

Process safety practice

Pilots use checklists – should tanker drivers and process operators?

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Summary

The paper explores the use of checklists in high-risk industries, comparing aviation and medicine with process operations such as tanker loading and unloading. Checklists have significantly improved safety in aviation and surgery, not just for emergencies but also in routine tasks — but their effectiveness depends on thoughtful design, proper integration into workflows, and team dynamics. Poorly constructed or misused checklists can increase risk by fostering complacency or cognitive overload.

For tanker operations, checklists can be tailored to the frequency and complexity of the task, as well as the experience of the individuals involved. Lone operators performing routine tasks may not benefit from checklists, whereas teams—especially those with varying levels of experience—can use them to enhance coordination and reduce errors. Checklists are not a substitute for good system design or training. Their value lies in prompting critical thinking and teamwork rather than just ticking boxes.

Keywords: Checklists, process safety, human factors, team coordination, operational risk.

Introduction

Checklists are widely accepted in the aviation industry as core to flight safety. Whilst their use when responding to abnormal events is easy to understand because of the wide range of scenarios that pilots may have to deal with, they are also used for activities that pilots may carry out every day. Determining exactly how beneficial checklists are is difficult due to the low frequency of accidents, but it has been said that¹ "In aviation, the obligatory use of checklists could increase the safety of a flight by more than a factor of 10."

Medicine is another sector where checklists have been adopted. With backing from the World Health Organisation (WHO) checklists have become common in surgical operating theatres. One study² reported a decline in death rates as a result of surgery reducing from 1.5% before the checklist was introduced to 0.8% afterward. Also, inpatient complications reduced from 11.0% to 7.0% after the introduction of the checklist.

This seems like compelling evidence that checklists improve safety and maybe their use should be increased in the process industry. For example, a driver may load their tanker several times per day so are highly skilled at the task. But if a pilot or surgeon is expected to complete a checklist for similarly frequently

performed tasks, should a driver be expected to do the same?

It is clear that a checklist in itself does not make a task safe. The effect comes when it helps the person to perform the task more safely. To be effective they have to be very well designed and integrated into the way the task is carried out in practice. A badly designed or poorly implemented checklist may actually have a negative effect on safety.

What is a checklist?

For the purposes of this paper the term checklist refers to a simplified list of key actions that need to be confirmed or completed. It is not a full step-by-step procedure, but rather a prompt or reminder to help ensure that nothing important is missed, especially during critical phases of a task.

Checklists have to be tailored to the actual work situation and optimised so that they are as precise and accurate as possible, whilst also as short and self-explanatory as possible¹. Developing a good checklist can be challenging and may not be successful if their use is not taught through training and emphasised as important by leaders.

Procedures provide a more complete set of instructions for a task. Good practice is to provide them with a mechanism for place keeping, such as a tick box alongside each step. In this context they may be viewed as being a type of checklist. However, for the purposes of this paper the comprehensiveness of these documents mean they are outside the scope of the definition of a checklist.

Checklists in aviation

It is widely reported that checklists were first introduced in aviation around 1935 following a fatal crash of a Boeing B-17 during a demonstration flight. It was concluded that the new aircraft was too complex for pilots to fly without assistance. However, it was introduced to service successfully after issuing the pilots with checklists.

In the years after the B-17 crash the use of checklists has become standardised in commercial and military aviation. A report from NASA in 1990³ provides a very useful summary of how they are used, their capabilities and their limitations. It identifies the following objectives of checklists:

- act as memory guides
- ensure that all critical actions are taken
- reduce variability between pilots
- enhance coordination during high workload and stressful conditions.

Aviation uses two main types of checklist:

1. Do the step(s) then read the checklist to confirm
2. Read the checklist then do the step(s).

The first type is most common, especially in civil aviation, where pilots perform tasks from memory then work through the checklist with their team member(s) to confirm items on the aircraft are in the required status.

Limitations of checklists

Checklists are simplifications of tasks that are covered in more detail in flight operation and training manuals. They have developed from just an aid for competent pilots into a task in their own right with "inherent advantages and disadvantages"³.

The UK Civil Aviation Authority (CAA)⁴ states "There have been many incidents where the use of checklists has been a contributory factor." From the examples provided in its publication it appears that in many cases the poor design of checklists was an underlying issue that affected how they were used.

However, the NASA report² highlights that issues can arise due to reasons beyond the design of a checklist. Examples include:

- checklist use not initiated due to workload, stress, schedule pressures, distractions or unusual circumstances that means the cue to start the checklist is missed
- picking up a checklist as an automatic action but not actually reading it
- verification made from memory with no visual check of an item's status
- using all checklists for checking after groups of steps are performed, even when specified that they should be read before the steps are performed step by step
- moving to the checklist for the next task before completing the previous.

The report identifies psychological effects that explain how these issues arise for frequently performed tasks. People start to develop rigid mental models that allows them to process information more quickly. This is useful because they can divide attention and perform several tasks in parallel, which reduces their overall workload. The downside of this clever trick is that perception becomes less effective. People start to see what they are used to seeing and fail to detect that something is in an unusual state.

There are some practical issues with checklists. The original approach in aviation has been to have a copy of each available to the pilots that are used multiple times. This means:

- there is no method of place keeping, which is particularly problematic if disrupted or the checks cannot be followed in the exact sequence presented
- the pilot either holds it, leaving only one hand for actions, or places it somewhere in the cockpit, which may obscure displays or affect access to controls
- they can be difficult to read in low light.

Computer displays are now routinely used for presenting checklists. These can provide very effective place keeping and conditional branching, and some checks can be automated.

But CAA has highlighted potential issues⁵. Electronic displays can be particularly compelling to the user leading them to be less aware of what is actually happening around them. Also, it can be difficult to refer to multiple checklists at the same time and a backup solution is required in case of computer failure.

General guidance for effective checklists

Despite their limitations, the consensus is that well designed checklists can be beneficial. The surgeon Atul Gawande, in his book 'The Checklist Manifesto'⁶, made extensive reference to work in the aviation industry to understand how checklists can be used in medicine. He says an ideal checklist should:

- be precise
- be easy to use in the most difficult situations
- focus on the most important steps
- make priorities clear
- prompt better teamwork
- be used in training
- include between five and nine instructions
- fit on one printed page
- minimise clutter and use of colour.

He makes it clear that a checklist cannot fly a plane (or perform an operation) and if it takes too long to complete (more than 90 seconds is suggested) it becomes a distraction. Every checklist should be tested in the real world before being issued. It should follow the geographical and logical flow of the task, otherwise it adds complexity and potential frustration that may discourage use.

One of the main challenges is deciding what is important enough to include in a checklist. To satisfy the guidance above the number of items has to be kept to a minimum, and the main problem is deciding what to leave out. A company's legal department is likely to expect everything to be included and after an incident the media is likely to look at any omission on the checklist as a justification for criticism.

Role of teamwork

The NASA report³ makes it clear that the aviation industry sees use of checklists as a team activity. On a commercial flight there will be at least two pilots in the cockpit. This allows one to read out the checks and the other to perform the required verification. To be effective the people involved have to be able to work together. The industry has experienced major problems with this in the past. The implementation of Crew Resource Management (CRM) globally is viewed as having been very effective by assigning distinct role definitions, and promoting good leadership and assertiveness from people working in lower level roles. However, teams may sometimes become "overly cohesive," which can mean people avoid conflict and may have over confidence in the ability of fellow crew members.

How can we apply the principles to tanker operations?

Tanker loading and unloading in the process industry may be achieved by the following people:

- a driver working alone
- driver and site operator working together
- single or multiple site operators working together without the driver.

Loading and unloading is a very routine activity for most tanker drivers, meaning they are very familiar with the task. However, they may handle some materials and / or visit some sites infrequently, meaning they may be less familiar with some non-standard or unusual arrangements.

Some process operators may be dedicated to tanker operations, meaning they maintain a high level of familiarity with the task. For others it may be a small part of a much wider role. On some sites a single operator is dedicated to tanker operations but when absent they are covered by another member of the team who does not normally perform the task.

A matrix is presented below that proposes a philosophy for deciding in which circumstances a checklist or full procedure should be provided and used during tanker operations involving hazardous materials based on the people involved. The rationale is described below.

Driver or operator working alone

The NASA report³ and Gawande⁶ describe how checklists are used by teams in both aviation and medicine. A driver or operator working alone would not have any team members to work with.

If a lone driver or operator loads or unloads tankers frequently (more than weekly) they will clearly be able to perform the task from memory, but the psychological effect of practice will mean their attention to the task may be diminished. Expecting a checklist or full procedure to make a significant difference to how they perform the task is unrealistic.

The only effective solution in this case will be to design the system to be error tolerant. This means that the likelihood of human error is minimised, and if any do occur the consequences will be minor. The loading or unloading task should be as simple as possible, with a logical flow so that the task can be performed reliably without needing much attention. The basic engineered design should be inherently robust, with active engineered controls included if required.

Tanker operations by a lone driver or operator are one of the more challenging scenarios, partly because a written checklist or procedure is unlikely to provide any effective risk reduction. A human factors task analysis should be carried out to confirm the arrangements reduce risks to As Low As Reasonably Practicable (ALARP).

Even with good design it seems reasonable to state that a driver or operator should not work alone if they do not perform tanker operations frequently. A second person should be always present. This may also apply to very hazardous materials (e.g. chlorine, hydrofluoric acid).

Two person operations

For scenarios where a driver and operator perform the task together it seems reasonable to expect them to use either a checklist or full written procedure based on their personal experience of the task, noting that they may each perform the task at different frequency. This leads to a fairly simple guide for each person involved:

- frequent – competency only
- moderately frequent – checklist
- infrequent – full procedure.

However, this overlooks the team dynamics.

Ownership and team dynamics

For tanker operations at a process plant the plant operator has local ownership and it may be unreasonable to expect them to take instruction from a driver. Also, any checklist or procedure provided to the driver by their employer will probably only cover the actions they perform (and not actions of the operator), and it may be unreasonable to expect them to follow a procedure provided by the plant. This means the simple bullet point guide above may not be fully appropriate.

If the plant operator performs the task frequently but the driver does not, it may be appropriate for the operator to take the lead. There would be no requirement for the driver to have a checklist or procedure.

On the other hand, if the driver performs the task frequently but the operator does not, the operator, due to their higher level of ownership, should use a checklist or procedure so that they can be sure that all critical steps are carried out correctly.

If both driver and operator only carry out the task moderately frequently, or one of them does it infrequently, the solution may be for the operator to work to a full procedure. This may include some form of checklist for the driver so that they take an active role in all aspects of the task.

If both the driver and operator perform the task infrequently it should not take place without further controls.

OPERATOR \ DRIVER	FREQUENT	MODERATE	INFREQUENT	NOT INVOLVED (DRIVER ONLY)
FREQUENT	NONE	CL	PROC	NOT ALLOWED
MODERATE	NOT	PROC	PROC	NOT ALLOWED
INFREQUENT	NOT	PROC	NOT ALLOWED	NOT ALLOWED
NOT INVOLVED (OPERATOR ONLY)	NOT	NOT ALLOWED	NOT ALLOWED	NOT ALLOWED

NONE - NO CHECKLIST OR PROCEDURE USED (COMPETENCE ONLY)

CL - CHECKLIST (CRITICAL STEPS)

PROC - PROCEDURE (ALL TASK STEPS)

NOT - NOT INVOLVED IN TASK

Figure 1 – A guide to supporting drivers and plant operators when performing tanker operations

Two highly competent people

Whilst it may seem the ideal scenario for the driver and operator to be highly competent from performing the task frequently, the psychological effect of practice discussed above applies. Expecting either to use a checklist or procedure will be unrealistic and if they work closely together their ability to check each other's actions will diminish.

In these cases it may be better for one to perform the task alone, with the other only getting involved to make checks at key stages such as immediately before product transfer starts or before disconnecting.

Emergency actions

This narrative applies to routine tanker operations. One scenario where a checklist or other form of job aid may be effective is in an emergency. Displaying the key actions to perform on a sign in the tanker loading / unloading bay would seem to be a very effective solution and should probably be viewed as a mandatory requirement.

Determining the appropriate support

The matrix in figure 1 proposes a guide to supporting drivers and plant operators when performing tanker operations. Companies may wish to amend it to suit local requirements, and it may have validity for other similar tasks.

Conclusion

Experience from aviation and medicine demonstrates that well-designed checklists can help individuals carry out tasks safely and consistently. However, their effectiveness is not guaranteed. Just giving someone a checklist will not necessarily improve their performance. Poorly constructed or misused checklists can actually create cognitive overload, become

distracting, and potentially increase the risk of error.

This paper summarises how team dynamics and workplace culture, especially where individuals work for different organisations, play a crucial role in how checklists are used in practice. Failing to properly understand the task and its risks can lead to an over-reliance on written checklists or procedures that leads to a superficial box-ticking exercise, offering minimal real-world risk reduction.

Another aspect to consider is the physical environment where tasks are performed. Pilots and surgeons are usually protected from the weather, whilst tankers are usually loaded and unloaded outside in all weathers. Paper checklists can quickly disintegrate. Checklists can be presented on electronic handheld devices, provided they are suitable for use in hazardous areas, but can be equally difficult to use when it is raining and often illegible in sunshine.

References

1. Muller, M. *Increasing safety by implementing optimized structures of team communication and the mandatory use of checklists*. *European Journal of Cardio-Thoracic Surgery* 41 (2012).
2. *Safe Surgery Saves Lives Study Group*. *A Surgical Safety Checklist to Reduce Morbidity and Mortality in a Global Population*. *The New England Journal of Medicine* (2009)
3. Degani, A. Wiener, E. *Human Factors of Flight-Deck Checklists: The Normal Checklist*. NASA (1990)
4. Civil Aviation Authority. *CAP 676: Guidelines for the Design and Presentation of Emergency and Abnormal Checklist*. CAA (2006).
5. Civil Aviation Authority. *CAP 708: Guidance on the Design, Presentation and Use of Electronic Checklists*. CAA (2005).
6. Gawande, A. *The Checklist Manifesto*. Profile Books (2010).