identical to those used in boiler tube waterside care and may be done simultaneously on the same schedule. Be aware that the feedwater piping into the economizer may contain impurities such as dirt and grease, particulates that must be eliminated before entering the equipment.

So, of all waterside preservation efforts, none is more important than maintaining an up-to-date, active, boiler water quality control procedure.

1. During periods of prolonged shutdown, the economizer, like the boiler, should be drained, dried, and filled with an inert gas (N₂) maintained under pressure (5-10 PSIG) until placed back in service.
2. For short duration shutdown, water may be left in the unit. In the event the economizer may be exposed to freezing temperatures, it is recommended that a modest water circulation rate be maintained and a source of heat provided to prevent tube side freezing. A suitably sized removable auxiliary burner in the boiler or a strategically placed "salamander" may be used. Frequent draining and refilling of the economizer, instead of the procedure described above, is NOT recommended.
3. The temperature/pressure monitoring procedure described for gas side should also be followed for monitoring waterside conditions. An unusual increase in differential pressure or decrease in differential temperature is a good indication of tube side blockage or fouling, respectively, and should be checked and cleaned up at the earliest opportunity.

C. Weather Exposure:

Weather exposure protection for outdoor economizer installations are identical to that provided for other equipment of similar design and purpose.

The economizer, even if installed indoors, is susceptible to freeze-ups. Precautions must be taken in winter conditions by either circulating boiler feedwater or adding anti-freeze to the unit when it is shut down.

D. Casing Care:

Casing care and cleaning procedure is identical to that used to maintain ductwork. It is recommended that the periodic gas side inspection and cleaning mentioned earlier include inspection, cleaning, and repair of both the inner and outer casings. Damage from corrosion or other sources should be repaired as soon as practical.

1. Casings must be kept "gas tight."
2. Insulation must be kept dry and in place.
3. Outdoor installations must be kept "weather tight."
4. Piping, duct joints, and access covers must be kept leak proof.

E. Tube Replacement:

Tube replacement may be made relatively easily, since the E-Tech Economizer is designed to facilitate such work for the rare occasion it may become necessary.

1. Fin tube failure may be of two types. The first is feedwater leakage resulting from either external or internal corrosion damage. The

second is destruction of the fins due to gas side corrosion and erosion damage.

2. Should tube replacement become necessary, the following general procedure is suggested: (Economizer must be cold and drained).
 - a. Locate the damaged tube(s) by either direct visual or bore-scope inspection.
 - b. Cut both ends of the damaged tube(s) from the bundle, at the tube butt welds.
 - c. Pull the damaged tube from the bundle and replace with a new tube. (The new tube will be furnished with collars, correct finned length for your particular unit and, either a preformed or pre-welded 180° return bend.) If a single tube must be replaced right away, a bare tube may be used with little reduction (in most cases) of heat transfer
 - d. Prepare the tube ends and re-weld butt joints pressure tight.
 - e. Hydrostatic test the unit. Note that an AI may have to witness the hydro. Depending upon the repair, the unit may require a Code stamping.
 - f. Close casing.

VII. SPARE PARTS

A. Economizer:

Since the economizer is a relatively simple static device, the need for spare parts is virtually non-existent.

B. Sootblowers:

Spare parts, as recommended by the sootblower manufacturer, should be purchased and stocked. (See manufacturer's data enclosed herein.)

C. Instruments & Control:

Where instrument and control system components, such as valves, etc., are furnished with an E-Tech Economizer, spare parts, as recommended by component manufacturer should be stocked. (See manufacturer's data enclosed herein.)