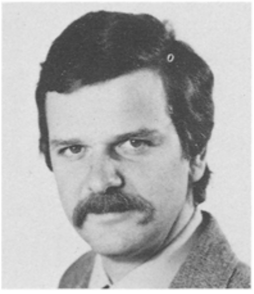

Processing of Oilseeds using Fluidbed Technology

G. FLORIN and **H.R. BARTESCH**, Department of Fluidbed Technology, Escher Wyss GmbH, 7980 Ravensburg, West Germany

ABSTRACT

The introduction of fluidbed technology in processing soybeans is discussed. Particular emphasis is given to energy and investment savings which are most significant with the newly developed EW-dehulling-conditioning process.

INTRODUCTION

In the past two decades, an increasing number of technical processes have been replaced using fluidbed technology. The reason for this development is that exchange processes between free flowing solids and gases can often be carried out much faster, with better definition and more economically than in conventional installations. Increase in energy costs have accelerated this development. Continuously, new applications and new design solutions are sought to improve exchange processes using fluidbed technology.

In the past few years, it has been introduced in oilseed processing. In this field there are numerous process steps where exchange processes such as heating, conditioning, drying and cooling take place. At the moment, different installations are used for the process steps, e.g., stack dryers, stack coolers, rotary dryers and coolers, shaft dryers and coolers, rotary and stack conditioners.

They generally have a high reactive volume which, in connection with the wide distribution of the retention time, leads to an inhomogenous treatment of the product. Further, they have a slow response in their control systems which, together with their other characteristics, give a non-optimal use of the supplied energy.

In this paper, using the example of soybean processing, it is shown that the following process steps have been improved using fluidbed installations: (a) Meal drying-cooling; (b) conditioning of cracked beans; and (c) dehulling and conditioning.

In Figure 1, the main steps in processing soybeans are shown. Marked are the above given process steps which have been executed using fluidbed installations.

Generally, the fluidbed ensures a very even retention time for each particle and hence a homogenous final product. It makes full use of available energy by precise and rapid control of the process and through recirculation of hot fluidization gases. No moving parts come into contact with the product, which is transported by the fluidization. This means low maintenance costs and high reliability. Particular advantage is presented through a newly developed dehulling and conditioning process where considerable savings in investment and energy cost are achieved through elimination of one heating-cooling stage and of the tempering tanks.

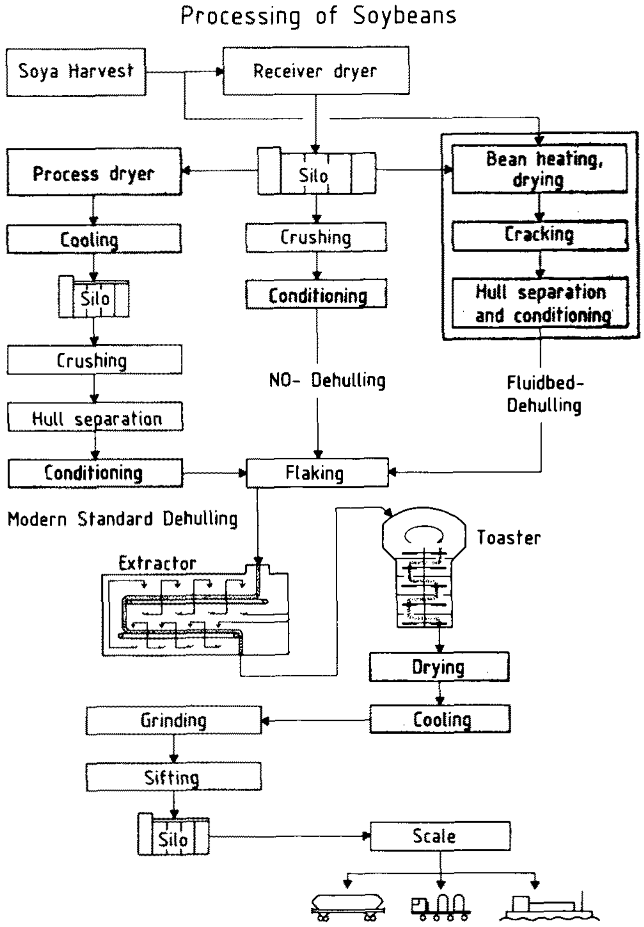

FIG. 1. The process stages, where fluidbeds installed are shadowed.

Drying and Cooling of Soy Meal

Figure 2 shows the flowsheet of the drying and cooling installation for soy meal.

Drying. The hot-wet meal coming from the toaster desolventizer is fed evenly via a sieve screw H to the fluidbed dryer T. Oversize product agglomerates (waterballs) are transported over the overflow of the sieve screw to the disintegrator, crushed and returned to the fluidbed.

The drying takes place in the fluidbed through cooling of the product which means utilization of the product heat and through hot air. The fluidizing air is evenly distributed to the working area, flows through the product and an intensive mass and heat transfer takes place. The moist discharge air of the dryer is cleaned with high efficiency cyclones F and vented to the environment.

The separated dust is added to the final product.

Cooling. The cooling takes place in the second fluidbed stage T through evaporation of moisture and through ambient air. The air is distributed to the working area similar to the dryer and flows through the product layer with an intensive heat exchange. The amount of discharge air from the cooler which corresponds to the drying air is dedusted and used as preheated drying air. The dust is added to the final product.

Characteristics of the fluidbed process, involving this drying-cooling through the complete fluidization and the precisely defined retention times, guarantee homogenous product treatment. This complete fluidization also avoids

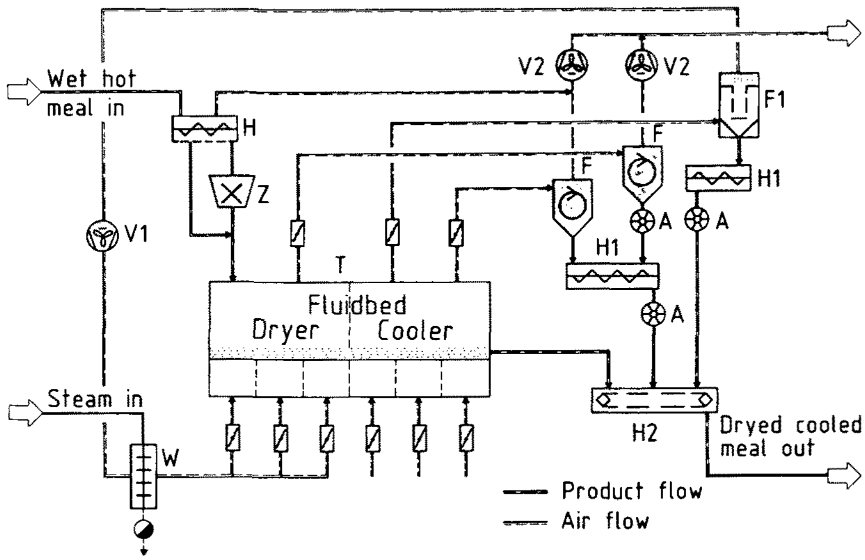

FIG. 2. Soymeal dryer/cooler. T: Fluidized bed-dryer-cooler; V1: recirculating air fan; V2: exhaust air fan; W: air heater; H2: sieve screw conveyor; Z: crusher; F: cyclone; F1, exhaust air filter; H1 collection screw conveyor; H2 finished product conv; A: rotary valve.

the formation of dead areas where germ growth could occur.

By comparison with conventional installations, the extremely short retention time ensures a precise and rapid control of the process. Further, the process makes full use of the available energy through recirculation of warm discharge air from the cooler. This furthermore reduces the influence of the environmental temperature which is particularly valuable for peak consumption periods.

To show this, the thermal energy consumption figures at 3 environmental temperatures for a standard fluidbed drying-cooling installation for 75 metric ton (t)/hr and a moisture reduction from 18% to 11.5% are plotted in Figure 3.

They are plotted with and without recirculation of warm air. It is evident that, without recirculation, up to 43% more thermal energy would be needed and that a decrease in ambient temperature from 80 F to 32 F will require only 15% more energy with recirculation, instead of 32% without recirculation.

A fluidbed installation is shown in Figure 4.

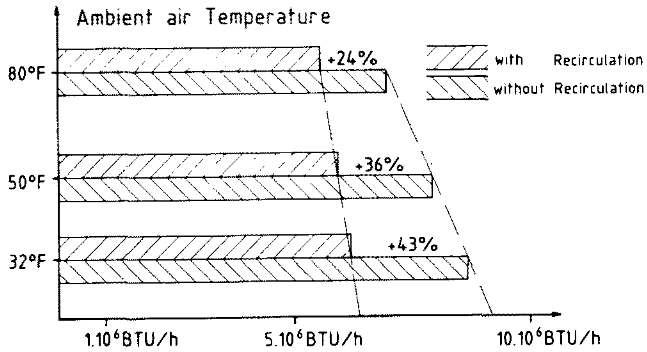

FIG. 3. Energy consumption meal dryer-cooler: 2000 tonne/day; 18-12.5% moisture.

Conditioning of Cracked Beans

Figure 5 shows the flowsheet of the fluidbed conditioning installation for cracked soybeans. The conditioning takes place in a fluidbed T with incorproated heat exchangers.

The particularly high heat-transfer coefficient for a fluidbed with integral heat exchangers enables a fluidbed installation to supply the product with the necessary heat using a heat transfer area of only 20% of a comparative tube bundle conditioner. The size of the fluidbed for a capacity of 2000 t/day is ca. 12.5 m^2 at 5 m length and 2.5 m width. This compares to a conventional tube bundle conditioner which would have a length of ca. 9 m with 2.6 m diameter.

The residence time in conventional equipment is ca. 20 min, which has led the processing industry to the belief that this time is a physical necessity for good conditioning. However, it has been proven with the first installation running for almost two years with a capacity of 100 tons/hr that the resulting residence time of 6 min is quite sufficient. The high turbulence in the fluidized bed brings about a uniform warming of the total product and each individual particle, so that it can be flaked into stable flakes even at lower product temperatures. It was found that the energy requirement did not increase (even appearing to be lower) and that maintenance intervals on the flaking rolls have not shortened but appear to be lengthening.

The air required for the fluidization is recirculated and only the volume of air is required to dry off the surface moisture—or air required if more thorough drying is desired—is allowed to enter or leave the system.

The drying effect by this process is less than in a standard conditioner due to the shorter residence time and therefore shorter diffusion time. This lower drying effect may be desirable for energy saving and material balance. However, a high drying rate can easily be achieved.

Summing up, the main advantages of fluidbed conditioning are: no moving parts in contact with the product which means low maintenance cost; full use of available energy;

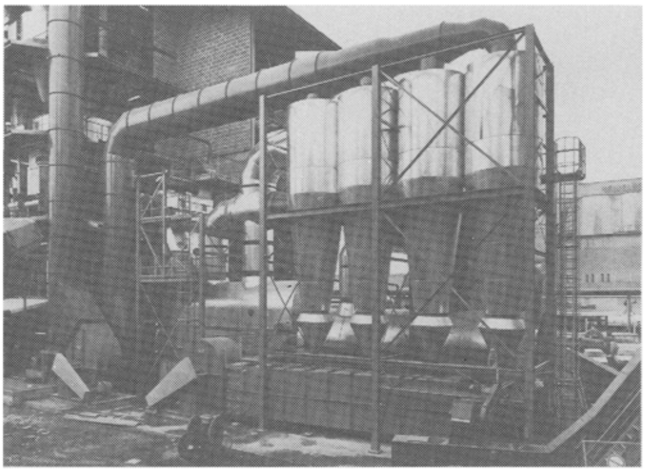

FIG. 4. Soymeal fluidbed drying cooling installation for a crush rate of 100 metric ton/hr.

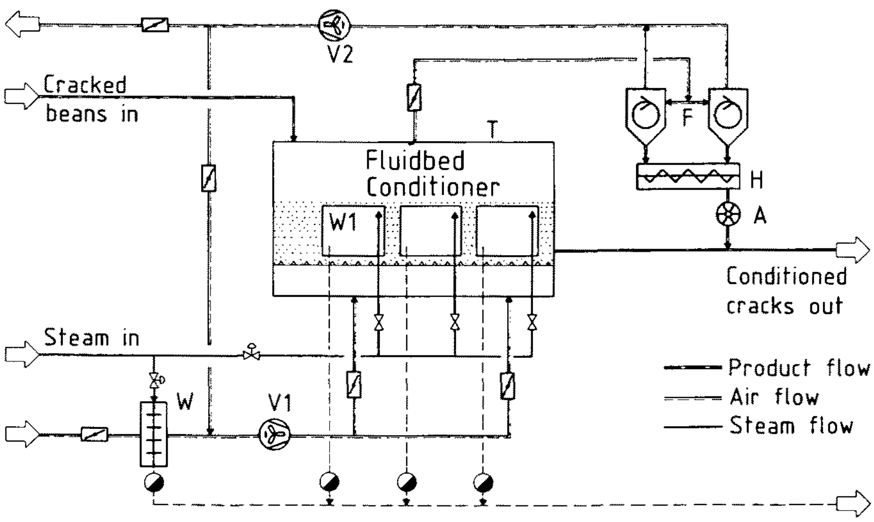

FIG. 5. Soybean conditioner. T: Fluidized bed-conditioner; V1, air inlet fan/recirculation ai fan; W: air heater; V2: exhaust air fan, F: cyclone, H: screw conveyor; A: Rotary airlock; W1: heat exchanger in fluidized bed.

short reaction time, hence quick and precise control; uniform warming of the product, resulting in an excellent flake even at lower product temperatures; and small size, hence little space requirements.

A fluidbed conditioning unit is shown in Figure 6.

Dehulling and Conditioning

We have developed a new process which, through the application of fluidbed technology, simplifies the dehulling of soybeans significantly. It eliminates process steps and saves ca. 50% of the thermal energy.

To illustrate this, Figure 7 shows a comparison between a modern standard dehulling process on the left side and th the newly developed system on the right side.

In the standard process, the beans are dried and cooled in a process dryer before they are stored in tempering tanks. The drying of 2% and the subsequent storage for at least 48 hr for tempering has been considered up to now as an absolute necessity to achieve satisfactory dehulling results. After the tempering the cold beans are cracked, the hulls are separated and the hull-free cracks are conditioned which means the product is heated up a second time.

The newly developed fluidbed dehulling process (right side of Fig. 7) is continuous and the beans are only heated once, cracked warm, the hulls separated and the product simultaneously conditioned. The combination of the heating/drying and conditioning stages with the elimination of the cooling and tempering stages presents significant savings in investment and energy cost. Additionally, through the appropriate selection and combination of the machines, further savings are made.

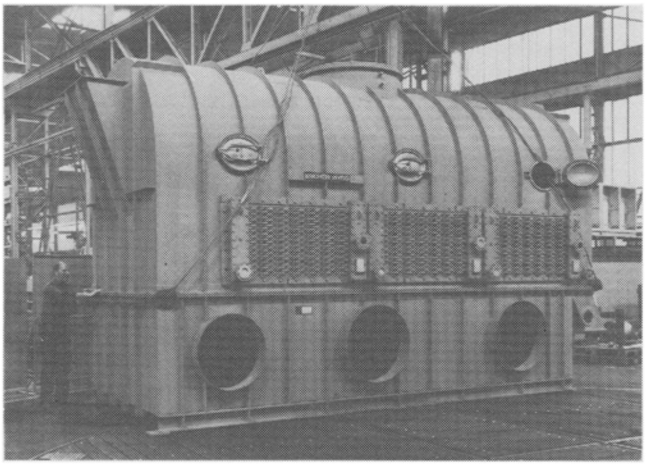

FIG. 6. Fluidbed conditioning unit with integral heat exchangers for a capacity of 100 metric ton/hr.

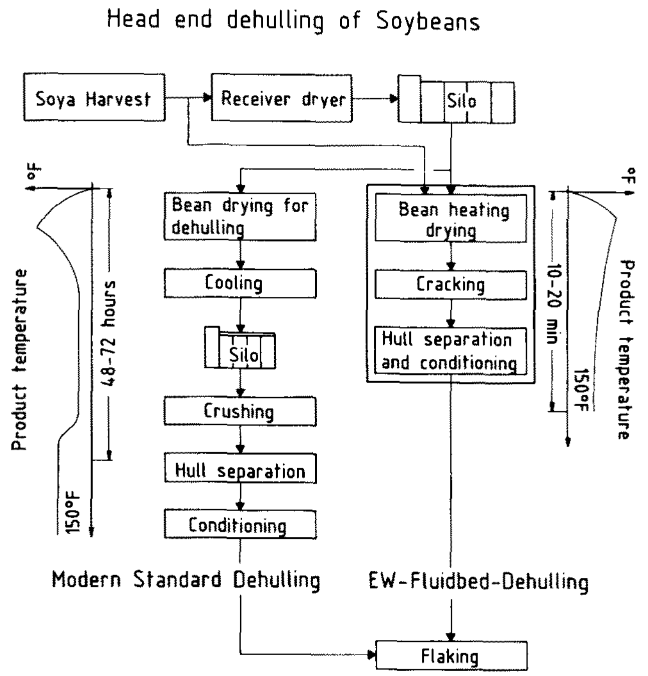

FIG. 7. Comparison of modern standard dehulling and newly developed fluidbed dehulling.

Process Description

Figure 8 shows a flowsheet of an installation.

1st stage: heating/drying and primary cracking. Soybeans are quickly heated in the first stage T to a surface temperature of 160-200 F (75-92 C), depending on the history of the beans. This heat treatment means mainly an intensive attack on the hull and the other layers of the bean. The hulls are detached and cracked open. In a subsequent mechanical treatment consisting of cracking rolls Z1 and hammer mills (Z2), the beans are halved and the detached hulls are freed. This combination of single-stand cracking roll and hammer mill was found optimal with extensive tests. It can easily be adjusted to the bean size and the impacting loosens all, even to the kernel crimped hulls.

2nd stage: hull separation and dehulling. The product stream consisting of half-beans and loosened hulls is fed via standard aspirators F2 to the second fluidbed C. The discharge air of this fluidbed is used as aspirating air and the hulls are separated from the main product steam.

The hull-free, half-beans are conditioned in this stage. The final temperature of the product for good flaking and extraction can easily be adjusted by the variation of the air temperature level at the end of stage two. This ensures best use of the available energy and reduces emissions to a minimum.

Energy required to heat up the beans in the first stage is supplied with integral heat exchangers or hot air, heated with steam or direct firing.

Processing of the aspirated product. The aspirated product stream, ca. 10-15% of the throughput, is separated from the discharge air with a cyclone F. From there it is fed to a second aspirator F3, where the cracks are removed and fed back to the main product stream.

The product in the air from the aspirator F3 is separated with a cyclone and divided into hulls and fines with a vibrating screen. The fines are fed back to the main stream in front of the flaking rolls.

This process, in comparison to the conventional process, presents numerous advantages; the main ones are: (a) continuous process; (b) reduction and elimination of process steps; (c) reduction of fines ;(d) reduction of emissions ;and (e) investment and energy savings.

(a) *Continuous and fast processing, high flexibility.* The product is only heated once in a short time, so only the surface reaches a high temperature. From then onwards, the temperature is adjusted to the required temperature for flaking and extraction. The short time is given through a small reactive volume which in connection with the fluidbed characteristics ensures fast and precise control and a homogenous product.

The drying effected in this short time is less than in the conventional system, even though excellent dehulling results are achieved. This drying rate, which is often desirable for energy saving material balance, can easily be increased by raising the outlet product temperature after the first stage. Generally, through adjustment of the temperatures in the fluidbeds, large variations of the drying rate can be achieved. This high flexibility also allows the direct dehulling of fresh harvested soybeans which was proven in extensive tests.

Another advantage of the short retention time of the product at high temperatures will be less degradation concerning oil quality and protein denaturation.

(b) *Reduction and elimination of process steps.* This is achieved by the combination of individual process steps in one process and the complete elimination of other process steps: the main ones being tempering and standard conditioning.

Another significant reduction is achieved because the equipment for separating hulls from oil-bearing materials, crushed product and fines, has only to be designed for 10-15% of the throughput.

Furthermore, the reduction in conveying equipment is significant.

(c) *Reduction of fines–improvement of plant operation.* The fines content of hot cracked beans is ca. 2%, with 1% coming from the first cracking stage–only this amount has

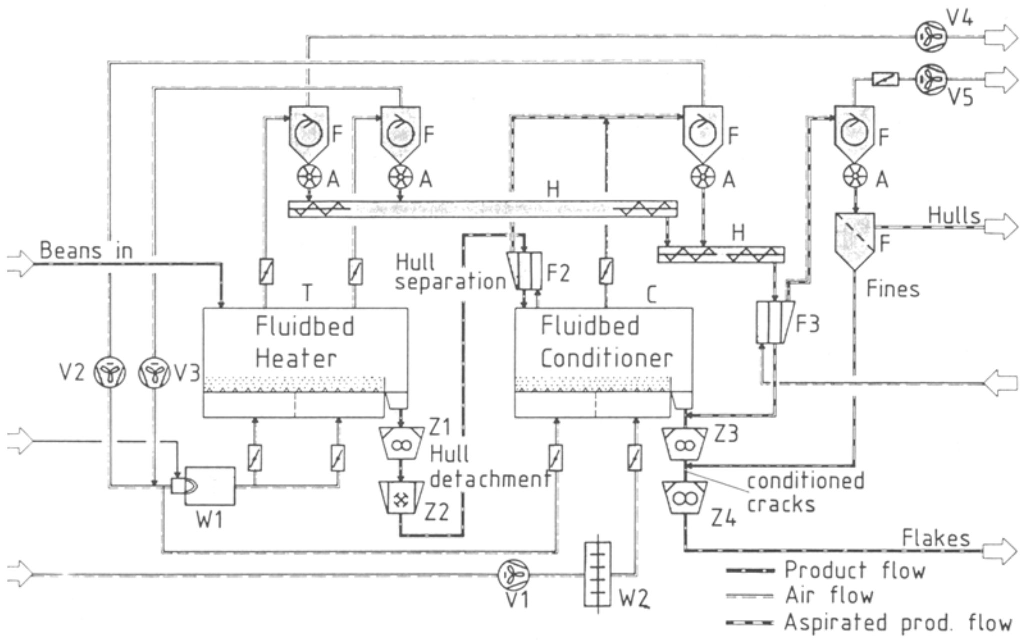

FIG. 8. Fluidbed dehulling conditioning installation. T: Fluidbed heater; C: fluidbed conditioner; V1: fresh air fan; V2,V3: recirculating air fan; W1,W2: air heater; V4,V5: exhaust air fan; F: cyclone; H: screw conveyor; A: rotary airlock; Z1,Z3: cracking rolls, Z2: hammer mill; F2,F3: aspirator; Z4: flaking rolls; F4: sieve machine.

to be handled in the hull-cleaning stages—and 1% from the second cracking stage. This compares to a fines content of 5% with cold cracking as an experience figure.

Through this overall lower fine content, an easier cleaning of the miscella from fines and a better percolation in the extractor can be expected. This means an overall higher capacity of the installation and a better drainage of the extracted flakes which results in a lower hexane content of the flakes fed to the desolventizer toaster (DT) reducing the steam consumption in the DT and in the meal dryer.

A further advantage of hot cracking in comparison to cold cracking is that, for the cracking rolls, an increase in capacity and a reduction of specific energy consumption can be expected. In any case, a reduction of wear and a longer service life of the cracking rolls is to be expected.

(d) *Reduction of emission.* Recirculation of most of the fluidizing air and reduction of equipment for hull cleaning reduces overall volume of discharge air to 50% compared to the volume of discharge air from the standard dehulling, taking into account the volumes from the receiver dryer, the hull separation and the conditioner. This fact, together with the smaller amount of fines produced (1% compared to 5%), reduces emissions to a fraction of that of the standard dehulling system.

(e) *Investment and energy savings.* Reduction and elimination of process steps under (b) presents a significant reduction in investment. The main savings are presented by the fact that no tempering tanks and no separate conditioning stage is required.

The thermal energy savings are presented through the elimination of the intermediate stage, by heating the product only once, and through the capability to dehull dry beans with a moisture reduction of only ca. 1% instead of 2% as specified with the standard dehulling systems.

Thermal energy consumption figures per bushel of beans are given in Table I for the standard dehulling and for the fluidbed dehulling system.

The figure of 9000 BTU/bu is taken as an average heat requirement throughout the year. The heat consumption figures of the fluidbed process vary depending on the conditions. Extreme conditions are when the beans are freshly harvested and the ambient air temperature is low. Dry conditions are with dry beans, small moisture reduction and summer conditions.

Overall, it can be stated that the heat requirement of the fluidbed process is only 50% of the standard process.

TABLE I

Heat Consumption Dehulling and Conditioning

Modern standard dehulling	
Process dryer	6000 BTU/bu
Conditioner	3000 BTU/bu
Total	9000 BTU/bu
Fluidbed dehulling	
Extreme conditions	5200 BTU/bu
Standard conditions	3800 BTU/bu
Dry conditions	3000 BTU/bu