Flow Control Division
Utility Products Group
400 North Lexington Avenue
Pittsburgh, Pennsylvania 15208
Telex: 866241
Cable: ROCKWL INT PGH

Rockwell
International

TECHNICAL STUDY

# TITLE: Disk Velocity at Impact with Seat for Line Break at Upstream Side of Size 14 Fig. 607 Non-Return Valve

ABSTRACT

Steam pressure, disk position and velocity are computed for a postulated line break condition adjacent to the valve inlet. All significant influences on disk movement are considered, including dynamic pressure distribution, pressure variations above and below the disk, and disk-body friction. Contact with the seat occurs after 0.009 seconds, at a velocity of 65.3 ft/sec. (19.9 m/sec).

AUTHOR: E. B. Pool  APPROVED B J Milleville
E. B. Pool

TITLE: Supervising Research Engineer

DATE: August 13, 1975

KEY WORDS

Valves, Angle; Valves, Nuclear

DISTRIBUTION

D. W. Duffey/B. J. Milleville
J. H. Loretan
R. A. Seethaler
R. W. Tartaglia
File 2573-48

8010310 722

## OBJECTIVE

This computation was performed to provide velocity data necessary for a companion report on the Energy Absorbing Capacity of the size 14 Fig. 607 Valve Body Seat and Disk. Studies of nuclear plant safety in the event of a postulated pipe break adjacent to the valve require determination of valve functional behavior and its consequences for conditions not previously analyzed.

## RESULTS

Velocity of disk at instant of contact with seat is 65.3 ft/sec. ( 19.9 m/sec).
Contact occurs .009 seconds after line break.

## ANALYSIS

The valve configuration is shown in the accompanying illustration. The analysis parallels that of J. M. Gwinn of Stone and Webster (ASME Paper 74PVP51) as regards the inlet (overseat) pressure after the line break. The pressure necessary to decelerate the normal flow and accelerate it to reverse critical nozzle flow reduces the original static pressure overseat to about half. The critical mass flow rate is determined by the equivalent nozzle area of the valve and the upstream conditions (no other flow restrictors are included). The critical area is at the cross section through the central guide rib so that the underseat pressure is independent of the upstream pressure, but is dependent on the back pressure created at the line break itself. This back pressure depends on the mass flow rate.

The other pressure which is vital to this analysis is the bonnet pressure (over the piston). The initial pressure is trapped in this cavity and expands on line break powering the initial acceleration of the disk, since the pressure under the disk suddenly drops to less than half at line break. There is some flow initially out of the bonnet cavity through the Equalizer pipe and past the piston clearance. This is inventoried in the computer program used to give the fluid mass at each time interval to calculate a new bonnet pressure based on the increase in bonnet cavity volume. After substantial change in lift, the bonnet pressure becomes less than upstream and leakage flow reverses to increase the mass of steam in the cavity along with its pressure. Meanwhile the continued increase in cavity volume as the valve closes tends to reduce the cavity pressure.

As the critical nozzle area decreases with lift, the flow decreases and the pressure above the valve seat moves back toward its initial value. The pressure under the disk drops toward atmospheric as flow is reduced.

Three experimentally determined coefficients are used in the analysis. The first relates pressure under the disk to inlet (overseat) pressure. The effective underseat pressure is not necessarily the same as the discharge pressure at the line break because of dynamic effects which are included in the coefficient. The second coefficient relates guide rib bearing load to inlet pressure. The third is the equivalent nozzle area. All of these

coefficients, as a function of lift, have been measured with load cells in an inclined bonnet globe valve under similar critical flow conditions on air. This Rockwell facility contains a 300 cu.ft. tank for air storage to 1500 psi. This supply is exhausted through the 6" test valve while pressures and loads are recorded on a 4 channel oscillograph. Since no similar data is available for angle valves, it has been necessary to assume the coefficients to be the same for inclined bonnet globe and angle configuration. This is the more plausible because the overall flow coefficients of Rockwell angle and Flite Flow valves are essentially equal in this valve. It may be assumed that the changed body configuration would therefore have only a small effect on the necessary coefficients. These coefficients have been incorporated into the empirical equations.

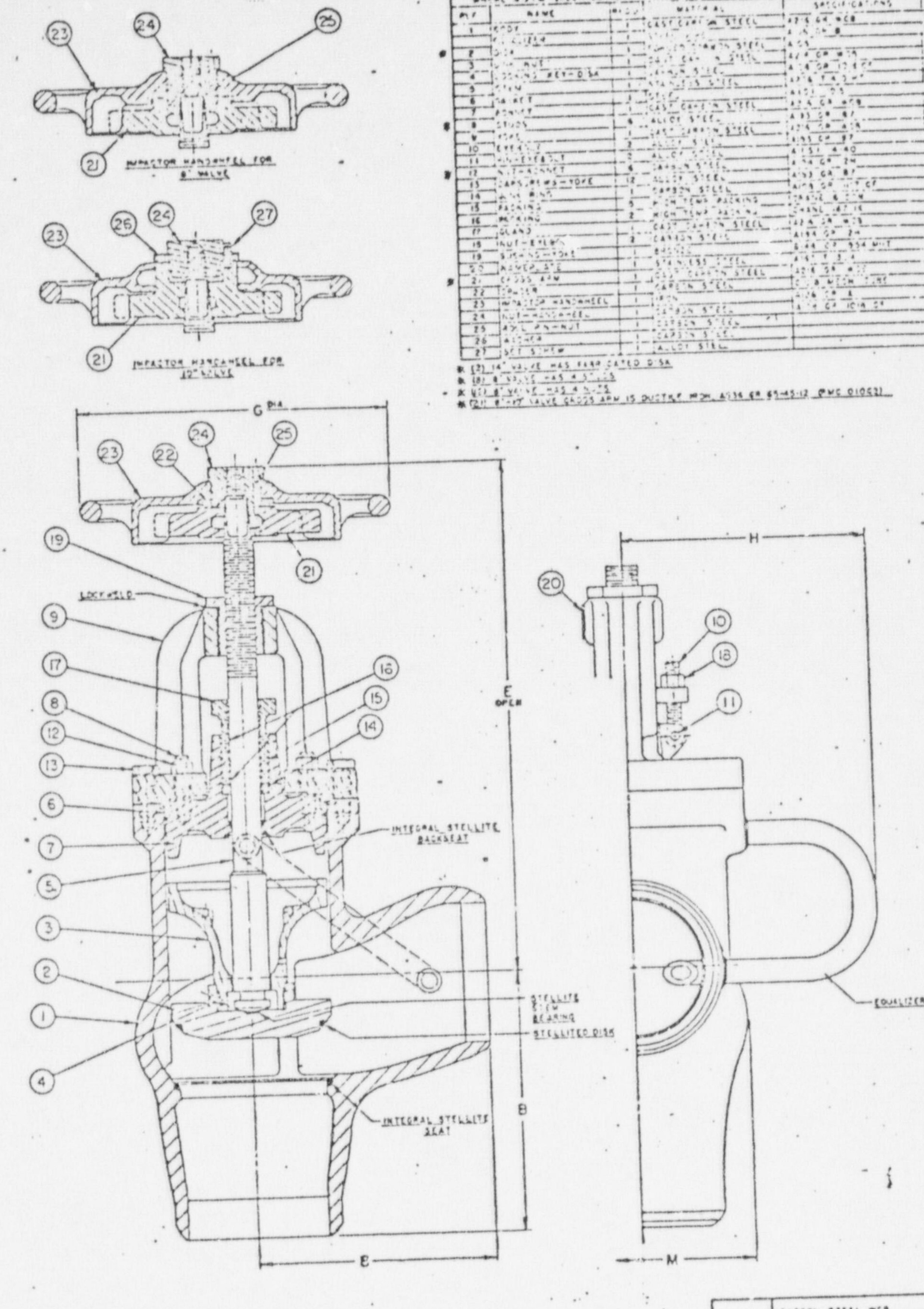
The force causing disk acceleration is then the difference between bonnet and under-seat pressure times the disk area. To this the disk weight is added and guide rib friction is subtracted. In calculating the latter, a high friction coefficient ($\mu = 0.6$) was used because of the elevated temperature. This retarding force is found to be a small fraction of the total force.

The residual unbalanced force is converted into acceleration which is numerically integrated with time to give disk velocity, which is again numerically integrated for disk position. A separate analysis will predict the consequences of this impact on the elastic-plastic deformation of the seat-disk geometry.

The results are shown in the attached computer printout. Only every 10th time step is printed.

Note that the wave front has traversed only 15.6 feet ( 4.8 m) before the valve is closed. Since this is less than twice the length of pipe, no pressure reflections will affect the valve before it has impacted the seat.

The integrated reverse steam flow escaping before the valve closure is 1.1 lbs. ( 0.5 )kg.




# LIST OF MATERIALS

WHERE ASTM SPECIFICATIONS [illegible] THE LATEST REVISION APPLIES

| PC. | NAME | REQ'D | MATERIAL | SPECIFICATIONS | RMC |
|---|---|---|---|---|---|
| 1 | BODY | 1 | CAST CARBON STEEL | A216 GR WCB | [illegible] |
| | [illegible] | 1 | [illegible] | A105 GR B | [illegible] |
| 2 | DISK | 1 | CAST CARBON STEEL | A105 | [illegible] |
| 3 | [illegible] NUT | 1 | CAST CARBON STEEL | A216 GR WCB | [illegible] |
| 4 | LOCKING KEY-DISK | 1 | CARBON STEEL | A [illegible] | [illegible] |
| 5 | STEM | 1 | STAINLESS STEEL | A276 T [illegible] | [illegible] |
| 6 | GASKET | 1 | [illegible] | AISI [illegible] | [illegible] |
| 7 | BONNET | 1 | CAST CARBON STEEL | A216 GR WCB | [illegible] |
| 8 | STUDS | 4 | ALLOY STEEL | A193 GR B7 | [illegible] |
| 9 | YOKE | 1 | CAST CARBON STEEL | A216 GR [illegible] | [illegible] |
| 10 | EYEBOLT | 2 | ALLOY STEEL | A193 GR B7 | [illegible] |
| 11 | [illegible]-EYEBOLT | 2 | ALLOY STEEL | AISI 4140 | [illegible] |
| 12 | NUT-BONNET | 4 | CARBON STEEL | A194 GR 2H | [illegible] |
| 13 | CAPSCREWS-YOKE | 12 | ALLOY STEEL | A193 GR B7 | [illegible] |
| 14 | [illegible] RING | 1 | CARBON STEEL | A193 GR [illegible] | [illegible] |
| 15 | PACKING | 5 | HIGH TEMP PACKING | [illegible] | [illegible] |
| 16 | PACKING | 2 | HIGH TEMP PACKING | [illegible] | [illegible] |
| 17 | GLAND | 1 | CAST CARBON STEEL | A216 GR WCB | [illegible] |
| 18 | NUT-EYEBOLT | 2 | CARBON STEEL | A194 GR 2H | [illegible] |
| 19 | BUSHING-YOKE | 1 | [illegible] | B 44 [illegible] 954 [illegible] | [illegible] |
| 20 | NAMEPLATE | 1 | STAINLESS STEEL | A [illegible] | [illegible] |
| 21 | CROSS ARM | 1 | CAST CARBON STEEL | A216 GR WCB | [illegible] |
| 22 | SPACER | 1 | CARBON STEEL | [illegible] | [illegible] |
| 23 | IMPACTOR HANDWHEEL | 1 | IRON | A126 GR B | [illegible] |
| 24 | NUT-HANDWHEEL | 1 | CARBON STEEL | A [illegible] GR [illegible] | [illegible] |
| 25 | AXIAL PIN-NUT | 1 | CARBON STEEL | | [illegible] |
| 26 | WASHER | 1 | CARBON STEEL | | [illegible] |
| 27 | SET SCREW | 1 | ALLOY STEEL | | |

* (2) 14" VALVE HAS FABRICATED DISK
* (8) 8" VALVE HAS 4 STUDS
* (12) 8" VALVE HAS 4 NUTS
* (21) 8" [illegible] VALVE CROSS ARM IS DUCTILE IRON, A536 GR 65-45-12 (RMC 01062)

WELDING ENDS PER [illegible]

# GENERAL DIMENSIONS

| VALVE SIZE | B | | E | | G | | H | | M | | WEIGHT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | INCH | MM | INCH | MM | INCH | MM | INCH | MM | INCH | MM | LB | KG |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 20.10 | 510.0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 240 |
| 8 | 13.50 | [illegible] | 28.50 | [illegible] | 24.00 | 610.4 | 15.50 | [illegible] | 19.44 | [illegible] | 950 | 431 |
| 10 | [illegible] | [illegible] | 32.48 | [illegible] | [illegible] | [illegible] | 13.70 | 348.1 | 23.52 | [illegible] | 1470 | 667 |
| 12 | [illegible] | [illegible] | [illegible] | [illegible] | 31.25 | [illegible] | 13.70 | [illegible] | [illegible] | [illegible] | 1760 | 798 |

| | |
|---|---|
| 600S | CARBON STEEL WCB<br>1440 PSI AT 100°F, 9930 kPa AT 37.8°C<br>600 PSI AT 850°F, 4140 kPa AT 454.4°C |

Flow Control Division
Rockwell International

EDWARD ANGLE NON-RETURN VALVE
PRESSURE SEAL BONNET-WELD END
GENERAL ASSEMBLY FIG. 607Y

D-106280

CHECK VALVE CLOSURE ON LINE BREAK PROGRAM — 07/30/75

ROCKWELL INTERNATIONAL CORPORATION
PITTSBURGH, PA.
PROGRAM NC3ES735

14 IN. FIG. 607 CHECK VALVE - HOME

DISK DATA
AREA= 140.4 SQ.IN. WEIGHT= 175.0 LBS. GAP WIDTH=0.0140 IN. GAP LENGTH= 1.310 IN.
FLOW FRICTION FACTOR= 0.0600 COEF. OF MECH. FRICTION=0.6000 DISK HEIGHT= 2.000 IN.

SEAT DATA
AREA= 130.1 SQ.IN.

EQUALIZER TUBE DATA
ID= 0.4570 IN. LENGTH= 28.30 IN. FLOW FRICTION FACTOR= 0.0230

INITIAL FLOW CONDITIONS
PRESSURE= 545.000 PSIA TEMP.= 476.00 DEG.F SP.VOL.= 0.827 CU.FT.PER LB. WT.FLOW RATE= 166.70LBS PER SEC.
GAMMA= 1.120

ISENTHALPIC (TO INITIAL FLOW CONDITIONS) AUXILIARY POINT
PRESSURE= 300.000 PSIA SP.VOL.= 1.551 CU.FT. PER LB.

LIFT DATA
INITIAL LIFT= 4.340IN. EQUIV.LIFT= 6.040 IN. (SUCH THAT BONNET CAVITY VOL= DISK AREA*(LIFTEQUIV-LIFTINIT))

PIPE DATA
AREA= 122.70 SQ.IN.

RUN DATA
NUMERICAL INTEGRATION (4TH ORDER RUNGE-KUTTA) TIME STEP=0.000500 SEC PRINTING INTERVAL=0.005000 SEC

| TIME<br>WAVE VEL<br>BON CAV PRES | LIFT<br>FLOW NO.<br>BON CAV.FL WT | DISK VEL<br>WT FLOW RATE<br>PRES ON DISK | DISK ACC<br>INLET VEL | NET DISK FORCE<br>INLET PRES | LIFT FORCE<br>INLET SP VOL | SIDE BRG FORCE |
|---|---|---|---|---|---|---|
| 0.0<br>1691.1<br>545.00 | 4.34<br>0.0290<br>0.177 | 0.0<br>220.6<br>63.59 | -13166.75<br>352.9 | -71616.3<br>339.57 | -71441.3<br>1.363 | 0.0 |
| 0.005<br>1339.2<br>264.23 | 2.80<br>0.0073<br>0.163 | -44.69<br>125.8<br>36.54 | -5762.48<br>176.2 | -31343.2<br>385.47 | -33492.3<br>1.194 | 2324.2 |

DISK IMPACT ON SEAT OCCURRED AT T= 0.0092 SECS WITH A VELOCITY OF -65.3 FEET/SEC

AT IMPACT DISK MOMENTUM IS 0.355290E+03 LB SECS KINETIC ENERGY IS 0.115039E+05 FT LBS

DISTANCE INITIAL EXPANSION WAVE TRAVELED DURING TIME TO IMPACT= 15.56 FEET

STEAM LOSS THROUGH VALVE= 1.09 POUNDS

OUTPUT VARIABLE DEFINITIONS AND DIMENSIONS

| | | | |
|---|---|---|---|
| T | TIME | SECONDS | |
| X | DISK LIFT OFF SEAT | INCHES | POSITIVE DIRECTION FROM SEAT TO BONNET |
| VEL | DISK VELOCITY | FEET PER SEC | |
| ACC | DISK ACCELERATION | FEET PER SQ SEC | |
| FL | LIFT FORCE | POUNDS | |
| FB | SIDE BEARING FORCE | POUNDS | |
| VW | WAVE VELOCITY | FEET PER SEC | |
| NI | INLET FLOW NUMBER | | |
| VI | INLET VELOCITY | FEET PER SEC | |
| WI | INLET WEIGHT FLOW RATE | POUNDS PER SEC | |
| PI | INLET PRESSURE | PSIA | |
| SVI | INLET SPECIFIC VOLUME | CU FT PER POUND | |
| PB | BONNET CAVITY PRESSURE | PSIA | |
| WB | BONNET CAVITY FLUID WEIGHT | POUNDS | |
| PU | PRESSURE UNDER DISK | PSIA | |