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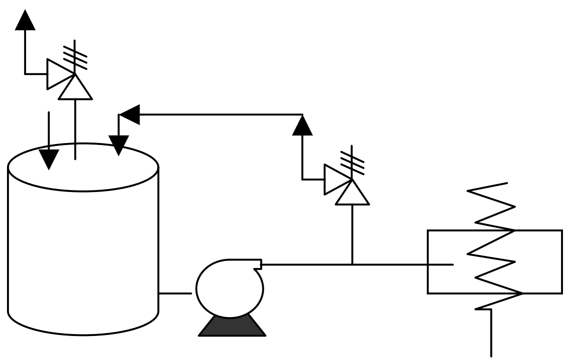
International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

THE HIDDEN FACTS OF PROCESS SAFETY VALVE RELIABILITY

Mohammad M. Alkhaldi,
Saudi Arabian Fertilizer Company (SAFCO), Saudi Arabia

1. INTRODUCTION

One of the major concerns in most of industrial petrochemical plants is how safety/relief valves are performing their required routine protection while at the same time provide relief for uncontrolled pressure problems. The most commonly used practice to ensure that proper performance is well maintained is to test the valves at the workshop as per their scheduled periodic inspection. This test will give the value of "*as received*" pressure which is an indication for safety/relief valves performance while on service and compare this value with the design set pressure to check for any deviation.



2. THE HIDDEN FACT

In industry practices particularly fertilizers, safety/relief valves (SRV's) may not provide their intended protection to process plant facilities for reason that their ***lift set pressures*** have deviated from their ***design set pressures***. This has been noticed when "as received " pressures found to have different values than design.

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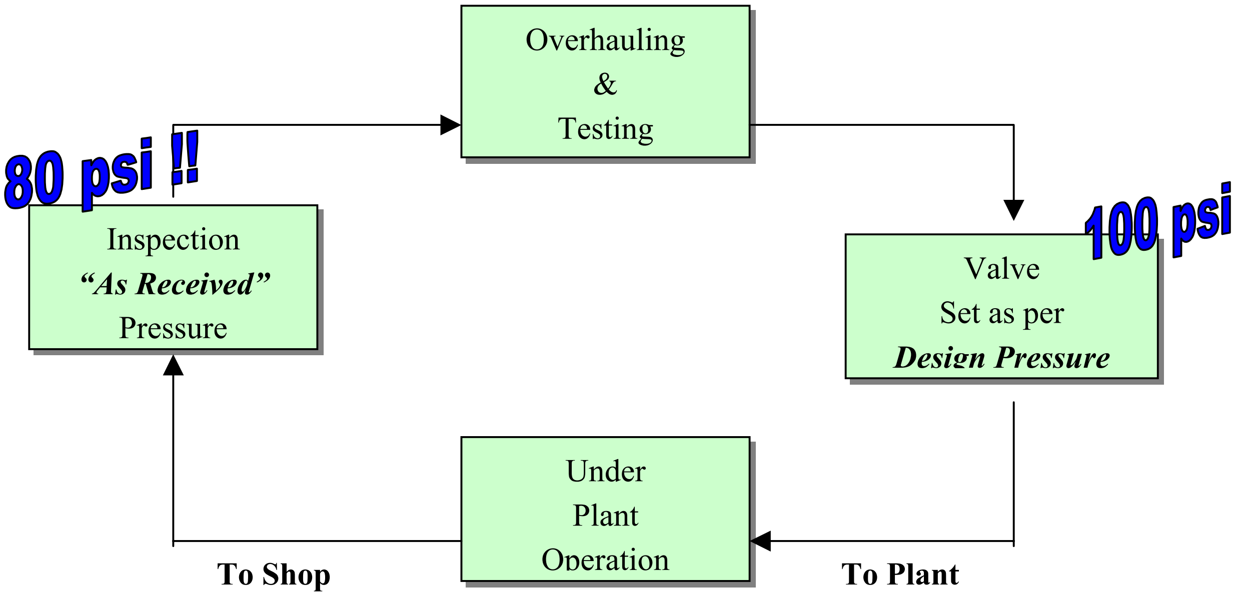
E-mail: MKhaldi@safco.net



This deviation between the two pressures has been noticed not only in our facility but most of petrochemical plants. Absence of standards having acceptable deviation limit that meet industry practices would expose guards of plant equipments to non-safe mode where possibility of serious incidents are very likely to occur. However many variables may be involved and affect positively or negatively this deviation and its consequences which will be illustrated further in this report.

3. CODES AND STANDARDS

3.1 ASME Section VIII

•Set pressure tolerances of SRV's in all services except boiler as per ASME Sec.VIII are :

- •+/- 2 psi for pressure up to 70 psi
- •+/- 3% for pressure above 70 psi

•Set pressure tolerances for boiler SRV's as per ASME Sec. I are :

- •+/- 2 psi for pressure up to 70 psi
- •+/- 3% for pressure above 70 psi up to 300 psi
- •10 psi for pressure above 300 psi up to 1000 psi

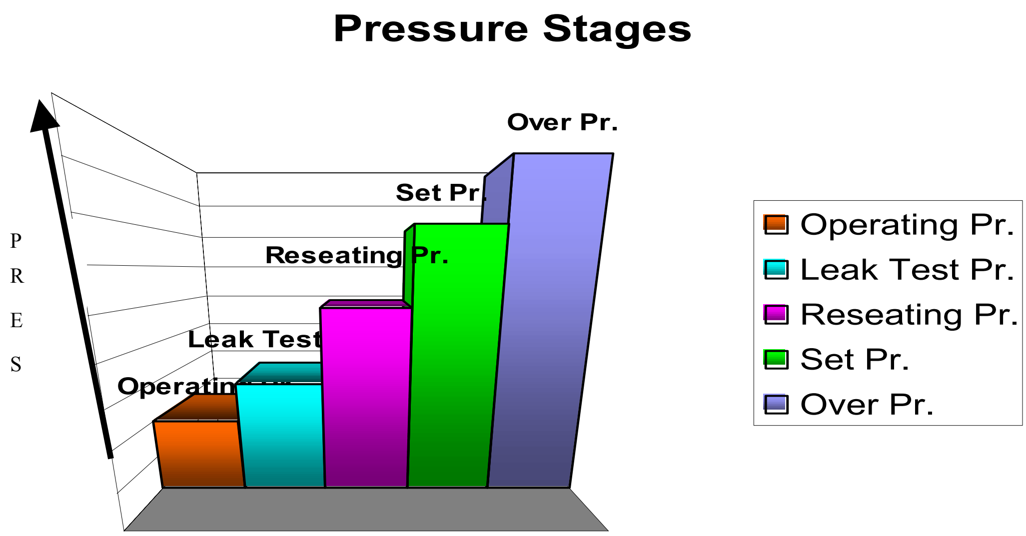
• Leak test as per API 527 :

- •90% of set pressure for valves set more than 50 psi
- •5 psi less than set pressure for valves set at 50 psi or less

3.2 API 576 : Inspection of Pressure-Relieving Devices "Recommended Practice"

4. PRESSURE STAGES

In every plant, SRV experiences different levels of pressures either during shop testing or service at field. These stages are illustrated in the chart below and you may refer to their definitions at the end of the report.

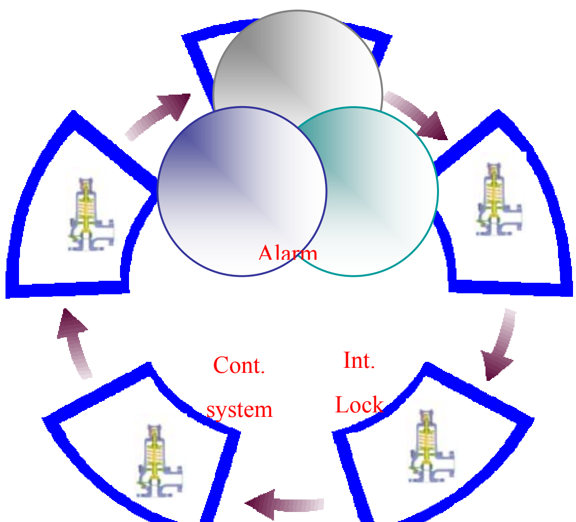


5. WHY SAFETY/ RELIEF VALVES

Process plants are usually equipped with different levels of protection systems like:

- Instrument Control Systems
- Alarm Systems
- Interlock Systems

However, when the above systems do not partially / fully activate or malfunction for specific reasons, mechanical safety/ relief valves (SRV's) will act as a "last resort" that overcome any upset-pressure situation. Beside their low repair costs, they play a major role and have an impact on various aspects such as environment, pressure incidents, insurance, etc.



6. NATURE OF DEVIATION

As part of a wider initiative and lack of standards that clearly state an acceptable range of deviation between "as received " pressure and design set pressure, this study was asked by our management to describe a threshold on eliminating operational problems regarding safety/ relief valves and their environment releases. Survey had been conducted to cover all SRV's in the Saudi Arabia Fertilizer Company at the Dammam plant to assess and review the existing practice whether they perform the required design parameters as per codes or not.

7. DATA CLASSIFICATION

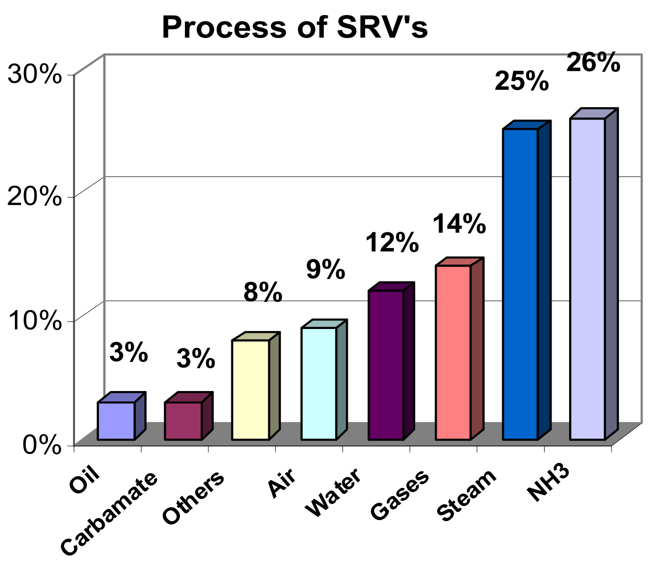
There is a total of 411 valve entries covering the period 2001 to 2003 and included all SRV's related details.

7.1 Valve Type

Mostly are spring loaded, few are pilot operated, and vacuum types.

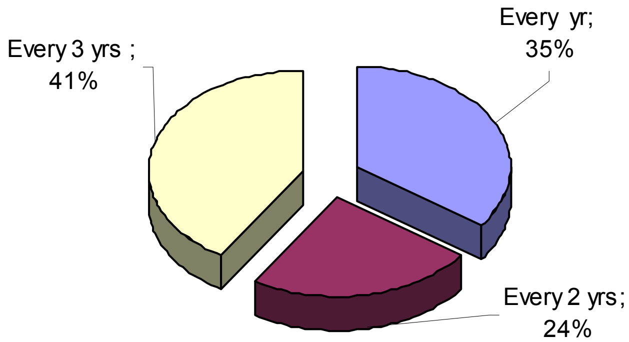
7.2 Process Type

	Process	Comments
1.	Oil	
2.	Carbamate	
3.	Others	MEA, melamine ,acid, sulfur, chemicals
4.	Air	
5.	Water	
6.	Gases	Syn., natural, CO2, N2, H2
7.	Steam	All types
8.	NH3	Gas & liquid



7.3 Test frequency

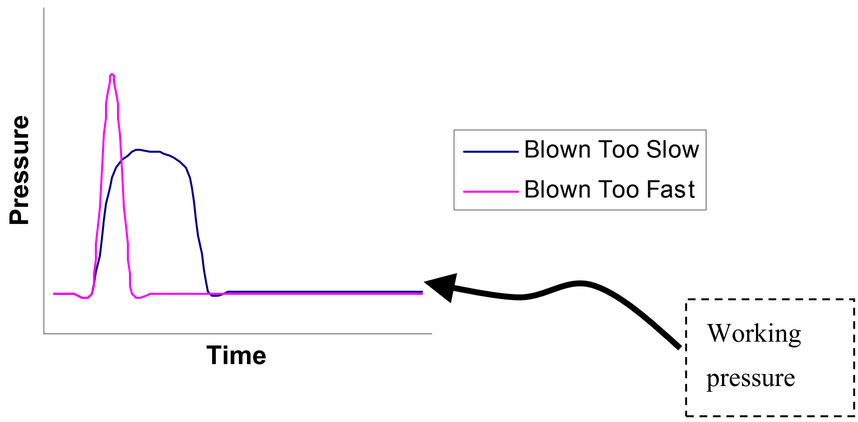
#	Test Frequency	% of total SRV's
1	Every one year	35
2	Every two years	24
3	Every three years	41



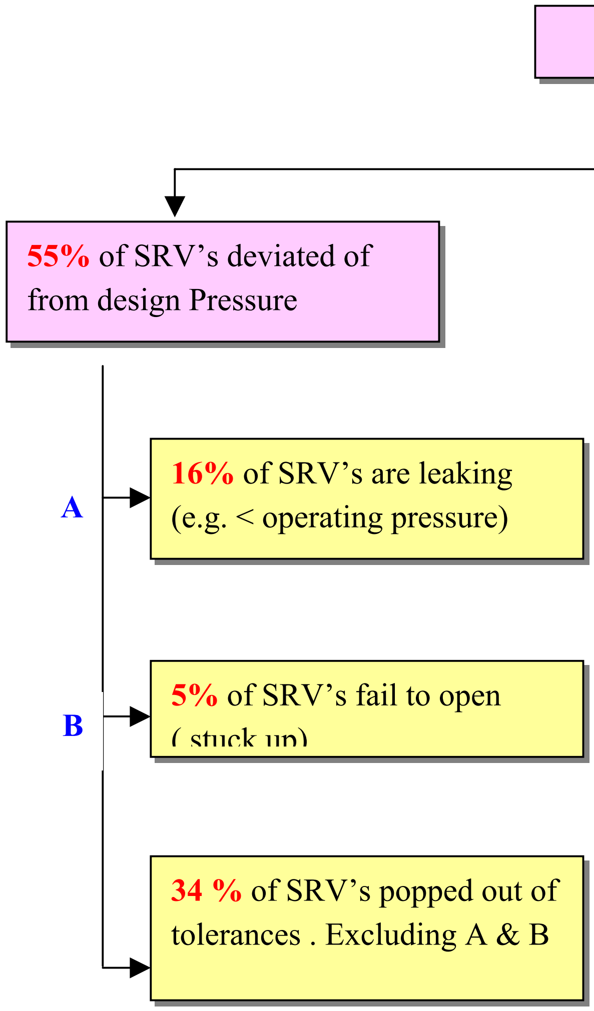
8. ANALYSIS FINDINGS

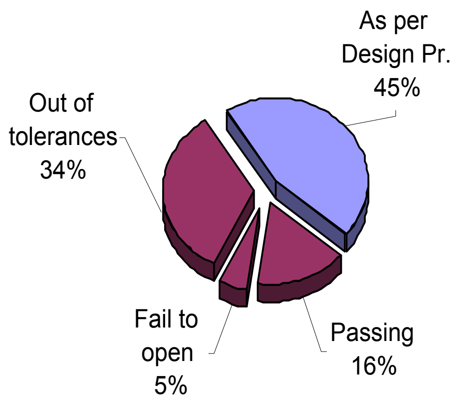
In all cases, when SRV's fail to operate the required performance while on service the following failure modes are observed:

1. **Fail to open**
2. **Fail to close**
3. **Blown down too short**: Relief valve is re-seating too early
4. **Blown down too long**: Relief valve is re-seating too long



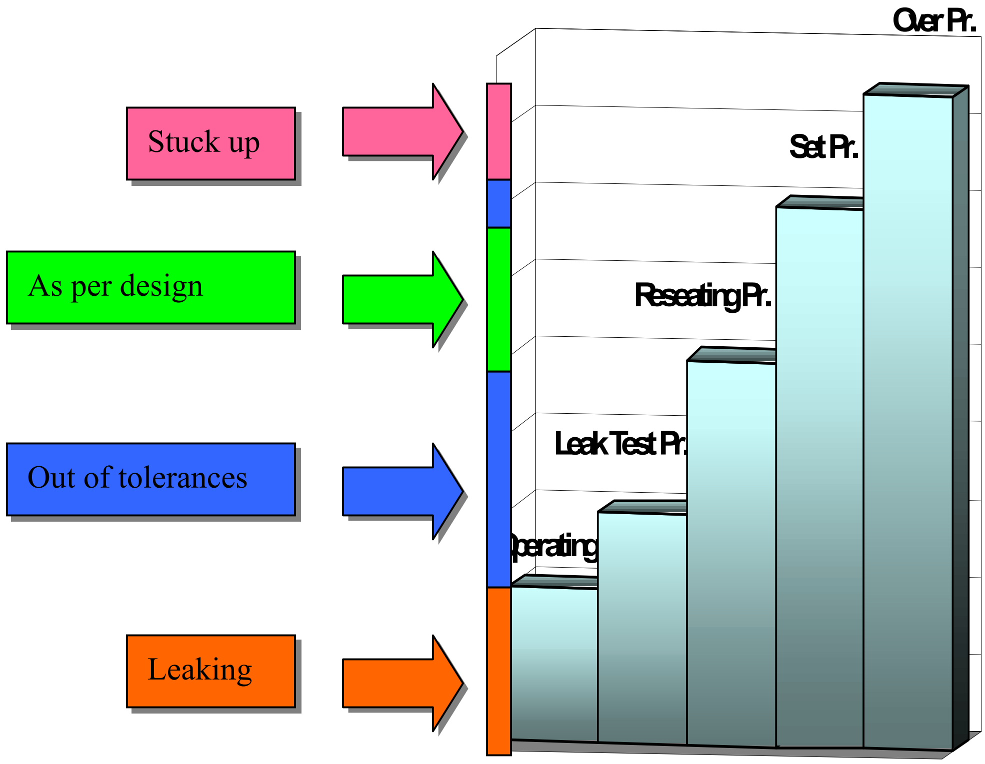
8.1 "As Received" test which is normally taken during shop testing of SRV's, shows that unexpectedly 45% found popped as per their design set pressures, whereas remaining 55% deviated from design set pressures.





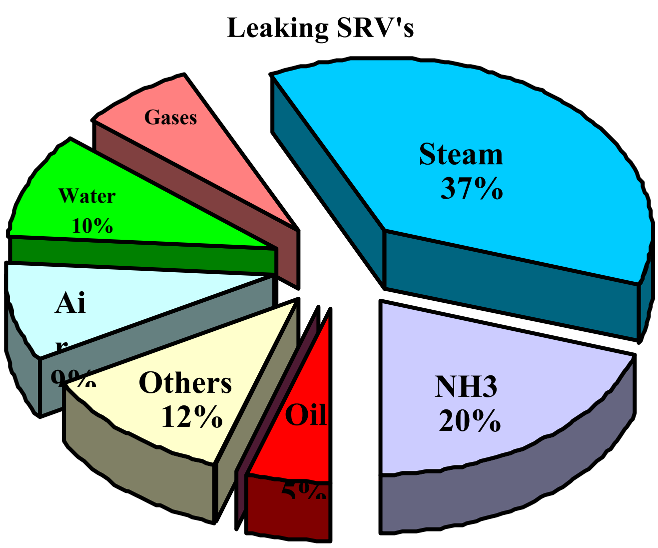
You may notice that 34 % of SRV's are neither passing nor stuck up but popped out of their standard tolerances. This is a serious alarming figure for industrial companies that lack approved or acceptable limits.

5% of SRV's were found stuck up which means that an explosion may occur at any time due to overpressure



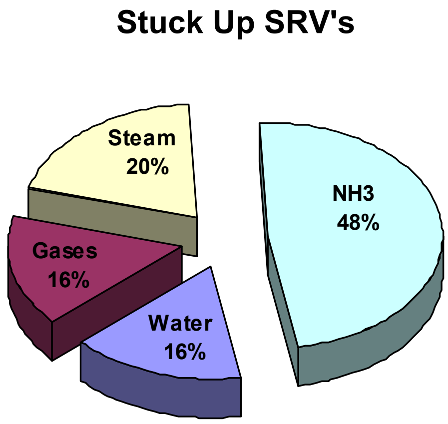
8.2 Leaking SRV's profile

Analysis findings revealed that 16% of SRV's are leaking while on service which means loss of production / process or emission into environment. 37% of leaking SRV's are mainly steam services, 20 % are ammonia. (see next chart for other services)



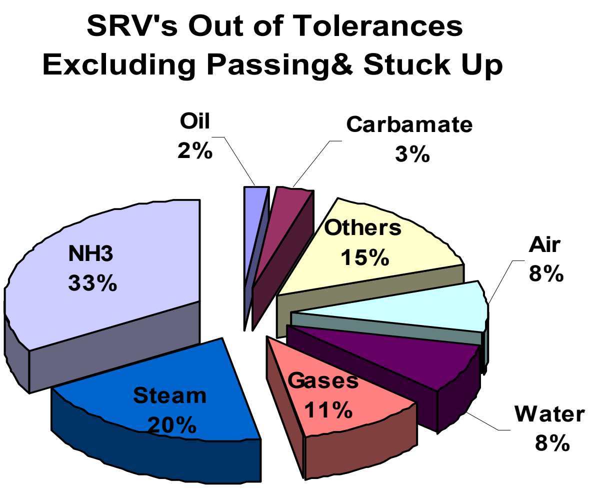
8.3 Fail to open profile

Analysis finding revealed that 5 % of SRV’s are stuck up while on service which means equipments are probably exposed to an overpressure condition. 48 % of stuck up SRV’s are mainly ammonia, 20 % are steam services. See next chart for other process.



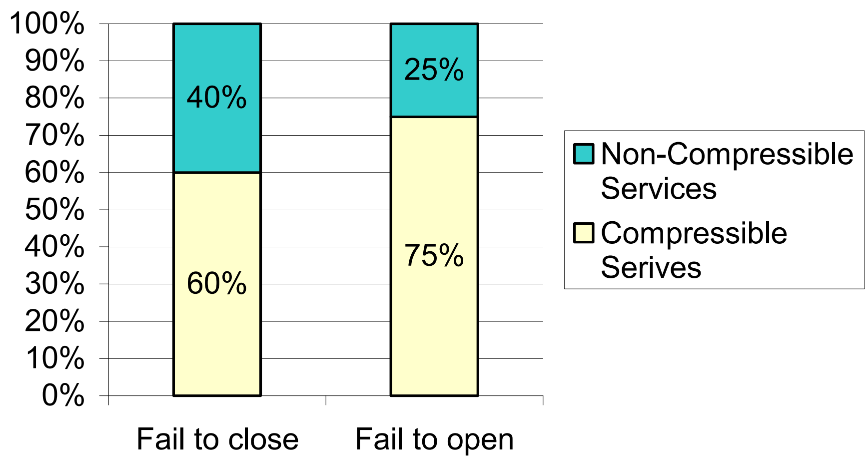
8.4 Out of tolerances profile

Analysis finding revealed that 34 % of SRV’s have been found out of their standard set points and not including of passing & stuck up. 33 % of these SRV’s are mainly ammonia, 20 % are steam services. (See next chart for other process)



8.5 Compressible vs. non-compressible services :

Criteria	Compressible Services	Non-Compressible Services
Fail to close	60	40
Fail to open	75	25



From above chart, safety valves of compressible services like steam and gases have shown more potential failure than relief valves type.

9. POSSIBLE CAUSES OF IMPROPER PERFORMANCE

9.1 Cyclic Operation

Abnormality, frequent shutdown/ start up or fluctuating of operating pressures up and down might impose frequent popping of the relief valve and subsequently would cause damage or failure.

9.2 Vibration

Presence of vibration or pulsation sources can affect / disturb valve internal such as seat tightness, cracks.

9.3 Corrosion

Most of industrial SRV's are subjected to have corrosion or deterioration problems due to attack of sever services.

9.4 Gumming and Sticking

Process with high content of solids and deposits with improper heating can cause valve to be choked.

9.5 Inferior Design

Improper design or selection of PSV materials that is required for a specific service can lead to valve malfunctioning.

9.6 Rough handling

This can affect tightness of the valve and causes a deviation on PSV set pressure.

9.7 Quality of overhauling

Lack of thorough and comprehensive procedures might affect performance of the valve.

9.8 Testing frequency

Improper determination of test intervals or test frequencies of SRV's can cause some deviation from design set pressure.

9.9 Hydro-testing of plant equipments

Any hydro-testing of any equipment without blinding SRV's connected to the same equipment can cause some deviation.

9.10 Close gap between operating and set pressure

This would cause SRV's to have frequent popping and subsequently passing problems.

10. RECOMMENDATIONS

A Thorough study shall be made for *ammonia* and *steam* services where most off-set pressures occur.

B Proper handling:

- SRV's shall be in vertical position during lifting, transportation and installation to ensure internal tightness intact.
- Bumping and dropping SRV's shall be avoided by proper rigging.

C To install rupture disc in services causing stuck up of SRV's for instance ammonia with water shall be considered

D Reduce source of vibration specially near pulsation or reciprocating equipments.

E Process Hazard Review (PHR) study which is an element of Process Safety Management (PSM) can be prepared whenever change of working parameters or redundant removal take place.

F Upgrade valve materials to avoid sever corrosion / erosion.

G Set a bench mark for acceptable or best practice deviation between "as received" and design set pressures with other similar petrochemical plants.

H To make risk assessment analysis and set a Safety Integrity Level which indicates your willingness to accept certain risk or deviation.

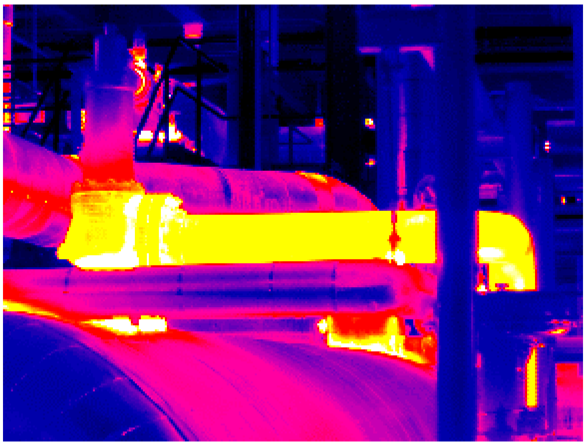
I Proper determination of Test Frequency interval:

- No standards or codes or manufacturers can specify test frequency intervals but some guidelines /techniques can be provided:
- History data and Mean Time Between Failure (MTBF) of each pressure safety valve can specify reasonable test frequencies.
- Manufacturers recommendations.

J On-line testing is another technique that is used to test and set SRV's while on service by means of test commercially called "Trevi test"

Trevi test device is used to verify the set pressure of a PSV without removal from service. It relies on knowing valve seat area as well as the spring rate in order to determine whether the set pressure is correct or not. Total downtime cost will be reduced by 50% approximately.

- Infrared thermography technique can be used as precautionary test to determine those leaking SRV's.



11. CONCLUSION

This report has focused on the integrity of safety/relief valves and their performance during operation and emphasizes that safety shall not be compromised when repair cost is considered. From the data collected and survey observations, approximately 55% of all safety/relief valves are found to be out of their normal condition, weakening the protection of equipments, personnel and affecting the environment. Further, more focus on both ammonia and steam SRV's for their compatibility with design and service conditions can be studied.

In summary the recommendations provided can be considered as guidelines toward minimizing or eliminating the gap of mentioned deviation. However, a global agreement within the industry such as fertilizers can be a powerful tool to standardize the best practice within an acceptable deviation.

GLOSSARY

Safety Valve is a spring-loaded pressure relieving device that is characterized by rapid, full opening and sharp popping sound. It is mainly used on compressible services such as air, gas, steam.

Relief Valve is a spring-loaded pressure relieving device that opens in proportion to the pressure increase above the set pressure. It is characterized by slow opening and used on non-compressible services such as liquid.

Set Pressure is a pressure at which a pressure safety valve (PSV) is set to open and relieve under service conditions.

Maximum Allowable Working Pressure is a maximum pressure permissible of a system under certain temperature.

Over Pressure is the pressure increase over the maximum allowable working of a system .

Re-Seat Pressure is a pressure at which the PSV re-establishes contact with the seat after popping or at which lift becomes zero.

Blown Down is the difference between the set pressure and the re-seating pressure.

Leak Test Pressure is a pressure performed close to set pressure to ensure valve seat tightness .

As Received Pressure is the pressure at which PSV pops when received at shop before carrying out any repair.

Safety integrity level is the safety function of a PSV may continue to perform work (possibly weaker) in spite of partial loss of implementation or simply is your willingness to accept certain risk.