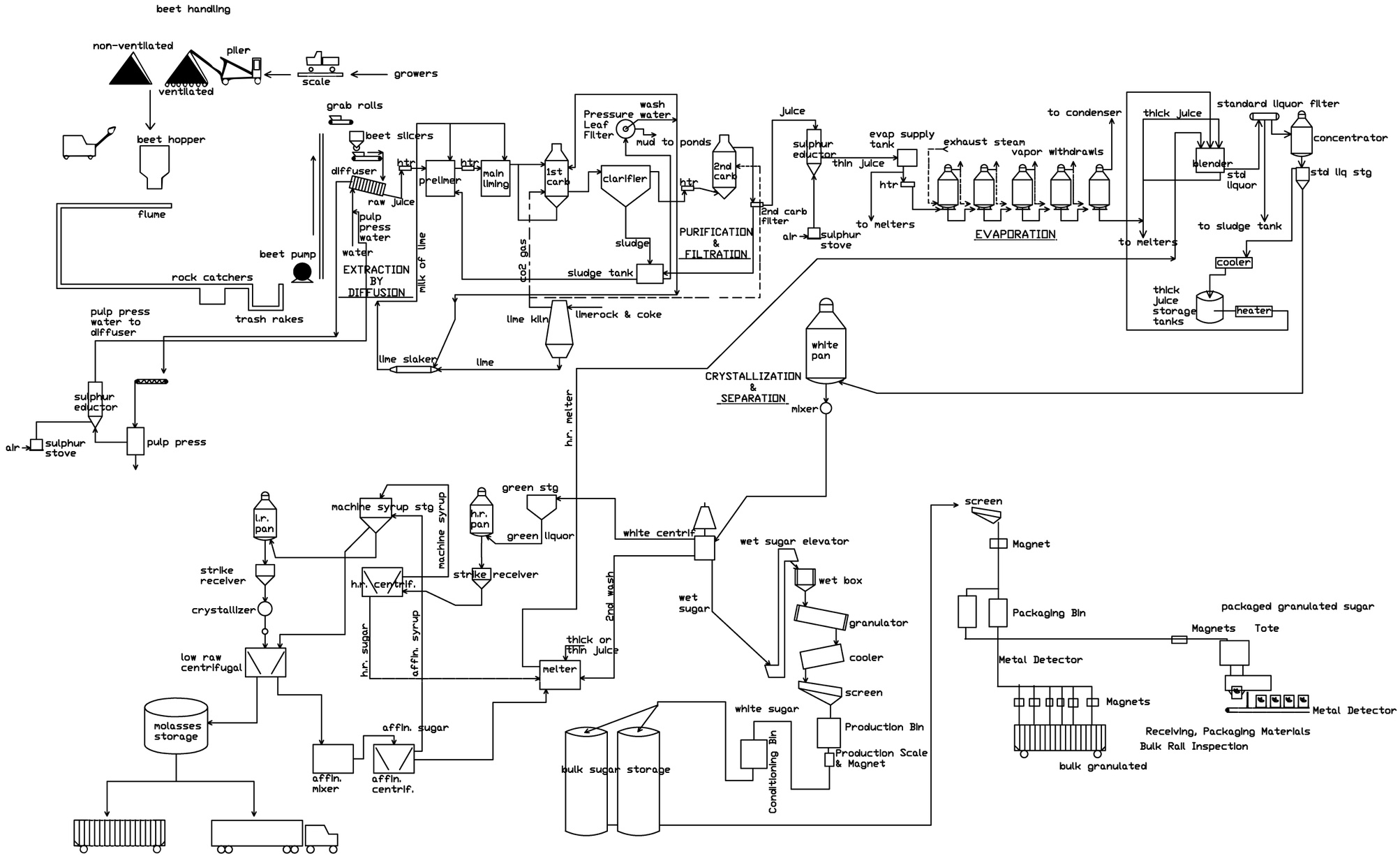
Wyoming Sugar Process Flow



EXHIBIT
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Beet Sugar Process
Flow Diagram

Wyoming Sugar Company
Worland, WY

WS001

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Wyoming Sugar Company Process Flow

The process of producing sugar from sugar beets can be conveniently separated into 6 stages: 1) beet handling, 2) diffusion, 3) juice purification, 4) evaporation, 5) crystallization, 6) pulp manufacture. Stages 2, 3, 4 & 6 comprise the Beet end of the factory, and 4 is the Sugar end portion of the process.

1. **Beet Handling.** Sugar beets are weighed during delivery by the growers. After weighing the beets are stacked by a piler which removes the free dirt from the beets. The beets may be placed upon ventilation system which reduces the beet temperatures. Reduced temperatures slow down microbiological and physiological action on the beets.

   Beets are transferred from the handling system to the beet flumes which serves a dual purpose of removing mud and trash from the beets and transports the beets into the factory.

2. **Diffusion.** The sugar beets are run through the beet slicers, from which they emerge as long thin strips, or cossettes. The cossettes, after weighing, are immediately run into the continuous diffuser. Worland uses a DDS Slope, this consists of a long trough, slanted upwards. The cossettes are propelled up the slope by scrolls with perforated-plate flights. Diffuser supply water enters at the top end, and percolates by gravity through the cossette mass, leaching out the sugar as the water proceeds countercurrent to the cossettes. The temperature is raised for better extraction by steam-heated jackets surrounding the trough. The sugar-enriched water leaving the low end of the diffuser is known as diffusion juice or raw juice. The sugar depleted cossettes leaving the upper end of the diffuser are known as pulp, and pulp processing will be described in section 6. The diffusion juice contains between 10 and 15% sugar, which is about 98% of the sugar which was in the beets when sliced.

3. **Juice Purification.** Diffusion juice contains nonsugar impurities in both true and colloidal solution, as well as sugar and water. The colloids, in particular, make it difficult either to concentrate the diffusion juice, or to crystallize pure sugar from it. Thus it is necessary to purify the juice with lime.

   The juice is first screened to remove any small particles of cossettes, and then heated, usually to 84 to 88 degrees C.

   Preliming or predefecation is used, in which a small portion of the liming agent is added to the diffusion juice, with proper control of time and temperature, to precipitate much of the colloidal matter in a comparatively irreversible form. The next step is the continuous addition of the balance of the liming agent. Carbon dioxide gas bubbles are simultaneously passed through the mixture to precipitate the lime as very small insoluble calcium carbonate crystals. Mixed with and adhering to the precipitated calcium carbonate, the sludge, including coagulated and colloidal material can be settled out in a clarifier.

The liming-carbonation is divided into first and second carbonation. The purpose of second carbonation is the removal of the lime remaining in solution after the thickener. Here further gassing with carbon dioxide takes place, and more calcium carbonate precipitate is formed.

Since second carbonation is at a lower pH than first carbonation, the calcium carbonate crystals are larger, and are easily filterable. The juice is passed through leaf filtration. The filtrate is then treated with a small amount of sulfur dioxide to inhibit color-increasing reactions, and usually an appreciable further reduction in pH results. At this point the juice is known as thin juice.

4. **Evaporation.** Thin juice is heated and sent to the evaporators. Multiple-effect evaporators are used; Worland uses seven individual evaporators, configured in a five effect system. Steam used for supplying heat to the first effect is drawn from either the in-house generation or pressure reducing station, but for each succeeding effect the steam used is that formed in the preceding effect by evaporation of water from the juice. This system allows multiple uses of the same heat energy, and results in decreasing pressures and temperatures as the juice proceeds through the effects. By going through the multiple effects evaporation system the percentage of dissolved solids in the juice is raised from 10-15% to 55-65%. The outflow from the last evaporator effect is called thick juice.

5. **Crystallization.** Thick juice is combined with crystalline sugars from the second and third pan boiling. The combined liquid is passed through leaf filtration. The filtrate is known as standard liquor.

   Sugar is crystallized by pan boiling, in the vacuum pans. The boiling must be at a low temperature to avoid inversion and caramelization, which necessitates low internal pressure. A quantity of standard liquor is boiled in the pan under vacuum, until the liquor is supersaturated sufficiently; that is, until it contains a greater concentration of sugar in solution than the equilibrium solubility of sugar at that temperature. The liquor is then seeded with a finely milled sugar in slurry with isopropyl alcohol. The seed crystals are then carefully grown, through control of the supersaturation by means of vacuum, temperature, feed-liquor additions, and steam.

   When the crystals are of the desired size and number, the mass of crystals and mother liquor, known as massecuite or fillmass, is then discharged from the vacuum pan into a large receiver, the mixer, which is equipped with a slowly moving agitator. From the mixer the massecuite is fed to centrifugals. The sugar centrifugal is, in essence, a perforated basket, which rotates around a vertical axis at high speed, within an outer, collector shell. The liquid surrounding the crystals is centrifuged or spun off, and leaves the basket through the perforations.

   Following two brief washes with pure hot water, the wet white sugar crystals are discharged from the centrifugal basket, and are sent to the drier or granulator and the

cooler. These are rotating cylindrical drums, with interior baffles, which pick up the sugar and allow it to fall through a current of moving air. Hot, filtered air is passed through the granulator, and cool filtered air is passed through the cooler. The cool dry sugar is screened, weighed and then sent to the bulk storage area for shipment to customers.

The liquid centrifuged from a massecuite is properly called syrup. In the first-boiling centrifuging the liquid is called high green, the liquid from the second-boiling centrifuging is called machine syrup.

The high green syrup serves as charge and feed liquor for the second or high raw boiling, which is carried out in the same way as the first boiling. High raw sugar results from the centrifuging of the high raw massecuite, the resultant liquid is machine syrup. The high raw sugar is dissolved with thick juice in the high raw melter, liquid from the high raw melter is pumped to the blender to mix with thick juice.

The machine syrup serves as charge and feed liquor for the third or low raw boiling. Low raw boiling is carried out in the same way as the second boiling, since the material purities (purity is the percentage of dissolved solids which is sugar) are much lower, and the sugar crystallization rates are slower is process is much slower. Following discharge of massecuite into a mixer, it is run into crystallizers and held for a period of time to permit crystallization to proceed as far as practicable.

Sugar from the low raw centrifuging is known as low raw sugar. This sugar is dissolved in thick juice in the low melter, and from there is run into the high melter. The syrup spun from the raw massecuite is molasses. Molasses is an end product, and no more sugar can be economically crystallized from it. Molasses is primarily sold for use as a cattle feed.

5. **Pulp Manufacture.** Wet pulp from the diffuser is run to pulp press where the moisture content is reduced from about 95% to between 70 and 76%. The water pressed from the pulp is sterilized and becomes part of the diffuser supply water. Pressed pulp is a saleable co-product.