SPECIFICATION AND EVALUATION OF BOILER PLANT TENDERS IN THE SUGAR INDUSTRY

By H. BIEBER
Babcock and Wilcox of Africa (Operations) (Pty) Ltd

Abstract
The paper is a methodical guide to the compilation and assessment of tenders for new boilerplant. Eight items are listed to cover the boiler specification and seven aspects of comparative tender evaluations are considered.

Introduction:
Unlike many other plants, boilers, except the smaller shell and package boilers, are not standardised to any extent. Hence the purchase of a boiler, particularly in the sugar industry, is fraught with difficulties and problems. It is hoped that this paper will assist sugar technologists, engineers and managers, when next they come face-to-face with this problem.

I. Selection of boiler plant:
The selection of boiler plant commences when it is decided that a new mill is to be built, or existing plant is to be replaced by more modern and efficient plant, or when present steam output is insufficient to meet future demand. The process of selection remains basically the same whether at that stage broad decisions have to be made in order to obtain a basis for budgeting or more detailed decisions have to be made in order to draw up a purchase enquiry. The initial step requires the prospective purchaser to draw up a specification which can be brief or detailed, but must contain certain specific information.

Such data as boiler output, operating pressure and final steam temperature are essential requirements to be specified and frequently, to establish this data, the purchaser will require a highly polished crystal ball in order to take account of the future. Whilst accountants will probably write off the investment for a new boiler in 10 or 15 years, the engineer or manager probably has to live with the plant for twice that period.

In calling for boiler plant proposals the following broad aspects should be considered.
(a) Plant capacity;
(b) Temperature and pressure conditions;
(c) Fuels;
(d) Performance at various loads;
(e) Boiler efficiency and heat-trap equipment;
(f) Duplication and back-trap equipment;
(g) Scope of supply;
(h) Purchasing specification;

(a) Boiler plant capacity
In specifying the maximum continuous output of the boiler it is well to bear in mind that the maximum efficiency of the plant lies around 80% of its maximum continuous rating. Boilermakers have not yet found a way of eliminating the overloading of boilers, but users are warned that continual overload conditions will increase boiler maintenance costs, apart from possible damage which may be done and result in outages. Boilermakers can readily advise the purchaser of the cost of steam per kilogram for certain specific conditions, to enable the purchaser to assess the approximate cost of any reserve steam capacity to cater for future demand increase.

(b) Temperature and pressure conditions:
The question of steam pressure and temperature is of considerable significance in the sugar industry and with the passage of time, the steam conditions for mill drives have increased. Hence, if there is a future possibility of new mill drives or even a new mill, it may be prudent to establish initial pressure and temperature condition to match those of the existing plant but at the same time, make provision in the design of the boiler to permit this to be operated ultimately at a higher steam pressure and temperature. The additional cost of this facility is generally insignificant when compared to the ultimate benefit the purchaser may derive.

Purchasers are advised to discuss these questions with boilermakers before a final specification is drawn up, and approximate cost figures can be readily established for such higher ultimate pressures and temperatures. The benefits of these preliminary discussions with boilermakers prior to finalising the operating conditions cannot be over-emphasised, a benefit both to the purchaser as well as to the boilermaker, and it is worth remembering that the boilermaker also has to live with plant he supplies.

(c) Fuels:
When boiler operating conditions are established, the purchaser also has to decide what fuels he wishes to employ. In present-day sugar mills bagasse will almost certainly be the major fuel, although increasingly other uses are being found for bagasse. The choice of fuel or fuels will determine the alternative methods of combustion which can be offered. As we are concerned with boilers for the sugar industry, this paper deals mainly with boilers which use bagasse as the primary fuel.

In the selection of the fuels, two other aspects have to be considered, namely, the question of steam demand when the mill is not crushing and the method of lighting-up the bagasse initially. Frequently steam is required for generating power for irrigation purposes, for refining, for domestic load or for occasions when no bagasse is available. As an auxiliary secondary fuel, both coal and oil are used in Southern Africa and
Mauritius and wood is frequently used for lighting-up purposes where this is available.

In certain cases the full boiler output would never be required when firing the secondary fuel. If this is the case, the purchaser should, in his own interest, advise the boilermaker of the maximum load which would be required when firing secondary fuel, or alternatively the boilermaker should be asked to advise the maximum load which can be achieved on the secondary fuel with the basic furnace design and firing equipment offered.

The question of fuel selection not only determines the type of boiler and furnace which can be offered, but also to a large extent the auxiliary equipment which is required such as economisers, air heaters and dust collectors, and consequently has a major bearing on the final cost of the plant.

(d) Performance at various loads:

Having now selected the fuels, boiler capacity, operating pressure and superheated steam temperature it must be remembered that the final steam temperature will vary with load and differ for the different fuels. In a radiant superheater, the steam temperature will fall with increasing load, whilst in a convection superheater the steam temperature rises with load. It is almost impossible with boilers of the type under discussion, to design a superheater which has both components in such a manner than a steady steam temperature is obtained over the practical load range, and we must expect the steam temperature to vary with load. By judicious design, the variation in steam temperature between say 60% M.C.R. and maximum continuous rating may be as little as 20 or 30°C, in which case it may be acceptable. If this variation should be larger, however, and not acceptable, the boilermaker can provide attemperating equipment which will give a steady superheater outlet temperature over an entire load range, for example from 60% to 100% of maximum continuous rating. The additional cost of this feature can be appreciable, not because the attemperator itself is a costly item, but because of the additional superheater surface which has to be installed in order to give full temperature control over the specified range of output.

Similarly, if a secondary fuel such as coal or oil is to be used, the total gas volumes arising from combustion will differ greatly, resulting in appreciably lower steam temperatures from those which occur when burning bagasse. Attemperation can also be used, but in many cases this would make the superheater considerably larger than necessary and the purchaser must consider whether the additional expenditure is warranted or whether the turbine can permit steam temperature variations providing that a specified maximum is not exceeded.

Drum type attemperators can only be used for relatively limited temperature ranges, and are of the indirect type. The direct contact attemperator is generally of the spray type using boiler feed water, and has a wide temperature range. It is frequently installed interstage, between primary and secondary superheater in order to ensure dry steam to the turbine. However, by reasons of versatility and construction, it is more expensive than the drum type.

(e) Boiler efficiency and heat-trap equipment:

Great strides have been made in the boiler industry in the last twenty years, particularly in the design of combustion equipment for vegetable fuels. By permitting lower excess air quantities, this has led to greatly increased efficiencies in modern boiler plants for the sugar industry. In certain cases this resulted in embarrassing surplus of bagasse which subsequently had to be incinerated. Hence before specifying high efficiency plant, the purchaser should examine availability of bagasse in the light of the anticipated load demand. If a shortfall of bagasse would have to be made up by purchases of the secondary fuel, then obviously there is a case for high efficiency plant. If, on the other hand, increased efficiency will only result in large surpluses of bagasse which cannot be stored and utilised in the off-crop, nor have any other economic use, then the additional cost of equipment to gain high efficiencies is not warranted.

The question of heat trap equipment such as air heaters and economisers forms part of efficiency considerations, although air heaters particularly may be installed for considerations such as maintaining ignition by the use of hot air. The main purpose of installing either economisers or air heaters, or both, at the back of the boiler is to reduce the combustion or flue gas outlet temperature, and to obtain increased boiler efficiency. Without this heat trap equipment, the flue gas temperature at the outlet of the boiler is frequently so high that special heat resistant induced draught fan impellers would be required. Hence the installation of an air heater or economiser increases efficiency whilst reducing the flue gas temperature to a level acceptable for an ordinary mild steel fan.

As boiler designs vary considerably, especially in regard to the convection surfaces, which absorb the heat in the flue gases to a large extent, the purchaser should never to too specific in demanding that an economiser or an air heater, or both be fitted as this may result in an uneconomic arrangement. The lower limit to the gas outlet temperature is one set by the dew point at partial load, which constitutes a corrosion danger. For this reason, in sugar mill boiler plant, it is possible to reach the optimum design for efficient plant by using an air heater only, achieving with this the minimum safe gas outlet temperature.

The question of efficiency and heat trap equipment is one which should be discussed with the boilermaker and should form part of a specification in order that proper comparisons can be drawn up when evaluating bids from various suppliers, bearing in mind that additional heat trap equipment adds to the complexity of the plant, to space requirement and maintenance.
Where a surplus of waste fuel presently exists, and thus the highest efficiency is not required, it is frequently possible and prudent to make provision for future economiser surface or for an air heater. Although this takes up space, the cost of such provision is generally negligible and has the added advantage that the maximum rated output of the plant is increased at the same time as the efficiency.

(f) Duplication and back-up equipment:

The S.A. Factories' Act stipulate that, except for oil fired boilers in certain circumstances, duplicate means must be provided of supplying the full feed water capacity to a boiler. Few people would quarrel with this statutory safety requirement. On large utility power stations, fans, air heaters, dust collectors etc. are frequently provided in two parallel streams. On large plants this is often dictated by the physical size of unit equipment, but on smaller plants it has been done so that one half of the plant could be operated on a reduced load by using a single stream. The questions of duplication and back-up must be answered in the light of the service intended, the load and capacity factors and the importance of continuity in plant operation. In the sugar industry generally this provision has so far been confined mainly to dual auxiliary drives and to having more than the minimum number of oil burners as a back-up facility. However, in future, with units of 100 ton capacity and larger, it may well be worthwhile to re-examine these features, from the point of view of having the facility of operating the unit on say 60% load with only one F.D. fan or one I.D. fan in operation.

(g) Scope of supply:

The scope of supply should be clearly defined by the purchaser at the outset. Whilst such items as the boiler proper, the firing equipment, the heat trap equipment, draught equipment etc., are generally regarded as items which contribute to the overall boiler efficiency, and as such should be provided by the boiler maker, there are other items such as dust collecting plant, ash plant, fuel handling equipment, feedwater preparation plant and instruments and controls which will have to be specifically considered by the purchaser. If the boiler maker is to provide this equipment he will add his handling and responsibility charges to the price. These charges could be saved by the purchaser, if the latter does his own co-ordination and procurement, but in certain cases this may be beyond the capabilities of a staff whose primary function is to produce sugar for some nine months out of twelve.

(h) Purchasing specification:

When after discussions with one or more boiler makers and after possible receipt of various budgeting information, the purchaser finally arrives at the stage where a specification can be issued for obtaining firm bids from suppliers, it is worth remembering that this should include all data necessary for the bid including such data as the fuel analysis, the space conditions, drawings if necessary of the existing layout and a clear definition of the scope. As far as is possible, alternative requirements should be eliminated in order that the primary proposal quality is not dulled by numerous other considerations in the evaluation stage. These alternatives should be investigated at an early stage with one or more suppliers and these alternatives can be used or discarded with proper use of the preliminary information.

The prospective tenderers should receive a clear and unambiguous purchasing specification, leaving the supplier sufficient freedom to put forward, where possible, his standard and well-tried equipment, whilst at the same time ensuring that the final bid meets all the requirements of the purchaser.

Adequate time should be given to the tenderers for the preparation of bids and changes should be avoided in the tender period as far as possible. It is true to say that the thought and effort which goes into the preparation of the bid specification is amply repaid in the quality of the tenders which are received.

2. Evaluation of boiler plant bids:

In the evaluation, consideration should be given to the following areas:-

a) Scope of supply and services;

b) Operational cost;

c) Ease of operation;

d) Maintenance cost;

e) Design and construction;

f) Service and spares facilities;

g) Price and terms.

Generally tabulation of the most essential and major details is the most convenient form to make comparisons between various bids and money values should be assigned wherever possible to the evaluation areas so that the final sum truly reflects the cost of the plant for the various bids.

(a) Scope of supply and services:

The importance of comparing 'apples with apples' when evaluating boiler proposals cannot be over-stressed. Despite the fact that the purchaser's specification will have spelt out the scope in detail, it is essential that the bids are carefully checked and analysed on receipt to ensure that the equipment specified has been included by the bidder. If in doubt the tenderers should be asked to clarify. Wide discrepancies in prices almost invariably can be ascribed, upon investigation, to differences in extent of supply rather than to specific design features of different suppliers.

(b) Operational cost:

The most well-known operating cost comparison traditionally made is on boiler efficiency but this must take into account both load factor and capacity factor, namely, the number of hours the plant will operate during the year as well as the average capacity at which it will operate. Particularly when dealing with a fuel
like bagasse which may have no commercial value, care has to be taken in making this operational cost comparison. A second area where operating costs should be compared is on the boiler auxiliaries requiring either steam or power in order to drive these. A third area, particularly applicable where steam is used in turbines, is the question of steam purity, as the life of the superheater, to a large extent, depends upon the purity of the saturated steam from the boiler drum. Unless comparisons between bids are made on the basis of identical conditions, fuel analyses and ambient temperatures, incorrect conclusions can be easily drawn.

(c) Ease of operation:
Unique design differences which exist between suppliers make this comparison essential in evaluating proposals. Operating ease takes into account consideration of layout of equipment, accessibility, insulation for personnel protection and location of operating points. This is one of the areas in which it is not simple to ascribe financial values to different proposals.

(d) Maintenance cost:
The design features should, as far as possible, keep maintenance at a minimum level but when required, easy to perform. There should be a minimum of regular maintenance and the degree of accessibility for inspection and maintenance is important. For example, brickwork which requires regular annual maintenance has to a large extent been eliminated in modern designs thus reducing maintenance required by modern plant. On the basis of experience and a close analysis of the proposals from various bidders, an estimate should be made of the annual maintenance expenditure differences between the proposals.

(e) Design and construction:
Between the different offers features will be found which are either favourable or adverse to the particular installation. This will depend largely on the purchaser's own evaluation and this should also include the quality of hardware which is proposed, such as valves, instruments and controls. Boiler design methods have undergone considerable change in the past decades and before emphasising older performance rules such as heat release, furnace liberation, furnace exit temperature etc., the actual significance of these numbers should be discussed with each supplier. Some of these rules applied to the older boiler designs for the protection of refractory and are thus no longer of significance.

(f) Service and spares facilities:
Essential to the efficient and reliable operation of industrial steam generating equipment is proper and timely servicing. This applies to the boiler installation as a whole as well as to individual proprietary items such as valves, mountings, instruments, fans, electric motors etc. It is most frustrating to deal with suppliers who are unable to provide spare parts or service and the value of these facilities cannot be over-emphasised and should be taken into account in an adjudication, as the purchaser never knows when he may have to call upon these very facilities.

(g) Price and terms:
No discourse on boiler purchasing evaluation techniques is of course complete without a mention of contract price, terms and conditions. In general, these should be realistically evaluated and credit should only be given where there is reasonable ground for back-up expectation and proof of performance exists. It should be borne in mind that guarantees of performance are only as good as the ability to back them up.

Conclusion
Of necessity this is only a brief discourse on the selection of boiler plant and evaluation of boiler tenders and therefore there are no details of design and technicalities. On these matters the purchaser is to a large extent reliant on the known performance and integrity of the tenderer and on his own knowledge and experience. It is hoped that this brief discourse may prove of some little value in highlighting the variable factors and the options which are open to the purchaser.