Technical Note: Does the spring setting of a safety relief valve really deviate after being in operation?

A.M. Muller[1] and **M. Heyns**[2]

(Received February 1998; Final version February 1998)

According to statistics from SASOL, set pressures of safety relief valves (SRVs) tend to deviate more than the allowable deviation margin of 10%. This was determined by doing a Leak test on the valves when they were removed from the plant to be overhauled. Tests were done at different stages to determine when the deviation actually occurs. The different stages are discussed in this paper and results are given. Another series of tests was done to determine if there is any correlation between the set pressures quantified by Leak testing and Trevi testing, which is an in-situ *calibration method. This was done because only Leak-test values of set pressures were available on the valves and these values had to be compared with Trevi values after certain stages. It was also determined if SASOL's Leak tests were done according to Dresser's (valve supplier and manufacturer) specifications. The tests showed that SASOL's Leak tests gave approximately the same results as Dresser's calibration method.*

Introduction

SASOL at Secunda, South Africa, found by doing a pre-test (Leak test) on safety relief valves (SRVs) after a period of time in operation, that many of the SRVs start to leak at a different, in most cases lower, pressure than they were set for. SASOL was very concerned about this situation, because thousands of rands are wasted through leaking product and significant savings would result if this integrity problem was solved. It was decided to do certain tests to determine if the spring stiffness or the spring setting was influenced during handling or operation.

Influence on safety relief valve set pressures during transportation, handling and installation

To determine the stage when a deviation in set-point occurs, it was decided to monitor certain SRVs during a shut-down at SASOL. The valves were monitored with a Trevi-test apparatus,[1] which is an *in-situ*[2] calibration method, at the following stages: Stage 1: Before removal from the plant; Stage 2: After removal from the plant; Stage 3: After transportation to the workshops; Stage 4: After repairs were done on the valves; Stage 5: After transportation to the plant for re-installation; and Stage 6: After installation.

The monitored valves were chosen to:

- be from different plants
- have different set pressures
- have different sizes
- be of different makes

Three valves were used from which two of them were from the same plant. This was inevitable due to practical circumstances during the shut-down. Two of the valves satisfied four conditions and were believed to give satisfactory results. Before the tests were carried out, a test was done to determine the repeatability of a Trevi test. It was found that the test results stayed constant within a deviation margin of 0.55% from the first reading, as shown in Table 1. The original set pressure was set according to SASOL's Leak test calibration method.

The results of the monitoring tests are tabulated in Table 2. One of the valves (21PSV-1001A) was only available as from after transportation to the workshop. Trevi tests were done at the different stages and a Leak test was also done after transportation to the workshop and after repair. This was done for comparison between the Trevi and Leak test set pressure values. From this comparison, the Leak test may show a set pressure of zero kPa, whilst the Trevi test shows a much higher pressure. This is because the Trevi-test apparatus is spring-force related. Table 3 summarises the percentage deviation from action to another as is shown graphically in Figure 1. For valve number 21PSV-1001A, a maximum deviation of -1.08% occurred during installation. For 40PSV-1100, a maximum deviation of 2.85% occurred during transportation to the workshop. A maximum deviation of 2.23% occurred for 21PSV-2025 during installation.

Figures 2 to 4 show a graphical representation of the Trevi-test results of the tests done on the valves at different stages. According to these figures, slight deviations in the set pressures are observable after the valves have been transported and installed at the plant. Because there were no pressure and high-temperature gases involved, the only factor responsible for these deviations could be handling. According to Figure 3, the original pressure before removing the valve from the plant, is lower than the final pressure after installation. This could be because of vibration during operation, material properties, or physical damage

[1]Postgraduate student, University of Pretoria

[2]Associate Professor, Department of Mechanical and Aeronautical Engineering, University of Pretoria, Pretoria, 0002 South Africa

Table 1 Repeatability test

Valve number	Set press	1st Lift [kPa]	2nd Lift [kPa]	3rd Lift [kPa]	Maximum deviation from1st lift [%]
40PSV-1100	640	625	628	628	0.48
21PSV-2025	5370	6784	6772	6747	−0.55

Table 2 Trevi test at different stages

Valve number	Set press (LEAK) [kPa]	Before removal (TREVI) [kPa]	After removal (TREVI) [kPa]	After transpor-tation to workshop (LEAK) [kPa]	After transpor-tation to workshop (TREVI) [kPa]	After repair (LEAK) [kPa]	After repair (TREVI) [kPa]	After transpor-tation to plant (TREVI) [kPa]	After installa-tion (TREVI) [kPa]	Final setting (TREVI) [kPa]
21PSV-1001A	3130	N/A	N/A	2800	3118	3125	3416	3416	3379	3118
40PSV-1100	640	628	632	0	650	640	657	650	646	632
21PSV-2025	5370	6747	6784	6150	6661	5370	5612	5550	5674	5352

Table 3 Deviations from one action to another

Valve number	Percentage deviation from:				
	Before removal → After removal	After removal → After transportation to workshop	After repair → After transportation to plant	After transportation to plant → After installation	Total deviation as from setting in workshop
21PSV-1001A	N/A	N/A	0.00	−1.08	−1.08
40PSV-1100	0.64	2.85	−1.07	−0.62	−1.69
21PSV-2025	0.55	−1.81	−1.10	2.23	1.13

Table 4 Tabulated results from pressure cycles

Valve number	SASOL pre-test	Trevi pre-test	Original set-press	New set-press	First leak pressure	Open/'pop' pressure	90% of new set-press	Bubbles per minute	Final Trevitest
					[kPa]				
212PSV -4A030	0	1388	1400	1400	1420	1420	1260	0	1295
					1420	1420		0	1295
					1420	1420		0	1295
30PSV-IF033-2	0	344	350	350	350	---	315	0	251
					350	---		0	251
					350	---		0	251
30PSV-1F019A	5200	7893	8321	8321	---	---	---	---	---
210PSV -17005	550	533	515	514	510	---	463	0	---
					510	---	---	0	---
					510	---	---	0	---
210PSV -17004	535	508	564	564	560	---	508	0	532
11PSV-5B010A	3200	3058	3090	3090	3110	3110	2781	0	---
11PSV -5B007	0	2692	3090	3090	3140	3140	2781	0	3028
210PSV -17006	2920	2837	3040	3140	3160	3200	2826	0	3084
11PSV-5B005	1600	---	3400	3400	---	---	3060	---	---
11PSV-5B010B	2200	---	3090	3090	3090	3090	2781	0	---
210PSV -17001	1600	---	3504	3504	3550	3550	3154	0	3238
210PSV -17009	400	3516	3504	3504	---	---	---	---	---
40PSV -7122C	130	108	131	131	130	---	118	0	164
40PSV -7122A	130	108	131	131	130	---	118	0	168
40PSV -7122B	130	123	131	131	130	---	118	0	180
40PSV -7132	3850	3866	4000	4000	---	4020	3600	0	3866

--- Data not available due to practical circumstances

Table 5 Comparison between Leak and Trevi tests

Valve number	First leak pressure (1)	Final Trevi-test (2)	Difference (1)&(2) %
212PSV4A030	1420	1295	−8.80
30PSV1F033-2	350	251	−28.29
210PSV17004	560	532	−5.00
11PSV5B007	3140	3028	−3.57
210PSV17006	3160	3084	−2.41
210PSV17001	3550	3238	−8.79
40PSV7122C	130	164	+26.15
40PSV7122A	130	168	+29.23
40PSV7122B	130	180	+38.6
Absolute average – higher pressures:			5.71%
Absolute average – all valves:			16.74%

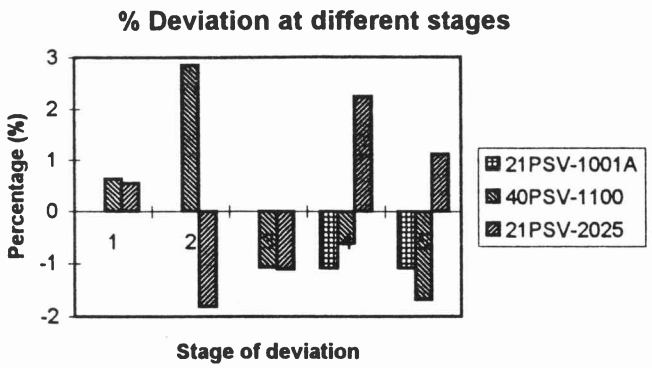

Figure 1 Graphical representation for deviations from one action to another

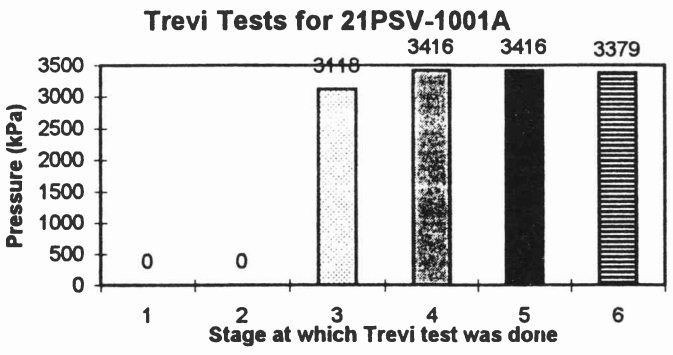

Figure 2 Graphical representation of Trevi-test results for 21PSV-1001A

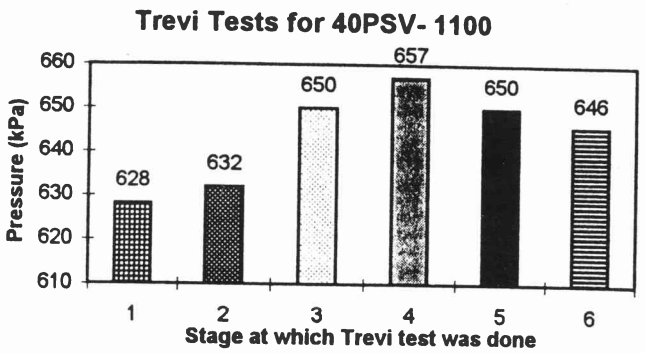

Figure 3 Graphical representation of Trevi-test results for 40PSV-1100

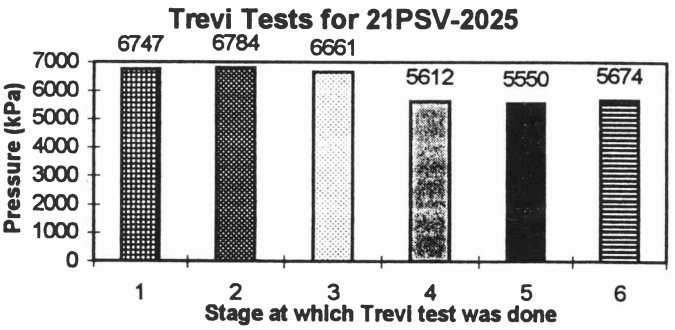

Figure 4 Graphical representation of Trevi-test results for 21PSV-2025

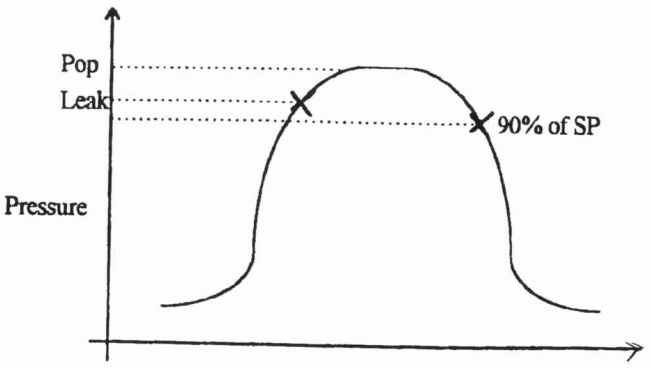

Figure 5 Pressure cycle

Table 6 Original set pressure *vs.* Trevi pre-test

Valve number	Original set pressure (1)	Trevi pre-test (2)	SASOL pre-test (3)	Difference (1) & (2) %	Difference (1) & (3) %
212PSV4A030	1400	1388	0	−0.86	−100
30PSV1F019A	8321	7893	5200	−5.14	−37.51
210PSV17004	564	508	535	−9.93	−5.14
11PSV5B010A	3090	3058	3200	−1.04	+3.56
11PSV5B007	3090	2692	0	−12.88	−100
210PSV17006	4040	2837	2920	−6.68	−3.95
210PSV17009	3504	3516	400	+0.34	−88.58
40PSV7132	4000	3866	3850	−3.35	−3.75
			Absolute average:	5.03%	42.81%

to the valve. Figure 4 shows that either a too-high set pressure was set at first or a deviation was caused during operation.

Leak testing *vs.* Trevi testing

The tests in this section were done to determine if SASOL calibrates their SRVs according to Dresser's (valve manufacturer and supplier) specifications.[3] The tests were also done to determine if there is any correlation between SASOL's Leak testing and Trevi testing. The tests were carried out as follows:

- When an SRV arrived at the workshop, SASOL did a pre-test (Leak test). A Trevi test was then done and both the values were tabulated.
- The valve was then overhauled by SASOL and set to the prescribed set pressure. This set pressure was also tabulated.
- With the valve on the test bench, the pressure was then further increased until the valve 'popped'. This cycle is illustrated in Figure 5. Both these values were tabulated.
- The pressure was then decreased down to 90% of the set pressure. The number of bubbles was counted and tabulated.

Table 4 summarises the results of these tests. The repeatability of the testing methods was first determined by repeating the test three times for three valves. From the results, it was clear that the values stayed constant in all three cases, which proves the consistency of the testing methods for a newly overhauled valve. Furthermore, it is clear that SASOL's Leak test gives approximately the same results as the Dresser prescribed calibration method. This can be seen in Table 4 in the 'First leak pressure' and 'Open / pop pressure' columns. By definition, the 'First leak' pressure is SASOL's set pressure and the 'Open/pop' pressure is Dresser's set pressure.

Table 5 shows the comparison between SASOL's Leak testing and Trevi testing. From this comparison, it is clear that Trevi testing cannot be compared to Leak testing at low pressures, but only for the higher pressures, 560 kPa and above. Also note that all the Trevi-test values are less than the 'First leak' values for the higher pressures. According to Table 5, the average difference between 'First leak' and the Trevi values are only 5.71% for the higher pressures.

From these results, it is possible to compare the set pressures of certain valves over a period of time. In other words, the most recent Trevi pre-test results may be compared to the original set pressure of the valve from which only the Leak-test data are available. By doing this, it is possible to determine if the valve spring stiffness deteriorated over the period of time.

Investigation on spring stiffness after being in operation

It is therefore possible that for pressures of 560 kPa and above one may compare Trevi testing with Leak testing for a newly overhauled valve. Table 6 shows that the difference between the original set pressure and the Trevi-test value, after a period of time, only differs more than 10% in one case. The absolute average deviation is only 5.03% while in the case of the Leak testing the absolute average deviation is a high 42.81%. From this, it is clear that the spring stiffness of the valves did not deteriorate significantly with time, because the Trei test is spring-stiffness related.

Conclusion

The following can be concluded from the tests described above:

- The repeatability of Trevi and Leak testing are both very good.
- It is clear that the spring setting does not physically deviate during transportation, handling, or installation, according to the Trevi tests done at those stages. This means that the setting does not change, but the valve may still leak due to improper seating.
- It is also proven that the way SASOL calibrates their valves satisfies the way prescribed by Dresser.
- It can also be concluded that Trevi testing can be related to Leak testing for a newly overhauled valve. This finding was used to prove that neither the spring stiffness nor the spring setting deteriorated with time.

Because it is proved that the physical setting and the spring stiffness do not change significantly, it is clear that SASOL does not have a spring setting problem but a leakage problem. This means that further investigation is needed to find the cause of leakage.

Acknowledgment

The author would like to thank SASOL Limited, without whose generous support this project would not have been possible.

References

1. Furmanite. Trevi testing Brochure.
2. Thibault DG & Zahorsky JR. *'In service' set pressure testing of safety valves.* Crosby Valve & Gage Company, 1991.
3. API Standard 527, *ANSI* B147,1–72).