MANUFACTURER'S ROLE IN BOILER LIFE EXTENSION

by
J. T. EUNSON, Senior Vice President
Technical Operations
RILEY STOKER CORPORATION
WORCESTER, MASSACHUSETTS

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RILEY STOKER
POST OFFICE BOX 547
WORCESTER, MASSACHUSETTS 01613
An Ashland Technology Company

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In preparing this paper, it became clear that there are basic premises that need to be mutually understood by the owner and the manufacturer. First is the difference in perception of the boiler condition held by you, the owner/operator, and Riley, as the designer/manufacturer. Figures 1 and 2 show this potential difference in perception.

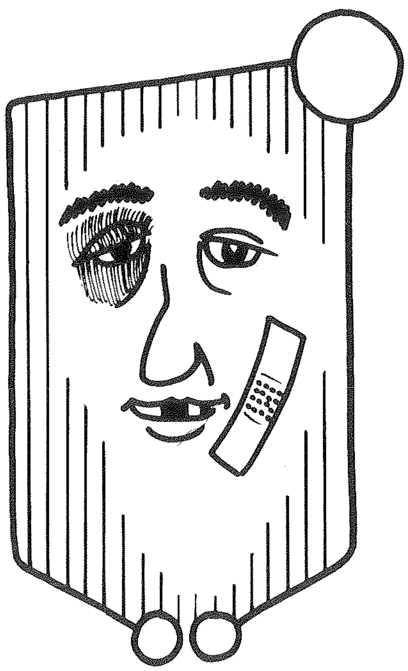

Figure 1 The Utility's View of the Boiler (Ready for Retirement)

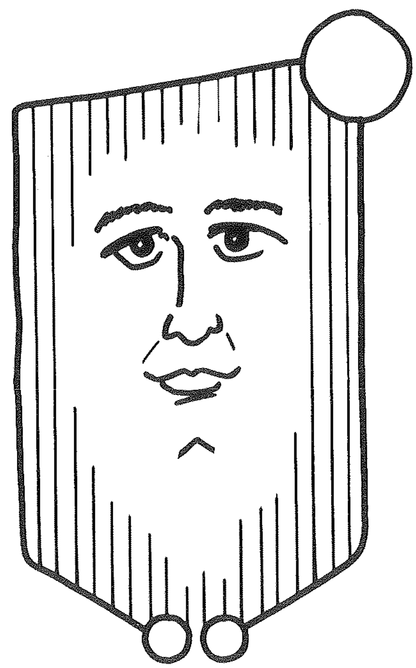

Figure 2 The Manufacturer's View of the Boiler (In the Prime of Life)

Such a difference is understandable considering the attitude and repair position taken by the utility industry toward Original Equipment Manufacturers (OEM's) recently. Without the proper input and communication, any OEM views his creation as he thinks the unit should be. Perhaps he is not aware of the conditions which actually exist. Because of this potential for difference in perception, any owner/operator should close this perception gap when working with the designer/manufacturer. Figure 3 depicts the probable condition of the boiler.

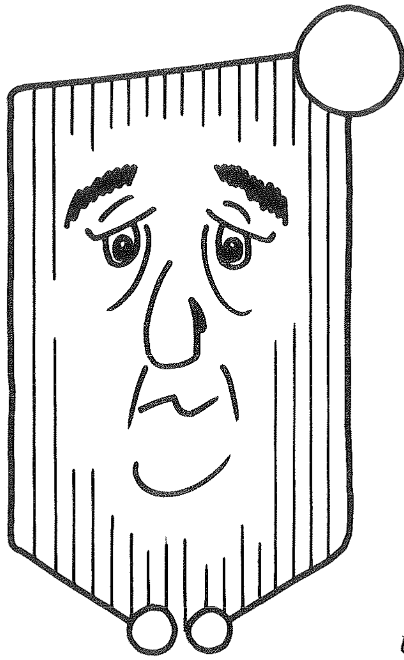

Figure 3 The Actual Condition of the Boiler (In Mid-Life Crisis, Not Clearly Understood by a Casual Observer)

What can be done to reduce the perceived differences and understand the actual condition and future capabilities? Several traditional methods exist which allow us to understand the condition of the boiler and help determine what can reasonably be expected as future operating criteria. The type of services offered and available in descending order of complexity are:

- BOILER AVAILABILITY IMPROVEMENT PROGRAM (BAIP) A thorough review of unit performance, existing physical condition and operating techniques evaluated over a period of approximately one year. See Figure 4.
- CYCLIC BOILER STUDY A detailed study of the thermal and mechanical implications of changing the basic cycling needs of a unit, shown in Figure 5.
- TEAM INSPECTION SERVICE (TIS) A detailed inspection of the physical condition of the unit, outlined in Figure 6.
- NON-DESTRUCTIVE TESTING (NDT) Limited inspection by qualified personnel to evaluate the condition of specific areas of concern. See Figure 7.

THE BASIC OBJECTIVES OF THE BAIP PROGRAM

- **Understand the overall operation of the boiler system**
- **Determine the root causes of identified problems**
- **Develop corrective actions to eliminate these problems**
- **Work with the utility to improve availability/reliability**

THE FOUR PHASES OF A BAIP PROGRAM

- **Phase I. Program Development**
- **Phase II. Unit Performance Analysis**
- **Phase III. Team Inspection**
- **Phase IV. Analysis and Reporting**

Figure 4 Boiler Availability Improvement Program

Implications of Cyclic Boiler Study:

- Redesign of superheater:
  - Upgrade metal selection
  - Replace with drainable type
- Increase mechanical flexibility of boiler connections
- Increase superheater and reheater spray capacities
- Add superheater bypass system
- Add downcomer blowdown system
- Add economizer protection
- Add temperature probe to restrict gas temperatures entering superheater during startup
- Modify equipment for turndown
- Consider smaller capacity pulverizers for reduced load operation
- Add steam coil for airheater cold end protection
- Upgrade drum internals for cyclic operation
- Add pressure reducing valves for variable pressure operation
- Add turbine bypass system
- Upgrade control system

Figure 5 Cyclic Boiler Study

The TIS is a four-part program and includes:

- Unit inspection and evaluation
- Preliminary findings—both oral and written at the time of the plant visit
- Materials testing—off-site
- Final report findings and recommendations

The utility writes the entire scope of the TIS, which could include:

- Inspections to determine if a boiler which has been run below rating for years could now be brought up to its original design specifications.

- In-depth inspection and study to determine the feasability of upgrading the temperature, pressure and/or capacity of a unit.

- Determinations of the work required to permanently repair long-standing boiler or fuel burning problems to which in-plant personnel were able to apply only temporary fixes.

- Tests to establish overall unit efficiency and establish requirements for improvement.

Figure 6 Team Inspection Service

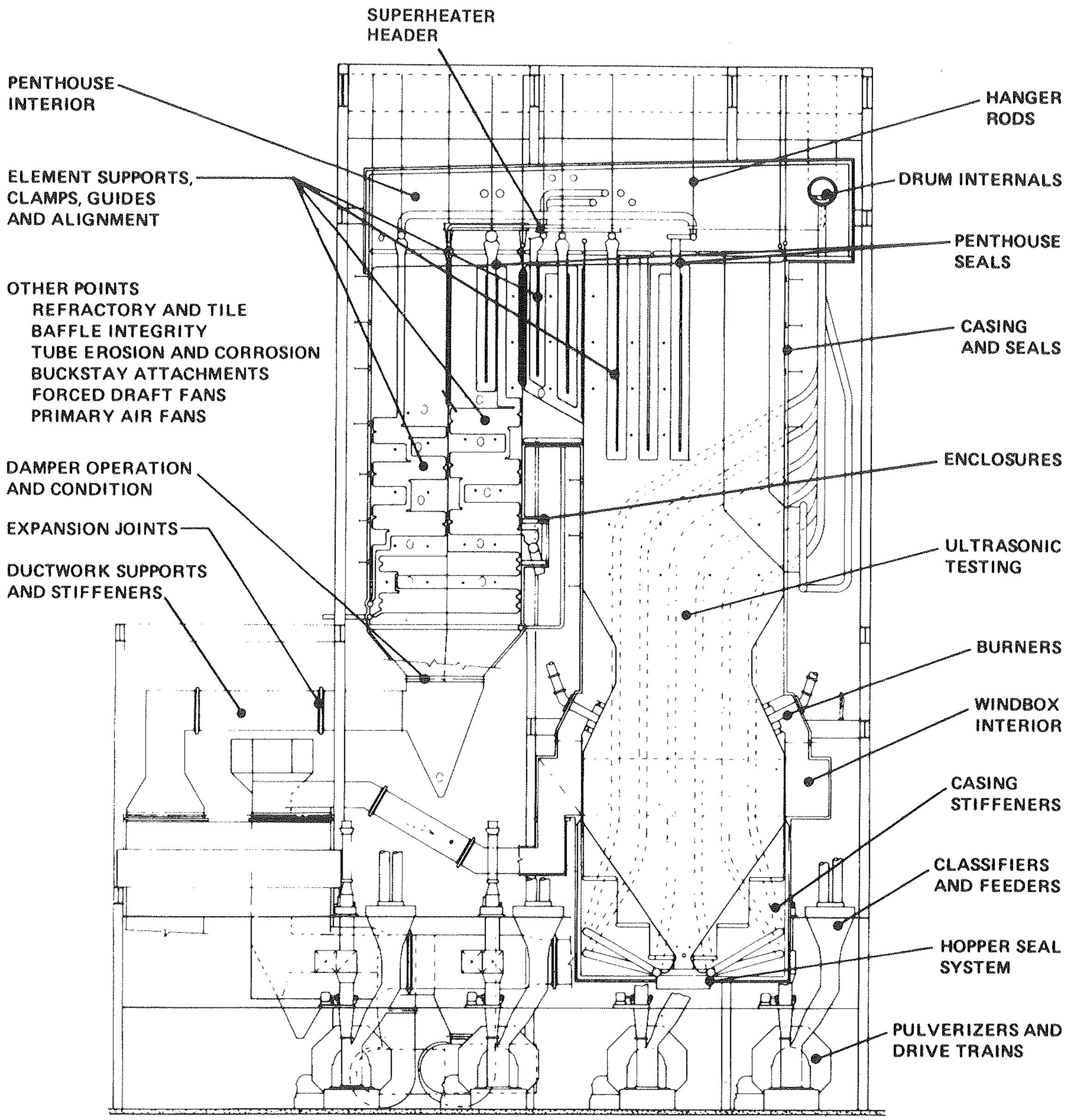

Figure 7 Non-Destructive Testing Examination

The above services will result in a written report. Each type of evaluation, however, is geared to a different and specific goal of the owner/operator. These goals range from a simple evaluation of wall thinning for a replace/no replace decision to detailed recommendations on operational changes which will enhance availability. Typically, these services and reports will not provide specific insight on life expectancy. Life extension projections require significantly more complex analysis and judgment on what can reasonably be expected. The parts of the life extension puzzle that need to be reviewed are shown in Figure 8. Note significant differences in potential changes based upon the complexity of future needs identification.

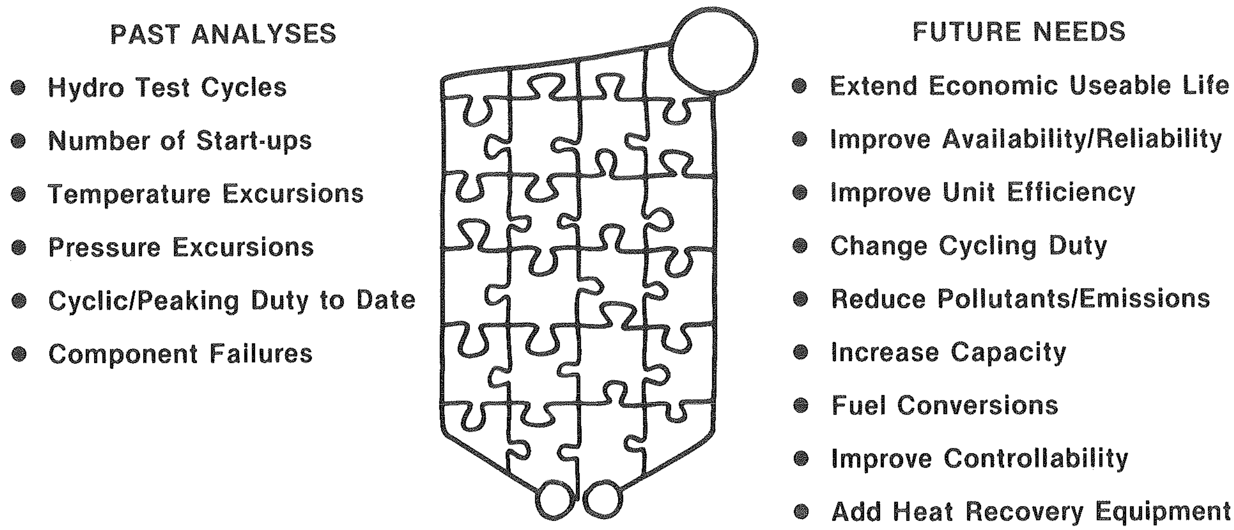

Figure 8 Life Cycle Analysis Puzzle

Each piece of the puzzle brings information, insight and direction to the decision on life extension. To compare how past experience merges with future requirements, Figure 9 shows the major considerations of an individual component within the boiler system. We, as designers, would design each specific component to meet the original specification requirements. For each input to the design, judgments are made with the final designed component being a composite of all inputs. Changing one requirement may pose no problem—or could cause a significant problem—depending on the magnitude of the desired/necessary change.

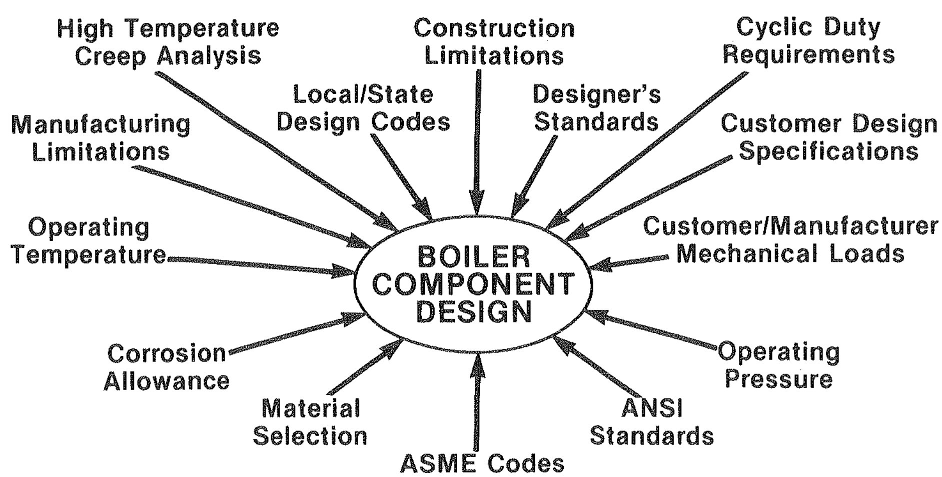

Figure 9 Component Design Considerations

Let us consider one specific component of the boiler: the superheater (SH) outlet header. Typical headers, each having many individual pieces, are shown in Figure 10. The limitations of an existing SH header would typically be as shown in Figure 11. These limitations are divided into two basic categories—those that are easy to establish and those that are difficult to establish and/or predict. In the easily established category, the inspection services mentioned earlier will verify the limitations. In the areas which are difficult to establish, different techniques are appropriate and necessary.

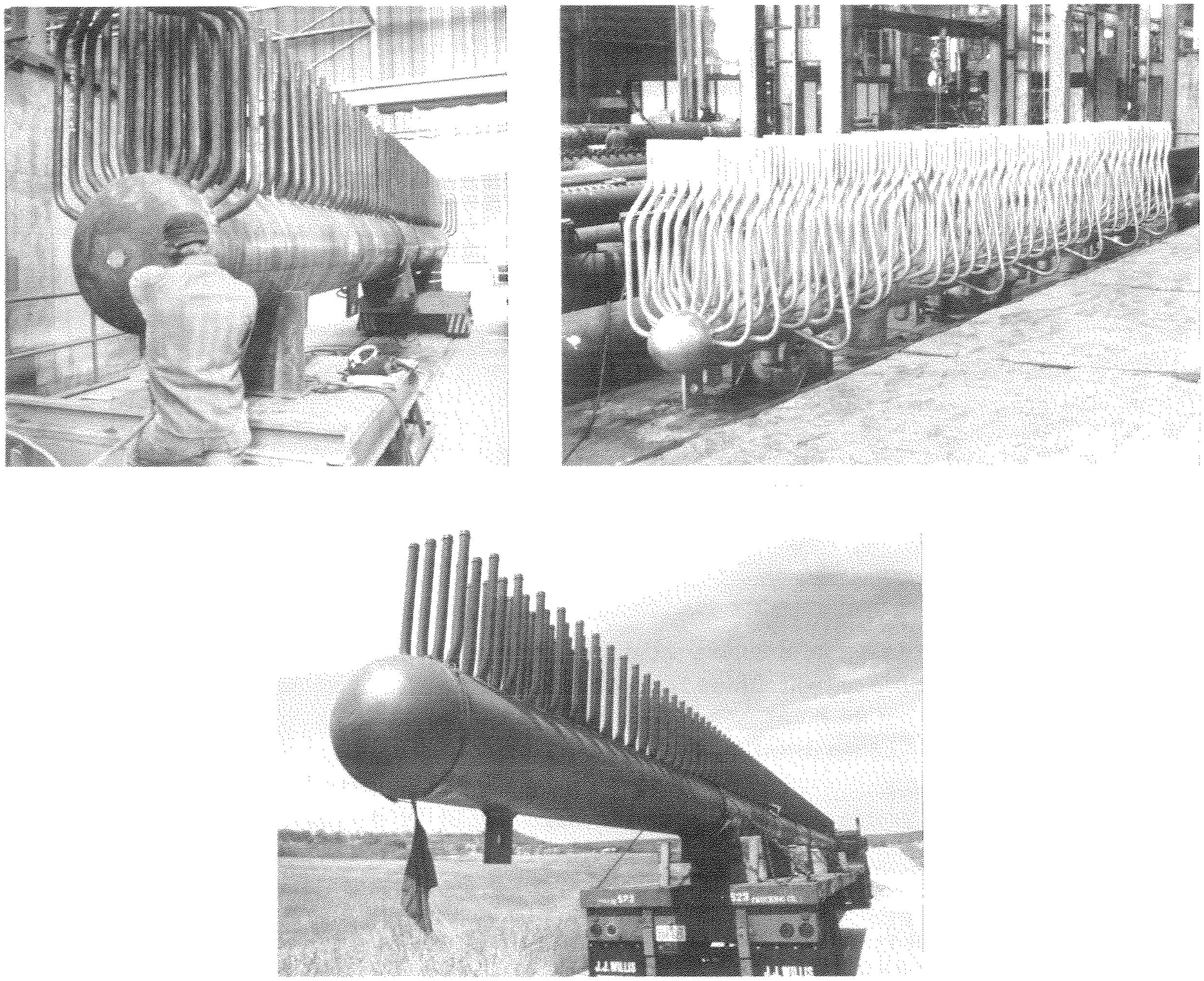

Figure 10 Typical Superheater Headers

Easily established:

- Design temperature limits of materials
- Design pressure limits of materials
- Corrosion allowance provided versus actual
- Hydrostatic tests performed and planned
- Base loaded or cyclic duty
- Mechanical loads from boiler/hangers
- Mechanical loads from customer piping
- Repairs/maintenance performed on component

Difficult to establish:

- Number and magnitude of hot and cold starts
- Upset conditions experienced
- Percent of useful life experienced

Figure 11 Typical Component Limitations

These techniques have two parts—the analytical and the physical component testing.

ANALYTICAL

- Establish detailed histograms for each component as shown in Figures 12 and 13 to gather data which will allow an analysis of the operating impact on existing material conditions
- Transfer the analysis techniques from Section I to Section III of the ASME Boiler and Pressure Vessel Code to provide life cycle calculation capability
- Perform detailed fatigue analysis of each component

PHYSICAL COMPONENT TESTING

- Verify critical dimensions/thicknesses to establish current geometry/integrity
- Perform metallurgical examination to determine any changes in material properties
- Perform NDT examinations in areas of concern that arise out of the analytical review

The manufacturer's expertise becomes invaluable integrating the information available on a unit's present condition and expected future operating requirements. Only the boiler manufacturer brings the subtle knowledge of how boilers designed to Section I of the ASME code must be reviewed in more detail to complete the picture on life cycle analysis. This is particularly critical when the utility is considering changing the cycle duty from that originally specified for the boiler. Figure 12 shows a typical histogram developed for a base loaded boiler drum. These operating requirements were factored into the originally-designed thermal and mechanical requirements. Figure 13 shows a typical histogram developed for a cycling boiler drum. Note that the ramp rate, frequency and magnitude are substantially different from the base loaded unit. Implicit in this difference is the requirement to review the material selection, flexibility analysis, high temperature creep and fatigue life expectancy to increase the sophistication of design analysis. As a manufacturer, we know when to apply Section I ASME, ANSI B31.1, Section III ASME, or high temperature creep analysis techniques to the mechanical component design. In addition, there are comparable thermal analysis techniques that are used as well as mechanical design tools covering the boiler components not addressed by the industry recognized codes.

In summary, Riley Stoker Corporation has more than 70 years of design, manufacturing and construction experience in boilers and fuel systems. Over this period of time we have grown to become experts in our field and believe that there is an essential role for the Boiler Manufacturer in any consideration of the boiler life extension. Only the manufacturer can offer the utility industry the following unique skills which are available from qualified boiler design firms which couple theory with practical experience:

- Availability of original design calculations and assumptions
- Data base of comparative experience
- Analytical tools specifically tailored to boilers
- Ability to predict which components will be affected by life extension
- Ability to predict overall unit performance based on desired/anticipated changes
- Extensive experience in the inspection and maintenance of boiler systems
- Vested interest in being represented by reliable, cost effective equipment
- Long-term orientation to utility customers

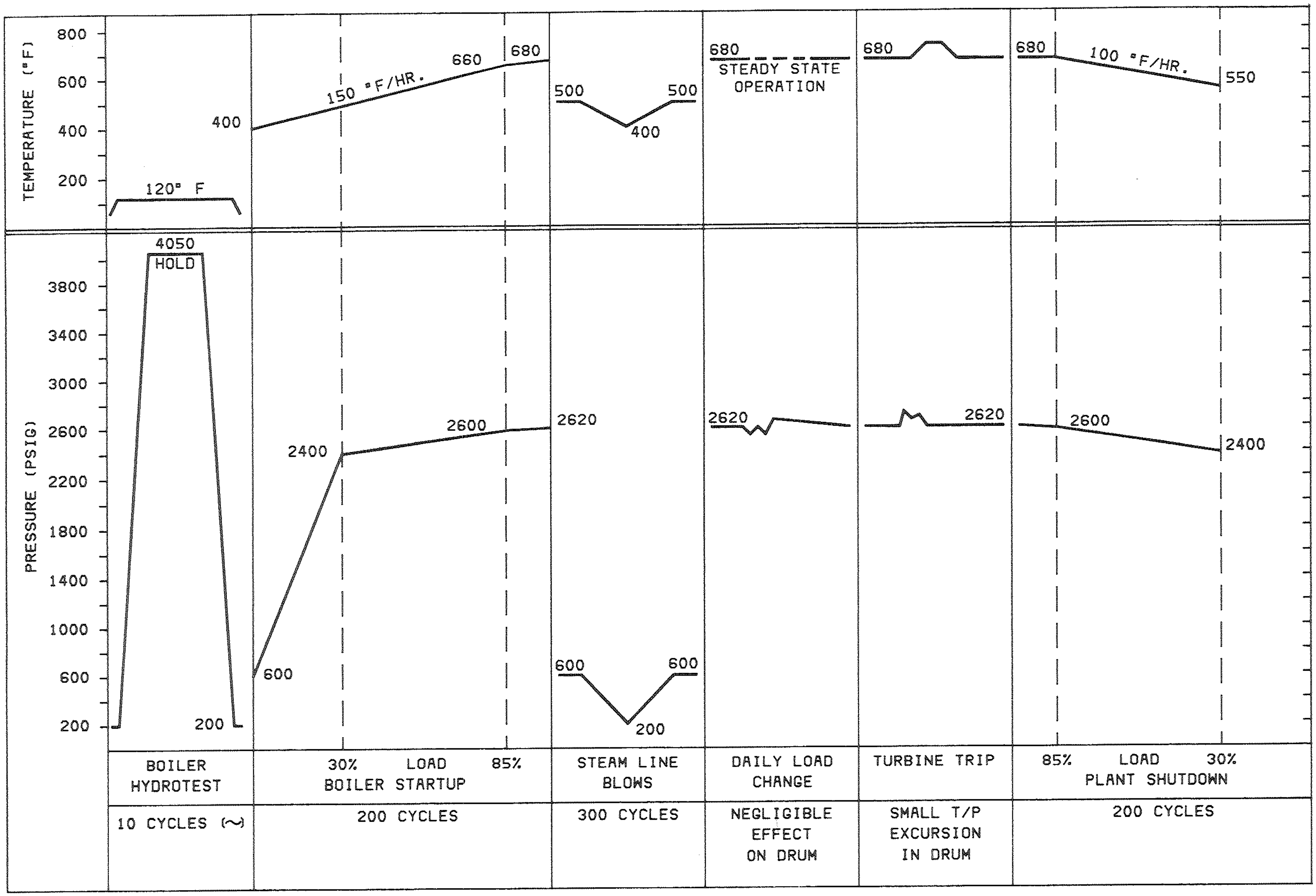

Figure 12 Histogram of a Base Loaded Boiler Drum

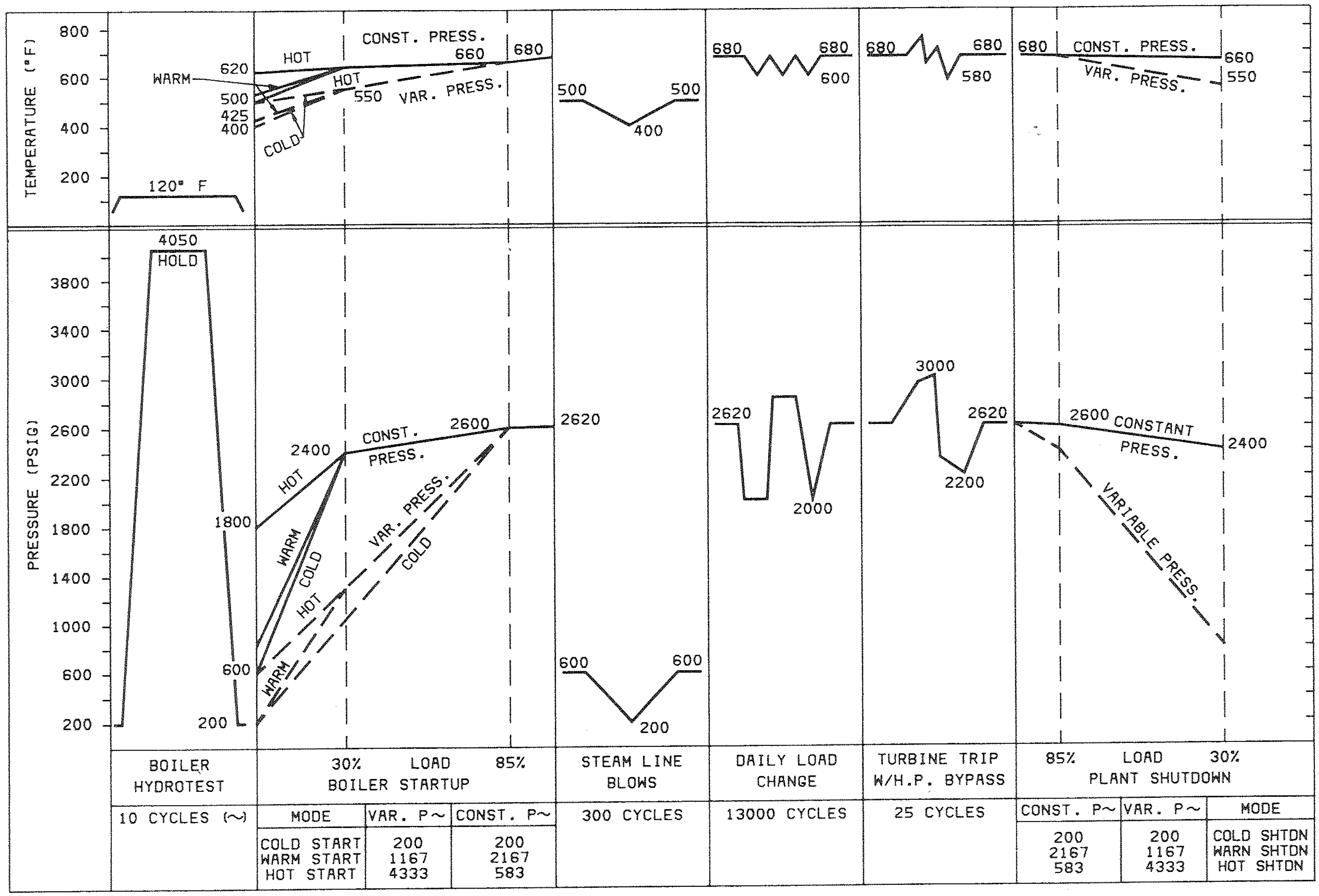

Figure 13 Histogram of a Cyclic Boiler Drum