Excess Flow Valves in Codes and Standards

Several codes require excess flow valves in pipelines so that in the case of line rupture, the flow will be shut off. In theory, this is a good idea, however, in practicality, it has many limitations. The sizing and practical uses make the sizing difficult if sometimes impossible, depending on the design parameters.

Code Requirements

NFPA (NFPA 2 7.1.24.1) and IFC, require emergency isolation that includes excess flow valves for shutdown and other methods of isolation. Other methods include:

1. Electronic excess flow control - a flowmeter can be used. Appropriate parameters can be programmed in terms of peaks and delays.
2. Pressure-activated excess flow (variation of above). This is also used in dispensers, as a loss of pressure can be a proxy for a broken/leaking line.
3. Shutoff valves that are controlled from leak detection with the leak detector location being the challenge. In certain applications (such as forklifts), it's easy to put a detector in the fueling area and call that emergency isolation.

There are (2) categories of excess flow valves, self-contained system, and active systems:

Excess flow valve use needs to be differentiated between large, complex pipeline systems with multiple sources and customers and significant public exposure risk from smaller, single-source pipelines with single customers and limited public exposure. The risk profiles are very different.

The issues with any excess flow valves, especially in smaller piping systems are:

1. Possible peak flow rates from the system may not be high enough to shut the excess flow valve. This can be due to high-pressure drop in the piping system at higher flow rates. This is especially true in systems where the inlet to the pressure-reducing regulator pressure degrades, as the product is used from the hydrogen supply system, such as a gas source (cylinders and tube trailers) that is replenished with gas. This can occur when additional components are added to the pipeline, such as another pressure-reducing regulator to reduce the pressure further down the pipeline, a long pipeline, or other high-pressure drop component. In other words, the flow capacity of the piping system decreases as the supply pressure decreases. If the excess flow valve is designed for the highest flow (when the trailer is full), it will not close with the trailer at the lower peak flow rates from the supply pressure is diminished.
2. Flows rates that are too high and will shut down a critical application when there is not a break in the pipeline. This can occur when a surge vessel is filled or a line is rapidly opened.
3. The code does not define a % breakage at which the device should activate (10%, 50%, or a full break)?
4. The break location in the pipeline may be critical, especially with long, small lines. It may easily change the peak flow rate if the system shuts down if the break is at the storage system or at the end of the pipeline. The pressure drop will change the maximum flow rate in the pipeline and varies based on the length of the line and components.
5. The pressure changes (such as a regulator set point change) which changes the flow characteristics of the excess flow valve.

Examples are provided below:

1. Peak flow rates are too low from the system to ever close the excess flow valve
   Take a system designed for a peak flow rate of 8000 scfh from a tube trailer. A regulator is provided that has a Cv of .139 with isolation valves and check valves on both sides of the regulator. The set pressure of the regulator is 200 psig.
   The maximum pressure of the tube trailer is 2700 psig. At this pressure, a temperature of -20 Deg F. and delivering 200 psig into the pipeline, the pressure control manifold maximum flow rate is ~60,000 scfh. As the pressure reduces, so does the flow. See the table below.

Pressure (psig)	**Max Flow (scfh)**
2700	60,000
1500	36,000
800	18,000
400	8,000
All @ -20 Deg F	

   At 100 degrees F, the chart flows would be reduced, making the situation worse.
   Normally the manufacturers recommend the set point of the excess flow valve is 3 times the peak flow needed. As per the table above, if the set point was 24,000 scfh, the excess flow valve would not shut off at all below ~1200 psig in the trailer.

2. Flows rates that are too high and will shut down a critical application when there is not a break in the pipeline.
   Example: A normal peak flow for an application is 8,000 scfh, but on occasion, 25,000 scfh is used to fill an empty pipeline and surge tank. Although 25,000 scfh is not critical to the operation, hydrogen at 8000 scfh is critical. If the system shuts flows off, parts are destroyed that were currently under manufacture. With the example above, if the set point is 24,000 scfh, the excess flow valve will shut during a surge and cause manufacturing losses. The user in this example removed the excess flow valve.

3. What size break in the line would trigger the excess flow valve?
   Example - If a system has a houseline normally has a flow of 8000 scfh, but the system could flow up to 60,000 scfh (regulator failure). This may not trigger the excess flow valve, depending on the opening location in the pipe and the size of the opening. This example uses a downstream pipe o f 1.5" copper tube .035" wt, with 1' of pipe after the regulator,
   See the chart below, using set point of 3 x the peak flow, the excess flow valve set point would be 180,000 scfh and would not actuate until larger than a **½" dia hole was open**, assuming the houseline regulator would pass that much flow.

Opening Size (circular dia)	**Flow (scfh)**
1/8"	3,000
1/4"	25,000
3/8"	80,000
½"	150,000
All @ 100 Deg F	

4. Length of pipeline issues.
   In the previous example, the pipe break was 1' from the system regulator. If the houseline is 1000' feet long and to 1.5" Copper tube and the break is at the end of the pipeline, the chart would change per below. All wall thickness used were .035". The pressure drop in the houseline becomes significant when the break is larger than 3/8" or the pipe line is flowing 70,000 scfh or more. In this case the excess flow valve would not open until **greater than a 5/8" dia** hole was open. So the location of the beak affects the closing of the excess flow valve.

Opening Size (circular dia)	**Flow (scfh)**
1/8"	3,000
1/4"	25,000
3/8"	70,000
½"	110,000
5/8"	150,000
All @ 100 Deg F	

5. Houseline pressure changes
   Looking at a system designed for a peak flow rate of 8000 scfh from a tube trailer. A regulator is provided that has a Cv of .139 with isolation valves and check valve son both sides. The set pressure of the regulator was originally 200 psig and is now to be reduced to 50 psig, as new equipment needs the lower pressure. In addition, set point of the excess flow valve will change due the pressure.
   The maximum pressure of the tube trailer is 2700 psig. At this pressure, a temperature of -20 Deg F and delivering 200 psig into the pipeline, the pressure control manifold maximum flow rate is ~60,000 scfh. As the outlet pressure reduces, the flow maximum flow through the regulator increases, but the pipeline pressure downstream decreases.

In summary, there are many variables that affect the actual shutoff off of the excess flow valve either when needed or when not wanted.

The suggestion to the CGA and NFPA would be that excess flow valve design be limited to larger, complex pipe systems, especially where these large pipelines run through the public domain. The risk profile for these large pipelines in the public domain is much higher than the small systems in an industrial environment.