UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
230 PEACHTREE STREET, N.W. SUITE 1217
ATLANTA, GEORGIA 30303

MAR 2 9 1977

Central File
50-390
391

In Reply Refer To:
IE:II:NCM
50-438 50-327
50-439 50-328
50-259 50-390
50-260 50-391
50-296

Tennessee Valley Authority
ATTN: Mr. Godwin Williams, Jr.
Manager of Power
830 Power Building
Chattanooga, Tennessee 37401

Gentlemen:

The enclosed Circular is being distributed for information, in the belief that the subject matter is of sufficient safety significance to warrant specific attention. A specific reply is not requested.

Sincerely,

Norman C. Moseley
Director

Enclosure:
IE Circular 77-05
"Liquid Entrapment
in Valve Bonnets"

A0 2

6D

IE Circular 77-05
Date: March 29, 1977

FLUID ENTRAPMENT IN VALVE BONNETS

Description of Circumstances:

Gate valves of the type known variously as "split-disc," "flexible-disc," "double-disc," etc., have the ability to seal against both seats at the same time. Under certain circumstances, when the valve is closed, fluid may be entrapped in the bonnet cavity, and if the system is then heated up, an uncontrollable rise in pressure in the bonnet cavity can result. The reported effects of such pressure rise range from inability to open the valve, to structural failures of internal parts of the valve or failure of the bonnet. Consequences range from loss of function of the valve to fluid escape and injury to personnel or damage to equipment in the vicinity. Detailed information is provided in the enclosure to this Circular.

Discussion:

The most common cause of fluid entrapment is the orientation of the valve. Valves in pipelines where the pipe is horizontal, or nearly so, and where the valve stem is oriented horizontal or below the horizontal, result in the bonnet cavity constituting a drain pocket, where process fluid or condensate can collect while the valve is open. If the valve is then closed the drainage is trapped. Valves are often installed in such positions for reasons of space or operator convenience. Other pipe and valve orientations can, under credible circumstances, entrap fluid. An example is filling a section of steam line for hydrostatic test, draining the line without opening that particular valve, and then heating up the line with steam. A variety of actions have been proposed to alleviate the situation, including internal pressure relief passages, external pressure relief paths, and specially controlled procedures.

You may wish to alert your engineering, operating and maintenance staff to the existence and characteristics of the subject of this circular, and to consider the potential of your facility(s) for an occurrence of the type described. Depending on circumstances, any of a variety of corrective actions may be appropriate. Most of these are, however, susceptible to human error, and, to the extent feasible, we suggest that valves be installed to minimize the potential for entrapment of fluid.

Enclosure:
Ltr., dtd 2/24/76, P. H. Awtrey,
Walworth Co., to J. H. Tillou,
NRC, w/encl.

Walworth Company

P.O. Box 1103, Huff Avenue
Greensburg, Pa. 15601
(412) 837-6100

February 24, 1976

United States Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive
Arlington, Texas 76012

Attention: Mr. J. H. Tillou, Chief
Licensee Contractor and
Vendor Inspection Program

Subject: Potential Overpressurization Problem in Valves

Gentlemen:

Confirming our conversation of January 30, 1976, this is to advise you of the possibility of an overpressurization that can happen in gate valves having flexible wedges or having discs with equivalent flexibility. Our particular concern is with Pressure Seal steel gate valves having flexible wedges and being installed with the stems horizontal or below horizontal.

Overpressurization is covered in the following paragraphs from ANSI B31.1-1973, "Power Piping" and ANSI B16.5-1973, "Steel Pipe Flanges, Flanged Valves, and Fittings":

ANSI B31.1-1973, Page 26, Paragraph 107.1C

> Where liquid trapped in a closed valve can be heated, an uncontrollable rise in pressure can result. (An example might be a flexible wedge gate valve, installed with the stem horizontal, having heat from warm-up of the pipeline applied to liquid from the testing, cleaning, or condensed fluid, such liquid being entrapped in the bonnet section of the closed valve.) Where such a condition is possible, the Owner shall provide means in design, installation, and/or operation to assure that the pressure in the valve shall not exceed that allowed by the Code for the attained temperature. Any resulting penetration of the pressure wall of the valve shall meet the requirements of this Code and of drains in ANSI B16.5.

United States Nuclear
Regulatory Commission

February 24, 1976

ANSI B16.5-1973, Page 2, Paragraph 2.2.3:

> Fluid Thermal Expansion. Certain double seated valve designs are capable of sealing simultaneously against pressure differential from the bonnet section to the adjacent pipe in both directions. In such valves, a circumstance in which the bonnet section is filled with liquid and subjected to an increase in temperature can result in build up of pressure in the bonnet section. Where such a condition is possible, it is the responsibility of the purchaser to provide or require to be provided means in design, installation, and/or operation to assure that the pressure in the valve shall not exceed that allowed by this standard for the attained temperature.

For discussions and recommendations concerning this subject in the aforementioned valves, please refer to attached Exhibits A, B, and C.

We shall be available for discussion relating to this or shall try to supply further data if desired.

Yours very truly,

P. H. Awtrey
Chief Engineer

PHA:mc

Attachments

P.S. Concerning the Exhibit A (BUSHIPS Instruction 9480.72 with its Enclosure 1), attached copies of letters of February 2 and 12 give permission to release this information.

Walworth Company

P.O. Box 1103, Hoff Avenue
Greensburg, Pa. 15601
(412) 837-6100

February 2, 1976

Naval Ships Engineering Center
Center Building
Prince Georges Center
Hyattsville, Maryland 20782

Attention: Mr. J. F. Conway, Section Head
Valves, Piping Components, and Structural Analysis Secti
Code 6153E

Subject: BUSHIPS 9480.72
Ser 648A5-308
18 June 1964

Gentlemen:

Confirming our telephone conversation of today, permission is requested for Walworth Company to submit a copy of the subject letter, along with its Enclosure 1, to the United States Nuclear Regulatory Commission for use by it in dealing with a possible problem in overpressurization of valves.

I have discussed with the Nuclear Regulatory Commission the possiblity of overpressurization, especially as applied to steel gate valves having flexible wedges and mounted with the stem horizontal or below horizontal, and would like to use the subject document as background material.

If you have any later material that could likewise be used on this subject, I would appreciate receiving a copy and permission to submit it to the Nuclear Regulatory Commission.

Yours very truly,

P. H. Awtrey
Chief Engineer

PHA:mc

NAVAL SHIP ENGINEERING CENTER
CENTER BUILDING
PRINCE GEORGE'S CENTER
HYATTSVILLE, MARYLAND 20782

IN REPLY REFER TO
6153E3/ECC
9505
Ser 287

12 FEB 1976

Walworth Company
P.O. Box 1103 Huff Avenue
Greensburg, Pennsylvania 15601

Attention Mr. P.H. Awtrey
Chief Engineer

Gentlemen:

Enclosure (1) is forwarded in response to your letter of 2 February 1976.

Please be advised that the Naval Ship Engineering Center has no objection to enclosure (1) being used in any articles or conversations pertaining to the subject in question.

As a matter of information, the pertinent contents of enclosure (1) now, and have for some years, formed an integral part of the overall steam system design requirements for Ships of the United States Navy.

Sincerely yours,

J. F. CONWAY
Head, Valves, Piping Components and
[illegible]
[illegible]
By direction of Commander
Naval Ship Engineering Center

Encl: (1) BUSHIPS INST 9480.72
Ser 648A5-30 of 18 June 1964

PEOPLE—PERFORMANCE PRIDE—PROFESSIONALISM

EXHIBIT A

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO
BUSHIPS 9480.72
Ser 648A5-303
18 June 1964

BUSHIPS INSTRUCTION 9480.72

From: Chief, Bureau of Ships
To: Distribution List

Subj: Surface ship steam system valves, operation of prior to warmup

Encl: (1) Requirements and Procedures for Modifying Steam System Flexible Gate Valves as Necessary

1. Purpose. To promulgate instructions concerning the operation of valves prior to the admission of steam to the system.

2. Scope. This instruction applies to all valves in surface ship steam systems of non-nuclear construction. It does not apply to nuclear construction for which separate requirements have been developed. Further, although specifically directed at protecting flexible wedge gate valves from overpressurization, this instruction applies to all steam system valves due to the desirability of removing water from all components of steam systems prior to warmup.

3. Background. The purpose and primary reason for using flexible wedge gate valves in steam systems is to prevent binding when the valve is in the closed position. In high pressure-temperature steam systems, pipe line expansion produces stresses and strains at valve end connections which tend to slightly distort the valve bodies. If the valve wedge is solid, this distortion will cause the valve seats to press against the solid wedge, and, in effect, clamp the valve shut. This problem is overcome with flexible wedges, which are best described as two circular plates attached to each other by an integral hub in the center. With this design, the wedge will flex as the valve seats press against it, thus avoiding the clamping effect. Because of this very desirable characteristic, the Navy, as well as industry, uses flexible wedge gate valves in all cases where piping system expansion is a significant factor.

4. Discussion. The necessity of draining steam systems prior to putting steam on the line is mentioned in several documents, including the BUSHIPS Manual. Unfortunately, it is not adequately covered in these documents and there have been instances where the preparatory action of drainage prior to steam admission has been overlooked. As a result, several isolated instances of serious damage to flexible wedge gate valves have occurred. It is characteristic of flexible wedge gate valves that if water enters the body neck as a result of system hydrostatic tests, or by other means, while the valve is closed, it will be trapped, regardless of the valve position, unless the valve is either opened or the water is removed via a body neck drain. Briefly, this is due to the fact that with the valve in the closed position

ınd a differential pressure across the wedge, the upstream side of the wedge vill move away from its seat, permitting water to enter the neck cavity. ıs the body neck and line pressures equalize, or the pressure is rapidly ;aken off the line, the upstream side of the wedge moves back against its ;eat, sealing off the body neck and trapping any water which may have entered.

If the water remains in the body neck, as it will if the valve is ıot cycled or drained, and steam is put on the line, a situation closely llied to a boiler without a relief valve exists. The steam having a higher ressure than the water in the neck, will prevent water from flowing into the ine even though the upstream face moves away from the seat. As the ressure equalizes, the cycle whereby the water initially became trapped, s repeated, only this time the water has been heated by the incoming steam.

The steam, however, continues to heat the water due to its close roximity and higher temperature, causing the water to expand. If the initial uantity of trapped water was large enough, the initial temperature differ- ntial between steam and water great enough, and the heating cycle continues ninterrupted, the end result is predictable. The water pressure will build p, due to the water's expansion being restricted, until either the body eck ruptures, the bonnet lifts off, or the seat rings collapse.

It should be noted that this phenomena has been proven by calcula- ions and controlled tests, during which a pressure was generated in the ody neck equal to ten times that which existed in the line. As far as actual ıstallations are concerned, there are only two known cases where this over- essurization has resulted in damage on non-nuclear surface ships and both ccurrances would have been avoided had proper warmup procedures been employed.

Action.

a. Warmup Procedures. The following steps should be incorporated to all operating procedures covering warmup of steam systems, if they ready do not form a part of same, prior to the admission of steam:

(1) Cycle all valves to ascertain that they are operational and ave them in the open position for at least one minute to permit drainage the body into the line.

(2) Open all drains on the valve bodies and in the line.

(3) Line up the system for warmup in accordance with existing rating procedures. All valve body drains should be left open to permit inage throughout the warmup period. Other drains should be positioned existing instructions.

(4) Proceed with warmup operation and close valve body drains at the conclusion of same.

b. Modifications. Valves located with their stems below the horizontal may require modification in addition to the requirements of section 5.a to protect them from the possibility of overpressurization. The modifications and how to perform them, as necessary, are given in enclosure (1). These modifications are generally considered to be outside the normal capabilities of a ship's force. Therefore, they should be performed during a shipyard or tender availability period.

c. BUSHIPS Manual. The Manual will be revised with regard to steam system drainage and the subject will be considerably amplified.

6. Effective Date. This instruction becomes effective upon receipt.

J. J. Stillwell
By direction

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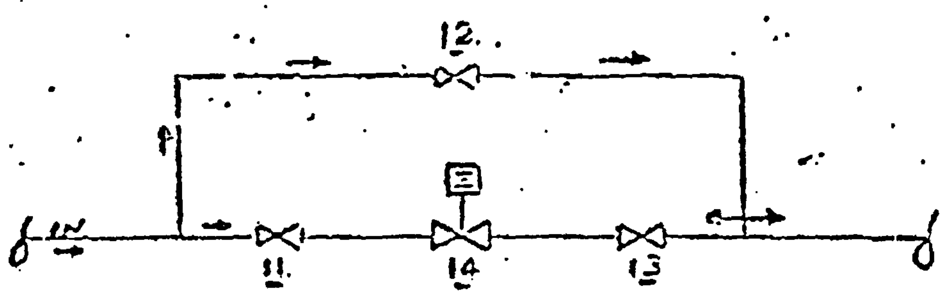
X-7 BUSHIPS Special List

There is one other example, which follows, and which has been included to demonstrate the care that must be taken in determining whether a valve is "one" or "two" way and, further, the care which must be taken in determining the correct modification.

The case in point is a conventional reducing station, per the following sketch:



The valves to be considered here are 11, 12 and 13.

Valve 11 is a one way valve, when closed, with steam pressure always coming from the "IN" side.

Valve 12 is a throttle valve, globe or needle type, and is not involved.

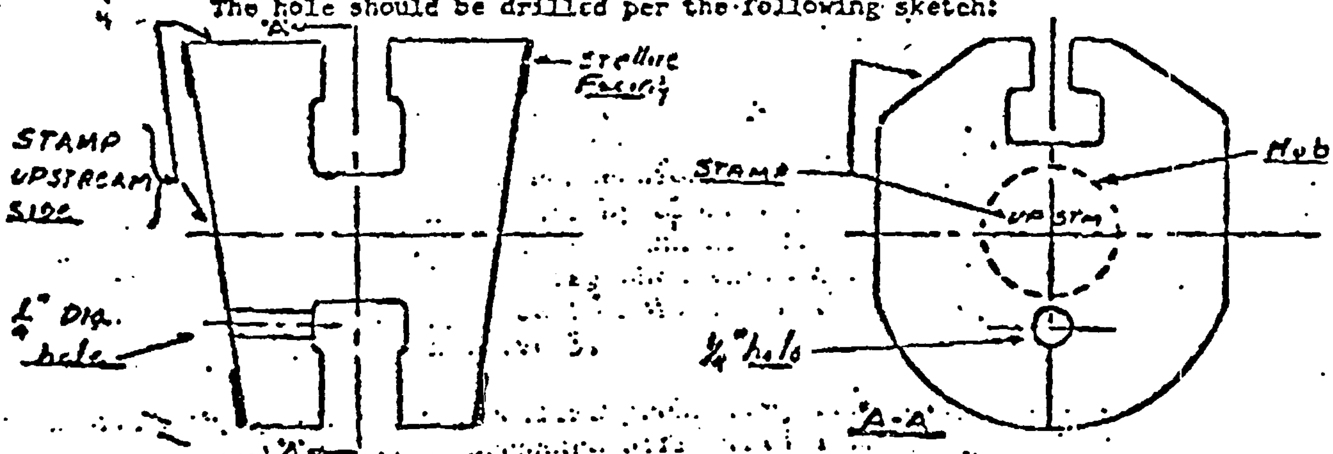
Valve 13 is a one way valve BUT, it is a one way valve in the direction opposite to normal. If valves 11 and 13 are closed to isolate valve 14, and 12 is opened for operational purposes, then valve 13 will be pressurized from the downstream side and it must be modified accordingly.

With the above examples as a basis for determining the type of valve, the modifications to be applied are:

a. One way valve - Drill a hole in the upstream side of the wedge.

b. Two way valve - Install a drain to atmosphere in the valve neck.

The hole should be drilled per the following sketch:



The "one way" valves in the above sketch, by the aforementioned nition, are 5, 6, 7, 8, 10.

The "two way" valves in the above sketch, by the aforementioned nition, are 3, 4 and 9.

The "borderline" valves, depending upon a particular installation are d 2.

Based on the above sketch, the definition of a "one way" valve can xpanded as follows:

a. Any valve located in a system after any cross connections so it cannot be pressurized from the direction that is opposite to al. Refer to valve numbers 5, 6, 7, 8, 10.

b. The last valve in any system. Refer to valve numbers 5, 8, 10.

c. Any valve located before any cross connection: from other ems, which has a valve located between it and the cross connection, at it can be isolated if the cross-connect valve is open. For example, s 1 and 2 can be isolated if the cross-connect valve 9 is opened, osing valves 3 and 4, respectively. Since these valves will only ze pressure* from the boiler side normally and can be isolated from systems, they can be considered as "one way" valves.

Valves 1 and 2 therefore are examples of the "border line" mentioned above. If valves 3 and/or 4 were not present, then valves /or 2 must be considered as "two way" valves since it would not be ble to isolate them if valve 9 were open.

efinition of "two way" valves can be expanded as follows:

a. Any valve which will be pressurized* in the direction ite to normal when cross connections are opened. Refer to valve rs 3 and 4 which are normally pressurized* from the boiler side but osed and the cross-connect valve is open (valve 9), they would be rized from the opposite direction.

b. Any valves in branch connections which lead to a common header annot be isolated from the header by closure of a valve between them e header. Refer to valve numbers 3 and 4. If boiler "B" was secured lves 2 and 4 closed to isolate it, then valve 4 would be pressurized* he boiler "A" side, or opposite to normal. Reversal of this procedure then replace valve 4 with valve 3.

The terms "pressurized", "realize pressure", etcetera, refer to lves being subjected to a pressure differential when in the closed on.

REQUIREMENTS AND PROCEDURES FOR MODIFYING STEAM

SYSTEM FLEXIBLE GATE VALVES AS NECESSARY

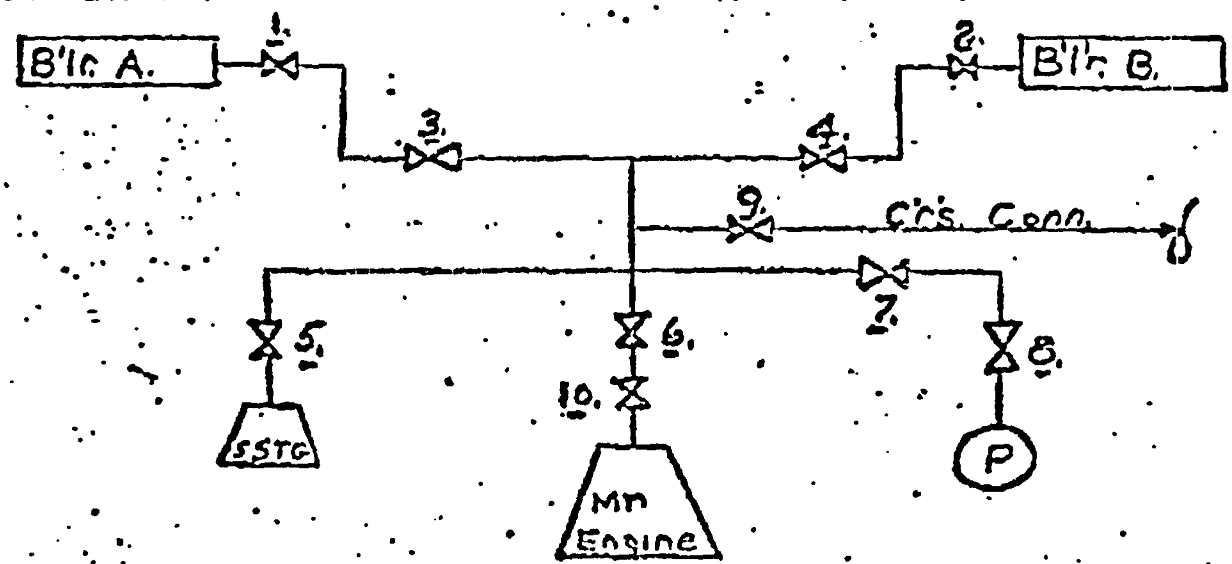
If a gate valve is installed with its stem located below the horizontal and a drain is not located on the valve neck, there is no means of removing any water which might be located therein except by cycling the valve. The wedge or disc entering the neck cavity will displace its volume of water into the piping system, where it can be drained off. Unfortunately, the quantity of water removed by this action from the necks of flexible wedge gate valves may not prevent overpressurization because the wedge only displaces about 30 percent of the neck cavity, which is not enough. Additionally, there is no way of preventing some of the displaced water from re-entering the neck cavity as the wedge is moved to the closed position.

This being the case, modifications may be necessary to all inverted flex-wedge gate valves in steam systems, if prevention of overpressurization is to be guaranteed. If these valves already have body neck drains, no modifications are necessary. The required modifications in turn, are dependent upon whether a valve is considered as being a "one way" or "two way" valve.

Briefly, a one way valve is any valve which when closed, will realize a pressure differential from only one direction under any conditions. Any valve whose location falls outside of this limitation is, of necessity, considered a two way valve.

There are valves which are borderline cases and/or can fall into either category, particularly if an error in line up is made. Therefore, the following sketches and more detailed description have been included to clarify what determines whether a particular valve is "one way" or "two way".

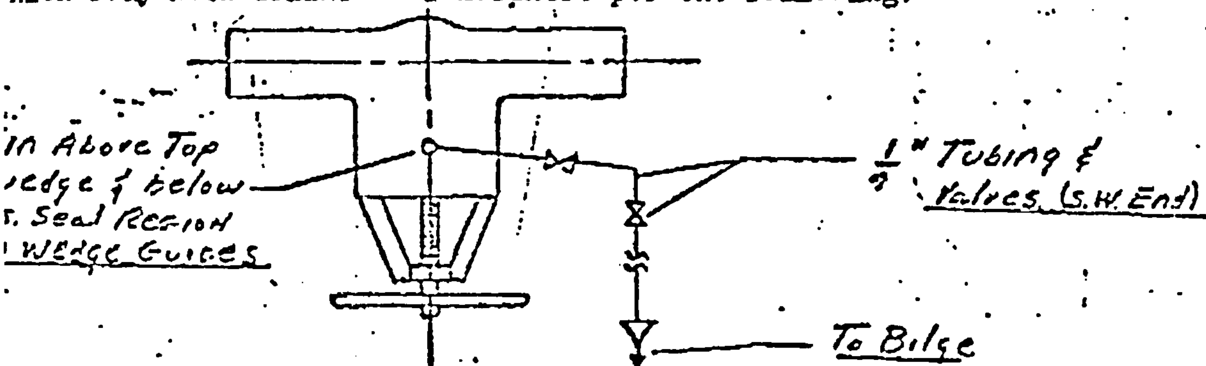
It should be noted that these examples do not take operator error into account.



A plate should be attached in a conspicuous location reading "THIS VALVE HAS A VENT HOLE IN THE UPSTREAM SIDE OF THE WEDGE. IF WEDGE IS REMOVED MAKE SURE IT IS REPLACED THE SAME WAY."

This modification for "one way" valves will prevent over pressurization since the hole provides a constant vent to the upstream piping. The reason for using this type of modification for these valves is to minimize the number of drains that must be installed.

For "two way" valves, the drilled disc is unacceptable since it would provide a constant leakage path through the valve when closed, and steam pressure is applied to the side opposite the drilled hole. Therefore, "two way" valves with the stem located below horizontal must be provided with body neck drains to atmosphere per the following:



NOTES -

1. Location of drain hole in the neck should be close to the top of the neck BUT care should be taken not to drill through the pressure seal region. Someplace between 1/3 to 1/2 down from the top of the valve (looking at the valve in the upright position) should avoid the region, but this should be checked before any drilling. See Note 9.

2. Pre-heating and stress relieving (as necessary) should be in accordance with MIL-STD-271A.

3. Drain valves per MIL-V-22094.

4. Welding per MIL-STD-278.

5. Drain holes into valve bodies shall be in accordance with MIL-STD-22A.

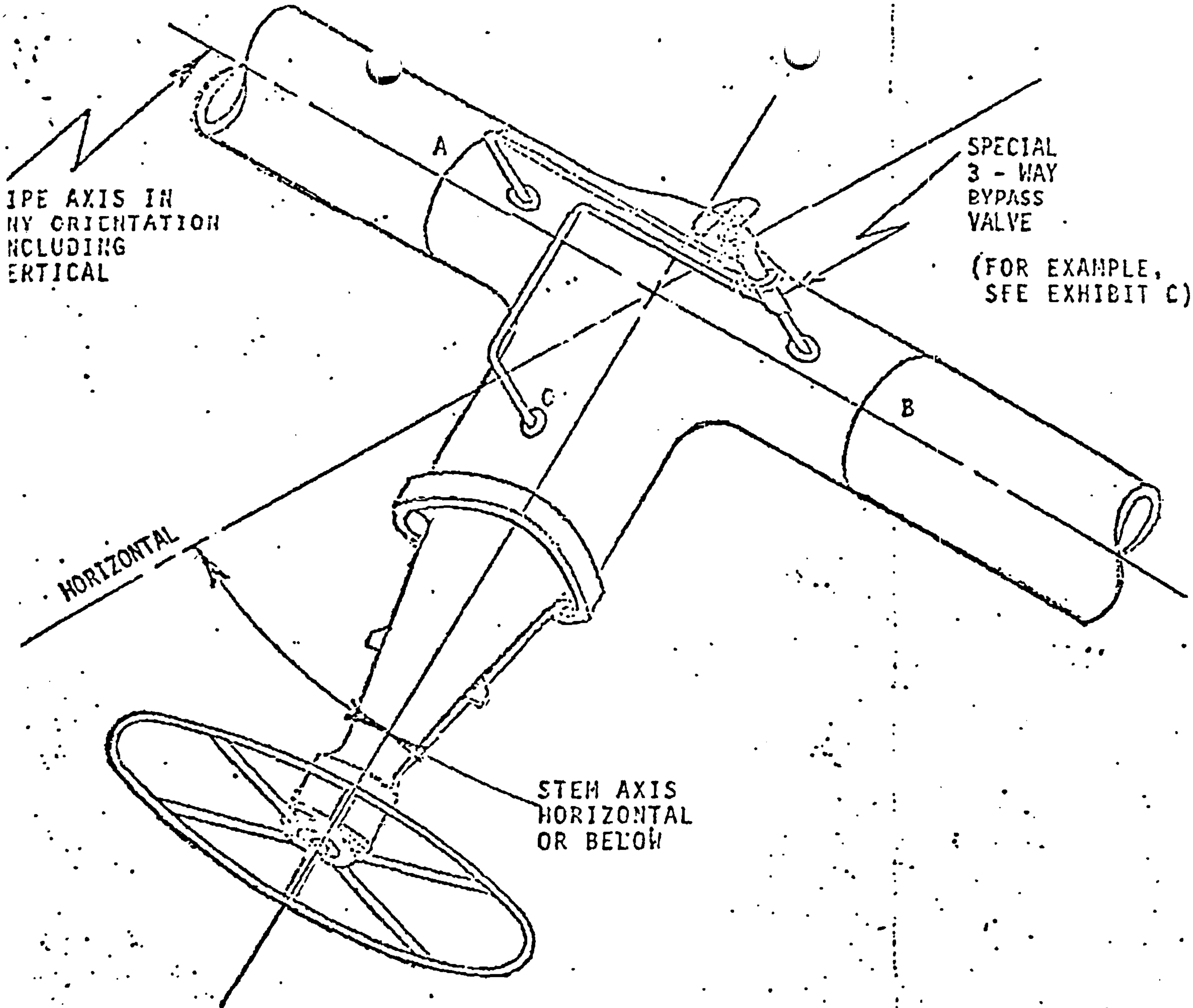
6. Drain valves and piping shall be 1/4" IPS. Materials same as gate valve body.

7. When drilling hole, drill far enough off center to avoid wedge guides inside the valve body.

8. Be careful to avoid valve stem if hole is drilled with the valve partially assembled.

9. The pressure seal region is in the top of the valve body and is evidenced by a stainless steel or stellited overlay; hole should be drilled below this overlay.

Enclosure (1)



1. Body neck "C" should be vented to pipe run "A" or "B" that is upstream by seating or backseating bypass valve.

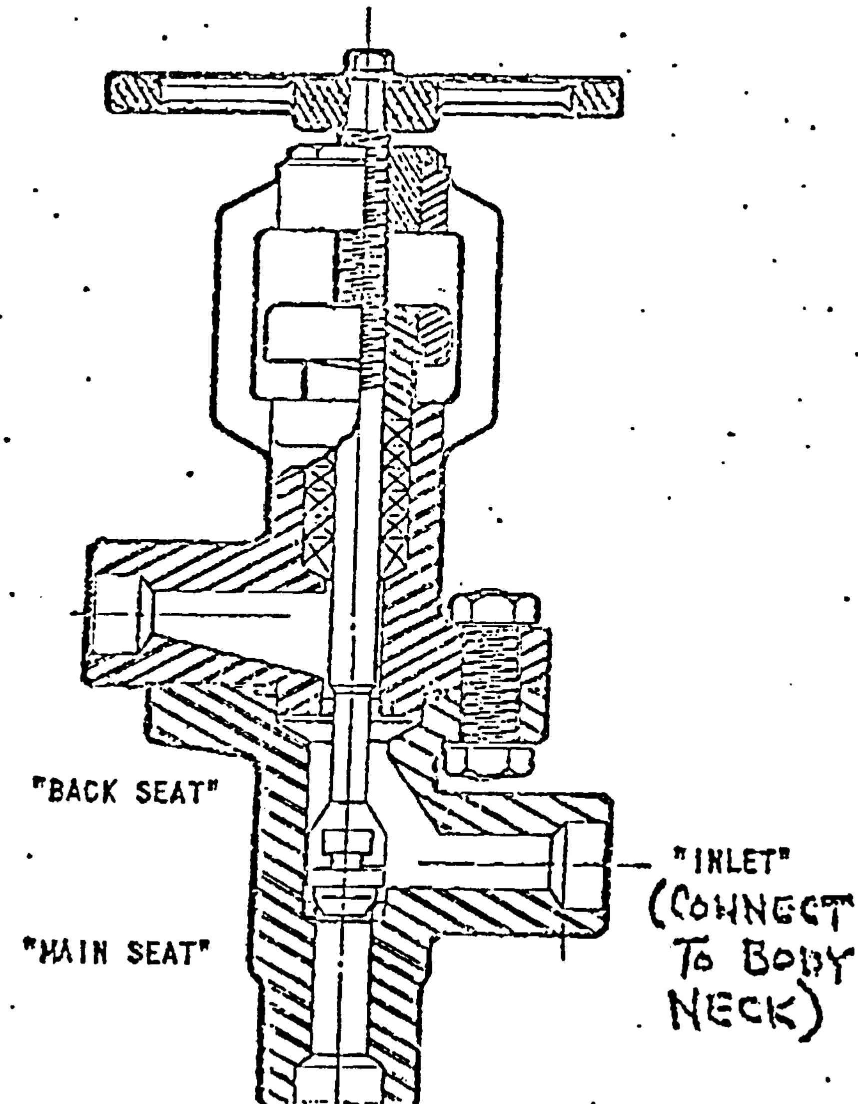
2. With bypass valve in mid-position, bypass action will occur between "A" and "B" with "C" vented to both.

3. Piping and operation may vary with particular bypass valve used. Appropriate tag describing operation should be attached in conspicuous location.

4. Piping may be installed below main valve.

MODIFICATION OF A FLEXIBLE WEDGE GATE VALVE WHERE FLOW MAY BE IN EITHER DIRECTION

EXHIBIT B



"BY-PASS FLOW. MAIN SEAT THRU BACK SEAT