The Incinerator Crane and its Application in the Building

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Abstract

The paper presented at the 1964 Incinerator Conference developed a guide for sizing the Incinerator Crane and offered criteria for the crane application requirements. This paper will be considered a sequel to it, in that it places emphasis on fitting the crane into the building as well as preparing the building for the crane. In addition, a brief report is given on advancements and improvements in Incinerator Cranes since 1964.

Introduction

In the writer's 1964 paper entitled "The Incinerator Crane" the following was stated under "building considerations."

"Engineers must be cautioned that sufficient space must be provided for the crane in the building. Squeezing the crane can only result in imposing restrictions on the crane manufacturer that can be detrimental to the overall operation. Parking areas for servicing the crane are important. Ample side and overhead clearance must be given. Considerations of ample structures to carry the crane or cranes, with the high impacts and shock loads, really affords protection to overall building and crane life. Crane rails utilizing the continuous rail and restricted float principles eliminate need for expansion sections while affording a better overall system. This rail, with its tight joint between rail ends eliminates the usual impact that exists when wheels pass over the joint. It also has the desirable self-adjusting ability not present when hook bolts are used. Costs between the older hook bolt and standard rail joint system and the ones described above are comparable."

General Clearances

First to be considered are general clearances for the crane. Only units with capacities from 1½ to 3 cubic yards will be covered in this paper. Larger cranes are being built at this time and more are being planned, but we shall restrict this presentation to the accepted current standards. We caution that all dimensional data discussed and shown herein should be considered as a general guide only. The crane manufacturer should be consulted very early in the planning stages.

Fig. 1 illustrates the cross section of a typical building through the area of and above the charging floor and the crane runway. The "A" dimension is the actual height of the crane above the runway rail. It is recommended that at least 6 in. clearance be allowed between the high point of the crane and the lowest overhead obstruction, be it the truss, lights, mainline conductors or piping.

The "B" dimension is shown to remind the Engineer that sufficient side clearance is important. The actual dimensions shown will allow a minimum of 3 inches clear.

The "C" dimension depicts the most critical vertical dimension in the crane application. It is a function of
The "C" dimension is determined with the grapple in the open position. The type of equalizer used also has a contributing effect. The "C" must include a space cushion for protection against tripping the hoist power limit switch on every raising cycle.

A 3 ft dimension is shown between the bottom of the grapple and the top of the hoppers. This must be considered a minimum. A greater distance would be preferable. Allowance of 3 ft or more, recognizes the repeated refuse overflow characteristic with the grapple and becomes a contributory factor to the same refuse being deposited directly into the hopper rather than being dragged over the hopper sides.

The "D" dimension is a function of the direction of the grapple opening and the location of the holding and closing drums. Dimensions shown consider the grapple opening being either parallel or perpendicular to the crane bridge but with the hoist drums mounted perpendicular to the crane bridge. Both the hopper and the pit wall relations to the crane are in part dictated by this "D" dimension. When approaching the centerline of the hopper, the grapple should be capable of an overtravel of at least 4 ft. The relationship of the grapple to the bin wall is of equal importance. Unless the grapple can reach the wall proper, refuse to be picked up with the grapple near the wall can never be retrieved without excessive casting of the grapple or special raking and prodding by incinerator personnel.

Fig. 2 shows horizontal, or plan, dimensions recommended. In establishing the data illustrated in the table accompanying the sketch, considerations have been given to the all-important dictates of providing for complete access to the storage bin by the grapple, as well as crane parking and service areas.

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**FIG. 1 CRANE CLEARANCES**

The crane bridge and trolley as well as the grapple, and must be related closely to the aforementioned "A". Invariably this "C" dimension is determined with the grapple in the open position. The type of equalizer used

<table>
<thead>
<tr>
<th>CAPACITY</th>
<th>A</th>
<th>B</th>
<th>C*</th>
<th>D*</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½ yard</td>
<td>61.0&quot;</td>
<td>11.0&quot;</td>
<td>91.1&quot;</td>
<td>91.3&quot;</td>
<td>41.0&quot;</td>
</tr>
<tr>
<td>2 yard</td>
<td>61.0&quot;</td>
<td>11.0&quot;</td>
<td>91.1&quot;</td>
<td>91.3&quot;</td>
<td>41.0&quot;</td>
</tr>
<tr>
<td>2½ yard</td>
<td>61.6&quot;</td>
<td>11.2&quot;</td>
<td>10.5&quot;</td>
<td>10.9&quot;</td>
<td>91.6&quot;</td>
</tr>
<tr>
<td>3 yard</td>
<td>61.6&quot;</td>
<td>11.2&quot;</td>
<td>11.3&quot;</td>
<td>11.8&quot;</td>
<td>91.6&quot;</td>
</tr>
</tbody>
</table>

*1-Grapple
2-Bucket
3-Includes 4"0" overtravel

**FIG. 2 CRANE CLEARANCES**
When one crane is utilized, space as shown on the left side of the sketch covered by crane 1 and on the right by 3 should be considered. Naturally, end stop protection equivalent to the listed "K" must be provided at the 3 end. Ample parking and service area is available at the left with complete storage bin access also provided.

A two-crane plant would require a minimum interior length which would be the summation of $2F + P + N + \text{BIN LENGTH} + 2L$. Again, the bin access-parking area criteria are met. It is recommended that the "P" and "H" dimensions be considered the absolute minima, because extreme operator caution is necessary at both ends under the conditions imposed.

**Mainline Conductors**

The location of the mainline conductors must be a major consideration. Unless they are placed in an accessible area, maintenance will not be performed. Depending on plant layout, the conductors can best be located:

1. On the charging floor side, nested in the runway beam.
2. Mounted above the runway rail vertically along the building column.
3. Suspended from the roof truss.

Fig. 3 shows the locations described above. The third system appears most favorable as maintenance can be easily accomplished from the crane service platform. It is also best located for personnel safety. An important point for the engineer to remember, is to provide a sufficient overhead beam or channel between the trusses, running parallel to the crane runway trail, to support the mainline conductors at frequent intervals. A rule of thumb dictates the support of rigid angle conductors on at least 8 to 10 ft intervals. Whenever possible, it is suggested that a center tap-in (electrically) be provided. When two cranes are on the same runway it is also well to consider providing isolating switches at each end of the runway in the respective crane parking areas. Should there be interest, the mainline conductors can be made of steel, aluminum or copper angles. The former is most prevalent. Aluminum and copper are becoming more common due to the larger motor horsepowers, longer runways and resultant greater current capacity demands.

**Runway Design**

The design of the runway and its subsequent suitable fabrication and erection contributes materially to the proper overall installation. The improperly designed runway will result in excessive deflections and lateral instability with undue wear occurring on the crane itself.

There is a growing misunderstanding of the application of impact factors to crane loadings. The applicable codes dictate the use of a vertical impact factor of 25 per cent. This 25 per cent is to be understood as a value taken on the maximum wheel load of the crane. It cannot be interpreted as 25 per cent of the live load. This is
A. Dead Load Due To Runway Beam and Rail
\[
W = \frac{W_0}{96}
\]

B. Single Wheel Reaction
\[
F = \frac{M_{\text{max}}}{D} \quad M_{\text{max}} = \frac{F D}{4}
\]

C. Two Wheel Reaction
\[
M_{\text{max}} = \frac{F (D - G)}{2D} \quad \text{(when } G > 0.586D, \text{ use "A" above)}
\]

D. Three Wheel Reaction
\[
M_{\text{max}} = \frac{F (D - G)}{2D} \quad \text{(when } G > 0.450D, \text{ use "C" above)}
\]

NOTES:
1. \(W\) = dead weight per foot
2. \(F\) = wheel load with impact
3. \(G\) = wheel base or space between wheels (Inches)
4. \(D\) = distance between support points (Inches)

The sum of the lateral stresses plus the result of the vertical moment divided by the section modulus of the runway beam section selected must not exceed the allowable stresses dictated by applicable codes.

**Fig. 4** COMMON REACTIONS ON THE CRANE RUNWAY

particularly true for cranes such as the bucket type since the ratio of the live load to the total of the crane is relatively small.

Lateral loads are assumed to be equal to 20 per cent of the summation of the lifted, or live, loads, and the trolley weight. One half, or 10 per cent, is taken into each runway rail with the loading acting horizontally at the top of each rail, normal to the runway rail. This 10 per cent load is distributed over the total number of wheels on each runway. (Special attention is called to the higher impact percentages imposed by the State of New Jersey.)

The longitudinal force is to be considered as equal to 10 per cent of the maximum wheel load. Here again it is interpreted to act at the top of the rail in line with the runway beams. Fig. 4 illustrates the most common reactions on the crane runway. In all cases shown here, loads are considered identical irrespective of being drive or idler side wheels. Only four-wheel cranes are involved in this study.

It should be understood that the vertical impact value could well be increased beyond the 25 per cent mentioned above, with no detrimental effect on the runway. The 25 per cent value is arbitrary. It has, however, proved fairly satisfactory to date. More detailed information on determination of runways, etc., is readily available in the AISC (American Institute of Steel Construction) Steel Construction Manual and other appropriate design manuals.

The runway beam is made of structural shapes, such as standard I-beams, standard wide-flange beams, or a combination of either of the beams with channel caps. For heavier cranes and runways with excessively long distances between columns, it may be necessary to utilize built up sections. In any event, it should be sufficient to accommodate the rail and rail clamping systems used.

The alignment of the runway rails is something that cannot be overemphasized. The span of the runway, or the distance between the rails, must be parallel, \(\pm \frac{1}{4}\) in. Vertical alignment of the rails with respect to each other should be \(\pm \frac{1}{8}\) in., and the rails should be straight within the same tolerance. Any deviation should be corrected immediately.

**Runway Rails**

Fig. 5 shows the key dimensions of the most commonly used rails in incinerators. These are the ASCE 60, 80, Bethlehem 104 and U.S. Steel 105 lb. These rails may be affixed to the runway, either by hook bolts or rail clips. The former is the system that has been used for many years, and it does have its severe limitations. The setting of the span is quite specific, and any adjustments can only be accomplished by the loosening of all bolts, resetting of the rail, and subsequent tightening of the same bolts. A much more satisfactory system today is the floating rail system, such as advocated by the major steel rail fabricators. This rail system allows for both lateral and longitudinal expansion, contraction and some mis-alignment. Fig. 6 shows a typical cross section of this system. Both the floating-clamp and tight-clamp arrangements are shown, but only one arrangement would be used on both sides of the rails in any installation. With the former, sufficient clearance is allowed between the face of the filler and the side of the rail base to allow restricted self-adjustment. The tight-clamp system requires removal of the clamp plate and rotation of the filler 180 degrees to its opposite edge if adjustment is necessary. In both systems the filler has eccentrically located holes which allow the desirable adjustments.
The longitudinal connection between rail sections can best be accomplished by use of the splice bar described in Fig. 7. This bar, properly applied, serves the function as well as if the rail were welded. In some instances it is superior to a welded section as the latter requires extremely well controlled conditions at the time of welding. Experience has shown these conditions are usually not prevalent. The allowance of a few inches at each end of the runway enables the use of a continuous rail for the full length of the runway, irrespective of expansion joints in the building.

Runway End Stops

The end stops on the crane runway serve as the best stop for this type of rail. Fig. 8 illustrates a typical solid-type end stop and its relationship to the rail end. The stop must be developed to take both the tension and the shear loads imposed by the crane. No attempt is made herein to dictate design of this stop although the configuration shown has proved most satisfactory. We recommend the stop be the crane manufacturer's responsibility with the proper location of the stops being the function of the steel erector. In the writer's opinion, stops should not be located in their final position until the crane is on the runway and proved to be square. In lieu of this, it is suggested that some adjustments be
provided for the most important final positioning to insure crane squareness when meeting these end stops.

The Crane

There have been some significant changes and improvements with respect to the incinerator crane since 1964.

Of primary interest to the operator should be the success of Static Stepless Control. The predictions of greatly reduced maintenance and virtual elimination of wear in the electric holding-brake have been realized. The vastly superior plugging and instant reversal characteristics, and the positive direction of grapple movement due to the use of eddy-current brakes in the hoist train, give control to the operator that was not considered possible a few years ago. There need be no reservations on adoption of the refined Static Stepless Control on both new and old cranes.

Utilization of the new AISE Mill Motors has not proved advantageous to date. The rather limited thermal characteristics of these motors require use of frame sizes well in excess of the actual horsepower needs. The penalty to gear trains and the dead weight of resultant structures is severe. At the present time, there is no question that a properly sized NEMA motor with the correct thermal rating is most logical and practical.

The increasing preference for the grapple in lieu of the bucket has resulted in accelerated improvements in the former. These improvements, however, brought about increased grapple weights, which now affect standard crane capacity ratings. Experience prompts the revised crane ratings as shown below:

<table>
<thead>
<tr>
<th>Grapple Capacity</th>
<th>Crane Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½ cu yd</td>
<td>3 ton</td>
</tr>
<tr>
<td>2 cu yd</td>
<td>3½ ton</td>
</tr>
<tr>
<td>2½ cu yd</td>
<td>4½ ton</td>
</tr>
<tr>
<td>3 cu yd</td>
<td>5½ ton</td>
</tr>
</tbody>
</table>

The revised ratings above, along with the use of Static Stepless Control and its heavy reactors and panels, cause increased wheel loadings on the crane runway. Final building design must take these greater loadings into consideration.

Recently there has been some discussion of the possible use of the orange-peel type grapple now employed in some European Plants. Its use merits serious investigation. The radical differences between the orange-peel and U.S. type (tine-grapple) must be reconciled. These include grapple and peel weights, application to hoist machinery, radically greater dead weights of machinery, greater space allowances and different electrical requirements. It would be expected that our qualified U.S. bucket and grapple manufacturers will contribute materially to this subject shortly. Until that time, the discussion remains open.

Conclusions

The crane dictates much of the size and design of the building. Insufficient allowances of space and building strength can only result in severe operational restrictions and unexpected crane and building structure problems. Early consideration to the overall application, as it relates to the crane, cannot be overemphasized. This paper serves as a guide — the engineer must contribute his talents in cooperation with the crane specialist from this point.