Ben Barker, Cool Sorption, Denmark, outlines methods of improving the availability of vapour recovery units through smart arrangement and maintenance.

A ROUTINE TO RELY ON

Looking back at the first wave of vapour recovery units (VRUs) installed in Europe some 30 years ago, what was then state-of-the-art would largely be deemed 'experimental' today. Focus was on testing and verification of the overall concepts and not always on reliability. Since then, attention on emissions has sharpened considerably and most truck depots and onshore ship terminals are no longer allowed to operate without a functioning VRU.

For the VRU manufacturer, reliability has therefore become the single most important sales parameter. Often, the terms 'availability' or 'up-time' are used instead of 'reliability', since it is easier to quantify ('availability' = hours available/hours required [percentage]).

The focus of this article is VRUs based on adsorption on activated carbon followed by regeneration under vacuum. For several decades, this has been the most commonly used process for vapour recovery.

There are many ways of improving the availability of a system. One strategy, often seen in VRU specifications, is to request installed spares (redundancy) of all rotating equipment. While this seems to be a straightforward approach, it is costly in terms of installation and becomes relatively complicated in terms of control, operation and maintenance; equipment cannot be expected to kick in when needed unless it is used frequently. Therefore, the controls must be set up to ensure that the back-up equipment runs regularly, but still less often than the primary equipment. This in turn means uneven service intervals, which can be difficult to arrange in practice. And even if rotating equipment, and perhaps control valves, control systems and instruments, are made in redundant design, then other elements such as on/off valves and solenoid valves are still vulnerable to failure.

In some cases, a degree of redundancy can be obtained at little additional cost by installing 2 × 50% or 3 × 33% capacity on rotating equipment instead of 1 × 100%. This arrangement can enable the entire system to run on reduced capacity instead of being completely stopped in case of equipment failure.

Since the total cost of an installation will always be a strong driver, the goal is to maximise reliability while minimising investment and operational costs, including service and maintenance.

The following is a list of important drivers for ensuring maximum availability at reasonable cost. A long-term strategy with good maintenance and continuous feedback from existing installations ensures an average VRU availability of above 99%.

Technology selection

Several different unit processes can be applied for vapour recovery, each having their individual advantages and draw-backs. The most widely used have been condensation by means of temperature and/or pressure, adsorption, absorption and membrane filtration, very often in different combinations.

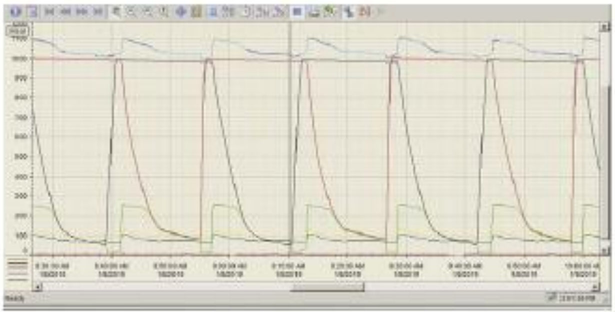

Figure 1. Logged data from a pressure-swing based VRU.

Figure 2. VRU maintenance.

Through years of trial and error by different VRU manufacturers and clients, the outcome has been that over 90% of all new VRUs are based on adsorption onto activated carbon, regeneration by vacuum and re-absorption of the recovered hydrocarbons in a steady flow of fresh absorbent (typically gasoline). The process is relatively simple and after many years of refining the design and controls, the process has proven extremely safe and reliable.

Component selection

Components should be robust and well-known, with a good track record and long maintenance intervals. It is also important to ensure that chosen equipment can be serviced onsite and does not require regular factory overhaul, since this will severely impact the overall VRU availability.

Condition monitoring

The VRU control system should not only control the process and alert if any parameter is moving beyond pre-set limits but also monitor and record key process parameters for further analysis (Figure 1).

As an example from a pressure swing system based on adsorption of the hydrocarbon on activated carbon, a detailed analysis of the pressure curves can disclose a lot of information about VRU load and status of carbon, vacuum pumps, valves, actuators and instruments. This information should be used as an integral part of the maintenance concept.

Periodic preventive maintenance

A firm scheme for regular, onsite preventive maintenance is crucial for the long-term reliability of a VRU. To ensure reliability and the overall safety of the system, the service job should not only include replacing lubricants and seals but also contain a careful check of all instrument and control loops.

On VRUs where sufficient data from the condition monitoring is available, the onsite services can be supplemented with regular remote or virtual service visits where an expert uses the logged operational data to make an in-depth analysis of relevant key parameters (Figure 2). Such a virtual visit can very often be used to determine which parts are beginning to show signs of wear and should therefore be ordered in advance and brought to the next onsite service.

Spare part strategy

Even with the best preventive maintenance, a risk of unplanned stop due to failure of a component will always remain. Every VRU owner is different and there are many ways to tackle readiness of spare parts. But it is advisable that a spare part strategy is in place so that at least the most likely situations are planned for in advance. A sensible spare part strategy should – for each group of parts – include an evaluation of the following:

- Most common type of failure (slow decline or sudden failure).
- How failure will be detected (via control system, daily inspection by local staff, regular remote service visit or regular onsite service).

Table 1. Example of spare part contingency plan from pressure-swing based VRU

Equipment type	Source				
	VRU local stock	VRU central/ sister stock	VRU supplier stock	Part-manufacturer stock	Part-manufacturer order
Activated carbon[1]					✖
Process pumps – bearings and seals	✖				
Process pumps – rotor/ housing/motor/coupling					✖
Instruments[2]	✖		✖		
Valve seals (butterfly)	✖		✖		
Valve actuator repair kits[3]	✖		✖		
Vacuum pumps – bearings and seals	✖		✖		
Vacuum pumps – rotor/ housing/motor/coupling[4]					✖
PLC/power supply/I/O cards[5]	✖		✖		

Notes

1. There is a slow, constant degeneration of activated carbon. The VRU should be designed with additional capacity, ensuring that it will not become an issue for a long time after the VRU is commissioned. In a well-designed system, the carbon has a lifetime of 10 – 12 years and in many cases the emission is still below the limits after 17 years. Under all circumstances, degeneration is a slow process which should be monitored and logged via regular carbon samples analysis – typically starting after 6 – 8 years.
2. Even if it only happens very rarely, instrument failure is likely to be the most frequent reason for unplanned stops in VRUs. The failure is typically sudden, and the control system should be designed to pick it up at once. The VRU supplier will often have the most common spare instruments on stock but it is also advisable to keep spares onsite to ensure minimal downtime.
3. Due to the very high number of cyclic operations, even the best high performance, double eccentric valves will begin to leak at some point, typically after 5 – 10 years. Valve failure is almost never acute but will grow slowly over time. A leak can be seen by studying the trend curves in the system and will be detected in the periodic preventive maintenance which includes a leak test.
4. As an example, Cool Sorption has used the Busch R5 rotary vane pump in the majority of VRUs for around 15 years. In this period, not one breakdown of that pump type has been recorded. The R5 is a relatively slow running (1500 rpm) and quiet pump. A major overhaul is typically done after 10 years.
5. Errors on the PLC itself are extremely rare, but faults on input/output (I/O) cards and power supplies are not uncommon on older VRUs. The VRU supplier should have most spare components on stock.

- Criticality (will the VRU stop or can operation continue for some time?).
- Delivery time for repair and/or new part.
- Who will fix it and how long will it take?

Furthermore, it is advisable to have a contingency plan for acquiring necessary parts in case of unplanned breakdown (Table 1).

Conclusion

When keeping things simple, sticking to well-known solutions and having a dependable maintenance scheme, there is every reason to expect a VRU to have an availability of 99%, meaning that it is online 99% of the time it is expected to be online. Planned and unplanned maintenance can take up less than 1% of the time as an average over the lifespan of the VRU.