4.4 Summary of Strain Gage Data

Material strains were recorded continuously during all of the tests listed in Table 4.1 at the locations specified in Section 7.3. These strain measurements are used to obtain estimates of the local stress levels at these locations and to determine whether permanent deformation occurred.

It should be noted that the highly transitory nature of the impact tests which imply a highly complex stress state makes it difficult to accurately compare the inferred stress levels with ASME static yield stress levels.

The maximum values of strain and the stress inferred by multiplying the strain values by Young's Modulus are listed in Table 4.2. The ASME static yield stress limit for 300 series stainless steel, as given in ASME Boiler and Pressure Vessel Code, Appendix I, Tables I-2.1 and I-2.2, was exceeded on the disc and arm in several tests with no permanent deformation either visually observed or measured by the strain gages. There are two factors which could produce this result.

First, the actual yield stress of these materials could be highter than the ASME values for yield stress. For the 347 stainless steel used in the test disc, the traceable manufacturer's material test report and certification indicated the actual measured value of the yield stress to be 47.4 kpsi (158% of the ASME value for yield stress). In addition, the 347 stainless steel used in the Susquehanna VB discs originated from the same heat number as the material used in the test valve disc and, therefore, has a measured yield stress also equal to 47.4 kpsi. Since the arm is not part of the pressure boundary, it does not have a similar traceable material report. However, the 304 stainless steel specified in the engineering drawing and used in the arms of all of the valves at Susquehanna and Limerick as well as the test valve (assured by the AGCo implementation of the ASME Section 8 Quality Assurance requirements) has nominally the same strength as the 347 SS material.

Second, the impulsive application and relief of the impact load does not allow enough time for the material to deform permanently. The characteristic duration of the opening impact load is typically several milliseconds.

Finally, to reiterate, the primary purpose of these tests is to evaluate vacuum breaker operability after pool swell and is not to provide ASME qualification of this valve and, as such, the strain gage measurements are only of secondary importance.

TABLE 4.2

Maximum Strains and Stresses in Phase IV Tests

Strain Gages on	Material on Which Strain Gage is Mounted	Susquehanna Opening Impact Test 16 rps		Shoreham Opening Impact Test 18 rps		Susquehanna and Shoreham Closing Impact Test -16 rps	
		Strain μin/in	Stress* ksi	Strain μin/in	Stress* ksi	Strain μin/in	Stress* ksi
Main Shaft							
#11	17-4PH	-2180	-63.7	-2260	-66.0	-1760	-51.4
# 9	17-4PH	2180	63.7	2540	74.2	-1220	-35.6
#12	17-4PH	1220	35.6	1840	53.7	680	19.9
Arm and Disc							
# 8	304SS	-1730	-49.0	-1720	-48.7	690	19.5
# 5	347SS	1600	45.3	1490	42.2	1050	29.7
# 2	347SS	-250	-7.1	-110	-3.1	-950	-26.9
# 3	347SS	700	19.8	120	3.4	350	9.9
Single Bar Linkage							
#10	Carbon Steel (516-7)	400	11.2	380	10.6	-420	-11.7
#13	Carbon Steel (516-7)	-210	-5.9	-290	-8.1	-190	-5.3

ASME Values of Young's Modulus and specified minimum yield stress for the materials used in the test valve are from ASME P&BVC, Section 3, Appendix I, Tables I-2.1, I-2.2, I-6.0, I-6.1.

Material	E x 10^{-6} (at 70°F)	Yield Stress, ksi
17-4PH	29.2	115
304SS	28.3	30
347SS	28.3	30
Carbon Steel	27.9	38

* Stress is estimated by the product of strain and E for the particular material.