

RAPID PRESSURE RELEASE STUDY

KLX FRAC RELIEF VALVE SYSTEM (FRVS)*

Avoiding downhole overpressure is critical for safe, efficient and economical frac operations. To ensure that the KLX FRVS delivers next-level pressure release, KLX Energy Services performed a Computational Fluid Dynamics study to determine the unit's exact pressure management performance metrics. The numbers speak for themselves, explaining why with the KLX FRVS deployed to more than 250 wells nationwide there has never been an overpressure event with the unit in place.

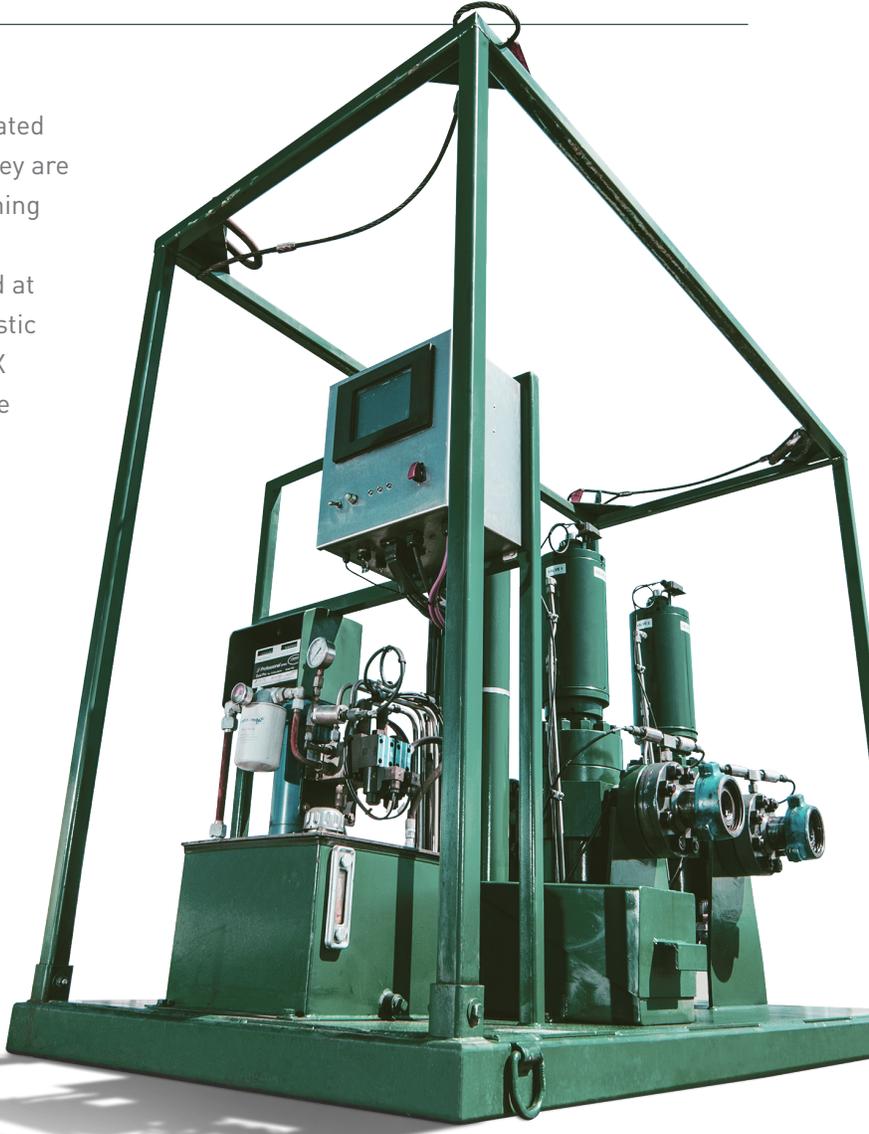
About this Pressure Release Study

The objective of this study was to determine the estimated number of barrels released, and the speed at which they are released, from an operator frac system during an opening event. Specifically, the study measured barrels lost at various stages of the unit's operation, from fully closed at pressure to fully opened. The results determined realistic functional field performance levels and proved the KLX FRVS to be fast and effective during a pop-off (pressure relief) event.

Methodology and Considerations

This study measured the unit's pressure relief performance at three specific pressure limits: 8ksi, 10ksi and 12ksi. Additionally, pressure release from each pressure level was correlated to the unit's deployment at different valve gate positions during a full opening pressure relief cycle: 25% open, 50% open, 75% open and fully open. The simulation used fresh water as its testing medium.

The FRVS unit reaches a 100% open position in just 1.2 seconds. So BBL loss for each stage of operation was also corresponded to its associated opening time, allowing for overall performance calculation. Valve size on the test unit was 2-9/16.



Pressure Relief Performance Results

Measurements for each of the pressure selections and open positions was determined as follows:

OPEN POSITION	8,000psi	10,000psi	12,000psi
25%	1.26	1.41	1.55
50%	3.01	3.37	3.69
75%	6.15	6.88	7.53
100%	13.62	14.81	15.76

*values reflect BBL/SEC

These values were then multiplied by the opening time for each event to give the total BBL loss during each opening scenario.

	OPENING TIMES	OPEN POSITION	8,000psi	10,000psi	12,000psi
25%	.25	25%	.32	.35	.39
50%	.4	50%	1.21	1.35	1.48
75%	.4	75%	2.46	2.75	3.01
100%	.15	100%	2.04	2.22	2.36
		TOTAL BBLs LOST	6.03	6.67	7.24

*values reflect BBL/SEC

Given a constant applied pressure, the number of barrels lost over time can be calculated using:

$$\text{BBLs LOST} = \text{BBLs LOST DURING OPENING EVENT} + \text{BBLs LOST FULLY OPEN/SEC * SECONDS THE VALVE IS OPEN} + \text{BBLs LOST DURING CLOSING EVENT}$$

Using this equation we've calculated the number of barrels lost over time during a pop-off event as follows:

SECONDS OPEN	8,000psi	10,000psi	12,000psi
1	25.67	28.15	30.24
5	80.15	87.38	93.28
10	148.25	161.41	172.08
30	420.65	457.52	487.28

*values reflect BBL/SEC

CONCLUSION: PROVEN RAPID RELEASE

At these rates of pressure relief, operators can be comfortable that the KLX FRVS will release operating pressure at a rate more than sufficient to prevent over-pressurization of the frac system upon reaching the unit's pre-set pressure limits. The testing team performed additional field tests whereby the unit decreased system pressure from 9,500psi to under 4,000psi in less than 1.5 seconds. For questions about the results of this study, or for more information of the KLX FRVS, contact your KLX Energy Services representative.

*KLX FRVS patent pending



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