BRICKING SOLUTIONS
A DIVISION OF BROKK

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ENGINEER'S REPORT:

Design, Development & Testing Of Bricking Solutions' Safety Cages

SCOPE:

Bricking Solutions (formerly Pneumat-O-Ring International) historically has manufactured an aluminum protective cage which had the ability to protect personnel from falling, small "coating" fragments up to the range of a single refractory brick falling several feet. The scope of the present, ongoing, development is to provide an extremely light weight protective enclosure with will protect personnel from larger falling objects that have traveled several feet before impacting the enclosure.

DESIGN:

I. Data

A. From industry feedback, Bricking Solutions' personnel experience and maintenance consultants, including refractory brick installation companies, the maximum weight of any particular object, be it coating or several failed brick in an adhered group, was initially set at 250 lbs. for design purposes.

B. Kiln geometry and coating thickness both determined the practical minimum distance at which the safety cages could be maintained during use. Initial design input was determined to be a minimum of 6 inches, which from a geometric review resulted in a possible fall height of approximately 2 feet.

II. Design Objectives

A. From experiences of use and damage to the previously provided enclosures, it was easy to determine that the basically flat top of the bowed style frames resulted in a complete "catching" and stopping of larger falling objects without any deflecting of the material which would reduce the total vertical load required to be withstood by the framing.

B. Secondly, there was ample historical evidence that the semi-rigid skins previously used received extensive damage as well as failed connecting welds from the impacting loads of larger falling objects.

C. Our initial design direction was three fold:

1. Provide a peaked frame system that will provide side deflection to any falling object and reduce the vertical impacting load into the enclosure frame.
2. Since the actual peak will be the closest to an actual falling particle and it will be "hit" with the least force. However, it will theoretically be rigid and have to stop the particles completely before the object can deflect to either side. The ridge of the peaked frame must therefore be structurally strong enough to withstand the direct impact yet flexible enough to provide some deceleration distance for stopping the object.

3. Any kind of rigid or semi-rigid enclosure cover must be replaced with a high-strength, highly flexible and anchored with low stress concentrated support points.

III. Design Development:

A. Keeping the foregoing criteria as our primary goals, we initially selected to allow all framing connections to flex and some to slide when impact deflection occurs. This flexibility did initially create some stability problems in our narrower, taller enclosures.

B. Our selection of woven "high-strength" steel wire fabric provides extremely high-strength for catching and deflecting large falling objects, and it's extreme flexibility provides maximum distance for deceleration of the velocity of the falling object which results in the minimum impact factor to the enclosure framing system.

C. It was initially determined that this enclosure design would be to protect personnel from one or possibly two maximum impacts without inspection and possible repairs required to return the enclosure to its original design resistance.

D. The ridge beam is a formed high-strength aluminum angle designed per the "Aluminum Design Manual" Part 1-B by the Aluminum Association, Inc., to withstand the required direct impact forces from a maximum weight falling object. This ridge beam is rigidly attached to the peaked end frames, however, to allow for the resultant deflection under design impact loading, the end frames are designed to flex inwardly without damage.

E. The mid span fabric support beams are designed to both deflect and yield under maximum design load. Therefore, they are considered "sacrificial" and we recommend having spares.

F. The woven steel fabric is installed over stud type pins and in areas that we must restrain the fabric, it is held on the pins with large washers and wing nuts. This fabric cover is the most flexible component of the design system and also the most sacrificial from a yielding standpoint when impacted with maximum design loads.

G. In testing, we were able to restrain loads with the fabric well beyond our framing design capabilities and actually held objects in excess of 3,000 lbs without a catastrophic failure of the fabric.

H. The peaked end frames are also designed in strict accordance with "ADM" Part 1-A, 1-B, 11-A, & 11-B and are fabricated to ANSI/AWS D-1.2 specifications. The key area in transfer of impact loads to the enclosure side panels, which act as the systems support columns, is at the specialty corner connection. To provide the strength, fit, and flexibility that we require, a custom extrusion die was made and we use this die to produce the specialty run 6061-T6 high-strength aluminum required.

I. The side frames are subject to more direct column loading and do not require as high a flexibility allowance. Therefore, we use expanded sheet on the side frames to both provide additional rigidity and protect personnel from bouncing materials.

J. The bottom side frame is provided with adjustable support legs. These legs have "positive" anti-slip feet that positively do not allow the legs to slide on either coating or refractory brick if the enclosed is impacted.

IV. Testing

A. Each major design modification and improvement has been intensively reviewed for physical load carrying characteristics, quality of fit and fabrication, and predetermined limits of deflection under yielding characteristics.

B. Enclosures using updated components and materials are tested by impacting an actual 250 lbs object from the design heights onto all areas of the enclosure's top and side panel

top areas. Once the test enclosure has successfully withstood all design load impact loads, the heights for dropping are increased to simulate the 3:1 safety factors that are theoretically designed into each structure. Under these test conditions we witness considerable yielding of components, however, to date have not had a catastrophic failure of any enclosure assembly. If the test enclosure remains in structural shape and integrity after our 3:1 safety test, we occasionally load the unit to failure using objects heavier than the standard 250 lbs test object; i.e. ecology blocks or portions of ecology blocks up to 2-3 thousand lbs.

V. Conclusions

A. We believe that the progression of this development, including the design parameters, production quality control, instruction manuals for end user education, and documentation of actual testing results has resulted in an advanced, extremely light weight for strength and "safe" personnel protection enclosure.
B. We must, however, insist on both "knowledge of use" and immediate "repair and maintenance" if required from use or damage.
C. Testing photos, videos, and documented results are available upon request.
D. For any questions regarding these safety enclosures; please contact Verne L. Lindberg, P.E.

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