Safety Valves

• ScSSV – surface controlled subsurface safety valves
• Storm Chokes – subsurface controlled subsurface safety valves
• Surface valves

• Primary purpose is shut-in of the well in event of loss of surface wellhead integrity.
Valve Actuation Control Point – Is it a Surface Controlled SSSV or a subsurface controlled SSSV?

- Surface – supplies hydraulic pressure to valve – holds open the valve against a spring or nitrogen charge that seeks to close the valve.
- Subsurface – flow from the well itself can be used in some cases to shut-in the well.
Valve Reliability

• Malfunction rates of several recent ScSSV installations have caused an examination of causes:

• Failure causes:
  – Piston failures and leaks within the valves
  – Control line crushing
  – Control line splice failures
  – Control line junctions with the valve
  – Valve damage (hinge pins and sealing surfaces)
Terms

- **Failure** – a failure to close when hydraulic pressure is lost – (very low incident)
- **Malfunction** – uncommanded closure or slam closure during production (more common)
Subsurface Controlled Valves

- Original safety valves
- Also referred to as storm chokes
- Activated by maximum flow of the well
- Required monthly recalibrating to be effective
Subsurface Controlled Safety valves are restrictions in the flow path held open by a spring. When the flow rate through the valve becomes so high that the resistance force collapses the spring and the force of the reservoir holds the valve shut. The well can be reopened by pumping into the well. This valve has to be reset every few weeks as reservoir pressure falls to ensure that “wide open flow” would still be adequate to collapse the spring and close the valve.
A subsurface controlled ball valve.
Poppet, ball and flapper valves were in common use.
SCSSV - Surface Controlled Sub-Surface Safety Valves

• Why? – does not require regular wireline entry to reset the valve.

• Types
  – Ball
  – Flapper

• Mode
  – tubing retrievable
  – wireline retrievable

• Features, Lockout, Equalization, Set Depth
Flapper and Ball Valves
Flapper closed – note old style elastomer seal.
Initially, flapper / seat combinations are capable of sealing 15,000 psi + (bubble tight). After time?????
Cut-Away flapper and housing designed to maximize flow area.
Inner housing on a tubing conveyed flapper type SSSV.

Housing is cut out to allow valve opening and still support opened flapper. Flapper or tube not shown.
Flapper type SSSV - tubing retrievable.

Shown in the open position - hydraulic pressure from the surface opposes the mechanical spring pressure and holds the valve open.

In deep water models (deep set necessities), the spring is replaced by a nitrogen charge or balance line.
Rough schematic of a ball type SSSV valve with dual line control.
Tubing conveyed, flapper type SSSV.

Shown closed, with tube retracted.

Pressure Equalization is required before opening.

Best method of pressure equalization is to pump in from surface.
Pressure Equalization Features

• Valve cannot open against pressure from below. Must be equalized to open easily.

• Methods
  – Pump in from above: best approach whenever practical.
  – Self equalization feature in valve
    • Push-pin in flapper
    • Labyrinth seal in valve body

Self equalization features sometimes not recommended – another leak path?
After closing a SSSV, pressure equalization is needed.

May also be assisted by mechanical force such as small tubing or coiled tubing.

In general, equalizing valves are not recommended because of complexity and reliability issues.
Comparison of tubing retrievable and wireline retrievable valves - flapper only shown. Note – both are push-pin equalization path valves. What effect will large gas flows have on push-pin seal integrity?
Estimates of gas pressure equalization times from below ScSSVs.

Note that the time is generally independent of pressure and very dependent on volume of gas.

<table>
<thead>
<tr>
<th>Pressure below the flapper</th>
<th>Time to equalize 1 ft³</th>
<th>Time to equalize 500 ft of 4-1/2” tubing</th>
<th>Time to equalize 1000 ft of 4-1/2” tubing</th>
<th>Time to equalize 2500 ft of 4-1/2” tubing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 psi</td>
<td>12.5 sec</td>
<td>9.1 minutes</td>
<td>18.2 minutes</td>
<td>45.5 minutes</td>
</tr>
<tr>
<td>1500 psi</td>
<td>12.6 sec</td>
<td>9.2 minutes</td>
<td>18.3 minutes</td>
<td>45.9 minutes</td>
</tr>
<tr>
<td>2000 psi</td>
<td>12.8 sec</td>
<td>9.3 minutes</td>
<td>18.6 minutes</td>
<td>46.4 minutes</td>
</tr>
</tbody>
</table>

Venting through the valve creates washouts – pump in from the surface whenever possible. Non venting ScSSV are more reliable according to Sintef data. Large valves are not usually equalizing.
Conveyance Methods

• Tubing conveyed valves
  – Advantage: maximum opening and minimum restriction to flow. Allows some wireline and CT access capability.
  – Disadvantage: must pull tubing to repair.

• Wireline conveyed valves
  – Advantage: can be replaced by wireline
  – Disadvantage: a significant restriction in flow path.
Nipple for holding a wireline set retrievable SSSV.

Notice the connection port at the upper right - connects the annular hydraulic line.

The wireline valve nipple can be added above a tubing conveyed valve for extra flexibility in case of a tubing valve malfunction.
A cut-away of a wireline conveyed ScSSV locked into a profile

Slam closure puts extreme forces on locks – a major problem in large bores

Seal selection in large bore wells requires different seal stacks – and testing for specific applications.
Set Depth

• Shallow Applications
  – Spring type valves

• Deeper Applications
  – Nitrogen dome valves
  – Balanced pressure valves (takes 2 lines)
Remedial Possibilities

• In-Place Repair – non intervention
  – Sealants
  – Cycling the valve

• In-Place Repair – intervention
  – Lockout and set wireline valve
  – Lockout and set storm choke

• Pull and Replace
One of the most common line crushing reasons is pinching of the line between the tubing coupling and the casing wall.
Crimping Damage to SCSSV Control Line – Shell Oman
DHI Video record of a stuck flapper in a SSSV. Tubing pull required to repair.
Closing the ScSSV

- High rate slam closure – verification testing needed at AOF (worst case).
  - Can the flapper become a “wing” and float?
  - What are pressures at closure above and below the valve?
  - What is the closure time? Is “water hammer” a problem? Water hammer is generated from closing a valve too quickly in an all liquid well.
  - What is the closure stress effect on couplings above the valve? We have seen leaks in upper connections after repeated slam closures.
  - What is the closure time for the valve?
ScSSV Selection Recommendations

- API RP14A, class 2, **MONOGRAMMED**! (also known as ISO 10432).
- Metallurgy matched to conditions.
- Big bore and high rate valves tested and qualified for the specific well application.
- Have best-practice installation procedures.
SSSV Conclusions

• Although Subsurface safety valves can offer a barrier against flow in the event of a wellhead collapse or other catastrophic event, the valves themselves present reliability problems that often require workovers.

• Control line crushing, plugging and leaks at junctions have been isolated as one of the most common valve malfunction causes.