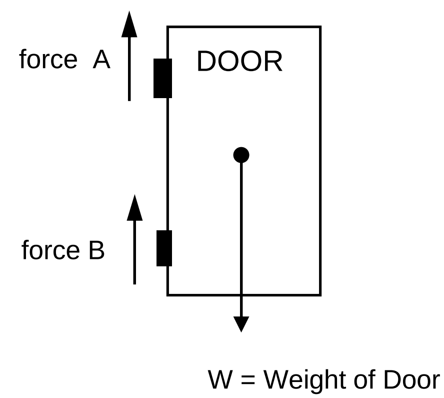
STRENGTH OF HINGES

The question of hinge strength often arises during the design of an enclosure;
It is not difficult to lab test and conduct stress analysis even on a range of hinges as large as EMKA's – about 130 different designs and materials, the challenging part is to correlate these academic evaluations with real life.
Not only door dimensions, orientation and position of the center of gravity, but also the position of the hinges and the tolerances of installing them can have a profound effect on the load carrying capability of a hinge.
In this discussion I am only considering the most common door orientation, that is, with the hinges in a vertical plane.
Some of the complications relate to the following:

- Vertical load due to weight.
- Load sharing between hinges.
- Negative load sharing.
- Horizontal load due to position of C of G and hinge spacing.
- Load due to gasket force against door.
- Shock loads due to transportation, earthquake or explosion.

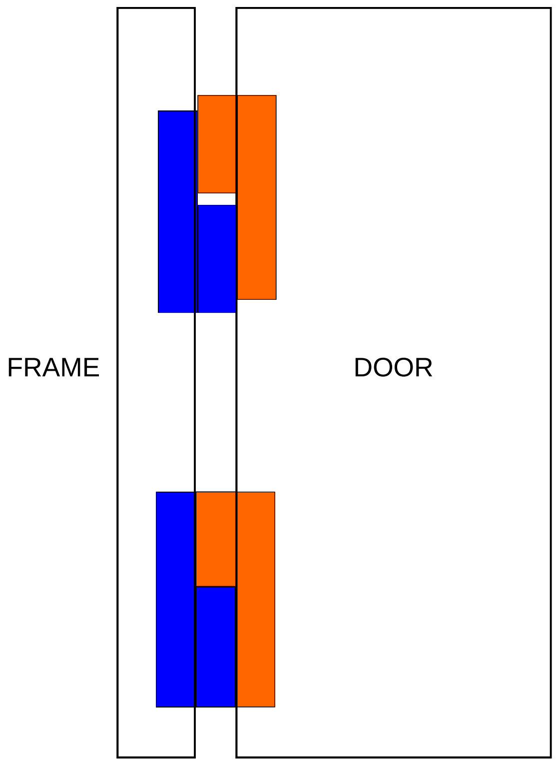
Vertical load due to weight

- The total weight of the door plus anything hanging from it, or in engineering terms:
- total mass x acceleration due to gravity (W) = force A + force B
- In a perfect world the vertical load on each hinge should be this force divided by the number of hinges, or force A = B in the sketch alongside.



Load sharing between hinges

- In this perfect world mentioned above the hinges are made exactly to nominal dimensions and installed precisely so each hinge carries the same load.
- Since this perfection is impossible one hinge must take all the vertical force. See the sketch alongside: the red parts of these lift-off hinges are attached to the door. The door part of the upper hinge is installed above where it should be so the lower hinge takes all the load.



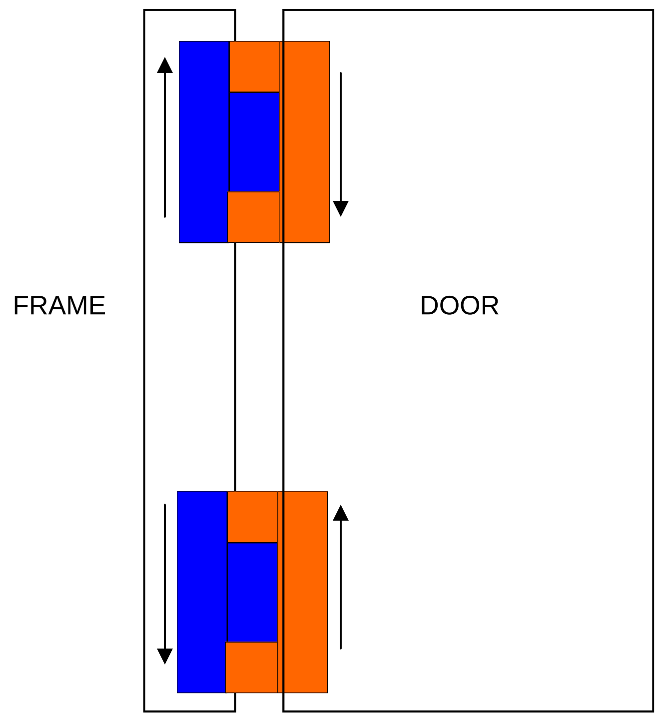
Load sharing between hinges

- The last slide may not tell the full story because as a hinge is loaded it, and the surrounding metal, will deflect, usually enough so that other hinge(s) will take some of the load.
- A hinge manufacturer can calculate his tolerances and hinge stiffness, but cannot know the stiffness of the enclosure or the door nor the accuracy with which the hinge is installed.
- The best a hinge manufacturer can do is to assist the enclosure production people to achieve the best possible accuracy by incorporating location bosses as EMKA does on many of its die cast hinges.
- The flexibility of a hinge depends on its design and the material from which it is made.
- A glass reinforced nylon hinge is significantly less strong than a similar zinc alloy hinge, however it’s greater flexibility will allow it to share the load more effectively.

Pre-loading

In the example above: if the hinges were captive instead of lift-off and the same installation error occurred there would be a large force tending to bow the door and force the frame parts of the hinge apart. See the arrows

It is quite possible that these forces could exceed the weight of the door.



Shock loads due to transportation, earthquake or explosion

Shock loads can be caused by a short circuit in an electrical panel, an earthquake or most commonly, by vibration or rough handling during shipping. These transient loads are difficult to evaluate without testing.

The loads during shipping can be greatly minimized by securing the outer edge of the door. A type of latch that prevents the outer edge of the door from any movement can solve a "hinge strength" problem!

Door stops can solve the problem of over-extending the hinge.

Material selection can be important to counter these loads.

Load due to position of C of G and hinge spacing

A simple force diagram like that on the next slide will show that the further the center of gravity is from the hinges the greater the horizontal force will be.

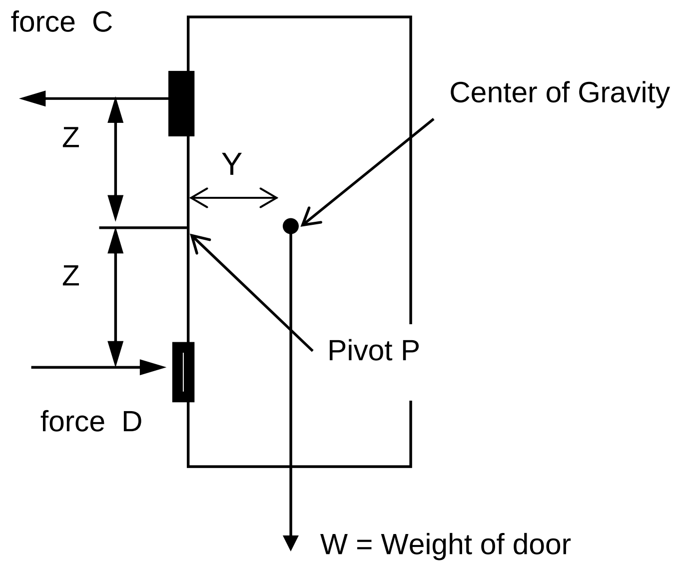
Closer inspection will also show that the wider the hinges are separated the smaller the force. A third hinge will not help to resist this load significantly. This horizontal load combines with the other forces to stress the hinge.

Load due to position of C of G and hinge spacing

Algebraically

Z(C + D) = WY

Therefore an increase in Y or decrease in Z will increase hinge loads for the same total weight.



Load due to gasket force against door

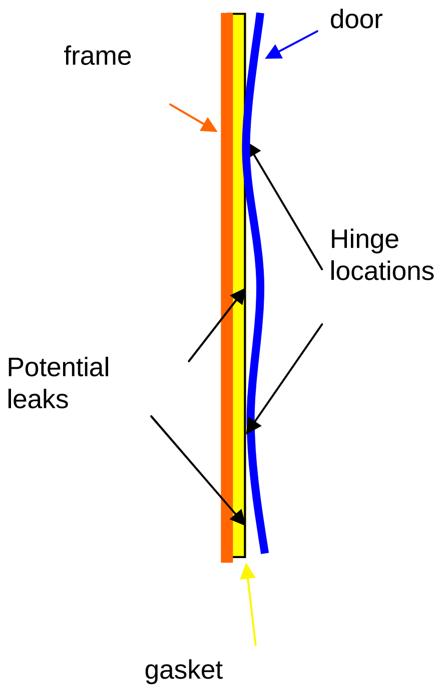
- With a typical foam gasket the force to provide a NEMA 4 seal is about 40# per foot of gasket length; so for a 6' high door the force from this source will be about **240#** on the hinge side alone. If the gasket is over-compressed the load can greatly exceed this.
- If EMKA bubble type gasket is used this force may be reduced by about 75% to around 10# per foot
- This force is significant mostly in that it tends to bend the door away from the gasket thus potentially causing leaks, it is for mainly for this reason that 3 or 4 hinges are used.

Load due to gasket force against door

The sketch exaggerates this condition, but demonstrates the necessity for multiple hinges. To minimize the problem the following steps may be taken:

- Use low compression force gasket—bubble type
- Stiffen doors, a deeper return flange helps

This phenomenon occurs on the opposite (latching) side of the door so multi-point latching is needed. Several of EMKA's closing systems use latches and hinges with identical hole patterns which facilitates reversible doors as well as totally reliable sealing.



Materials

Material	Strength	Corrosion	Elastic Deformation	Comments
Nylon 6.6	Low	None, good UV resistance	High	Good for shock loads and load sharing
Mild steel	Good	Needs plating	Good	Can be welded Good resistance to abuse
Stainless	High	304 Good or 316 Excellent	Good	Can be welded to stainless enclosures. 316 for off-shore or GR 487
Zinc alloy	Good	Good with plating or powder coating	Low	Allows location features and quick assembly methods

Testing

Laboratory testing may be misleading. When testing one hinge, unless it is restrained in some way, it bends significantly before failure in a way that is not possible when the door part is actually attached to a door.

Testing two hinges introduces the load sharing problem.

Summary

- It is easy to calculate theoretical static loads for each hinge.
- It is impossible to predict to what extent load sharing between hinges will occur.
- It is very difficult to calculate or even test for transient loads during shipping or when a door might be opened past its maximum angle.
- To understand the forces due to a gasket, the stiffness of the door and the flatness of the surfaces as well as the spring rate of the gasket must be known.

Summary cont.

- Because it is easy to "run the numbers" and develop a load value it is easy to believe that this number is meaningful.
- With modern materials and relatively lightweight doors if the door looks to have enough and large enough hinges it almost certainly has a generous safety factor. The actual failure rate from normal use is miniscule.
- Because of the many complicating factors discussed testing is an integral part of the design process. EMKA is happy to recommend suitable hinges for testing.

Rules of Thumb

1. Test
2. Install hinges as accurately as possible, use hinges with location bosses if possible
3. Use low compression force gasket
4. Use a door stop to prevent over-rotation
5. Carefully consider door stiffness for gasketed (NEMA 4 etc.) enclosures
6. Immobilize the latch side of the door during shipment.