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AN ALL METAL INDIUM VALVE SEAT FOR LARGE DIAMETER IN-LINE GATE VALVES*

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I. INTRODUCTION

Metal valve seats having acceptably low creep characteristics require sealing forces on the order of 500-5000 lbs. per lineal inch of seal.[1,2,3,4] Closing mechanisms for these "hard" valve seats (copper-stainless steel, "kovar"-gold, etc.) require initial accuracy as well as repeatability on closure. Some designs require highly polished surfaces. Also some materials with good initial sealing characteristics (i.e., low sealing force requirements) work harden and require higher subsequent sealing forces.

Metal valve seats having reasonable sealing force requirements (100-500 lbs. per inch) have undesirable (for "in-line" use) creep characteristics.[5] Designs exist which use lead or indium as the sealant in the bottom of a square groove. A precision machined, flat bottom knife edge fits closely into this groove. A plastic flow or "coining" of the sealant is achieved but it is at the same time "hydraulically" confined to the groove by the knife edge. Machine tolerances between the sealing "knife" and the groove reduce extrusion of material, but in large diameters these tolerances become impractical due to precision requirements placed on the valve closing mechanisms.

II. CONFINED INDIUM VALVE SEAT

The principle of hydraulically confining a soft metal seal material in a groove appeared to merit investigation. A configuration similar to that shown in Fig. 1 was constructed in an intuitive approach to achieving such a seal. Indium was used as the sealing material. As shown, the diameter of the seal was 7.45 inches.

The indium was initially melted in the groove (1/16 inch diameter wire used as bulk material) in a hydrogen furnace at approximately 850°C. This served to wet the indium to the wall of the confining geometry. However due to the large coefficient of expansion of indium compared with the stainless steel components of the seal, craters developed in the indium in the center of the knife edge groove. These were filled by selectively melting sections of the indium seal on a hot plate in air.

The seat was prepared by pressing the knife edge into the indium and successively carving away the excess indium with a sharp knife until the knife edge face plate "flushed" with the indium retaining flanges. Throughout all tests the valve seat was cycled at pressures ranging from approximately 100 to 500 lbs./inch. In each case before the test at the successive sealing force, whether greater or less than the previous force, the seal was physically separated, rotated, and reseated. This cycling was done manually under what would be considered adverse conditions (i.e., no repeating valve mechanisms). Essentially no pilot existed to protect the indium seat from being "shaved" when the knife edge was manually reinserted.

The welded stainless steel retaining flanges were initially 30 mils thick. Until these were "thinned down" to approximately 18 mils seal performance was erratic. Subsequent tests are shown in Fig. 2. No apparent deterioration in sealing ability occurred with the number of closures. Sequence of seal loading was random.

Creep of the confined indium seal could not be measured with a micrometer after over 400 closures. However a thin ribbon of indium approximately 60 mils wide was extruded past the edges of the confining flanges. After the test run this indium was carved away and weighed (approximately 0.2003 grams). The effective creep amounted to 0.3 mil.

III. REPAIR PROCEDURE

After removal of the extruded indium, difficulty was experienced in achieving a satisfactory seal. Inspection of the indium groove under a 120X microscope resulted in the discovery of numerous metal chips. These chips probably were introduced when the stainless steel confining flanges were "thinned down."

A groove was machined out of the indium seal. Indium wire was placed in the bottom of the groove and fused to the seat material with a heliarc torch. More wires were then added to the groove until a crown weld of indium was achieved. The crown was then carved back with a knife and the seat again prepared as described above.

Due to erratic behavior during the first 15 closures the repaired seat was pressed to a load of 550 lbs./inch, but in subsequent tests loading was never in excess of 400 lbs./inch. The following 450 cycles showed without exception leak rates of less than 1×10^{-7} std. atm. cc/sec. of He with sealing forces less than 400 lbs./inch. As a rule when a sealing force of approximately 400 lbs./inch was used a leak rate of less than 1×10^{-8} std. atm. cc/sec. of He was realized. In only one instance did a sealing force of less than 300 lbs./inch result in a leak rate of more than 10^{-6} std. atm. cc/sec of He (approximately 5×10^{-6} cc/sec.) in 16 closures in the 200 to 300 lbs./inch force interval.

IV. CONCLUSION

Obvious disadvantages would include the fact that the low melting temperature of indium prohibits bakeout of the valve body without provision for cooling the valve seat.

The above confined indium valve seat has obvious advantages from the standpoint of the requirement of relatively low sealing forces per unit length of seal. Repair of such seals also seems not to present a problem. Determination of required precision repeatability of the valve mechanisms is yet unknown. On the whole, however, it appears that reliable non-creep seals may be obtained with required sealing forces of much less than 400 lbs. per lineal inch with little difficulty.

REFERENCES

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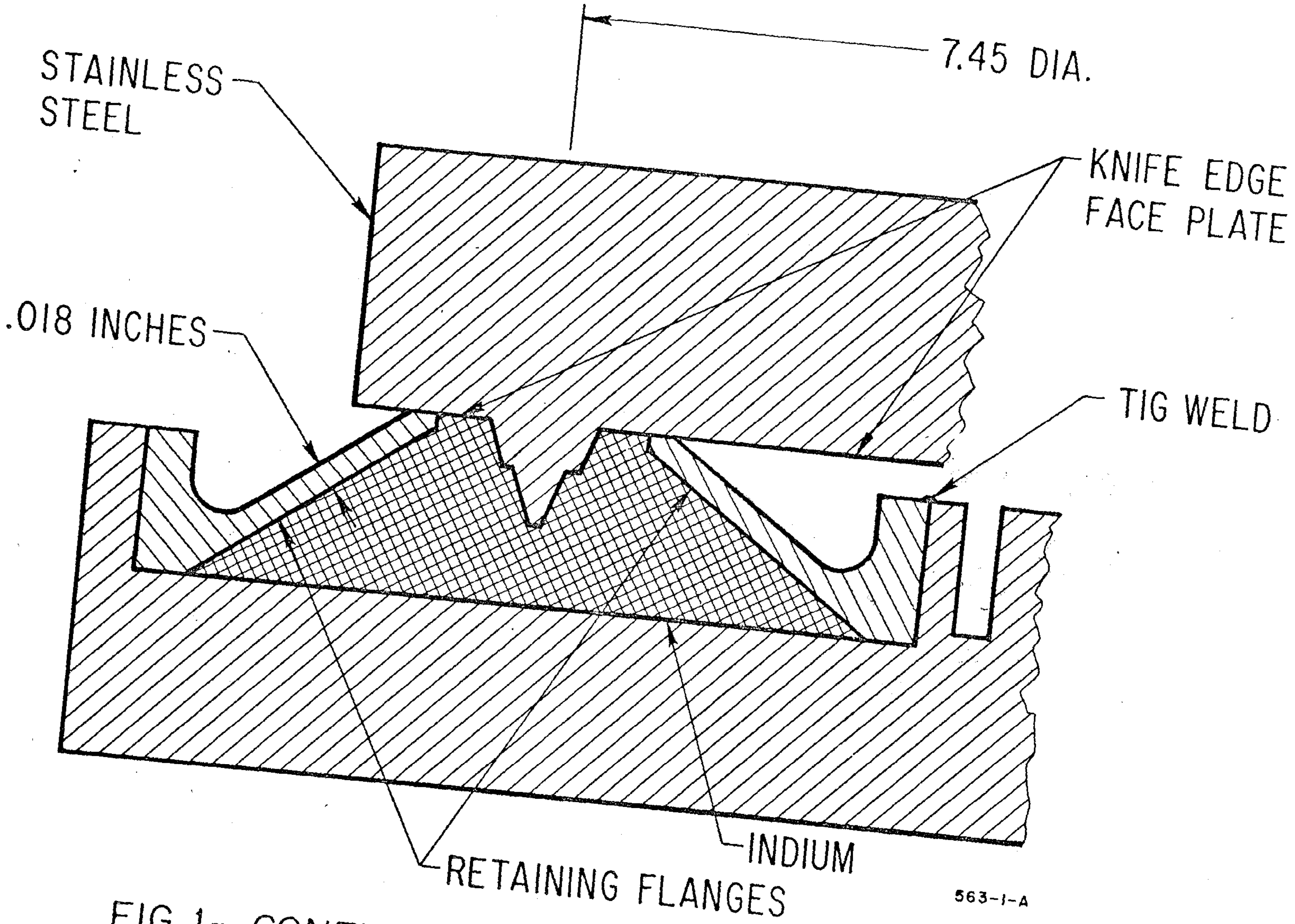
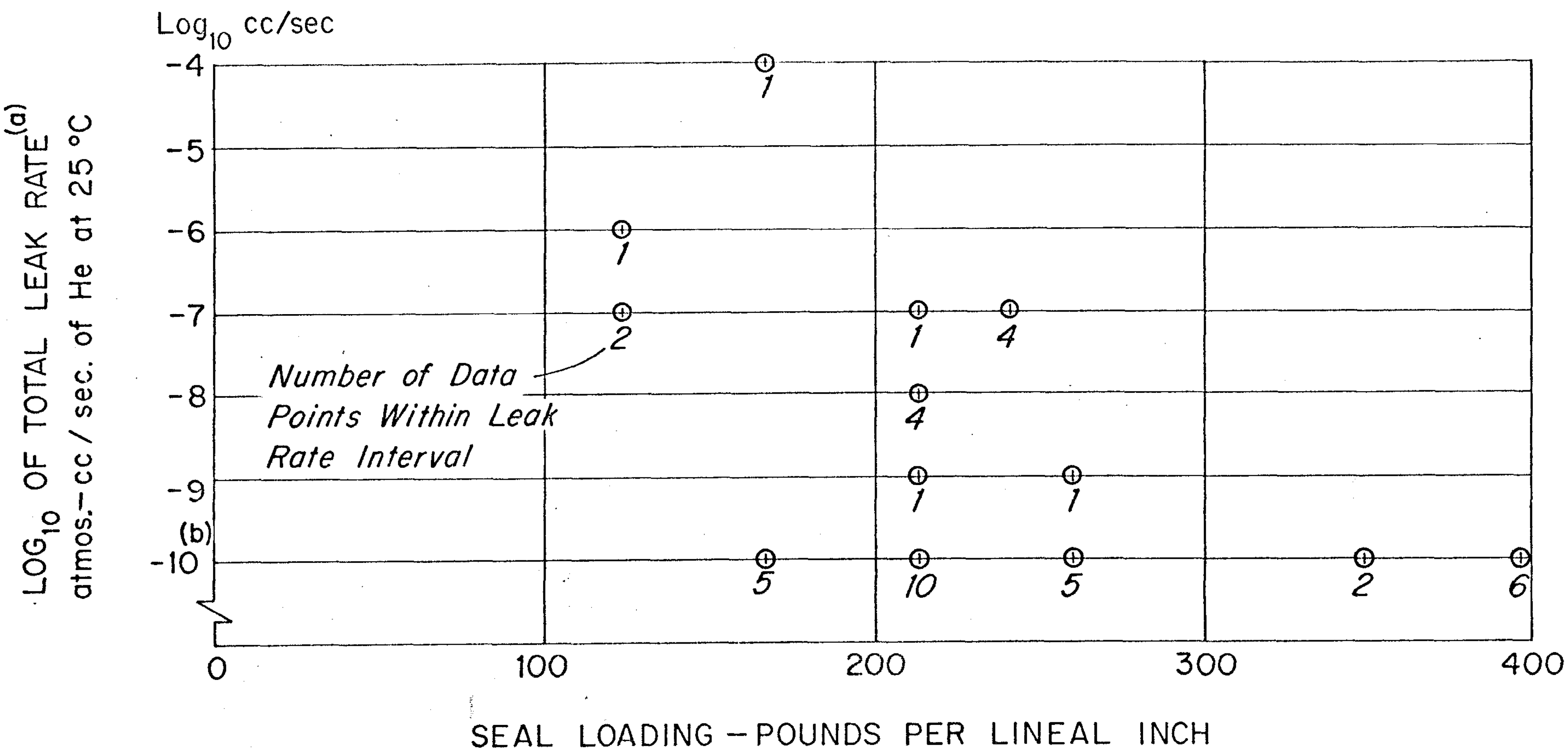


FIG. 1--CONFINED INDIUM SEAL SECTION



(a) Values of Leak Rate $\geqq 10^{-9}$ cc/sec Rounded to Nearest Integer

(b) All Values of Leak Rates $< 10^{-9}$ cc/sec (i.e. no indication)

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FIG. 2--CONFINED INDIUM SEAL LEAK RATE AS A FUNCTION OF SEAL LOADING

Seal cycled approx. 7 times at 396 lbs/inch without leak check between each cycle; then leak rate was measured at indicated seal loading (sequence random)