

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



Rockwell  
International

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## TECHNICAL STUDY

TITLE: Disk Velocity at Impact with Seat for Line Break at Upstream  
Side of Size 24 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 0.023 seconds, at a velocity of 106.9 ft/sec. (35.6 m/sec.).

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

TITLE: Supervising Research Engineer

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### KEY WORDS

Valves, Angle; Valves, Nuclear

### DISTRIBUTION

D. W. Duffey/B. J. Milleville  
J. H. Loretan  
R. A. Seethaler  
R. W. Tartaglia  
File 2573-49

1411 303

7910100 57.9

## OBJECTIVE

This computation was performed to provide velocity data necessary for a companion report on the Energy Absorbing Capacity of the size 24 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 106.9 ft/sec. ( 32.6 m/sec).  
Contact occurs .022 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.

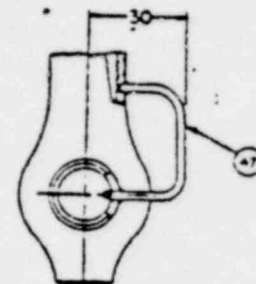
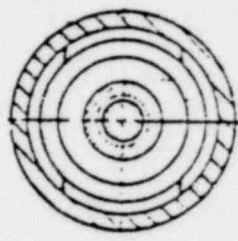
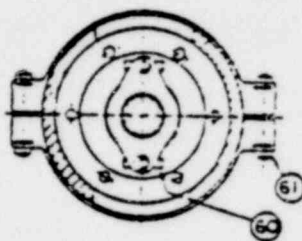
The residual unbalanced force is converted into acceleration which is numerically integrated with time to give disk velocity, which is again numerically integrated for disk position. A separate analysis will predict the consequences of this impact on the elastic-plastic deformation of the seat-disk geometry.

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

Note that the wave front has traversed only 43.6 feet ( 3.3 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 21.6 lbs. ( 9.8 )kg.

# POOR ORIGINAL

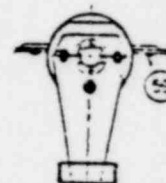
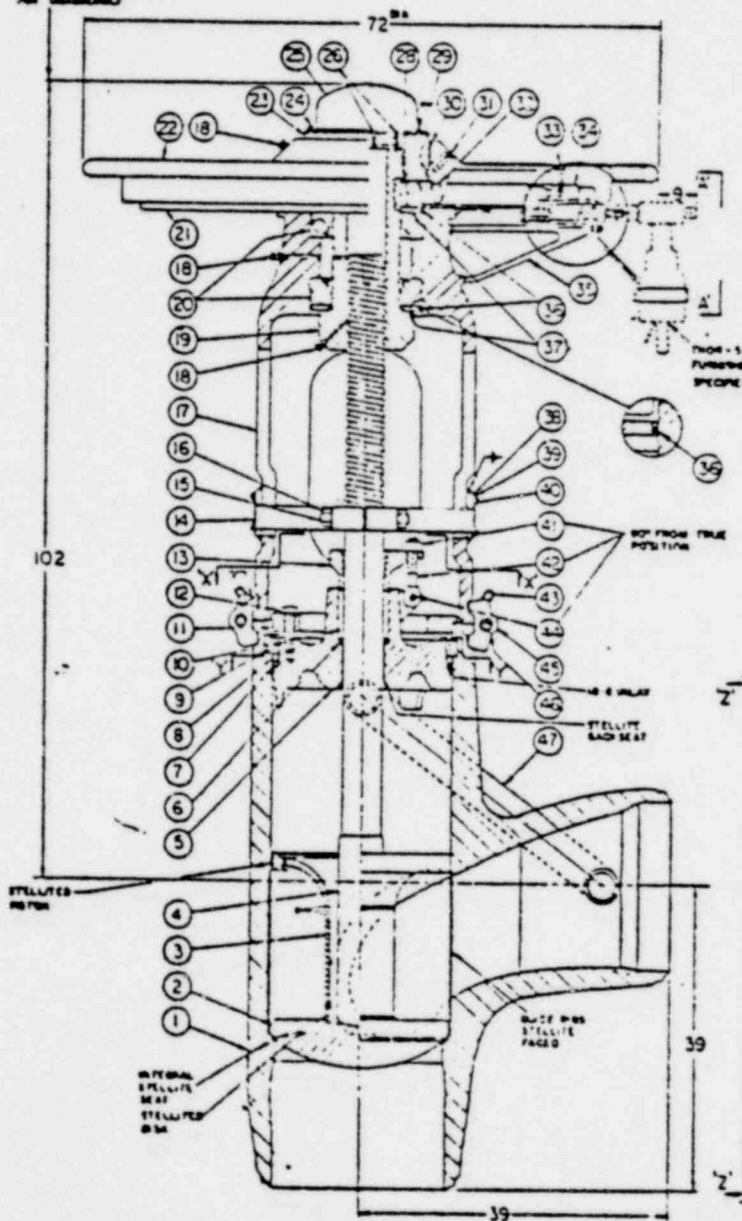


VIEW F-Y

44  
FOR DISASSEMBLY

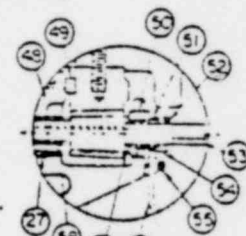
SECTION X-Y

SECTION P-Q



VIEW E-X

FROM SECTION - 40  
FURNISHED ONLY WHEN  
SPECIFIED



DETAIL OF IMPACT GEAR  
FROM SECTION 7

1411 306

WELDING ENDS PER ASA SPEC. FOR S.W. OR R

PATENT NO. 2,042,455; 2,042,456; 2,042,457

VALVE SEAT - 1/2 IN. DIA.	
SERVICE	RATINGS
CAST ALUMINUM STEEL WELD	200 PSI AT 100°F
CAST ALUMINUM STEEL WELD	200 PSI AT 100°F
CAST ALUMINUM STEEL WELD	200 PSI AT 100°F
CAST ALUMINUM STEEL WELD	200 PSI AT 100°F
CAST ALUMINUM STEEL WELD	200 PSI AT 100°F
CAST ALUMINUM STEEL WELD	200 PSI AT 100°F
ROCKWELL	
BALANCE PLANT	
FOR PUMP WITH 1/2 IN. DIA.	
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES	
PNEUMATIC SEALING METHOD, SEE SPEC. FOR PNEUMATIC SEALING METHOD	
GENERAL DIMENSIONS	
PUMP & PNEUMATIC SEALING METHOD, SEE SPEC. FOR PNEUMATIC SEALING METHOD	
PUMP & PNEUMATIC SEALING METHOD, SEE SPEC. FOR PNEUMATIC SEALING METHOD	

CHECK VALVE CLOSURE ON LINE WATER PROGRAM  
 FICKELL INTERNATIONAL CORPORATION  
 PITTSBURGH, PA.  
 PROGRAM W065V55

07/30/75

3 MILE - 24 IN. FIG. 607 CHECK VALVE

#### DISK DATA

AREA = 392.3 SQ. IN. WEIGHT = 647.3 LBS. GAP WIDTH = 0.0250 IN. GAP LENGTH = 2.000 IN.  
 FLOW FRICTION FACTOR = 0.0027 COEF. OF MECH. FRICTION = 0.0000 DISK HEIGHT = 2.250 IN.

#### SEAT DATA

AREA = 378.4 SQ. IN.

#### EQUALIZER TUBE DATA

ID = 2.3200 IN. LENGTH = 65.90 IN. FLOW FRICTION FACTOR = 0.0185

#### INITIAL FLOW CONDITIONS

PRESSURE = 923.000 PSIA TEMP. = 540.00 DEG. F SP. VOL. = 0.556 CU. FT. PER LB. WT. FLOW RATE = 774.90 LBS PER SEC.  
 GAMMA = 1.275

#### ENTHALPIC (TO INITIAL FLOW CONDITIONS) AUXILIARY POINT

PRESSURE = 900.000 PSIA SP. VOL. = 1.036 CU. FT. PER LB.

#### LIFT DATA

INITIAL LIFT = 19.375 IN. EQUIV. LIFT = 23.515 IN. SUCH THAT JENNET CAVITY VEL. DISK AREA = (LISTEQUIV - LISTINIT)

#### PIPE DATA

AREA = 390.40 SQ. IN.

#### RL4 DATA

NUMERICAL INTEGRATION WITH EXCER. RUNGE-KUTTA TIME STEP = 0.000500 SEC. PRINTING INTERVAL = 0.005000 SEC

TIME WAVE VEL BOIL CAV. PRES	LIFT FLOW NO. BOIL CAV. F. WT.	DISK VEL WT FLOW RATE PRES. UN. DISK	DISK ACC INLET VEL	NET DISK FORCE INLET PRES	LIFT FORCE INLET SP VOL	SIDE BRG FORCE
0.0 1901.9 923.00	19.38 0.0940 1.691	0.0 1272.8 214.40	-13901.82 672.4	-279557.4 362.50	-278910.4 1.432	0.0
0.005 1091.7 923.49	17.64 0.0896 1.372	-51.37 1257.1 155.80	-6450.53 656.4	-129716.4 366.73	-130583.9 1.416	1514.5
0.010 1142.5 304.78	13.64 0.0749 1.324	-72.52 1197.6 155.61	-2943.54 600.2	-59192.8 382.04	-60509.5 1.359	1963.7
0.015 1279.7 232.66	9.09 0.0417 1.483	-85.32 998.3 105.43	-2374.49 447.6	-47749.6 426.64	-49936.2 1.216	2833.6
0.020 1610.1 191.69	3.60 0.0022 1.586	-97.86 291.5 31.52	-2660.32 101.7	-57514.4 547.21	-62869.3 0.946	5996.9

DISK IMPACT ON SEAT OCCURRED AT IN 0.0229 SECS WITH A VELOCITY OF -106.9 FEET/SEC

AT IMPACT DISK MOMENTUM IS 0.215016+04 LB SECS KINETIC ENERGY IS 0.114951E+06 FT LBS

DISTANCE INITIAL EXPANSION WAVE TRAVELED DURING TIME TO IMPACT = 43.61 FEET

STEAM LOSS THROUGH VALVE = 21.57 POUNDS

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POOR ORIGINAL

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	PCUNDS	
VW	WAVE VELOCITY	FEET PER SEC	
NI	INLET FLOW NUMBER		
VI	INLET VELOCITY	FEET PER SEC	
WFI	INLET WEIGHT FLOW RATE	POUNDS PER SEC	
PI	INLET PRESSURE	PSIA	
SVI	INLET SPECIFIC VOLUME	CU FT PER PCUND	
PB	BONNET CAVITY PRESSURE	PSIA	
WB	BONNET CAVITY FLUID WEIGHT	PCUNDS	
PU	PRESSURE UNDER DISK	PSIA	