

# The closure of high pressure vessels: a hydraulic high-torque wrench\*

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There are two main groups of closures for high pressure vessels. These are:

(a) the self-sealing closures which require only a small force to close them and are made tighter by the applied pressures, and

(b) the non-self sealing closures. These require the sealing surfaces to be forced together with a force at least equal to that which will be exerted on the closures by the pressure. When the pressure becomes high enough the force squeezing together the sealed surfaces is counter-balanced by the pressure, and the seal leaks. The maximum pressure obtainable without leaks is thus a function of the force applied to the sealing surfaces, and so of the torque applied to the tightening nut. Consequently the seal acts as a safety valve.

The safety valve thus obtained is often very valuable if the pressure becomes dangerously high. For example, if a chemical reaction which is being carried out in a closed system becomes explosive the pressure in the reaction vessel may become very high before there has been time enough for material to leave the vessel by the normal exit and burst the safety-disc. If the seal of the vessel opens at a pressure sufficiently below the bursting pressure the danger due to the explosion is reduced.

The higher the pressure and the larger the vessel the more difficult it is to provide the closing force necessary for such a seal to be used. This force can be somewhat reduced by using a partly self-sealing closure such as a lens ring, or a cone ring with an included angle of 40 or 50° between the faces, but it is still frequently rather high. For example a vessel which we use up to 1500 b ( $b \equiv \text{bar} \equiv 10^6 \text{ dyn cm}^{-2}$ ) and have tested to 2300 b has an internal diameter of 3 in. and is closed by a cone ring with an included angle of 40° between the sealing faces. The head, cone ring, and body are tightened by means of a gland nut with a 4 in. diameter thread with 12 threads per inch. A torque of 6000 ft.lb was required to tighten the vessel so that it would just open at its test pressure of 2300 b. If the seal is to be used as a safety valve this torque must be applied in a reproducible manner. The common practice of hitting a wrench with a sledge is not adequate. We have therefore devised, and describe in this note, a hydraulically operated torque wrench which can be easily and cheaply made and is suitable for an almost unlimited range of torques. It is not, of course, restricted to use with pressure vessels.

The wrench was made in order to tighten nuts with a

hexagon head and a similar hexagon was machined on the top of the body of the vessel. Two wrenches of the shape shown in the diagram were cut from 1 in. boiler plate steel, and short pieces were welded at the end of the arm of one of them to ensure that the ends were in line. The hexagons on the wrenches were cut with a diagonal inclined at an angle of 15° to the arm of the wrench so that by reversing and interchanging the wrenches they could be put in a suitable position for use with the jack no matter what was the relative positions of the hexagons on the body and the head. It is necessary to leave a gap, in which the wrench can be rotated, between the nut and the hexagon which is on the body. The jack which is used to force apart the ends of the wrenches is a 4 ton hydraulic jack (by Blackhawk Mfg. Co.). The force exerted by the jack is measured by measuring the oil pressure with a

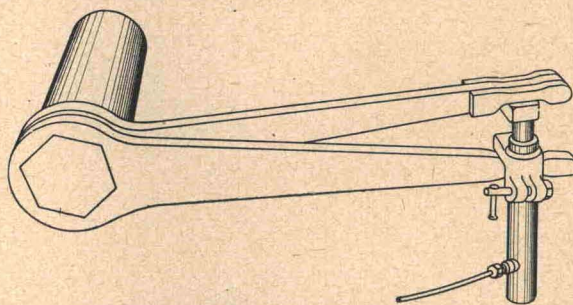


Diagram of torque wrench

Bourdon gauge. The torque exerted on the nut is easily calculated from the area of the piston of the jack, the pressure of the oil, and the distance between the jack and the axis of the nut. Any required torque is readily reproduced, and the opening pressure of the vessel can be reproduced to about 150 b in 2300 b. Wrenches of a given size can be used for smaller hexagons by inserting appropriate spacers between the wrench and the nut.

That the safety valve obtained in this way is effective is shown by the results of an explosion which we had in this laboratory. The explosion occurred in both the vessel and its connecting tubing. The tubing, which bursts at 5000 b or higher, ruptured, and a Bourdon tube was overstrained by an amount which suggests that it was subjected to about 5500 b. Although the explosion also occurred within a vessel of 1 litre capacity no detectable change within  $\pm 0.0005$  in. of the internal dimensions occurred. The yield pressure of the vessel was about 2500 b so we infer that the seal opened before the pressure had risen much above this value.

A similar principle has been used previously\* to close vessels intended to hold steam at pressure up to 55 b. The ends of the wrenches were forced apart by means of a screw thread and no provision was made for measuring the torque.

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\* OSBORNE, N. S., STIMSON, H. F., and FLOCK, E. F. *J. Res. Nat. Bureau Standards*, 5, p. 411 (1930).