Technical Information Document

TID No 3 – Design, Use, and Maintenance of 'Visijars' (closed-circuit samplers) for sampling and testing

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1. Introduction

‘Visijars’ are also known as closed-circuit samplers. They are clear glass containers with a lid, permanently connected to a sample point to help perform the Visual Appearance Check and other field quality control testing. Their use is increasing for drawing samples, particularly during aircraft fuelling operations.

Closed-circuit sampling systems are often preferred to sampling using open containers as they reduce the HSE risks associated with sampling activities (especially on the apron) by minimising the potential for fuel to be spilled or come into contact with operators. However, closed-circuit sampling systems can lead to an increase in other risks relating to fuel quality if they are not used or maintained properly. For example:

- failure to identify contaminants and non-conforming fuel
- accidental addition of contaminants to a previously clean fuel sample

This Technical Information Document (TID) discusses the common types of improper use / operation of closed-circuit sampling systems and provides further guidance on the best practices that should be followed.

2. What is the purpose of a ‘Visijar’ / why do we use them?

The main use of a “Visijar” is for safely taking representative fuel samples so that basic field quality control checks can be made. In the past these were taken using ‘open’ sampling methods (either from a tank top or from a sample tap / point) into a clear glass jar, from which the fuel could be analysed.

Open sampling methods are still an acceptable method for drawing a sample, but these methods have weaknesses including; exposing the operator to fuel vapour and potentially liquid, addition of contaminants from the surrounding environment (e.g. rain / dust / rust from sampling points) and the potential for a product spill.

An increased focus on workplace health and safety has led to the development of sampling solutions designed to reduce the risks / problems associated with open sampling methods. Closed-circuit sampling systems have been effective in reducing these risks, however further development of closed-circuit sampling systems now appears to be undermining some of the fundamental requirements for sampling and testing.

Throughout this Technical Information Document, operational knowledge of the use of closed-circuit sampling systems and associated best practices will be discussed to help users to ensure that ‘Visijars’ continue to provide representative samples for accurate product evaluation.

3. Flushing and sampling basics

It is important to have a good understanding of the principles of manual sampling and how contaminants enter and travel within the fuel supply infrastructure. This will highlight best practices in the use of closed-circuit sampling systems.

Different types of product contaminants are likely to be carried with the fuel along a pipeline with varying degrees of ease. Fine particles and suspended water (haze) are more easily transported, while free water and larger particles are harder to move. Contaminants can adhere to surfaces more than fuel does, they consequently tend to travel more slowly and therefore may require a significant volume of product to be flushed at high velocity to effectively mobilise and remove them.

Therefore, low velocity product flushing will often result in a Clear & Bright sample as the ability of fuel to transport any contaminants into the sampling point will be limited.

However, fully opening the final sampling valve fully does not necessarily guarantee a good flow from the source (e.g. a low point). In many cases the pipe diameter gets smaller en route to the sampling point, so although the velocity appears to be very high at the sampling point, the product velocity at the source (e.g. low point) can be considerably lower.

The table below (table 1), shows the calculated liquid velocities through various diameters of pipework based upon a flow rate of 30 litres per minute. From this data it is clear that even though the fuel velocity at a small diameter sampling point may appear to be sufficient to mobilise most contaminants, if that small diameter pipework is being used to take a sample from a larger diameter line (e.g. a 4" low point drain line), the flow velocity in the larger section will be significantly slower and therefore unlikely to transport contaminants to the sample point.

Procedures for sampling into a 'Visijar' must make sure that a good flow velocity is achieved all the way from the source. This is usually achieved by taking a line sample (e.g. opening the sampling valve whilst the fuel is still flowing into the fast-flush tank).

Table 1 – pipe diameter vs flow velocity at 30 litres per minute

Pipe diameter (mm)	Flow velocity (m/s)
15	2.8
20	1.6
50 (2")	0.25
100 (4")	0.06

Key Message

It is important to understand that a clear and bright sample that passes the Visual Appearance Check does not necessarily indicate that the fuel in our systems is clean. Sometimes, flushing might not have successfully mobilised and removed contaminants, allowing them to remain undetected in the system.

3.1. Key differences between Flushing and Sampling

Before any samples are taken, effective flushing is required. The velocity and volume of the flushing required depends on the type of sampling point that is being used and the actual sampling system itself. All flushing activities shall be performed at the maximum achievable flow velocity to achieve a good cleaning action, mobilising contaminants and transporting them through the system to allow removal.

When a sample is drawn from a low point (or any other point where contaminants are expected to accumulate), it is important to clean out these contaminants before a representative sample can be taken. Thorough flushing is required as a simple displacement of the line content volume (a frequently used practice) will almost certainly not be enough to remove these contaminants from the system.

When a sample is drawn from bulk fuel (e.g. a sample point on a pipeline, or from Upper, Middle, Lower sampling points on a tank) and where there is no expectation of significant contaminants, flushing the line content volume is usually enough to achieve a representative sample of the current batch.

In most operations the flushed fuel can be recovered back to storage after the contaminants have been settled and removed. Therefore, flushing a volume greatly in excess of the line content is always encouraged, as flushing a large volume at the highest achievable flow will provide the best possible conditions for taking a representative sample. Any contaminants will be mobilised and transported to the recovery tank for removal from the system.

Key Message

Samples shall only be drawn after adequate flushing has been performed. Flushing a volume greater than the line content at the maximum achievable flow velocity should achieve a good cleaning action, mobilising as much dirt and water (contaminants) as possible and therefore facilitating their removal from the system.

4. Considerations for installing a closed-circuit sampling system

A closed-circuit sampling system shall be capable of drawing a representative sample. More information on the correct sampling techniques is included in section 5, *'Operation of a closed-circuit sampling system (sampling & testing)',* of this document, but the fundamental design, configuration and installation of the system needs to be acceptable to enable correct sampling.

Operators shall make sure that the sampling pipework goes to the correct location so that the appropriate samples can be drawn.Sampling points shall be accurately labelled.

Where sampling will be performed during the night (e.g. without enough natural light), suitable lighting shall be provided.

Where existing systems do not currently conform to the points raised in this TID, operators should consider modifying their design to make them more suitable.

4.1. Flushing activities

'Visijars' can provide a convenient way to access a sample for product examination / quality control checks, but they are not designed to be used for flushing activities for several reasons.

1. Insufficient flow velocity and volume to mobilise contaminants for flushing

   The maximum flow that can be achieved when flushing through small bore pipework into a 'Visijar' is oftennot enough to effectively flush low points (e.g. of tanks or filters). Therefore, the sample observed may be Clear and Bright, but the flushing has not successfully removed contaminants, allowing them to remain undetected in the system.

2. Contamination of the closed-circuit sampling system lines

   Even where the flow velocity is enough to mobilise contaminants, these will still move more slowly than the fuel so will often get 'trapped' in the lines leading to the closed-circuit sampler. When contaminants get caught in these lines, they can be very difficult to flush through, and may require flushing of several times the 'Visijar' volume to remove (this is particularly true for water which tends to stick to pipe walls). If these contaminants are not successfully removed, they may contaminate future samples that are drawn, potentially resulting in false failures of quality checks and operational disruption.

As a consequence of these two issues, samples should only be drawn into 'Visijars' for product examination after flushing activities have been performed.

When flushing has to be done through Visijars due to poor equipment design, the operating procedures shall demonstrate that the weaknesses of this method (detailed above) have been compensated for to enable representative samples to be drawn (e.g. additional flushing before a sample is drawn for testing). Flushing via a 'Visijar' from a location where contaminants are expected to accumulate for removal (e.g. a tank low point drain) is never recommended. However, this practice may be deemed acceptable (after evaluation) in a location that usually has a low level of contaminants (e.g. into plane sampling).

Systems should be designed so that low points and / or pipework are flushed directly into a fast-flush tank (at high velocity) to remove the bulk contaminants that are expected to be present (e.g. settled water and particulate).

Recommended practice for operators would be to design equipment that allows a visual observation of the flushed product, so that any contaminants that are present can be documented to help build a picture of what is 'normal' for the equipment / site / supply chain. This may be via a sight glass in the line, or by obtaining a low point drain sample from the fast-flush tank after flushing and settling.

4.2. Pipework (length / volume / complexity)

As contaminants can be difficult to move through the system, the design of closed-circuit sampling systems should be such that the length, volume and complexity of the pipework supplying a 'Visijar' is minimised.

Simplifying the design of the pipework will make ongoing operations easier by reducing the flushing volume required before samples are drawn and, therefore, reducing the potential for contaminants to enter the pipework. Contaminants that do enter a closed-circuit sampling system can be difficult to remove and may require the flushing of a significant fuel volume to clear (multiple times the line / sampling system volume).

4.3. Positioning of 'Visijars'

'Visijars' shall be easily accessible to make correct operation easy to achieve. They require regular cleaning of both the internal and external surfaces so it is vital that operators can access them, preferably without the need for steps or a platform.

Cleaning is usually achieved by the operator placing their arm inside to wipe the internal surfaces (including the base) with a lint-free clean cloth or paper towel. For this to be possible, the top of the 'visijar' needs to be below the operator's shoulder height. Where there is a requirement to use steps or a platform, this activity should be managed appropriately (e.g. risk assessed).

In general, 'Visijars' should not be in elevated positions so as to minimise the energy required to transport contaminants to the jar. In gravity powered systems, this will also reduce the possibility that there will be insufficient head pressure to obtain a sample.

Note: When cleaning the internal surfaces, appropriate PPE shall be used to avoid contact with skin. Where an operator's sleeve comes in contact with fuel the contaminated clothing should be removed immediately.

4.4. Self-closing valves

The inlet pipework into a 'Visijar' shall be fitted with a self-closing valve to reduce the risk of a spill.

4.5. Sampling points

Where closed-circuit sampling pipework meets the main line from which the representative sample is taken, a sampling probe should be installed facing upstream (against the direction of flow) (see figure 1).

It is not recommended to have a simple port type connection between the sampling pipework and the line to be sampled as this is unlikely to achieve correct representative samples (see figure 2).

Figure 1

Schematic of a suitable sampling probe / pipework

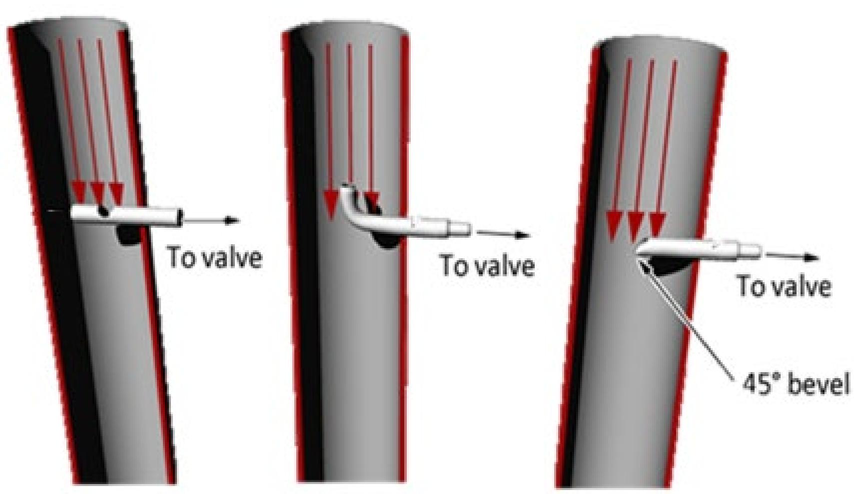
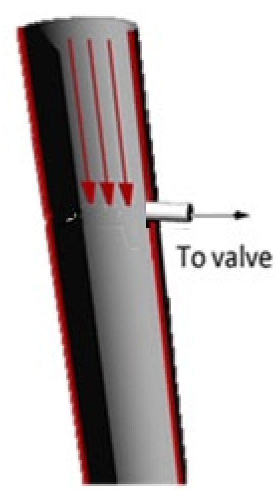


Figure 2

Schematic of improperly designed sampling pipework



4.6. Separate open sampling point

It may be necessary to draw a sample into a sample container for laboratory testing if something unusual is observed (e.g. into a can). Therefore, it is recommended that at least one open sampling point is included in any closed-circuit sampling system. Open sampling points should be designed so that they are independent of the 'Visijar' (e.g. so that fuel does not need to pass through the 'Visijar' in order to be sampled).

It may also be useful to have another open sampling point on the 'Visijar' outlet pipework to collect anything of interest which is observed during normal closed sampling.

These open sampling points are identified on the example closed-circuit sampling system shown in figure 3.

Any open sampling point shall be equipped with a self-closing valve, bonding point and dust cap.

4.7. Closed-circuit sampler design

The actual design of the 'Visijar' can also have a big impact on the effectiveness of the sampling and testing.

Older closed-circuit samplers are designed to be wider than they are tall (e.g. the diameter was larger than the height). This type of sampler (often referred to as a Deans Reel) often fails to create an acceptable vortex during sampling, which compromises the Visual Appearance Check. The newer closed-circuit samplers currently available have a diameter which is significantly less than their height, resulting in the creation of a more pronounced vortex, and consequent improvement in the accuracy of the Visual Appearance Check

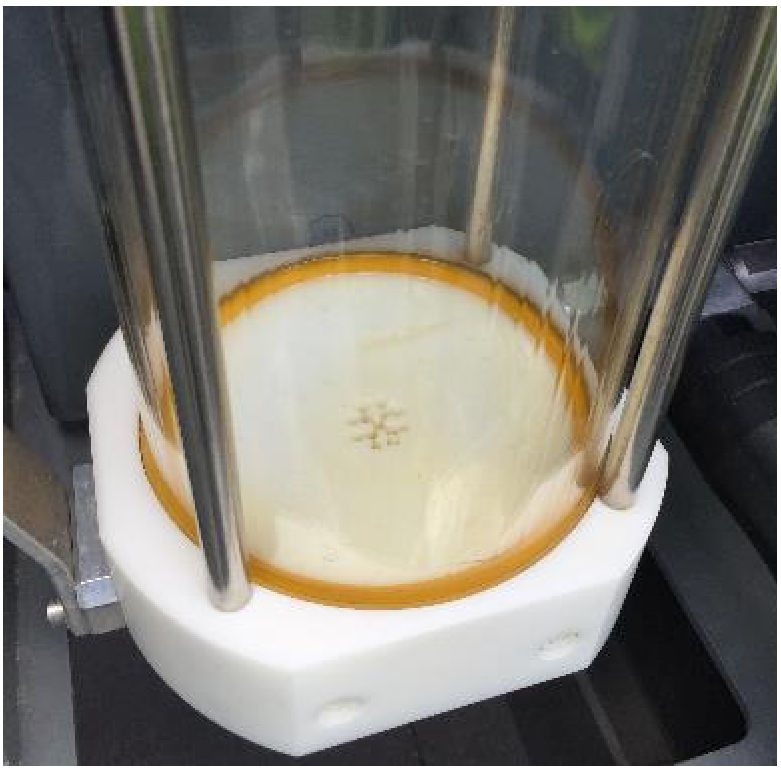
Picture 1

Example of closed-circuit sampler (deans reel) which tends not to create an acceptable vortex during sampling

One closed-circuit sampler currently available is equipped with a base which contains multiple small holes (see picture 2). This is designed to be i a ‘capsule catcher’ (to capture any Chemical Water Detector capsules which may accidentally be dropped into the sampler) but consequently has the potential to hide small contaminants from the view of the operator, which would invalidate the Visual Appearance Check.

Picture 2

Example of closed-circuit sampler which could hide contaminants



Key Message

Correct design and construction of closed-circuit sampling systems is required to achieve reliable sampling of representative samples.

Avoiding complex pipework will simplify flushing and providing good access to the ‘Visijar’ will assist operators to keep the jar clean and perform quality checks.

5. Operation of a closed-circuit sampling system (sampling & testing)

As 'Visijars' are used to draw samples so that field quality control checks can be performed, it is essential that these samples are representative of the location they are taken from, and that any testing performed is not adversely affected by their use.

The basic steps required to take reliable samples using a closed-circuit sampling system are outlined below:

5.1. Preparation for sampling

5.1.1. Flushing

Before fuel flow is sent into the 'Visijar', flushing of any low points and pipework shall be performed to remove any settled contaminants and to displace the line content (this is covered in more detail in section 2, *'Flushing and sampling basics',* and section 3, *'Considerations for installing a closed sampling system'*, of this document).

Only the small-diameter pipework leading directly into the 'Visijar' may be flushed into it, and the jar should also be rinsed before sampling with at least twice the volume of these small-diameter lines.

5.1.2. Cleanliness

Fuel wetted surfaces are likely to accumulate dirt quickly. Consequently 'Visijars' will collect a layer of contaminants, especially those located on vehicles which tend to collect a general film of dirt from driving around the airport.

In order to facilitate an effective Visual Appearance Check, it is essential that sampling equipment is kept in a clean condition. Therefore, 'Visijars' shall be cleaned regularly (both inside and outside).

In addition to regular cleaning, they require routine maintenance / checks. More information on these can be found in section 7, '*maintenance of 'Visijars''*.

5.1.3. Removal of vortex breakers

Closed-circuit samplers are designed so that the fuel entering the jar creates a vortex (see picture 3 below), this is an essential requirement for the Visual Appearance Check to be effective. It ensures that any solid contaminants or free water that may be present collect at the base of the container, making it easier to observe them. Anything that prevents the formation of this vortex or obscures the operator's view of the sample has the potential to reduce the effectiveness of the Visual Appearance Check (which is a critical quality control check).

Picture 3

Example of a good vortex created during sampling.

Therefore, no accessories that disrupt or prevent the formation of a vortex shall be installed in a 'Visijar' during sampling or Visual Appearance Checks.

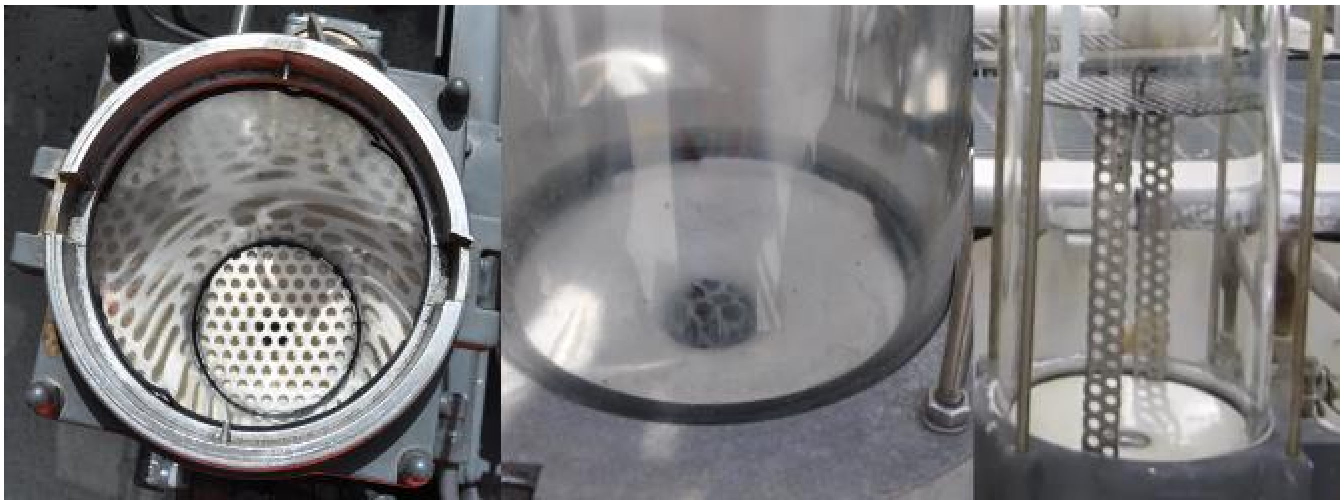
Examples of items that can disrupt vortex creation and / or impact the effectiveness of Visual Appearance Checks include:

5.1.3.1. Gauze / mesh screens (see Picture 4 for examples)

These (usually locally produced) accessories are used to catch chemical water detector capsules that may accidentally drop into the 'Visijar'.

Picture 4

Examples of locally produced ‘capsule catchers’ that shall not be used



Where a device to catch CWD capsules is required then a ‘capsule catcher’ of the type shown in Picture 5 may be installed.

Picture 5

A ‘capsule catcher’ device of this type may be used

5.1.3.2. Inserts for density measurement (hydrometer / thermometer tubes, see Picture 6)

Although these inserts may be supplied by the manufacturer, they have a significant effect on the vortex formation and obscure the view of the sample during the Visual Appearance Check.

Therefore, these hydrometer / thermometer inserts shall be removed from all 'Visijars' when performing sampling and Visual Appearance Checks.

Where fuel density and / or conductivity testing is required, they may be re-inserted only after the Visual Appearance Check has been completed.

Picture 6

Inserts used for density measurement

5.1.4. Failure to close the bottom / drain ball valve during the sampling and Visual Appearance Check

The 'Visijar' bottom / drain ball valve shall be closed during sampling and testing activities. If it is not closed, the vortex is likely to drive any contaminants present down into the 'Visijar' outlet pipework, therefore invalidating the Visual Appearance Check.

An informative video has been produced to illustrate the effect of these 'Visijar' accessories on vortex creation. This video can be viewed on the link below

Link to video on the effect of vortex breakers: https://youtu.be/LXOriOLQkcA

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Picture 7

Screenshot from the video showing the effect on vortex formation

Key Message

'Visijars' shall not contain anything that could prevent or disrupt the vortex formation or obscure the operator's view of the sample during a Visual Appearance Check.

Where density and / or conductivity measurement is also required, any associated equipment shall be removed from the 'Visijars' when performing sampling and Visual Appearance Checks but may be re-inserted afterwards.

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5.2. Drawing a sample

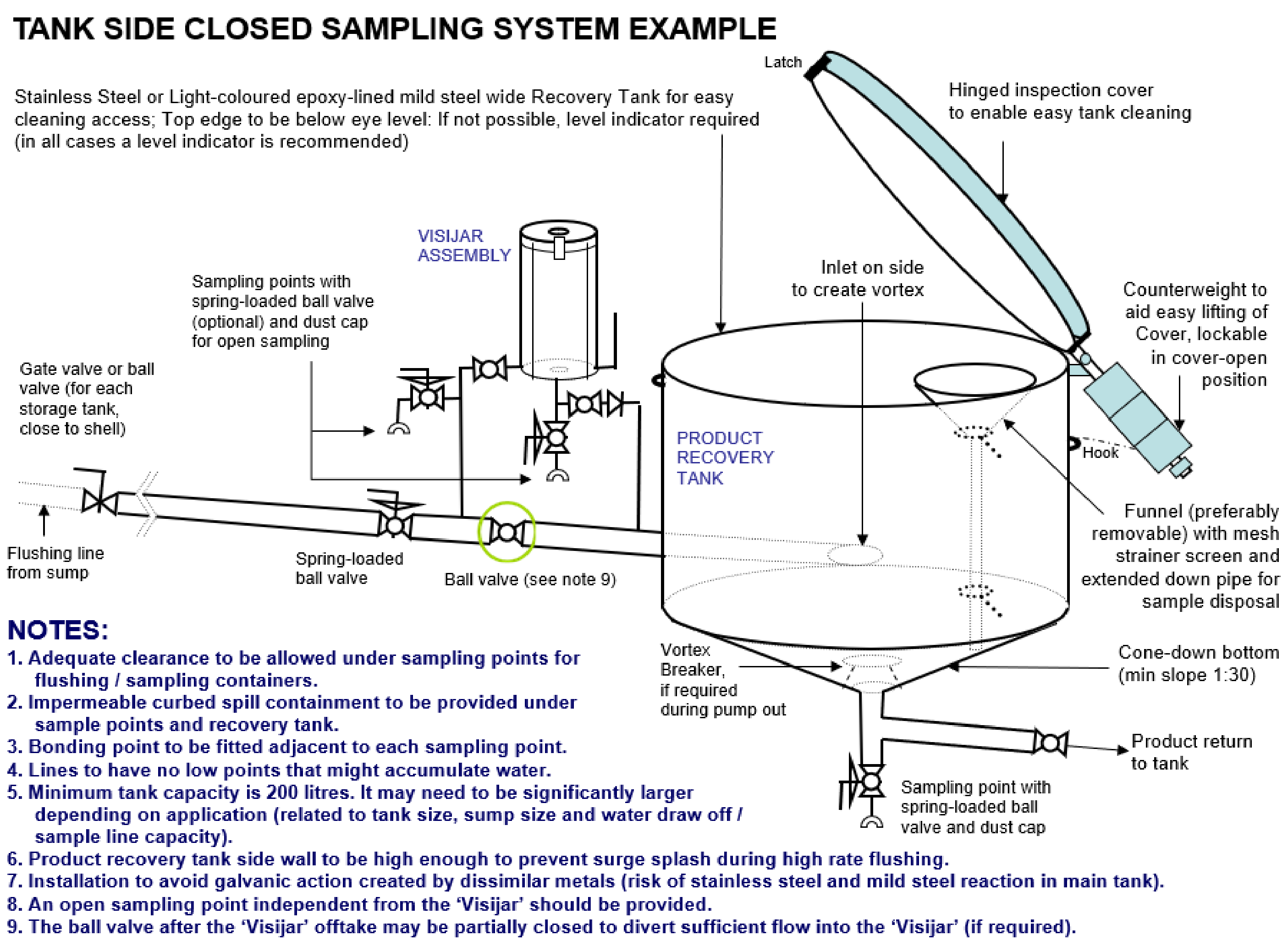
A sample for the required quality control testing shall only be taken after the necessary preparation for sampling has been completed (e.g. flushing, cleaning and removal of accessories).

Whether taking a sample, or flushing, the same principles of mobilising contaminants apply. The maximum possible flow velocity shall be achieved from the source whilst maintaining maximum flow, fuel can then be allowed to enter the 'Visijar'.

In order to achieve a reasonable flow into the 'Visijar', the main line (used to achieve maximum flow) may require a slight flow restriction (after the sampling line to the jar), therefore encouraging a greater flow of fuel into the 'Visijar'. This can be achieved by partially closing the valve on the main line (identified by the green circle in figure 3 below).

Figure 3

Example closed-circuit sampling system, identifying the valve which may be partially closed to achieve enough flow to the 'Visijar'



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5.3. Testing

5.3.1. Visual Appearance Check

The Visual Appearance Check is a simple but very important part of the aviation fuel quality control chain. In order to be able to perform an accurate and reliable Visual Appearance Check using a 'Visijar' it is essential that the sample is taken correctly in order to make sure that: it is representative of the area being sampled (e.g. tank low point), and, it enables the test to be correctly performed.

By following the guidance given above (in 5.1, '*preparation for sampling*', and 5.2, '*drawing a sample*'), a 'Visijar' can provide a convenient way to accurately evaluate the cleanliness of the fuel within the system.

In addition to the Visual Appearance Check, the fuel in the 'visijar' is often used for the other quality control checks.

5.3.2. Chemical Water Detector (CWD)

CWD testing is a routine part of into-plane quality control checks, with the most commonly used test kits requiring fuel to be passed through them with the use of a small syringe.

The bottom of many 'Visijars' are equipped with a port which can accommodate the CWD and syringe (as shown in picture 8); however, this is often not used due to leakage and therefore the test is performed via the top of the jar.

If a CWD test port leaks when the sample is drawn from it, this is likely to be because of a worn seal (the location of which is identified in picture 9). The leak should be reported as a defect and the seal replaced at the next maintenance opportunity.

Picture 8

'Visijar' with CWD port

Picture 9

Cut-away of CWD port showing the internal seal

It should also be noted that the CWD ports can suffer from moisture during certain weather conditions (e.g. condensation in the mornings). To reduce this, CWD ports should always be fitted with a protective cap.

Accessories to facilitate CWD testing at the top of ‘Visijars’ are also offered by manufacturers (both manual and pneumatically powered options are available as shown in picture 10).

Picture 10

Examples of pneumatic and manual options available for performing CWD tests from the top of a ‘visijar’

Although CWD testing may be performed via the top of the ‘Visijar’, this is not be the best place to check for the presence of free water. Free/undissolved water will settle to the bottom, therefore the concentration of free water may be lower at the top of the sample. When CWD testing is performed from the top, this should be done without delay after the Visual Appearance Check to avoid the potential of fine droplets of free water (suspended water) settling and therefore being missed by the CWD test.

5.3.3. Visual Appearance Check plus CWD

The JIG Standards state; “The primary field check for suitability of aviation fuel is the Visual Appearance Check. This may be confirmed by the use of a Chemical Water Detector test for Jet fuel to indicate the presence of free water in the sample. The application of the Chemical Water Detector test is mandatory for samples that can be considered representative of into-plane fuel quality, although it may also be used in other sampling applications where it is considered appropriate to have a verification of free water status”.

During JIG inspections it is often observed that a lot of attention is given to the Chemical Water Detector test, while the Visual Appearance Check is not carried out to an acceptable standard. It should be noted that the Visual Appearance Check is critical test to confirm the fuel is suitable for use and should therefore be given the care and attention to detail that would be expected for a critical procedure.

Note: it is now acceptable in the JIG standards to use an EI 1598 qualified inline water sensor to monitor free water content in place of performing CWD testing (Bulletin 110).

Key Message

The primary check of acceptable fuel cleanliness is the Visual Appearance Check. The use of a Chemical Water Detector test is to confirm the absence of trace levels of free water after the successful completion of the Visual Appearance Check.

Operations should continually emphasise the vital role of a comprehensive Visual Appearance Check for ensuring acceptable fuel cleanliness throughout the supply chain to the wingtip.

5.3.4. Density and conductivity

Where further testing is required this may be performed on the sample drawn into the 'Visijar', but any equipment or accessories needed to complete the test shall only be inserted after the completion of the Appearance Check (e.g. Thermometer / Hydrometer inserts. See section 5.1.3, *'Removal of vortex breakers'*, for more information).

6. Samples for laboratory testing or retention

Samples that are to be submitted for laboratory testing or kept for retention purposes should not be drawn via a 'Visijar' as passing through the jar may result in the sample not being representative of the source batch (e.g. contaminants can be lost or introduced from the walls of the jar).

Where samples are required for laboratory testing or retention, they should be drawn from a separate open sampling point that does not require the fuel to pass through the 'Visijar' (more information can be found in section 4.6, *'separate open sampling point'*).

7. Maintenance of 'Visijars'

Even where 'Visijars' are maintained to a good standard, they are prone to deterioration after prolonged exposure to fuel and sunlight, which may reduce the effectiveness of the Visual Appearance Check.

Where the condition of the sampler base has deteriorated (e.g. become discolored as shown in picture 9 below), it is possible to replace this component, or alternatively the base may be repainted with a suitable, light colored, epoxy paint. Where repainting is performed, care should be taken to avoid painting too close to the drain ball valve as this will lead to flaking of the paint when the valve is used.

In some instances, there have been reports of the glass walls of the 'Visijar' becoming 'cloudy' (stained or etched as shown in picture 9). In these cases, it may be possible to dismantle the unit to enable easier access for cleaning / polishing. If the 'cloudy' appearance cannot be corrected it should not be used until the glass section has been replaced.

It is possible to avoid / limit this deterioration by providing protection from sunlight. In some applications this is done using a cabinet, elsewhere the use of a protective cover / sleeve has been implemented successfully (as shown in picture 11). When used on the apron these need to be suitably tethered to the vehicle to avoid them becoming apron Foreign Object Debris (FOD).

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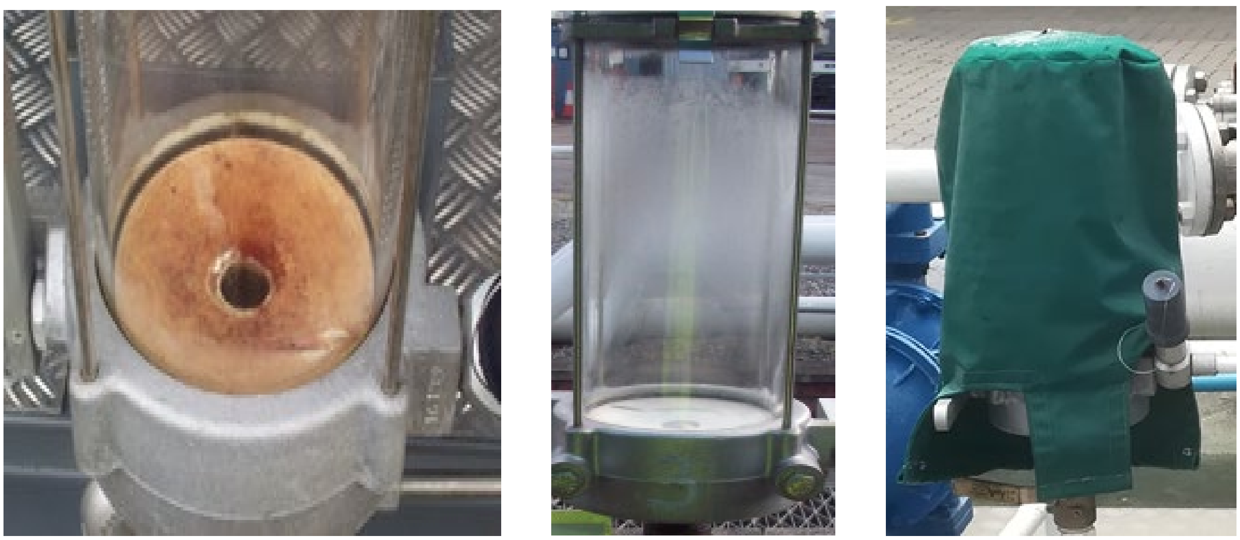
Picture 11

Examples of stained / etched 'Visijars' and a possible cover to limit such degradation



'Visijars' should also be routinely inspected to confirm general condition and that there are no leaks (e.g. cracks in the glass or failed seals between the glass and the base). Any leaks observed from closed-circuit samplers are not acceptable and the equipment should be not be used until the defect has been corrected (e.g. replacement parts have been fitted).