KNIFE GATE (Valve) vs SLUICE VALVE – from an Engineer's perspective

Knife Gate (Valves) (KGV in short), as claimed by a manufacturer to be more suitable vis-à-vis a gate valve, for use in waste water & sewage containing solid and fibrous wastes, always, is like turning engineering on its head. Considering the following:

(I) CHEST DESIGN

Pressure Cookers / Gas Cylinders, the two everyday used gadgets in our lives, have circular cross section. Would you accept, if these be offered in square or rectangular cross sections? The answer would always be NO. Let us analyse technically:

Since the stresses induced in a cylindrical or circular cross – section under the influence of internal pressure are determinable with a far greater degree of accuracy than is possible with any other shape, valves destined for higher pressures are generally designed with as many as truly or near cylindrical configurations as possible, such as the elliptical cross section of a sluice valve.

The formula of maximum fibre stress due to bending is given by:

$$f_1 = \pm (3p/t^2)(k^2 - r^2)$$

where,

f_1 = maximum fibre stress due to bending

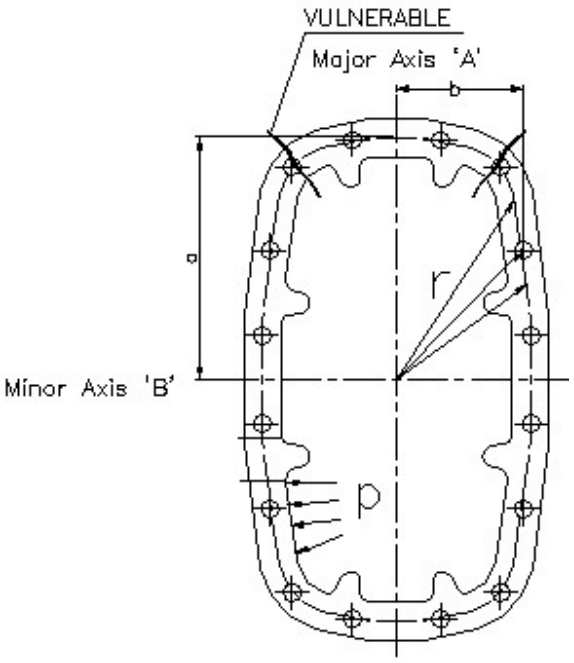
p = line pressure

t = chest thickness

k = polar radius of gyration of the shell about its axis

r = radius to point at which stress is required to be computed measured from the geometrical centre of the shell.

Note: minus sign denotes compressive stress



SLUICE VALVE CROSS SECTION

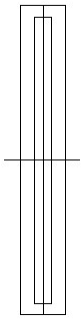
The value of k^2 may be determined from the mean value of r^2 if successive points are taken along circumference of the shell. For circular cross-section K=r and therefore this bending stress is zero.

The direct tensile stress at any point along the perimeter is given by:

$$f_2 = pr / t$$

By the foregoing one could determine the stresses ($f_1 + f_2$) combined at any number of points around the perimeter of the chest and so determine the maximum stress, but it would be found that **this would generally be located at the mid point of the long side, or at the junction of the long and short sides.**

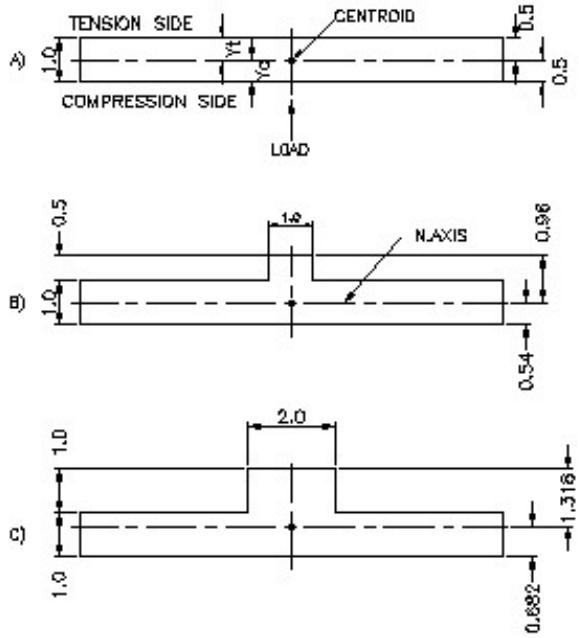
Therefore it is imperative to adopt as large a fillet radius as possible as stress here appreciably increases with diminishing radius. **A square cornered chest, as is the case with a KGV would induce abnormally high stresses.** The reason why all pressure vessels are rounded with no sharp corners.



KNIFE GATE VALVE CROSS SECTION

(II) RIBBING

Determination of chest thickness is not only subject to stresses imposed by line pressure, but also to additional or secondary stresses resulting from the end thrust occasioned by expansion of adjacent connecting pipework and in some cases from the effects of bending (where the valve is inadequately supported) and from other equally indeterminate effects. There are, however, limitations to increasing the plate chest shell thickness posed by physical properties of the metal, economisation of weight etc. To overcome this, **strengthening ribs** are provided to secure optimum strength with minimum expenditure of metal. Contrary to popular belief, ribs may weaken rather than strengthen the plate to which they are adjunct, as explained in the following illustration where Z denotes section modulus:



Z = 1.5 cm³

Z = 1.071 cm³

Z = 1.937 cm³

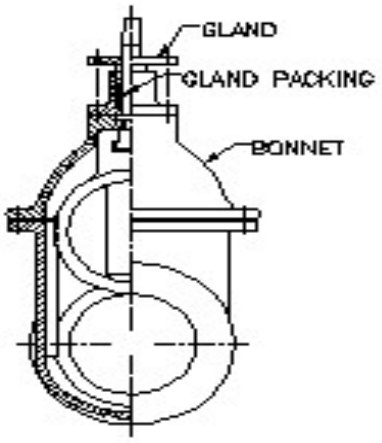
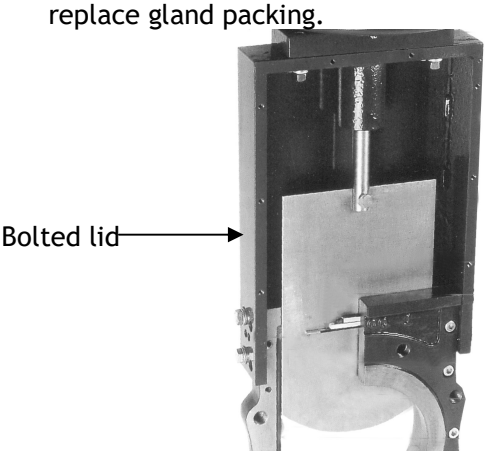
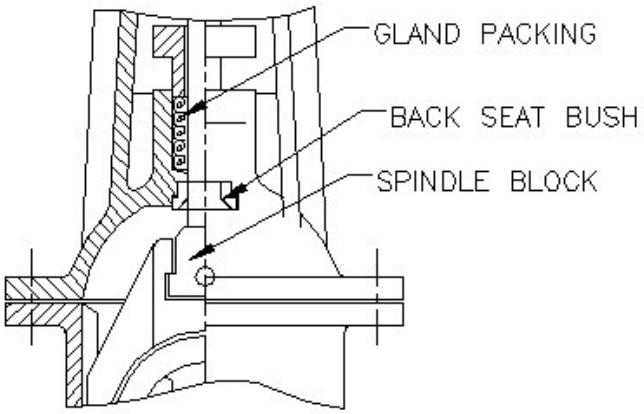
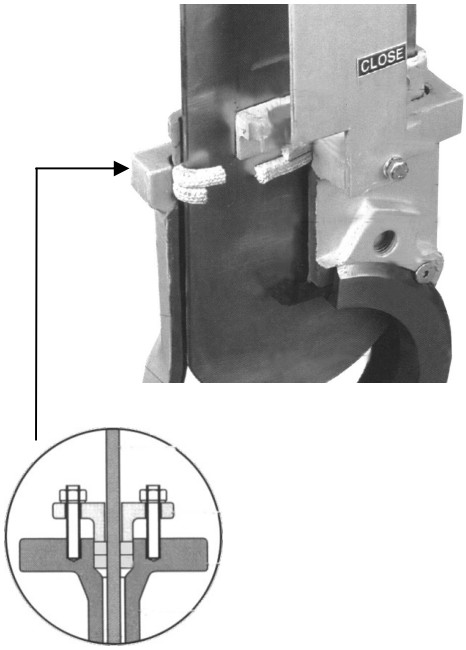
EFFECT OF VARIOUS RIBS IN LOCATION OF THE CENTROID IN RIBBED PLATES

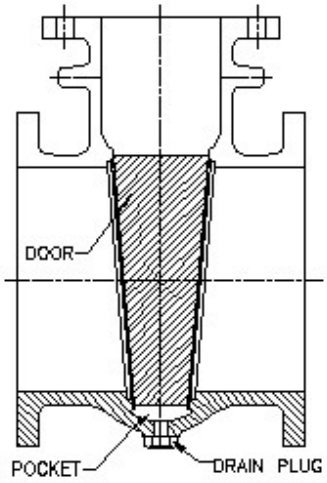
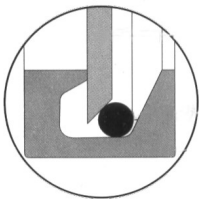
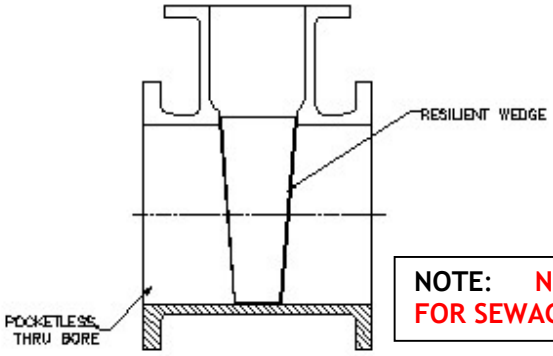
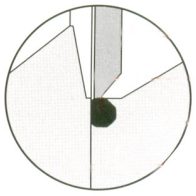
Clearly the introduction of such shallow rib (like at B) has practically reduced the strength of the plate to two thirds that of unribbed plate without a doubt this phenomenon accounts for the occasional failure of plates supposedly "strengthened" in this manner.

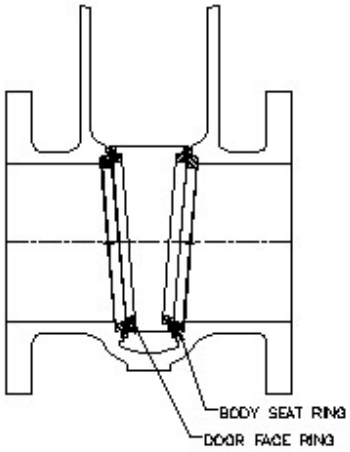
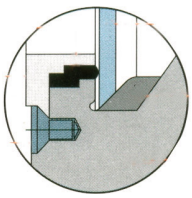
A proper rib (like at C) on the other hand has added more than a third of the original strength of a plate.

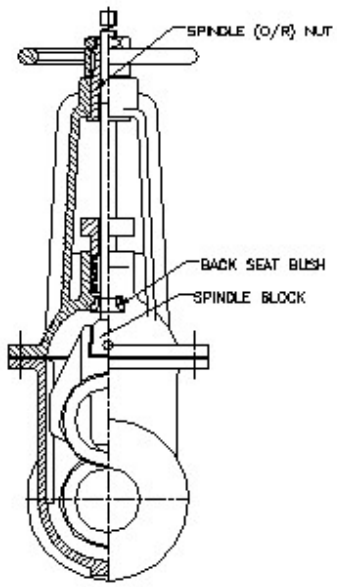
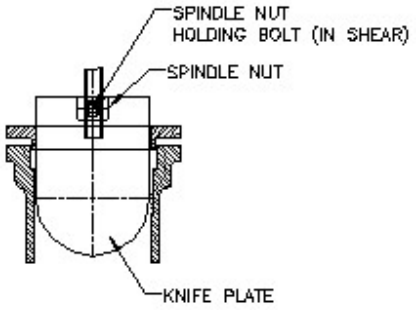
Sluice Valves chest is designed with optimum shell thickness strengthened by adequate ribs, both external & internal. KGV design on the other hand cannot accommodate external ribs or internal ribs, making it a square cornered chest inducing abnormally high stresses. The valve design books often expresses sigh of relief stating" **Fortunately these are generally of the cheap variety destined for very low pressures and relatively unimportant duties**" (extracted from "The design of Valve & Fittings" by Pearson) **prompting its use in plants treating sewage and not beyond; size seldom exceeding 300 mm ø.**

III) OTHER SALIENT FEATURES COMPARED

SLUICE OR GATE VALVE	KNIFE GATE (VALVE)
1) **BONNET** – This is part of the pressure vessel (Valve chest) and on top there is a gland. 	1) **BONNET (UPTO 300 DIA)** – Essentially a bolted lid not subject to pressure, the gland clamped directly on to the body. So one would need to remove it to replace gland packing. 
2) GLAND PACKING REPLACEMENT 	2) **GLAND PACKING REPLACEMENT** 
Can replace packing even when the pump is running. The area to be covered by the packing is small, around the spindle only and therefore easy for leakage control.	No back seat bush possible therefore change of packing only when there is no pressure or water in the valve – a shut down is a must. Area of packing is large, the cavity un-machined and all around the door, therefore difficult to stanch leakage.

3) **BELLY DESIGN**	**3) BELLY DESIGN**
 Yes, debris can lodge at the bottom. The DRAIN PLUG is provided for removal of this debris.	There are cavities below the seal which will collect debris as the plate / Door moves beyond the seal for positive closure. 
 Resilient Wedge Gate Valve has no such debris collection problem due to the straight thru pocket-less design of a body **NOTE:** **NOT RECOMMNEDED FOR SEWAGE / WASTE WATER**	

4) **SEAT & FACE RINGS**	**4) SEAT RINGS**
(Metal to metal seat)  The wear travel (20 to 35 mm) is provided to ensure 20-30 years of useful life to the seats. Depending upon the medium to be handled, different types of seat rings (Bronze to st.st.) is provided which cannot get damaged in service	 Rubber seal has a limited life and calls for frequent replacement, a tedious procedure in sewage

5) SPINDLE NUT	5) SPINDLE NUT
 For waste water / sludge /slurry, only outside screw rising spindle gate valve is recommended. The nut as also the stem thread is outside, not in contact with the liquid. So no breakage or maintenance problems exist.	Even though the spindle is non-rising, because there is no bonnet, it is possible to locate it above the gland packing and therefore easily serviceable. But the nut is held to the door plate by a bolt which is always in shear – not desirable. 

6) TORQUE	6) TORQUE
The torque components involved are : a) To impart axial thrust to force the wedge closed (function of pressure, wedge angle and coeff. of friction of seats) b) To overcome frictional resistances of collar c) To overcome resistance imposed by the gland	a) Same as in sluice valve except that the wedge angle is zero so the first element is quite low vis-à-vis a wedge gate valve b) Gland torque is very high due to the enormous area requiring bolted gland for preventing leakage. This more than offsets the low torque due to the flat door plate. So there is no appreciable saving in torque.

7) OPERATING TIME	7) OPERATING TIME
The standard forbids the use of multiple start of spindle thread so full time is required for the gate opening. These valves are used for pressures upto 16 bar and therefore higher torque and larger gear ratios are anyway called for.	A double or multi start spindle thread is used to lower the operating time. This reduces the core dia of spindle and therefore weakens it. These are meant for low heads (2.8 bar) and therefore have lower torques. So no ball thrust bearings or gear boxes are called for. Hence lower operating times.

8) SIZE (FLANGE TO FLANGE)

Prudent engineering practice demands that there be ‘n’ times ‘D’ (Bore dia of valve/pipe) space between two appurtenance, n ranging from 3 to 50 times depending upon application. So a thinner LOF of KGV does not translate into lower conduit lengths. Mass of a valve is miniscule compared with the mass of water and the hydraulic load and foundations are designed considering the latter.

9) HYDRO-TESTING /DROP –TIGHTNESS

MSS SP – 81 – 2001 covers valves i.e. KGV, that are intended for use in applications where shock loading are not encountered. Obviously due to reasons explained in (I) & (II) above.

Body test – **"Leakage through the packing or gate seal shall not be cause for rejection."** Sluice Valve standard and design, however, allows no leakage. Besides, with KGV one has to live with valves always leaking thru the gland. One shudders to think the situation arising out of this in a sewage handling plant. Moreover, some permanent distortion of stainless steel parts is acceptable during shell test.

Seat test – **"pressure tested at 40 psi (2.8 bar) differential pressure in the direction of closure. Maximum permissible leakage shall be 40 ml/min/NPS (1.6 ml/min/DN)."** Sluice Valve standard and design, allows nothing less than drop – tightness and seat test can be done at 6 to 16 bar and above

10) APPLICATION

A pumping application requires flow and therefore pressure from both sides (pump head when the pump is running and static head when the pump is shut off/ tripped). A valve must seal both ways. A knife gate valve, no better than a sluice gate, an end user would be ill advised to use it for any kind of pumping installation, regardless of size and pressure.

CONCLUSION

Sluice (non-rising spindle) valves for water and Gate valve (outside screw rising spindle) for sewage application have been around for over 2 centuries. There have been may new type of valves invented since but nothing has displaced it. With resilient encapsulated wedge, pocket less gate valves, these have only got better. Therefore use:

Valve Type	Application	CAUTION !!
KGV	- Waste water treatment plant for sizes 350 – 600 ø, heads not exceeding 20 mwc	i) Be prepared to change gland packing and seat frequently
Sluice Valve (non rising spindle)	- For water (Clear and raw) pumping and distribution	i) Badly designed valves and valves of dubious reputation may leak from gland
Gate Valve (rising spindle)	- For Waste water treatment and pumping, all sizes	i) Clearly lay down proper specification including for accessories of valve
Resilient Wedge Sluice / Gate Valve (non – rising stem)	- Upto 300 mm dia for clear water (distribution and pumping)	i) For smooth functioning of valve, use for isolation but not for extreme throttling.