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Utilities' Questions to Manufacturers

RILEY POWER INC.
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QUESTION 1

What efforts are being made by fossil-fired steam generator manufacturers to advance the technology of cleaning up the hot gas stream in a Pressurized Fluidized Bed Boiler prior to its entering the combustion turbine driver for the air compressor and generator?

ANSWER 1

Riley Stoker Corporation is involved with atmospheric fluidized bed boilers but does not market the pressurized fluidized bed technology and, therefore, respectfully declines to comment upon the state-of-the-art or related research and development efforts.

QUESTION 2

Recent studies made by power industry teams with EPRI sponsorship investigated the possibility of improved steam conditions for coal-fired plants to increase unit efficiency while at least maintaining existing reliability. Two study teams included representatives of utilities, an A/E, a turbine supplier and a boiler supplier. A project advisory board reviewed the work, drew conclusions, and redirected work of the contractors.

Both teams concluded that improved efficiency could be achieved, using proven technology, with throttle conditions of about 4500 psi and temperatures in the 1050° F to 1100° F range, with double reheat.

Although some of the earlier developmental units using high pressures and temperatures are still operating at somewhat reduced throttle conditions, the general application of super-critical units on utility systems has not lived up to its promise of higher efficiency, and advantages have frequently been offset by poor availability and reliability.

In light of past experience and recent studies, what confidence can be placed in possibilities for obtaining better efficiency while maintaining reliability? What types of development will have to be done to reach a commercially acceptable confidence level, and when do you anticipate that materials will be available to handle the temperatures involved?

ANSWER 2

Based on Riley Stoker Corporation's experience and on available literature, we regard the confidence level of achieving efficiency as medium, and the reliability level as less than that of conventional cycle designs.

Developmental work required to reach commercially acceptable confidence levels, which are presumed to mean higher reliability, includes attention in the following areas:

- *Metallurgical: There should be concern not only in the superheater and reheater surfaces due to the higher final temperatures, but also in the furnace wall tubes due to higher operating fluid temperatures. Additionally, new alloys would be helpful in providing more reliable attachments for support and alignment.*
- *Surface Configuration: The superheater and both reheater surfaces will require the sizing and placement to provide the temperature control range needed for the turbines. Surface selection, especially when made in an environment of changing fuel availability, is difficult at best.*

- *Control Technology: Besides the need to provide adequate control of the temperature from the three superheater sections to satisfy turbine and tube metal requirements, the controls will have to be able to handle the adaptation of super-critical units to full sliding pressure, fast start-up, and rapid load change operation.*

Materials research will have to include in situ testing on promising materials now available, particularly with regard to determining the effects of furnace gases and flyash on the metals (and their weldments) operating at the higher temperatures. While metals may be developed which can successfully resist these harmful effects, other research will be necessary to determine the methods or the special considerations required for making repairs to parts made from them. We estimate that five years of such research will make such materials available, given an emphasis on such research. Research funding is very restricted in the present declining market, and this problem must be recognized and addressed.

QUESTION 3

Superheater and reheater tube metal temperatures during transients and furnace slagging conditions frequently exceed the manufacturers' alarm temperature limit.

a. What is the long term effect of operating at 20° F above the manufacturers' temperature limitation on the life of the tubes in terms of years?

b. Why don't manufacturers design superheaters and reheaters with a greater margin between actual operating tube metal temperatures and the alarm set points?

ANSWER 3

a. The Larsen-Miller parameter has been used to extrapolate high temperature creep and rupture data to lower temperatures. Basically, what occurs in a short time at high temperatures will occur in a longer time at lower temperatures. A simple calculation will estimate the loss of life when tube metal temperatures are raised 20°F.

The Larson-Miller parameter, P, is:

$$P = T(20 + \log t)$$

where T is the temperature in degrees Rankine (°F + 460), t is the time in hours, and 20 is an empirical constant. P for design values is, say

$$P = (1075 + 460)(20 + \log 200{,}000)$$
$$= 38{,}800$$

If operating temperature is 1095°F, find t:

$$38{,}800 = (1095 + 460)(20 + \log t),$$
$$\log t = 4.98$$
$$t = 95{,}000$$

This represents a loss of life of about one-half, when the temperature is raised 20° F above design.

b. We live in an especially competitive market. Unless bidders request and receive credit for a more conservative design, a more costly design, at the time a tender is evaluated, it is unlikely that the margin between actual tube operating temperatures and alarm set-points will be increased. As long as purchasers will accept a minimal margin from one bidder, all bidders will offer a similar margin.

QUESTION 4

What is the status of the technology to accurately predict final steam temperature in new steam generators being offered?

ANSWER 4

By combining theoretical considerations, which more accurately predict the influences of parameters affecting steam temperature, with extensive testing of new boilers, Riley Stoker Corporation is constantly improving its ability to predict final steam temperatures of new steam generating units. While the current technology required for such predictions is adequate, improved tools for the determination of furnace heat fluxes, furnace exit gas temperatures, and coal slagging and fouling tendencies need to be developed. The latter is particularly important because of the varieties of coal being used, variations between the quality of shipments from a given mine, and the uncertainty of future fuel sources. Thorough understanding of the combustion process is required. Riley Stoker Corporation is presently installing additional research and development facilities to allow more detailed research in this area of solid fuels.

QUESTION 5

What have been some of the approaches to maintain reheat temperature at or near contract over the load range of a supercritical unit while minimizing reheat spray flow at full load?

ANSWER 5

Three methods have been used to maintain reheat temperature control at or near contract requirements over the load range.

- *Flue gas recirculation to increase mass gas flow and thus reheat temperatures at lower loads.*
- *Flame placement, using burner adjustments to bring flames closer to the reheater surface than they would normally be at lower loads.*
- *Multiple parallel pass design, which uses dampering arrangements in the convection passes with which to bypass the low temperature reheater surface during high loads.*

Each of these methods minimizes the use of reheater spray flow at full load.

QUESTION 6

In view of the extensive effort required in startup, field changes, and punch list activities, how have the manufacturers approached the problem of "designing in" better constructability?

ANSWER 6

Riley Stoker Corporation has "designed in" better constructability by using two major approaches.

- *Modularization: This concept, used in the design of pressure parts and burners, and being considered for structural steel components, reduces not only fit-up and other erection problems but also the time spent on field labor. Both of these effects result in improved productivity.*
- *Computer-Aided Drafting: The extensive use of this new tool reduces the probability of serious component inteferences and allows the designer an easy review of arrangements for accessibility to the steam generator and its auxiliary equipment.*

QUESTION 7

We are presently engaged in the preliminary phases of reconverting two 1,150,000 lbs./hr. 1005°F/2150 psig steam generating units built in 1957-1961 to coal firing. As part of the reconversion effort we have examined the types of coal presently available and have determined a significant difference in characteristics between these coals and those burned in the past.

In light of the above could you please list any modifications which were deemed necessary for your steam generators similar in size and age which have undergone reconversions. Please address such items as:

a. heat transfer surfaces and furnace modifications.
b. pulverizers and exhausters piping
c. soot blowers and wall blowers
d. furnace safety systems
e. dual fuel capability—#6 fuel oil and eastern bituminous coal—1.0% and 1.9% sulfur.

ANSWER 7

While Riley Stoker Corporation has not yet reconverted any of its units which are similar to those described in the question, we are pleased to address the items raised.

a. Heat transfer surfaces and furnace modifications would be necessary if this twenty year old unit had been designed for a low slagging coal (high fusion temperature). These modifications would include:

i. removing superheat and reheat surface,
ii. increasing the size of the furnace by installing waterwall platens,
iii. adding wall blowers to the furnace, and
iv. implementing an additive program to increase the ash fusion temperature.

If tight tube spacing is a problem in the convective areas, other possible solutions would be:

i. opening up the tube spacing,
ii. adding more soot blowers, or
iii. derating the unit.

b. Pulverizer and exhauster piping changes depend on the extent to which the coal quality deteriorated. Assume the following changes:

Characteristics	Design	Today
Moisture	*10%*	*25%*
Hardgrove Grindability	*54*	*50*
Higher Heating Value	*12,000*	*9,000*

If ball tube mills had been original equipment, the following changes would be expected:

i. lower pulverizer reserve,
ii. lower product fineness (less passing through 200 mesh),
iii. different burner turndown limits (per NFPA 85F),
iv. higher P.A. fan requirements,
v. increased coal pipe diameters,
vi. higher mill power consumption (increased ball charge), and
vii. higher temperatures in the primary air system, (however, this could be mediated by the addition of crusher-dryers to accommodate the higher moisture coal).

If Riley ATRITA™ pulverizers had been original equipment, the following changes would be expected.

i. lower pulverizer reserve,
ii. lower product fineness,
iii. different burner turndown limits, (per NFPA 85F),
iv. fan blade adjustment outward (exhausters),
v. additional burner hardware, and
vi. higher temperatures in the primary air system.

c. If we consider dual fuel capability, that is, firing with #6 oil and *eastern bituminous coal (1.0% and 1.9% sulfur)—in accordance with Question 7e.—which produces a* *more severe cleaning problem than firing either of the fuels independently, then the following changes would be considered:*

i. addition of wall blowers in the furnace,
ii. addition of long retractable or combination blower below the furnace arch,
iii. installation of long retractable blowers near the lower sections of pendant radiant surface,
iv. possible sootblower additions, modifications, or pressure changes in the convection passes.

d. Furnace safety systems have improved over the past twenty years, particularly with regard to the flame scanning and protective equipment. A review of what is now installed, combined with a study of the operating techniques now employed, might lead to a recommendation to make changes in this area. Another move which we would recommend could be the reinforcement of the furnace and gas ducts such that they would withstand ±25" W.G. or more, since units of the 1957-1961 genre were commonly designed for only 7" W.G.

e. When we consider dual fuel capability, #6 fuel oil and eastern bituminous coal—1.0% and 1.9% sulfur—we expect modifications and additions to be required in the following areas:

i. combustion controls,
ii. burner management systems,
iii. soot blowers (see Answer 7c),
iv. flame scanners (for all fuels), and
v. the cold end of the air preheater (protecting against pluggage and corrosion).

It is important to note that the environmental impact of a reconversion must be addressed.

QUESTION 8

Utilities across the country still vary in boiler water chemical practices. Many have converted to low solids coordinated phosphate treatment, but the benefits of such a program are being seriously questioned by some who have experienced excessive tube leakage. what is your recommended boiler water treatment control program and supporting field experience data?

ANSWER 8

The majority of units manufactured by Riley Stoker Corporation which operate above 2000 psig successfully use the zero solids treatment, employing either partial or full load demineralizers. A few units operate on low solids coordinated phosphate treatment, but we do not have enough information to develop a pattern of experience comparable to the zero solids treatment.

QUESTION 9

In the past when a major modification of a boiler is being considered (coal conversion for example), the utilities have requested the original manufacturer to undertake the engineering study.

Would the boiler manufacturers consider performing this type of a study on a competitor's boiler?

ANSWER 9

Yes. Riley Stoker Corporation's Plant Improvement Division (PID) has been performing major modifications of competitors' boilers for several years. Riley has added ball tube mills to a plant at Alberta Power, performed major repairs on a boiler at TVA, and converted another *boiler to a wood- and/or oil-fired unit. These conversions were made on different competitors' boilers. Riley's PID has the experience and capabilities to continue to perform major modifications and conversions on our competitors' boilers as well as our own.*

QUESTION 10

Flue gas conditioning systems may be required for optimizing precipitator performance. What recommendations or consultations would you provide for new and/or retrofit units?

ANSWER 10

Riley Stoker Corporation's standard practice requires electrostatic precipitator manufacturers to meet performance guarantees without the pre-treatment of flyash or coal when burning specified or similar coal. Special cases may occur in which adding a fuel or ash pre-treatment system to a difficult application or to a system whose fuel properties have changed prove economically attractive by avoiding the higher capital costs of extra fields and/or rebuilding the precipitator. Riley views fuel or ash pre-treatment as an alternative for correcting performance problems on existing units.

QUESTION 11

Based on your experience with reheat units operating in the 1050°F/1050°F range having 20 years of service or more, could you identify generic metallurgical problems and/or operational problems and the remedies that have been applied or recommended?

ANSWER 11

Riley Stoker Corporation has no units in the 1050°F/1050°F superheat-reheat temperature range. However, from our analysis of many high temperature tube ruptures over the years, we have seen superheater and reheater tubes that have operated at these temperatures. At tube metal temperatures of 1100°F and above, the following will likely occur:

a. Corrosion of the tube fire side by the constituents in the fuel ash, for both coal- and oil-fired units.

b. Heavier internal scale formation and its attendant problems—exfoliation and higher tube metal temperatures.

Note that a supercritical unit with 1050°F/1050°F superheater and reheater will have approximately the same peak tube metal temperatures as a standard sub-critical unit with 1005°F/1005°F superheater and reheater temperatures, because the steam side heat transfer coefficient is so much higher in a supercritical unit.

In order to avoid problems of corrosion, scale exfoliation, and increases in tube temperatures as a result of I.D. scale, special design modifications are required.

QUESTION 12

What is your position regarding the cost versus benefit to be gained from 100 percent radiography of shop and field welding of boiler pressure parts? (Give relative increase in cost as a percent of the boiler cost and state what is your normal practice.)

ANSWER 12

An effective sample plan for all non-destructive examinations, including radiography, will keep manufacturing processes—welding, bending, heat-treatment, etc.—under control. Further, screening of new welders by careful inspection of the first several welds made by each will sort out the good from the poor welders.

No inspection procedure can guarantee no weld leaks at hydrostatic test time. In fact, the last *unit Riley Stoker Corporation built using 100 per cent radiographic inspection of pressure part welds had several (at least 8) leaks during the hydrostatic test. The cost of 100 per cent Radiographic testing is about $10 per radiograph. Assuming approximately 100,000 welds (total of shop and field welds) in a modern unit, this amounts to $1,000,000. An effective sample plan may cost $100,000.*

Riley Stoker's standard procedure is to use a sample plan heavily skewed to the first welds made by a new welder.

QUESTION 13

Each fossil-fired steam generator manufacturer is requested to discuss, in depth, the extent and manner to which they incorporate design and operating considerations for combination base load and cyclic operation of new units.

Their presentations to Committee Members should also include whether or not they foresee a significant cost impact from the above.

Also, the fossil-fired steam generator manufacturers are invited to address if they maintain a three-fuel design capability, such as coal, oil and gas, for those utilities that may still desire such capabilities.

ANSWER 13

Riley Stoker Corporation finds that most of today's new units require consideration for combination base load and cyclic operation. Daily cycles and weekend shutdowns result in from 250 to 300 cycles during each year. This departure from the conventional long term, on-line cycle must include modified operational modes, innovative design techniques, and sophisticated control applications that treat the special problems cycling brings.

New coal fired cycling units are now designed for 2400 psig turbine throttle pressure and 1005°F/1005°F steam temperatures and are specified as "cycling units." "Cycling" is not a clearly defined term, therefore, boiler manufacturers must try to design units that combine the requirements of both base loaded units and cycling units. On rare occasions, such as a recent Riley Stoker Corporation involvement, cycling requirements are strictly defined—in terms of expected load ramps, pressure ramps, and the number of cycles per year. Data like these allow specific cycling calculations and analyses to help provide an optimum design for the steam generator's components. But most commonly this kind of information is not available to the customer or the manufacturer.

Design features Riley Stoker Corporation includes in a coal fired cycling unit are:

- *Stainless steel bumper or wrapper tubes or complete elements, installed in areas of high heat absorption on the lower portion of radiant superheaters.*
- *Drainable superheater and reheater sections.*
- *High pressure drops through the superheater and reheater.*
- *Oversized spray control systems, staged to allow correction to side-to-side imbalances due to load transients.*
- *Steam by-pass systems to allow turbine temperature matching for fast starts or hot re-starts. This system must include some means of reheater protection, either cooling flow through the reheater or an a firing rate limit.*
- *Flexibility and expansion provisions in drum nozzle/downcomer connections, superheater and reheater header relationships, superheat/reheat tube penetrations through waterwalls, economizer inlet header/terminal tubing arrangement, support and alignment attachments, and the casing, ductwork, and expansion joints.*

Coal fired cycling steam generating units constitute an advancement in the state of the boiler maker's art. As demand increases, coal fired units will be used more and more for cycling duty. They require meticulous design efforts, both for the pressure parts and for the burner and fuel systems, and also careful training and attention of the operating force. There are not insurmountable problems in either the design or the operation. Proper coordination is required *between the manufacturers of the major components used in such a power plant, now, more than ever with the advent of the coal fired cycling unit.*

Cycling units were originally thought of as less efficient than base-loaded units, and these were typically referred to as peaking units. The minimizing or elimination of heat recovery equipment like air heaters or economizers reduced the selling price.This concept is no longer compatible with today's inflated fuel prices and the need for fuel conservation. The features of the cycling unit all tend to make it more expensive.

Depending on their required mode of operation and the degree of cycling, our estimates show that coal fired cycling units can be expected to cost up to 5% to 10% more than conventional base-loaded units.

Riley Stoker Corporation has had in the past, and still has available, steam generating equipment with the design capabilities of firing three fuels, such as coal, oil, and gas. Riley would be eager and willing to work with any of the utilities in defining the requirements of a steam generating unit using three fuels.

QUESTION 14

Which criteria and methods should apply for repairing local areas of boiler tubes which have become thinned by erosion?

The following concerns regarding this subject need to be addressed, in specific and realistic terms, for pad welding of eroded tubes:

a. The National Board Inspection Code (NBIC) states in part R-402 that "wasted areas on tubes may be repaired by welding provided that, IN THE JUDGEMENT OF THE INSPECTOR, the strength of the tube has not been impaired." Utilities and the Authorized Code Inspector need better guidance and/or rules for tube repairs, so that decisions can be made which are both legally (per Codes) and technically sound.

   i. What limitations, if any, should there be on the maximum area which can be repaired on a tube?

   ii. What is the minimum tube thickness that can be satisfactorily repaired by pad welding?

   iii. What considerations, if any, should be given to the following, when deciding on whethr or not, or how to pad weld repair a tube?

      (a) Tube material composition

      (b) Location of tube in boiler

      (c) Service for which the tube is used

      (d) Other

b. Besides the above concerns, legally and technically sound and successful methods for pad welded tube repairs need to be better understood.

   i. If all are physically possible, is it better to weld vertically down, up or horizontal (considering such factors as residual streses, etc.)?

   ii. When, if ever, is it necessary to internally purge stainless steel tubes when pad welded?

   iii. If the tubes are internally contaminated with copper, how can hot shortness of repaired areas be best minimized?

   iv. Has oxy-acetylene welding been used more successfully than SMAW (stick) for repairing very thin areas? GTAW (TIG)?

ANSWER 14

Riley Stoker Corporation recommends against pad welding. Eroded or thinned tubes should be replaced by suitable "dutchmen." This replacement should be welded using a TIG root pass *and SMAW cover passes. To protect against uncorrected or unavoidable erosion replaceable shields are available and mildly effective.*

Regarding copper contamination, if so much copper is on the bore of a furnace tube, it is time for chemical cleaning—and elimination of the source of the copper contamination. If repairs have to be made to a ruptured tube to maintain the unit's integrity for chemical cleaning, replace it with a new tube section.

On the bore of the old tube, grind out the internal scale for 1 1/2 to 2 inches from the tube end, taking care to remove all the copper and also making certain that the debris is contained by using suitable dams inside the tube.

Make the welds, and chemically clean the unit.

QUESTION 15

What major design changes do you foresee in the furnace, superheater, reheater, and economizer in view of deteriorating fuel quality and how do you determine the actual gas flow in your design of the unit to reach maximum capacity?

ANSWER 15

As lower grade fuels become more popular, two phenomena affecting superheater, reheater, and economizer designs become critical:

a. *Flue gas quantity: With low BTU coals, there is greater flue gas product per million BTU input than with higher grade fuels. Convection surfaces must be designed to limit the gas velocity to less than 4000 fpm, the specific design velocity depending on ash content, to avoid erosion of tubing due to the ash in the coal. With poor ash constituents the maximum velocity may be well below 4000 fpm. As a consequence, convection portions of the boiler become bigger, heavier, and more expensive.*

b. *Fouling: Tube face-to-face spacing must also satisfy a spacing-temperature criterion that is established by examining a fuel ash sample and determining the ash's fouling tendency. Based on the guidelines established empirically, the minimum tube spacing which prevents pluggage at a given gas temperature is determined.*

These two guidelines are used in conjunction with one another to optimize the heating surface configuration of a new design.

Deteriorating fuel quality may also have a large impact on furnace sizing. Generally, poor quality coals have high slagging tendencies. To prevent large or running slag deposits on furnace walls, furnaces may have to be increased in size to what typically is seen in today's designs.

To determine the actual gas flow quantities for unit designs at maximum continuous rating (MCR), fuel weight is first calculated from boiler output and boiler efficiency at a design air preheater exit gas temperature and a design fuel stoichiometry. A combustion analysis of the fuel yields the mass of air required at the design stoichiometry. Air plus fuel less bottom ash fallout yields the gas flow quantity, in pounds.

QUESTION 16

Our history indicates poor availability on cold precipitators with gas recirculation temperature control. What is the industry experience with this method of temperature control on cold precipitators, and hot precipitators? Do you plan to use this method on future designs?

ANSWER 16

Riley Stoker Corporation's experience indicates that cold or hot precipitator availability is not related to gas recirculation temperature control. Riley does not anticipate future use of gas recirculation temperature control as a viable method on the basis of system economics, maintenance, and availability.

QUESTION 17

Availability of steam generating units continues to be of great concern to the electric utilities. Forced outage data show that the boiler is the primary cause for these outages and a review of these data indicate that the primary causes for these forced outages are boiler water walls, superheaters, reheaters and economizers. Pulverizer problems are the major cause for partial forced outages.

It is recognized that good availability is dependent, not only upon good design, good manufacturing and construction in accordance with the drawings, but also upon good operating and maintenance procedures. However, the foundation for availability is in the specifications and design and leads to the following three part question:

a. What items should be included in the specifications prepared by the utilities which will result in cost effective improvements in the availability of steam generating units, specifically with respect to those particular items described above which are the major cause for forced outages?

b. What information should the utility request in its specification to permit it to objectively evaluate each vendor's proposal for items which will improve availability?

c. Please discuss the design changes which your company will propose for the cost effective improvement of availability, the anticipated efforts of these changes from (1) boiler availability, (2) performance, (3) operation, and (4) maintenance.

ANSWER 17

Today's economic conditions dictate that the utilities and Architect/Engineers provide specifications and that the steam generator manufacturers provide designs which will result in cost-effective improvements in the operating availability of steam generating units. Basic ingredients of the specification are the steam generator's expected operating conditions and anticipated fuels. In order for the steam generator manufacturer to provide an adequate design, he must know how the equipment will operate, that is, whether it will be full load-constant pressure; variable pressure; or cycling. Inherent with each of these operating modes are the conditions under which they will be operated, such as variations in pressures, temperatures, and rates of load changes. All of these conditions will be factored into the overall unit design such that it can be optimized for the anticipated load pattern with the highest availability.

We in the steam generator manufacturing community realize the difficulty that utilities are having in specifying and obtaining contracts for coal in today's variable fuel market. However, in order to design the steam generating equipment properly, the fuel properties must be known at the time of design. The more fuel information the utility provides in the specification, the better opportunity the steam generator manufacturer has to optimize the design for the anticipated fuels. Ranges of fuels do not help the steam generator designers, rather, specific analyses of the fuels to be used are necessary to the design of the equipment.

Other values which may be included in the specification are furnace parameters, gas temperatures and convection pass tube spacing, gas side velocities, circulation ratios, departure from nucleate boiling (DNB) ratios, economizer surface type, etc. However, extreme care must be taken when specifying specific values because they are sensitive to fuel and operating mode conditions and are also subject to some degree of objectivity. Additionally, care must be taken to avoid specifying particular parameters which unfairly penalize a particular steam generator manufacturer. Riley is most willing to work with the utilities during the preliminary stages of specification in evaluating the pros and cons of specification parameters. It must be remembered that increasing conservatism does not always result in cost-effective improvements in availability. Bigger is not always better.

We continually hear the plea for higher availability, yet, for apparent economic reasons, there seems to be a reluctance to purchase equipment with proven higher availability. Specifically, two areas which Riley would recommend for consideration are drainable superheaters and reheaters and ball tube mill systems. Both of these can be shown to increase reliability, but *they do not come without economic or power penalties. These trade-offs can only be evaluated by the operating utilities.*

Following are examples of other areas in which Riley can offer options that improve the reliability/availability of steam generating units.

a. *Upgrade superheater and reheater materials. Tube metal selections are typically based on Riley's and industry accepted tube metal oxidation (outer skin temperature) limits. If this option is accepted, Riley can reduce its standard tube metal outer skin temperature limits by 50°F or more.*

b. *Extend quality control programs. Riley can provide the following services in addition to those included in its standard proposals and typically required by most steam generator specifications:*
   i. *100% radiographic examination (RT) of header nozzle welds*
   ii. *Verification of wall tube thicknesses of all tube bends by ultrasonic examination (UT).*
   iii. *Magnetic particle examination (MT) of all tube connections, attachments, seam, and nozzle welds after stress relieving. This applies to drums, headers, and piping.*
   iv. *Full-time quality control person, dedicated to a specific project, to supervise the quality control function as it relates to vendor surveillance and field construction.*
   v. *100% RT of tube welds performed in the shop and/or the field.*

c. *Line coal pipe elbows. To extend coal pipe life, Riley can furnish basalt/ceramic lining at all elbows in the coal piping system (mills to burners).*

d. *Extend operator training programs. Riley can provide additional training programs as desired by the utilities.*

e. *Contract maintenance and inspection programs. Riley has instituted programs with goals to increase availability through:*
   i. *a maintenance agreement which provides rapid and efficient corrective services based on terms previously established. Such an agreement provides early availability of the necessary drawings, standards, material, and personnel.*
   ii. *a boiler availability improvement program (BAIP) and a team inspection service program (TIS) to identify root causes of problems which have been encountered in unit operations and to develop corrections to these problems.*

In addition to the above suggestions, the following list describes five ongoing and completed Riley programs to improve unit reliability/availability:

1. *Training Programs, for both operators and Riley Service Engineers.*
2. *Ball Mill System Improvements, which include crusher-drier additions, bypass damper control, and coal inventory control (Powersonic).*
3. *Boiler Circulation Improvements, which resulted in steam purity improvement and increased boiler waterwall protection.*
4. *Tube Metal Selection Studies, which resulted in the lowering of outer skin temperature limits.*
5. *Inerting Provisions for Coal Milling Systems, which protect against damaging fires and explosions, and also against expensive outages.*

QUESTION 18

What measurements and tests should be done to evaluate extending service life of units now 20 to 30 years old by 10 to 20 years beyond the 35 year life?

ANSWER 18

The major consideration when attempting to extend the service life of a boiler is the condition of the metal in the tubes and drums. Riley Stoker Corporation would perform the following tests and measurements.

- *Ultrasonically test the tubes for wall thickness and remove selected tube samples for metallurgical examination. From these tests, Riley can make a prediction about the expected service life, and if this is not as long as desired, Riley would recommend the tube replacement required.*
- *Internal and external inspection of drums and metallurgical examination of drum metal samples. The inspection will include a search for cracks in the drum, especially in the area of the tube holes. If possible, any cracks found will be ground out and carefully repaired. The steam drum is most critical; its condition could be the limiting factor in extending the boiler's service life by 20 years.*
- *Inspection of auxiliaries, attachments, and ductwork. While these items are not considered critical, an assessment of their condition would be necessary. FD Fans, ID Fans, Air Preheaters, Dust Collectors, Fuel Burning Equipment, Boiler Casing, Boiler Baffles, and Refractory are all areas that require and receive maintenance attention. Usually their condition is easily perceived and evaluated.*

QUESTION 19

We foresee increased cycling operation of our units and find that those steam generators now being cycled experience repeated tube failures, due, in many cases, to lack of flexibility between adjacent welded parts. There is an equally serious problem with failure of expansion joints, particularly in pressurized furnace units.

What design improvements are manufacturers currently incorporating in their steam generators to alleviate these problems? Have designers successfully and economically addressed these problems in older units with 2,000,000#/hr. steam flow and above? How do they recommend the problem be addressed?

ANSWER 19

Special considerations must be given to steam generator components designed for cyclic operation. Regarding welded connections to pressure parts, Riley Stoker Corporation's engineers and designers evaluate and specify the following on new units:

- *Connections that meet fatigue requirements established through the use of engineering standards and ANSI B31.1, providing ample flexibility.*
- *Welding methods that minimize stress concentration.*
- *Minimizing the number of rigid welded connections through the judicious use of "stringer" tube design for support and "scissor" tubes for alignment.*

The failure of expansion joints, especially in pressurized units, can pose a personnel hazard, result in extensive damage to insulation and lagging, and cause unit outages. Major improvements Riley has made to extend expansion joint life and reduce maintenance are:

- *Pre-stressing the joint so a zero stress or neutral position exists when the unit is in operation.*
- *Using expansion joint systems which form toggle arrangements, to limit shear stress levels.*
- *Using non-metallic joints in selected duct and breeching sections which are exposed to excessive motion in confined locations.*

The foregoing concepts have been successfully implemented on a number of units now in operation. In each case, modifications were evaluated as being economical due to previous excessive maintenance costs or poor reliability.

Before using an older unit for cycling service, the utility should consult with the original manufacturer for a thorough evaluation of potential problems and a determination of operating constraints.

QUESTION 20

At present, Combustion Engineering, Inc., has a program titled Service Information Letters (S.I.L.) which make their customers aware of recommended solutions to current equipment problems. The turbine manufacturers have similar programs designated as T.I.L. and A.I.B. which have proven useful.

Do other boiler manufacturers plan to institute similar programs?

ANSWER 20

To alert our customers and company personnel to the latest developments and recommendations concerning equipment operation and maintenance, Riley Stoker Corporation very often uses a Service Advisory program.

This program provides our customers and our personnel with summaries of current knowledge of operating experience that will be helpful in maintaining or improving the equipment's safety, efficiency, or reliability.

QUESTION 21

What are your recommendations for inspecting and material testing of older units being considered for extended lives? The units we are considering were installed in the late 1930's and 1940's and were subjected to many hours of cycling service in recent years. If it appears practical, we plan to extend lives of some of these units by as much as 30 years.

ANSWER 21

To investigate the practicality of extending the lives of an older unit, Riley Stoker Corporation's Plant Improvement Division (PID) would begin its inspection and material testing in the superheater and reheater.

Repetitive flexing from cyclic operation, applied to a unit designed for base loading, may contribute to increased maintenance of pressure parts, casing, and ductwork. Cycling duty puts severe strains on welded connections and causes abnormal movements in superheaters, reheaters, and header connections—especially the superheater and reheater outlet headers. All of these welded connections should be inspected for cracks, particularly fatigue cracks. For units with more than 25 or 30 years service operating base-loaded, a change to accommodate cycling operation will require an upgrading of the alloys used in the superheaters and reheaters. Such duty is apt to cause metal temperature excursions above safe alarm limits and, unless more conservative designs are used, will cause microstructural degradation and loss of strength. Substitution of T-22 for T-11, and stainless steel for T-22 are necessary changes. Long term use will have resulted in corrosion, both on the OD and in the ID of the tubes, and there will probably be some tube wastage.

Microstructural analysis should be done on selected samples from high heat release zones of the furnace, and in the high temperature ends of the superheater and reheater. A few samples should be taken elsewhere in both the superheater and reheater at alloy transitions, where carbon steel joins T-11, for example. It is at these points where the hottest temperatures have existed for the lower alloy.

Corrosion of the air preheater and cold gas ducts may increase because of cycling operation. Cold end protection of the air preheater should be reviewed.

Each boiler and its service is different. An inspection of the specific unit would determine which parts would need replacing, where maintenance should be intensified, and what level of *operation the unit could be expected to give in the future. Riley's PID Team Inspection Service has been specifically designed to provide an expert mechanical appraisal of these units. The team is in and out in a matter of days and provides a report outlining solutions to the problems found.*

Riley's PID experience indicates that economics very often favor a rebuild over new construction. In some cases it may be necessary to downgrade a unit, so the total capacity need is an important factor to consider.

QUESTION 22

Utilities have traditionally used various factors and indices (such as forced outage rate, operating availability, etc.) in an attempt to evaluate steam generator performance by vendor for new and existing units. Based on the past statistics from EEI and looking toward the new data base from NERC (GADS Availability Program), how do you (the vendors) suggest that the utilities use this information to evaluate your equipment?

ANSWER 22

Riley Stoker Corporation strongly supports the independent and centralized data collection system and report of the National Electric Reliability Council's (NERC) Generating Availability Data System (GADS). We believe that the information and analyses can provide a very effective method for increasing steam generator reliability and maintainability. We do not, however, believe that the present system is sufficient for equipment evaluation.

There are many things that affect the availability of units that are beyond the control of the steam generator manufacturer and dependent on the user. The data mentioned previously can help identify components which are most vulnerable to breakdown, and those which require the most maintenance. The steam generator manufacturer, in his analysis can use this information when designing and manufacturing future units.

The utilities must recognize their contribution to unit availability and reliability. Critical to unit performance within the province of the utilities are operating and maintenance practices.

Further, unit performance is profoundly influenced by the level of conservatism called for in the specifications.

We recognize that the steam generator manufacturer and the utilities have a common interest in improving the availability and reliability of new units.The attainment of that objective is a mutual responsibility that will require the cooperative effort of both.

QUESTION 23

What is your position on plasma spray coatings for control of erosion and furnace fire-side corrosion on coal-fired units?

ANSWER 23

Plasma sprayed coatings may be useful in extending the service life of tubes that suffer erosion. For control of ash corrosion, Riley Stoker Corporation doubts if any coating will be effective over a long period of time. Riley tried to contain a severe oil ash corrosion problems on reheat tube supports by means of plasma sprayed coatings without success. Liquid ash constituents are so aggressive chemically, that the coating would be corroded in a fairly short time. In the absence of corrosion, abrasion resistance can be improved by suitable coatings. However, coatings applied in situ may not work as well, or last as long, as the same coating applied to a clean tube in a shop and then the tube installed in the boiler.

In order for plasma coatings to be applied properly, the tube surface needs to be clean; cleaner than is possible in an operating boiler.