Platinum Bursting Discs

APPLICATIONS IN THE PROTECTION OF CHEMICAL PLANT

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In any closed system under pressure the use of a safety device to protect the vessel against excessive internal pressure is essential. For many years the only method available was the use of a safety valve.

By far the most commonly used device of this kind has an escape vent normally closed by a conically seated plug held in place either by a spring or a dead weight. When the internal pressure is sufficient to overcome the retaining force the valve plug is lifted allowing pressure relief.

While simple and robust, the safety valve has its limitations. It is difficult to obtain a leak-proof seating between the conical plug and the vent; the working parts are difficult to protect against corrosion, the seat may be stuck to the vent by resinous material, while its small relieving area and high inertia make it ineffective against explosions.

Other devices have been suggested and many attempts have been made to produce designed weak spots in equipment by accurately machining grooves or slots in the walls of the pressure vessel. These methods relied on delicate precision machining and were often extremely difficult to execute. While in principle sound, in practice no reliable prediction could be made about the pressure at which the weak spot would yield.

The idea of using a thin breakable membrane to ensure the safe relief of pressure in a closed vessel is simple, direct and therefore attractive. The major difficulty that hindered the adoption of the method lay in ensuring that discs fitted successively into the same holder would always break at the same pressure. Attempts to produce foils that would answer this requirement were always unsuccessful until a technique was developed for rolling very thin foil of uniform and reproducible quality. Once this difficulty was overcome, a method of protecting pressure vessels was available that suffered from none of the above disadvantages, and the wide use of bursting discs throughout the chemical and petroleum industries now points to its established success.

As a protection device, a bursting disc must successfully perform two functions; it must burst when the pressure in the system reaches a certain value, and it must withstand without rupture all lower pressures to which it may be subject during working.

The mathematical relationship between the fluid pressure exerted on one face of a circular disc and the spheroidal form the disc assumes has been expressed by Lake and Inglis (1). Since the bursting pressure of a disc in a given orifice at constant temperature is dependent upon its thickness and the metallurgical condition of the foil, it is possible to make discs with a predictable bursting pressure from foil of precise thickness provided only that careful attention is directed to reproducing the exact composition and metallurgical condition of the foil. By close production control and special rolling techniques discs can be manufactured to burst with a tolerance of 5 per cent on the bursting pressure.

The use of a bursting disc to protect systems operated under pressure ensures that the system is leak-proof and that any abnormal working conditions or incorrect assembly will cause the disc to "fail safe".

Although some non-metals, notably graphite, have been used for bursting discs, the vast majority of discs have been made from

Bursting discs provide the simplest and most certain form of protection against the effect of excess pressure in a closed vessel. They cannot fail to operate, they have very low inertia, and they open immediately to provide an unobstructed passage for the relief of pressure. For corrosive conditions, platinum bursting discs are simple to install, inexpensive to replace, and can be used at relatively high temperatures. The illustration shows an eight-inch diameter narrow-face capsule type holder with platinum bursting disc and stainless steel vacuum support, the latter serving to prevent collapse of the disc under vacuum conditions.

metal foils. The most commonly used metals fall roughly into two groups which approximately reflect their individual tensile strengths. Metals such as aluminium, copper, silver, palladium and gold form a group that are particularly useful for low pressure applications. A second group including nickel, Monel and stainless steel are employed for high bursting pressure requirements and are especially useful for discs which are exposed to elevated temperatures.

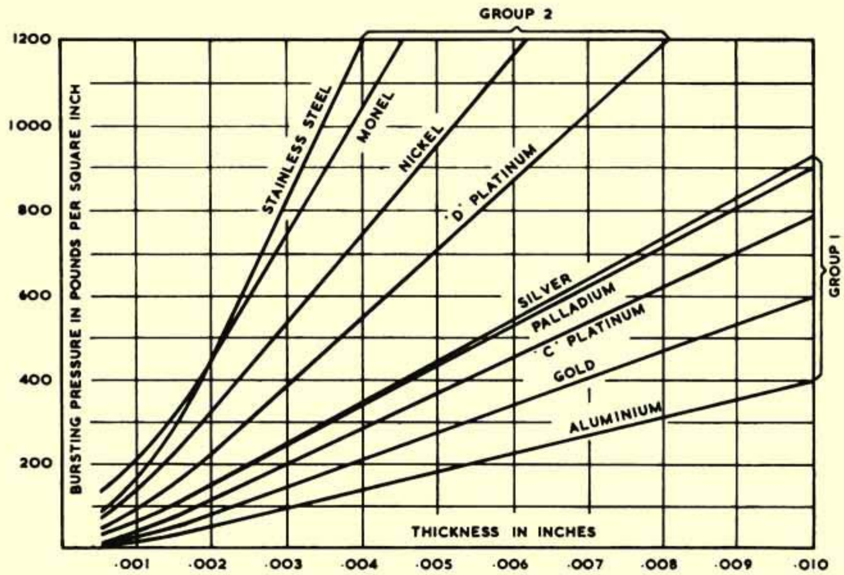
Platinum, by virtue of two alloys specially developed by Johnson Matthey, spans both groups and the high melting point, high annealing temperature and excellent resistance to creep of both alloys allow their safe use up to 450°C. Coupled with these advantages the pre-eminent resistance of both alloys to corrosion makes platinum the most versatile material available.

The use of pure metals is preferred for the manufacture of bursting disc foils because they can be obtained in a high state of purity. Extremely pure platinum can be prepared, but foil rolled from this material possesses a coarse grain structure and when subject to pressure an orange peel effect tends to develop on the spherical surface, destroying the cohesion of the foil.

By the accurate addition of minor quantities of other noble metals to platinum it is possible to produce thin platinum alloy foils with a fine grain structure in the annealed condition. Two such alloys have been developed known as "C" Platinum and "D" Platinum and each fits neatly into one of the two groups described above. The development of these two alloys permits the use of platinum over a very wide field of application.

The relationship between bursting pressure and thickness of various metals in a one inch diameter orifice is shown in the graph overpage; this also illustrates the grouping of the metals into two classes.

If a bursting disc is to operate successfully it must be mounted in a correctly designed



The relationship between pressure P and original thickness T for various disc materials in an orifice of one inch diameter (D). For other orifice diameters the bursting pressure may be calculated from the formula $DP/T=K$, where K is a constant for a particular material.

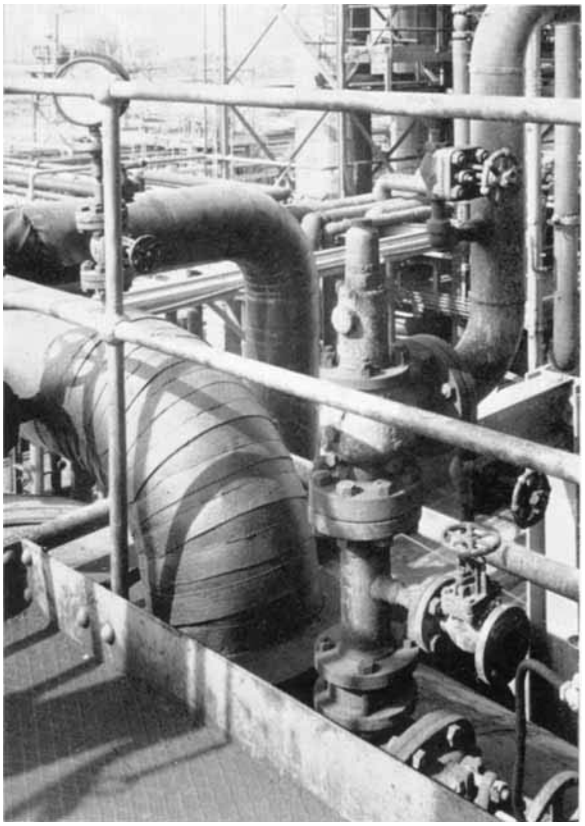
holder. The disc must be clamped between two smoothly machined flanges with an accurately machined radius on the edge of the orifice against which the disc bears.

The narrow face capsule type holder shown on page 43 is the one most commonly used. This assembly includes a vacuum support which fits into the locating recess, and the outside diameter of the capsule is such that the assembly will fit neatly within the bolt circles of standard flanges as defined in British, European and American standard specifications. For high pressure applications, and especially for laboratory scale autoclave work, a plug type assembly is used similar to that described in British Standard 2915: 1959, "Domed Metallic Bursting Discs and Bursting Disc Assemblies".

The thickness used for bursting disc foils lies in the range 0.001 to 0.010 inch. Slow corrosion rates that may be acceptable for thick-walled vessels obviously cannot be tolerated for bursting disc materials, while it can be easily understood that quite minor chemical attack causing pits in the bursting disc foil would rapidly develop into pinholes rendering the disc useless. The complete corrosion resistance offered by platinum makes for its frequent selection as a bursting disc for corrosive media. Initially the cost of a platinum bursting disc may appear high, but it should be remembered that after the disc has burst the metal of the fractured dome is still attached to the disc periphery. Thus all the original metal can be recovered and returned for refining and credit. The loss of production time and of product through failure of a disc due to corrosion often proves that an alternative material to platinum cannot be afforded in the long run.

The excellent corrosion resistance of platinum favours its selection for bursting discs to protect autoclaves used for laboratory work, and the advantages of using one disc for different chemical conditions do not need to be stressed. The same reasons lead to the

A platinum bursting disc is installed in the ethyl chloride plant of the Associated Octel Co Ltd at Ellesmere Port. It is located in the pipeline near to the lower end of the ribbed ducting



choice for autoclaves used in small scale production of expensive or uncommon chemical compounds.

Numerous applications occur in the field of industrial organic chemistry. Platinum discs are used on vessels digesting wood under pressure with sodium bisulphite and solium hydroxide, and on vessels used in the manufacture of the sulpha drugs when the highly corrosive materials employed subject the system to constant attack.

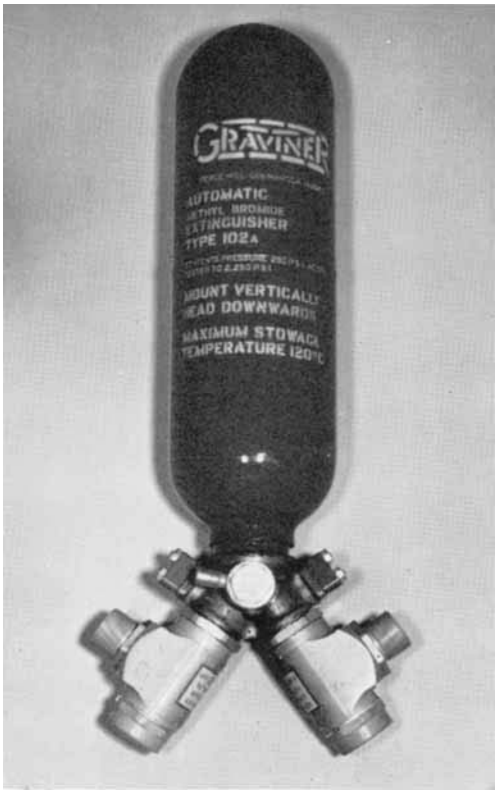
Many applications for platinum bursting discs are found in the petroleum industry, and a particular application is illustrated here. The photograph shows a narrow-face capsule type assembly, containing a platinum disc, clamped between the faces of two standard flanges, and located next to the lower end of the ribbed ducting. The disc is installed on a run-down tank used for chlorinated hydrocarbons and is normally in contact with ethyl chloride. This latter compound is an intermediate in the preparation of tetraethyl lead used in the production of the anti-knock compounds manufactured by the Associated Octel Co Limited at Ellesmere Port.

Platinum discs are also employed on storage vessels for hydrocarbons where they remove the possibility of slow corrosion arising from the presence of miscellaneous impurities. Their resistance to inorganic acids also permits their use on systems handling these fluids. A system in which platinum discs are used to protect a plant containing superheated water has been described by Patrick (2).

Some of the largest platinum bursting discs in use at the present time serve to protect the carboniser at the National Coal Board's Birch Coppice Colliery. The discs are eighteen inches in diameter and weigh approximately twenty ounces troy each. Platinum discs are employed because this is the only material which would withstand the corrosion products from coal dust and superheated steam.

An interesting application of platinum bursting discs is found in the Graviner fire extinguishing equipment used in modern jet aircraft. The extinguisher is generally installed in the wing of the aircraft and contains a liquid of relatively low boiling point. The platinum disc is fitted to relieve the internal pressure arising from volatisation due to inadvertent overheating. Without this safeguard the container could explode and so endanger the aircraft.

Various alternative methods of protecting the container were tried before a platinum bursting disc was selected. Experiments were



In the Graviner fire extinguishing equipment used in jet aircraft a platinum bursting disc is fitted at the three-way junction to relieve internal pressure due to inadvertent overheating

carried out using a soft metal plug in the side of the vessel. This was designed to melt if the vessel temperature rose above a dangerous level, but unfortunately the time lag between heat transfer to the plug and the build-up of internal pressure was too great and the vessels burst before the plug had time to melt.

Platinum was found to have complete resistance to seepage of fluid, and its corrosion resistance was excellent. The bursting pressure can be accurately predicted and a life of over five years can be expected.

References

1 G. F. Lake and N. P. Inglis, *Proc. Inst. Mech. Eng.*, 1939, **142**, 265–375

2 E. A. K. Patrick, *Trans. Inst. Chem. Eng.*, 1953, **31**, 114–119

Rhodium as a Polymerisation Catalyst

PREPARATION OF POLYBUTADIENE

In the production of synthetic rubbers from polymers and co-polymers of a series of dienes, notably butadiene, the properties and utility of the resulting polymer depend to a very great extent on the conditions of polymerisation and on the nature of the catalyst employed. Diene polymers and co-polymers are mixtures of 1,2 and 1,4 additions – each in the *cis*- and *trans*- form. Different methods of polymerisation cause certain structures to predominate and yield polymers of widely differing properties.

The stereo-specific activity of trivalent rhodium when used as a catalyst in the emulsion-polymerisation of 1,4 butadiene has recently been reported by R. E. Rinehart, H. P. Smith, H. S. Witt and H. Romeyn, of the United States Rubber Company (*J.A.C.S.* 1961, **83**, (23), 4864–4865). The chloride, nitrate and some other salts of trivalent rhodium were employed in dilute solution in water or ethanol and yielded polymers containing more than 98 per cent of the *trans*- structure. This form of the polymer is hard, brittle and crystalline, compared with the usual rubbery material which consists largely of the *cis*- structure. The novelty of this finding lies in the fact that stereo-specific polymerisations of dienes had not previously been possible by the commonly-used emulsion polymerisation technique, as catalysts which could be employed are affected by water.

Applications of this technique for the production of *cis*-polybutadiene offers very interesting commercial possibilities. This type of rubber is said to have considerable advantages over natural and styrene-butadiene rubbers in the manufacture of heavy-duty tyres, in that it exhibits higher recovery rates from load strains and better resistance to undesirable temperature rises.

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