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9 " Cavitation Problems in Sodium Valves",

X. ELIE, C.E.A., France.

ABSTRACT :

Cavitation poses few problems for sodium valves, in spite of the fact that the loops are not pressurized. This is no doubt due to the low flow velocities in the pipes.

For auxiliary loop valves we are attempting to standardize performances with respect to cavitation.

For economic reasons cavitation thresholds are approached with large diameter valves.

Introduction

Valves are, by nature, mechanisms in which the flow is disturbed ; often fluid speeds are greater there than in the pipe itself. They are therefore points where cavitation is likely to occur.

As Sodium loops are not pressurized, valves must be designed and operated with allowance for cavitation phenomena.

Practically all sodium valves are used for isolation only (to shut off flow). Except for highly specialized cases we are thus concerned only with the behaviour of valves in "fully open" position. Cavitation is considered acceptable during valve opening and closing cycles.

In this paper we shall examine the problems that arise for :

— auxiliary loop and test loop valves with nominal diameter of 300 mm maximum ;

— large diameter valves, i.e. valves for reactor secondary loops.

AUXILIARY CIRCUIT VALVES

At the present stage of L.M.F.B.R. development it has become necessary to develop a limited number of sodium valve models of reliable technology with performances adequate for large-scale secondary loop and test loop applications.

We have therefore defined general operating specifications for valves up to 300 mm diameter*. One of these specifications is relevant to cavitation phenomena :

"With the valve open, no cavitation should be detected for a sodium flow rate of 7 meters per second in the pipe, when the out-flow pressure is equal to atmospheric pressure".

Compliance with this specification is checked during qualification testing with sodium.

This general specification covers most service requirements except for sodium loop quick drain valves : a flow rate of 10 meters per second or even higher can be reached in the drain lines. However, it has not been considered necessary to provide a particular specification for these valves which are rarely subjected to rated sodium flow, and then only for short periods of time.

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* C.E.A./DEDR/DRNR/STRS/Bureau de Valorisation - Recommandation n° 3 - March 1974 -

a) Gate Valves (Figure 1)

Gate valve designs are particularly advantageous from the standpoint of cavitation :

— The fluid is not subjected to changes in flow-direction ;

— Full or practically full flow section ;

— Few or no obstacles in the flow channel.

Specifications compliance thus poses no manufacturing problems.

No operating incidents have ever occurred with this type of valve, particularly as flow rates in existing loops only rarely exceed 5 m/sec.

b) Globe Valves (Figure 2)

Fluid flow in globe valves is considerably more disturbed than for gate valves, because of the modified flow direction and the presence of obstructions in the flow channel.

The difference between the two types of valves is readily apparent in their respective pressure drop coefficients with respect to line flow-velocity

$$K \leqslant 0.5 \text{ for gate valves ;}$$

$$K \leqslant 5 \text{ for globe valves ;}$$

$$\text{where } K = \frac{\Delta_p}{\frac{1}{2}\rho v^2}$$

Valves of this type are frequently subject to cavitation phenomena in operation on test loops, even in wide-open configuration and at flow rates of 5 m/sec. In most cases, however, such cavitation is imperceptible except with high-precision measuring techniques, and may be disregarded.

No visible effects (erosion) have ever been observed from this cavitation.

A significant example is provided by the initial sodium cavitation test program in May, 1969, on an existing loop used to calibrate flowmeters : a large number of globe valves had to be removed from the circuit, as they induced spurious noise sufficient to impair acoustic methods of detecting the cavitation threshold in the test section.

In the RAPSODIE, PHENIX and SUPER-PHENIX reactors, globe valves are used only on circuits where the flow rate does not exceed 3 m/sec. Cavitation is thus unlikely to occur and has, in fact, not been detected to date.

Sodium qualification testing, which begins in 1976, will show whether globe valves can meet specification criteria (i.e. no cavitation at a flow rate of 7 m/sec).

LARGE-DIAMETER VALVES

The large-diameter valves on reactor secondary circuits are used to isolate the steam generators at actuation speeds which vary according to the individual reactor design.

a) PHENIX valves (Figure 3)

Combination plug-gate valves are used in PHENIX, with quarter-turn actuator for lateral plug closure and withdrawal.

For reasons of cost economy, restricted-flow valves have been used (380 mm dia. flow section for 500 mm dia. in the pipe).

Under rated flow conditions, the mean flow rate at the neck is approximately 7,8 m/sec., with an outflow pressure of about 4 bars absolute.

No cavitation has been detected in open position during testing with water or in normal reactor service.

b) SUPER-PHENIX valves (Figure 4)

As the cost of extrapolating PHENIX valves to SUPER-PHENIX would have been prohibitive, research efforts were turned to developing butterfly isolation valves with the valve stem offset from the disc plane. It is assumed that such designs will provide adequate seat leakage characteristics under projected operating conditions.

A 900 mm prototype valve has been built and is scheduled for testing in water at full nominal flow rate in 1976.

Rated flow speeds in SUPER-PHENIX will be 5 m/sec., and downstream pressure will be approximately 4 bars absolute. No cavitation problems should arise under these conditions, in spite of the presence of a permanent obstruction in the flow channel.

For subsequent reactor designs, economic feasibility studies indicate that it would be advantageous to increase the flow speed in the secondary lines, thus reducing both the total sodium mass and the mass of steel structures.

Of course there is an upper limit beyond which cavitation will occur, and the major question is whether or not this limit is reached before the point of maximum economy.

At present this question remains unanswerable for two reasons :

— the cavitation threshold of such valves is not yet known ;

— the optimum flow speed is dependent on the design characteristics of the loop.

CONCLUSION

Sodium valve design and the relatively low flow speeds encountered in sodium loops are such that no serious cavitation problems arise even in low pressure operation.

It must be kept in mind, however, that valves are among the loop components which are most sensitive to cavitation phenomena.

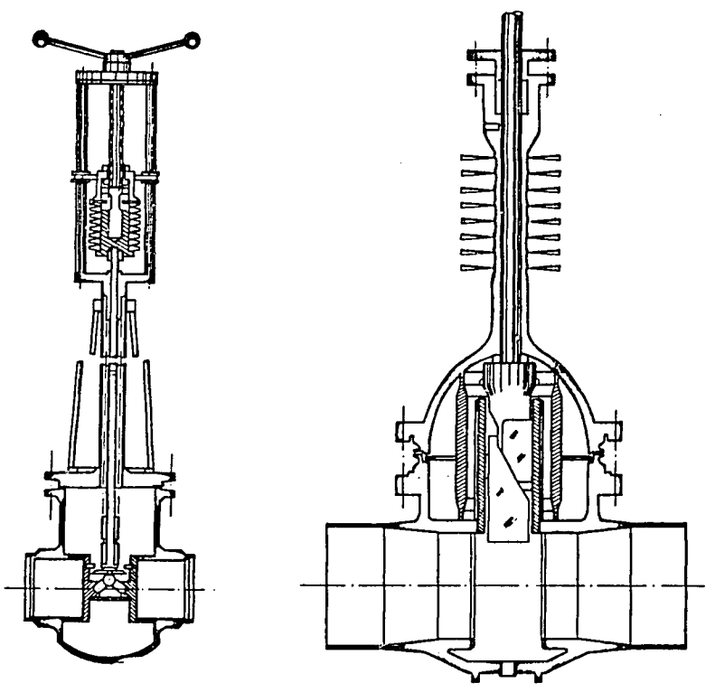
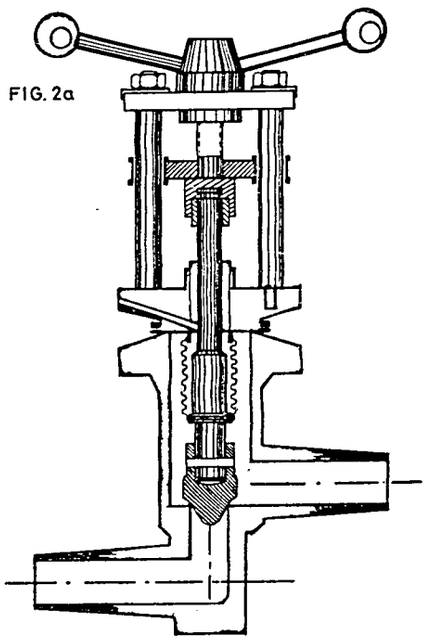


FIG.1 GATE VALVES

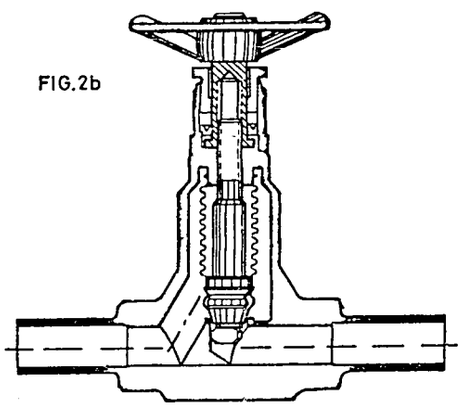
GLOBE VALVE WITH MISALIGNED ENDS

FIG. 2a



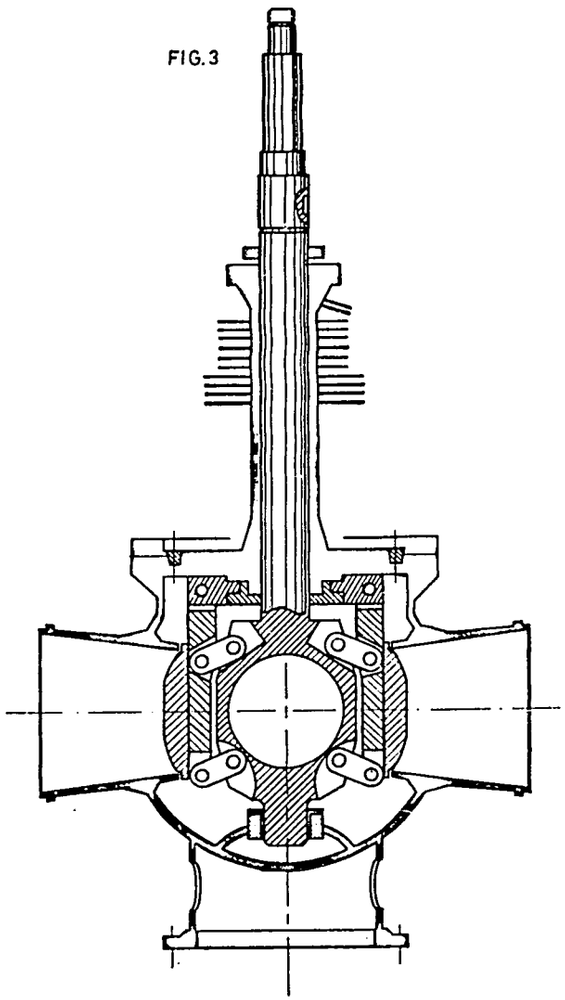
GLOBE VALVE WITH ALIGNED ENDS

FIG.2b



PLUG VALVE

FIG.3



ISOLATION BUTTERFLY VALVE

FIG.4 -900mm DIA-