

IMPROVED BOILER FEEDING USING ARCHBREAKER EQUIPPED REFUSE CHARGING HOPPERS

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ABSTRACT

Modern refuse-to-energy facilities utilize overhead travelling cranes, which are typically equipped with large orange peel grapples. The compression of the refuse in the grapple, as well as items such as appliances, leads to frequent blockages in the refuse feed hoppers. The utilization of an archbreaker in the hopper throat allows the crane operator to clear these blockages automatically. This paper discusses the development of such a unit.

INTRODUCTION

Modern refuse-to-energy facilities usually utilize travelling overhead cranes to charge refuse into the refuse feed hoppers of the energy recovery boilers. The charging requirements of today's large refuse-to-energy facilities dictate the use of grapples in the 6 to 14 cubic yard (4.6–10.7 m³) capacity range. When fully open, these grapples are 14–18 ft (4.3–5.5 m) in diameter (see Fig. 1).

Since the grapples are so large, it is difficult for the crane operator to identify oversize bulky waste in the refuse load. As a result, large items such as refrigerators, hot water heaters, rolls of carpeting, mattresses, bed springs, and automobile engines are frequently fed into the refuse feed hoppers. These items are all potential sources of blockage in the refuse feed hoppers.

However, bulky waste is not the only source of hopper blockages. As the refuse-to-energy industry has developed, there has been a general trend toward the use of orange peel grapples in lieu of clamshell buckets. The orange peel grapple, with its lighter weight and generally superior digging ability, increases the net load for a given size crane. The orange peel grapple is generally an open-sided design, which utilizes compression to support the weight of the refuse. The compression causes the refuse to interlock or bridge across the openings between the tines. If the grapple is not discharged properly, the interlocked refuse can bridge across the hopper throat. In an attempt to prevent bridging, experienced crane operators normally discharge refuse onto the sloped front wall of the hopper. The impact of the refuse against the wall of the hopper usually causes the interlocked refuse to break apart. Despite the efforts of the crane operators, blocked hoppers still occur frequently.

STATIC REFUSE HOPPERS

A number of the earlier refuse-to-energy facilities in this country were based on a "European" design (see Fig. 2). The "European" hoppers were designed with a relatively shallow front wall (35–45 deg. above the horizontal). The discharge throat at the base of the hoppers measured 4–4½ ft (1.2–1.4 m) across in the

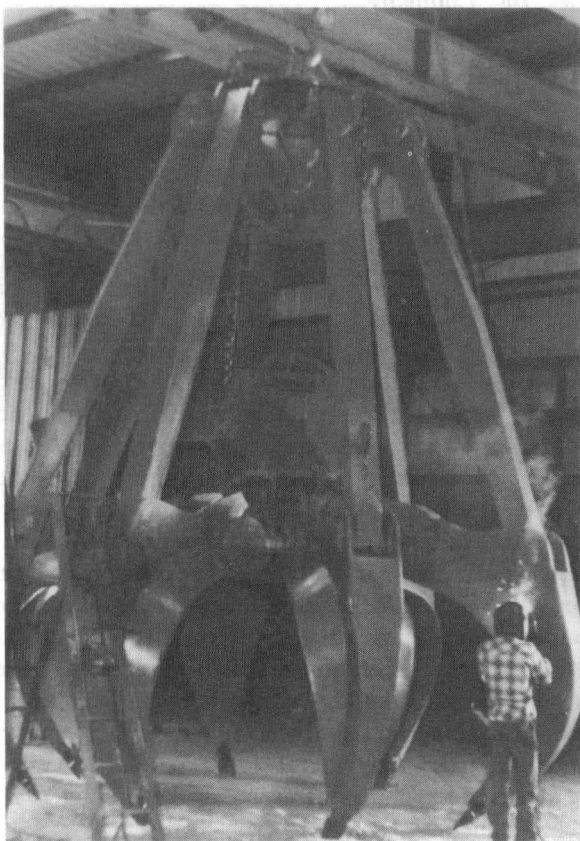
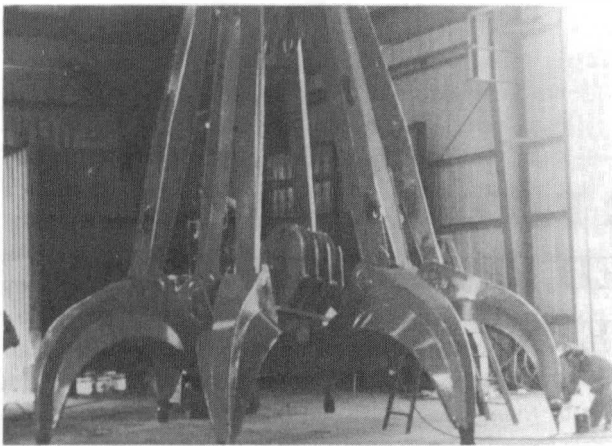


FIG. 1 A TYPICAL ORANGE PEEL GRAPPLE NEARS COMPLETION AT THE MANUFACTURER

This efficient digging device has become the standard for modern refuse-to-energy facilities because of its superior performance. However, its massive size, together with its ability to compress refuse, can lead to excessive refuse feed hopper blockage.

narrow direction, and were usually about the same width as the boiler furnace grate. A cut-off gate was installed in the throat of the hopper or in the chute below the hopper. This cut-off gate restricted the flow of refuse and air into the boiler during start-up and shutdown. The cut-off gate usually was built as a hinged flop gate, a guillotine, or a slide gate. In either case, the gate was operated by hydraulic cylinders which were operated from the grate hydraulic system. The refuse hopper and chute system was static, that is, once refuse was discharged into the hopper, gravity was the only force applied to push it down to the grate feeding system.

When the hopper discharge became blocked, there were three means for dislodging the refuse. The first method was to maneuver the grapple into the hopper and by manipulating the tines in a manner which closely resembled a closing hand, the crane operator either dislodged or removed the blockage. While it was sometimes effective, this procedure placed impact stresses on the grapple and generally increased maintenance.

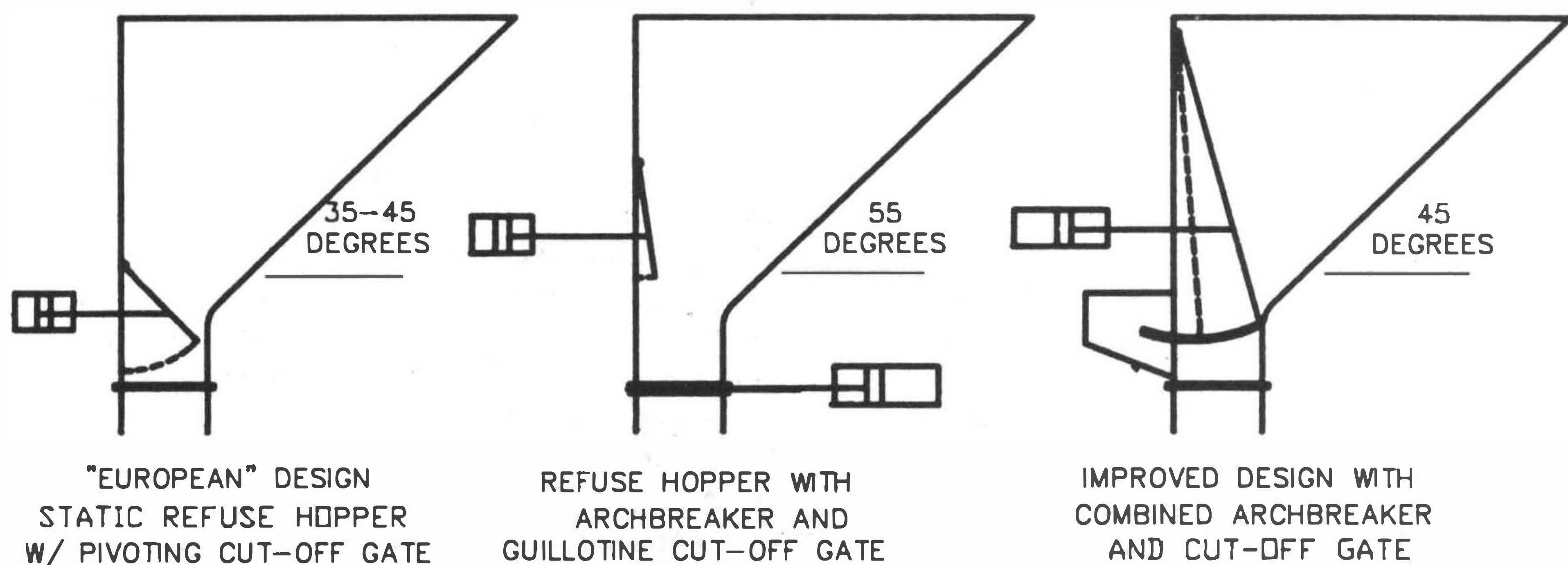
The second method was to remove the offending piece with a hoist. Refuse cranes are frequently equipped with auxiliary hoists for this purpose. In this method, the crane was positioned over the hopper and the oversized piece was lifted with the hoist and removed from the refuse handling area. If the crane was not equipped with an auxiliary hoist, then a portable hoist, or Come-Along, was used. In either case, this method was time consuming and potentially dangerous.

The third method was the "old fashioned way," where operators used pikes to poke at the hopper throat in an attempt to dislodge the bridged refuse. Obviously, this method was the least desirable and the most time consuming.

The key to the operation was the vigilance of the operator. Through visual inspection of the refuse during the recasting operation, the crane operators strived to avoid charging pieces which would tend to block the hopper throat. As facility size increased, this became more difficult, since the grapples became very large and tended to obscure large pieces within the grapple.

IMPLEMENTING THE ARCHBREAKER

In an effort to improve the efficiency of the refuse handling operation, a new design was developed to reduce the effort required to dislodge refuse which had bridged in hopper throats. The newer hopper design



THE DESIGN OF REFUSE FEED HOPPERS HAS PROGRESSED FROM THE EARLY EUROPEAN HOPPER DESIGN, WHICH IS COMMONLY USED, TO MORE SOPHISTICATED ARCHBREAKER/HOPPER DESIGNS. THE ARCHBREAKER FUNCTIONS IN A MANNER SIMILAR TO A BALER TO CRUSH OVERSIZE PIECES WHICH MIGHT ORDINARILY BLOCK THE HOPPER THROAT. THE CURRENT DESIGN EVOLVED THROUGH OPERATIONAL EXPERIENCE.

FIG. 2 TYPES OF REFUSE FEED HOPPERS FOR 750 TPD BOILERS

utilized a hopper cut-off guillotine and a separate arch-breaker assembly (see Fig. 2). The archbreaker which was installed low on the backwall of the hopper consisted of two crushing sections mounted side-by-side. Each section was pivoted at its upper surface and hydraulically actuated so that it swung forward about the pivots to: (a) dislodge bridges, or (b) crush oversize pieces. The two sections operated independently. Thus, if one section encountered a noncompressible object, the other section could complete its cycle.

The unit was operated in a reciprocating fashion so that it crushed during the forward motion and allowed the refuse to fall into the feed chute on the retracting motion. Thus, a large compressible item such as a refrigerator could be flattened and fed to the boiler without being removed from the hopper.

The archbreakers were controlled from the crane operator control console. Operation was simple: upon initiation by the operator, the archbreaker commenced operation and operation continued until the unit was de-energized by the operator.

With the archbreakers in operation, the frequency of blocked refuse charging hoppers dropped significantly. Blockages due to bridged refuse were virtually eliminated and blockages due to unprocessable bulky waste were reduced significantly.

However, several problems were encountered with the design. The hopper cut-off guillotine was designed to operate only when the hopper was empty, since its

primary function was to prevent air infiltration into the boiler during start-up and shutdown.

Under normal operating conditions, the gate was to be opened prior to the commencement of refuse feed. During shutdown, the level of refuse was to be below the guillotine prior to closing the guillotine. However, on occasion, refuse was fed to the hopper when the guillotine was closed. The weight of the refuse tended to warp the gate, causing it to become stuck. Another similar problem occurred when the gate was closed while refuse was still in the hopper. This also resulted in jamming the guillotine gate. In time, the guillotine gates became deformed, a problem which was exacerbated by warpage caused by heat from the boiler.

The archbreaker assembly was difficult to seal since it was constructed of two assemblies and the assemblies were not interlocked. This resulted in refuse and debris accumulating in the space behind the assemblies and preventing the assemblies from retracting completely. If left unattended, refuse eventually was forced through openings behind the archbreaker onto the plant floor below. This, plus debris being blown out of clearance openings by the air displaced by falling refuse, resulted in a housekeeping problem and a potential fire hazard.

The location of the crane operators also contributed to the problems. The crane operators were located in a remote pulpit on the tipping floor side of the refuse pit. From this location, they had a good view of the overall refuse storage area, but could not see into the

refuse feed hoppers. Thus, they could not anticipate a blocked hopper and visual hopper inspections required a long walk around the refuse pit. The crane operators quickly learned that by operating the archbreakers continuously, they could virtually eliminate hopper blockages and eliminate the walking required to inspect the hoppers. Thus, the archbreakers were operated continuously which contributed to increased maintenance of the assemblies.

Despite the problems, the archbreaker performed a valuable function within the plant. The number of hopper blockages which required operator involvement was reduced dramatically.

AN IMPROVED DESIGN

It was obvious that an improved design should be developed to address these problems. The improved design needed to provide the functions and operational advantages of the archbreaker/guillotine gate design while eliminating the operational deficiencies.

To reduce complexity and to eliminate the jamming problems experienced with the guillotine cut-off gate, the archbreaker was re-designed to serve both functions. The archbreaker height was increased so that in the improved design, the entire rear wall of the hopper formed the face of the archbreaker plate (see Fig. 2). This improved the archbreaking action, and allowed the archbreaker to seal the hopper throat when fully extended, which eliminated the need for the cut-off gate.

To prevent heat distortion of the archbreaker in the event of flashback from the boiler, the lower portion of the archbreaker assembly was fitted with a water-cooled chamber. Water from the cooling tower is circulated through the waterbox. Temperature is monitored at the archbreaker water outlet and water flow rate is controlled by a temperature control valve in the feed water line.

The two half-width archbreaker assemblies, which were utilized in the original design, were replaced with one full-width assembly. This eliminated the gaps which existed in the earlier design and prevented refuse from entering the area behind the archbreaker. In addition, adjustable steel seal strips were installed around the periphery of the archbreaker plate to prevent refuse from passing between the edge of the archbreaker and the hopper wall.

The watercooled chamber at the bottom of the archbreaker is curved and also sealed to help prevent refuse from getting behind the plate assembly. The leading edge of the archbreaker is shaped like a plow to prevent

refuse entrapment on the retraction stroke. These features, combined with the archbreaker's slow speed of 1 in./sec (0.03 m³/s), effectively prevent refuse from getting behind the archbreaker and creating jamming and housekeeping problems.

The archbreaker is powered by a self-contained hydraulic power unit. Two 6 in. (150 mm) bore cylinders provide a total crushing force of approximately 80,000 lb (356 kn) at the maximum operating pressure of 1450 psig (86.9 kPag).

The structural design of the unit allows the archbreaker to withstand the stresses generated when a noncompressible item is jammed against one corner of the blade and the cylinders develop full crushing force (see Fig. 3). This provides a margin of operating safety, since the cylinders are electrically interlocked.

The interlocking system adjusts the feed of the hydraulic fluid to each cylinder. This is accomplished by electrically interlocking the hydraulic cylinder displacement. Thus, if a jam occurs at one corner of the archbreaker plate, the hydraulic pressure in the cylinder nearest the jam will increase until the high pressure set point is reached. Since the displacement of both cylinders is controlled, the pressure in the other cylinder will be less. This reduces the amount of twist in the archbreaker plate. The interlocking system is adjustable to maintain the cylinder length difference as desired within the range of 0.01 in. (0.25 mm) to 1.2 in. (30.5 mm). The system is normally adjusted to limit the cylinder length difference to 0.1 in. (2.5 mm). This is well below the allowable working stress of the plate.

CONTROLS AND OPERATION

The controls for the improved archbreaker are installed in the crane operator's pulpit. However, they have been relocated to a position which requires the operator to leave his chair in order to initiate a cycle. The intention of this change is to force the operator to become more careful when feeding the boilers. It is also an attempt to make the operator inspect the hopper to determine the cause of a jam prior to initiating a crushing cycle.

The control pulpit has been relocated to the charging floor side of the pit in a position between two of the boilers. From this position, it is much easier for the operator to visually inspect the hoppers. In addition to direct visual inspection of the hoppers, the operator is aided by television monitoring of the hoppers.

The controls for the improved unit provide for two operating modes: archbreaking (crushing) and boiler

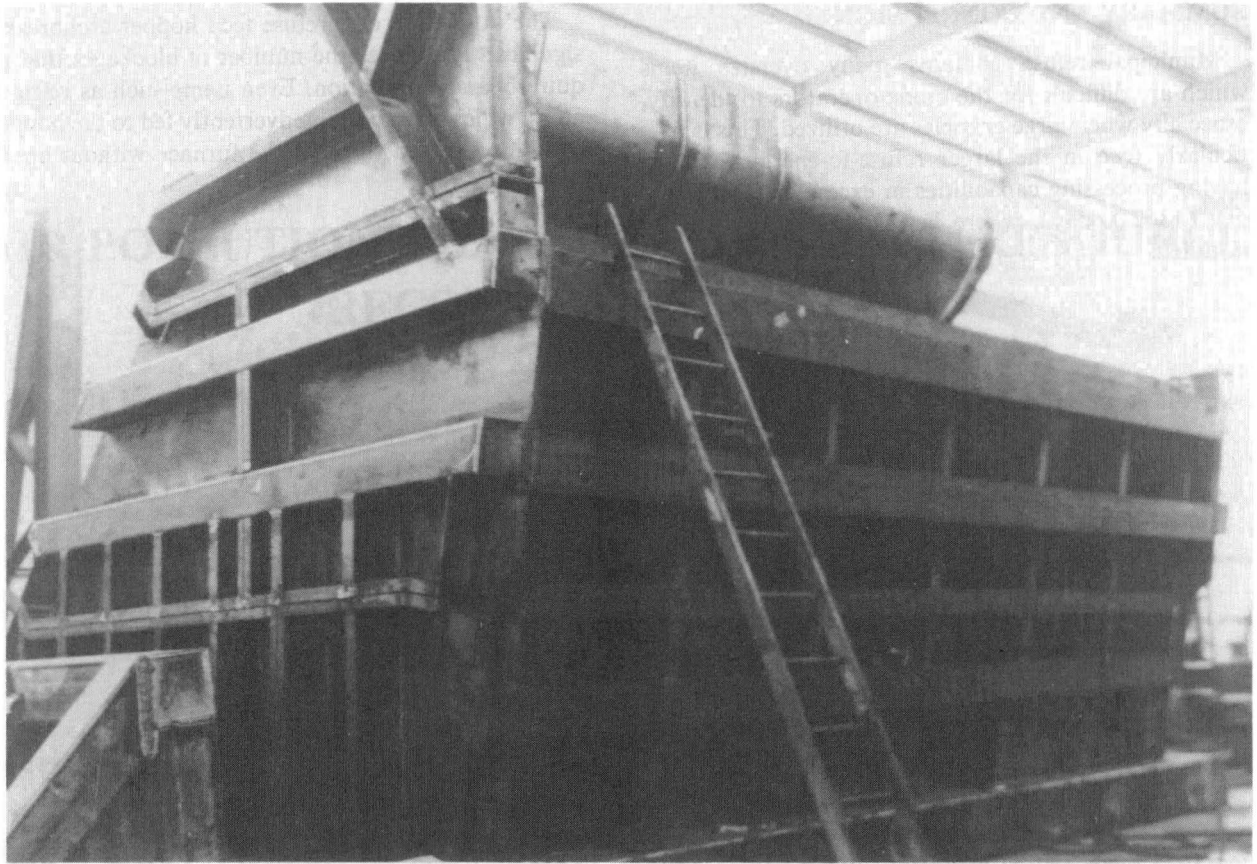


FIG. 3 THE IMPROVED REFUSE FEED HOPPER WITH ARCHBREAKER ASSEMBLY IS SHOWN DURING MANUFACTURING

The feed opening of the hopper is resting against the floor during assembly. The discharge opening is at the top of the photo. The rear wall of the hopper is not yet in place. The hopper is a massive weldment designed to withstand the impact stresses of falling refuse and the reaction loads from the archbreaker. The water cooled base of the archbreaker (not yet installed) is shown in the lower left.

cut-off. In the archbreaking mode, the gate moves through six cycles before returning to the retracted position. In each cycle, the bottom of the gate moves forward 6 in. (150 mm) or until full cylinder pressure is exerted (whichever occurs first), then retracts. Indicator lights on the control panel inform the operator of the gate position and of high pressure conditions. Typically, if a high pressure indicator light is illuminated during the last (sixth) cycle, the hopper is bridged by a noncompressible item. The operator then inspects the hopper to determine if the offending item must be removed.

When the cut-off gate mode is initiated, the gate moves forward until one of two conditions is satisfied:

the gate is fully extended as sensed by position switches on the hydraulic cylinders, or high pressure is achieved. Once again, indicator lights inform the operator of the appropriate condition. In a nonemergency situation, the operator normally retracts the gate until the refuse level drops, if the gate has not closed completely. The operator then closes the gate after the refuse level has dropped.

However, in an emergency situation, such as a fire, the operator can initiate a closing cycle and leave the control pulpit. The archbreaker will apply full clamping force and effectively seal the hopper. When full clamping force is achieved, the hydraulic unit automatically stops.

SUMMARY AND CONCLUSION

Municipal refuse contains many oversize items which are difficult for the crane operators to identify, especially when large grapples are utilized. This is particularly true in the larger refuse-to-energy facilities having processing capabilities in excess of 1500 tons/day (1362 t/day), where large grapples are usually installed.

The utilization of a refuse feed hopper archbreaker significantly reduces the number of blockages that require operator attention. Even items such as refrigerators, which have been inadvertently fed to the hopper, can be processed through the furnace without operational difficulty.