

## Receiving the glycols

### INTRODUCTION

70. From the error made in misidentification of the glycols, a chain of events occurred that led inexorably to the fuelling of aircraft with contaminated F-34, to the runway being sprayed with a mixture of FSII, ICA and water and to aircraft being de-iced with contaminated AL-34. The most significant aspect of this misidentification is that intuitively, it should have been entirely recoverable and detectable once the glycols had been delivered to their destinations.

### FINDINGS

#### Receipt of materiel

71. Firstly, the Panel considered whether it was incumbent on the recipient to check the arrival of a glycol and conduct any formal receipt process. JSP 886 is the Defence Logistics Support Chain Manual. Whilst its use is predominantly by those working in the logistics chain, it is based on some fundamental principles applicable to all in the MOD:

'Every item of materiel supplied or service provided by the MOD to its customers is paid for by the taxpayer. Every purchase of materiel, the cost of its receipt, storage, maintenance, issue, transportation, and deterioration, disposal or loss if it is not used or available for the purpose for which it was purchased, together with all the management activity and costs connected with those activities represents a considerable cost to the taxpayer. Each item of materiel therefore has a direct financial value and needs to be managed as if it were a resource.'<sup>11</sup>

72. The generic receipt process for all MOD stores is described in Volume 3, Part 15 Chapter 5 Article 3, which states:

'It is the responsibility of the supplier to ensure that stores supplied are fit for purpose and, if applicable, in accordance with contract conditions. All receipts will be subjected to basic checks on delivery to confirm that there is a valid order; that the correct stores have been supplied; that the quantity is correct; that there is no damage or deterioration, and that the stores are accompanied by the appropriate documentation, including where required that the serial numbers of the items correspond to those on the vouchers.'

73. However, fuels, lubricants and gases are listed as a specific exception to this and are dealt with under Volume 6 Part 2 Accounting for Packed Fuels, Oils, Lubricants and Gases. Chapter 6 section 1 opens with list of standardised products included under oils and lubricants and includes Augmentation, Coolant and Additive Fluids, known by the Joint Service Designator as AL, which includes FSII, AL-34 and AL-342. Section 3 article 14 details the receipt procedures for such items:

'Oils and Lubricant Receipt Procedures. All receipts of oils and lubricants are to be checked upon arrival to verify the quantity received corresponds to the quantity entered on the Issue Voucher and Convoy note, issued by the supplying unit.'

74. Further direction is then provided for F&L accountants on dealing with the issue voucher. However, the general principles did not state when in the logistic chain receipts should be checked nor did they detail who should conduct the check. Whilst the specific regulation for the receipt of

<sup>11</sup> JSP 886 Volume 4, Part 1: Fundamentals of Materiel Accounting, Chapter 2, Article 1a.



Fuels Oils and Lubricants described when the receipts should be checked, there is no clear guidance as to what should be checked and refers in the main, to F&L sections. Accordingly, the Panel found it difficult to read across any specific responsibilities that the PSD or the ICA compound personnel should have met, other than to check the quantity.

75. The Inquiry next considered if personnel at the PSD and the ICA compounds might reasonably be expected to have done more to identify the contents of the glycols.

#### **Delivery at the PSD**

76. The PSD is established with 4 posts: an experienced and fuels qualified Army SNCO; an RAF Logistic (Supply) Cpl to manage the computerised Bulk Fuels Inventory System (BFIS), and 2 Army Privates, both fuels qualified but with varying levels of experience. At the time, the SNCO PSD was absent on leave and this had been extended owing to the Chilean volcano eruption that had disrupted air bridge operations. His 2i/c defaulted to the Cpl who had no fuels experience but had attended the 3 week Fuels and Lubricants Managers and Supervisors' course at RAF Halton. There was no standard procedure for the arrival of the glycol and there were no accounts maintained at the PSD other than BFIS. Accordingly, there was no apparent requirement to sight or retain paperwork for a delivery. Whilst bulk fuel transfers were well regulated and controlled at the PSD, packed stock was issued to the PSD from R&D section who accounted for it. Tellingly, SNCO PSD opined that he too, would not have done anything differently (**Witness Statement 17**).

77. If it was unlikely that anyone at the PSD would have expected to sight and check delivery paperwork, then circumstances and human factors made it extremely unlikely that the glycol would have been checked on arrival. The 10 Jun 11 was a busy day for the PSD. MV Maersk Rapier had arrived and the team was preparing to start a complex operation to pump F-35 from the ship in to the storage tanks. A great deal of planning, preparation and checking had gone in to the set up. The serial was further complicated by the fact the SNCO PSD, who would normally have taken charge of the operation, was absent. However, he had been diligently preparing his 2i/c, PSD Cpl for the event, providing briefing material by phone and email and detailing precisely what routines and standing orders were to be followed. Equally, the small team were not left to fend for themselves. As an Ocean Terminal Receipt requires qualified individuals to oversee the process, OC F&L, FS F&L and SNCO Av Fuels were present, together with personnel from Interserve Defence Limited who managed work on the infrastructure and effectively licensed the site, known as Authorised Personnel Petroleum, or AP Pets.

78. The establishment of a new team to deal with the process was not without some teething difficulties. PSD Cpl was a strong character and was very proud of her and her small team's ability to deal with the SNCO PSD's absence. Together, they were entirely happy that the PSD was correctly set up for the receipt, pending one final check of pumps and valves. Consequently, the perceived 'imposition' of a management team to oversee the procedure was not entirely welcome (**Witness Statement 12**). As a consequence, during the management team's walk around, the decision to start altering the configuration of the valves provoked a confrontation between Cpl PSD and FS F&L before the FS firmly established himself as the appropriate and qualified operating authority for the PSD in the absence of the SNCO PSD.

79. Against this background, MOD Core Plant transport arrived with a glycol for delivery to the PSD. At the time, the PSD was very obviously closed, with barriers down across the road access and signs on the barriers warning that the depot was closed owing to an Ocean Terminal (OT) receipt. Perhaps unsurprisingly in the circumstances, Cpl PSD became angry and was about to turn the delivery away before FS F&L intervened, telling her not to worry about it and that SNCO Av Fuels had it all in hand (**Witness Statements 12 and 11**).



80. The receipt was flawless and although speed was not necessarily an appropriate indicator of safety and efficiency, it was anecdotally the second fastest recorded. However, during the process, a question from OC F&L, who was operating from the ship, was dealt with in a peremptory fashion by Cpl PSD over the radio. This subsequently resulted in an interview with OC F&L and FS F&L, although this was after the OT receipt.

81. As a background tale to contextualise the arrival of the glycol at the PSD, the forgoing should not be overplayed. However, it is important to recognise that a young inexperienced Cpl, very recently chastened for overstepping the mark, had been directed by her FS not to worry about the glycol. If she was ever likely to question its arrival without paperwork and demand some proof of contents, then it is the Inquiry's view that this likelihood was significantly reduced by this incident. The other members of the team, a lance corporal and a private were also present and similarly unlikely to question its arrival.

82. The next 2 occurrences where an intervention could have possibly been made were the connection and the first blending operation. However, these happened on the same day on 20 Jun 11 with the same team so the Panel considers that there was no change to the previous influences – the glycol had been already accepted by the team.

### Delivery to the ICA compound

83. The ICA compound had no manpower specifically provided to run it but was managed by SNCO Av Fuels. Together with 2 SACs from the F&L section, he took delivery of the 4 glycols from MOD Core Plant, on 17 Jun 11. None of them had worked in R&D before and none of them had taken receipt of a glycol before. Although there was a local procedure to decant the containers, it only detailed the connections to be made. Careful records of the total volume of de-icers and runway de-icer are maintained by the section but none of these require receipt paperwork. As with the PSD, there was no formal requirement to sight any delivery paperwork, although the more general rules in JSP 886 applied to the ICA, rather than the exempted AL series.

84. In the absence of a formal requirement at the local level, the Panel considered whether SNCO Av Fuels might reasonably be expected to have done something more to establish the provenance of the glycols. However, he had been involved in the initial attempts to identify the glycols and had been given the list of containers to contents by FS F&L. Subsequently, he had written the work order that had moved them, based on the list from FS F&L. He had already seen some paperwork on the glycols that he had handed in to R&D. Accordingly, the Panel consider that it was most unlikely that he would now question the identity of the glycols.

85. However, the first glycol that was delivered by MOD Core Plant was not one that he was expecting. The container number that arrived was CRXU 8511900. His testimony in **Witness Statement 10** records that he identified the Kilfrost label on the valve seal but the serial number of the container did not match up to his own work order. He re-checked the list and then went back down to East Cove to sight the remaining glycols. He identified the remaining containers as the 2 x ICA and AL-342. He returned to the compound and the decanting operation proceeded, having made the assumption that the container must be AL-34. Once empty, the container was returned to East Cove and the next glycol was collected. The next 2 deliveries were the ICA containers. The AL-342 was delivered in the following days, as it required a crane to remove it from the flatbed and leave it at the compound, where it remained.

86. There are a number of issues that could not be reconciled with this account. Firstly, the work order was wrong. It listed GESU 8003314 and GESU 8003192 as containing ICA, CRXU 8510328 as containing AL-34 and container CRXU 07649900 as containing AL-342. The latter container



had one too many digits and didn't exist on the company's database of containers. In attempting to identify what it might have been, the Inquiry attempted some simplistic transposition of numbers. No other combination was found except for CRXU 0764990, although this was a 20 foot palletised cube and not an ISO tank, although it was on the FIRS at the same time and listed just underneath the glycols on 460 Port Troop's unloading manifest. Accordingly, the Inquiry assesses that the numbers were most probably incorrectly transposed from this record. The actual container CRXU 8511900 was also listed as a standard ISO container on the same list, just above the other glycols (**Annex R**).

87. The testimony in **Witness Statement 10** that there were 4 glycols remaining in the park was at odds with the dates on work orders and the ship's manifest; there should have been only 3 remaining in the park as GESU 8003187 had been moved a week earlier to the PSD. The Inquiry considers that this is most likely a simple error in witness recollection. Most problematic, however, was the process of confirming the contents of the first glycol to arrive. The work order (and presumably, FS F&L's list) would have identified the remaining Cronos container in the park, CRXU 8510328, as containing AL-34, not AL-342. As there was no means of identification remaining on the glycols, it cannot be satisfactorily explained how SNCO Av Fuels then concluded that the container now at the ICA compound would have been AL-34. However this conclusion was reached, it fortuitously corrected the transposition of the 2 Cronos containers and meant that the correct one was subsequently decanted into the holding tank.

88. Regardless of how this was done, SNCO Av Fuel accepted that he had made an assumption and should have done more to establish the contents of the containers (**Witness Statement 10**). The Panel notes that it was unlikely he would have done so for a number of factors. His chain of command had provided him with a list and he had no reason to question it, even when faced with an issue over one of the serial numbers. Despite a very good and close working relationship, the authority gradient and the fact FS F&L was due to leave the Falkland Islands to return to the UK made it less likely. SNCO Av Fuels was very well aware of the earlier issues with FSII supplies and the pressure on the supply community to ensure that flying operations were not impeded through a lack of timely action in the logistics chain. He was also keenly aware that the de-icing compound did not have sufficient stocks to deal with the anticipated winter season and this delivery was his last opportunity to adequately prepare. Linked to this, the simple geographical remoteness of the Falklands Islands generates an expectation on the logistics chain to get it right – simply put there was a surprisingly widespread view that if it had made it all the way down to the South Atlantic, it must be right. Finally, his inexperience of the section, the lack of a directive or standard operating procedure (SOP) that might have mandated a check and the unfamiliarity of the evolution made it unlikely that he would generate the spare cognitive capacity to be able to assess the process. In effect, he had no previous experience on which to judge the procedure and his attention was predominantly focussed on a new task so he was unable to stand back and consider that there might be anything wrong with the task.



89. There are a number of weaknesses throughout the logistics system that supplies POL products principally by necessity through the development of ad hoc solutions and novel operating environments. But because of this, there are a number of important safeguards developed through years of experience. Bulk fuel arrivals are carefully processed and controlled and a significant staff effort is applied to ensure the process is conducted safely and correctly with stocks quarantined until re-certification testing is complete. The familiar Swiss cheese model may help illustrate this, at [Figure 5](#).

90. Other packed stock is a more routine matter with fewer safeguards but is still subject to checks and controls to ensure stock is brought on charge, rotated and used prior to shelf-life expiry dates and issued appropriately. And although mistakes do occur, approximately 15 times a year according to Materials Integrity Group, it is incumbent on the user to identify the product they are about to use, to check the labels and ensure it is the right product before using it – the illustration at [Figure 6](#) suggests the system has fewer defences which place greater reliance on the supplier.

91. Logically, the same should apply to any container. However, the use of glycols as a bulk transport system somehow manages to by-pass the defences, and it is the Inquiry's contention, that the holes in the cheese are even larger, as suggested at [figure 7](#). Irregular and significant by quantity, it would seem logical to suggest that glycols should attract greater attention. The logistics supply chain does not hold the technical expertise to identify and authorise the use of any item it moves. Therefore, someone must be responsible to check a label and sight the paperwork and the final user must be responsible for conducting some final check. However intuitive this may appear, it simply wasn't so.

## CONCLUSIONS

92. The Inquiry considers that the acceptance of the glycols at the point of delivery were seminal. There is nothing definitive in the regulations to require a check to be made although the principles that would underpin such a requirement are clear. Therefore, the Inquiry found the inadequate regulations in JSP 886 to be a **failed defence** and a **root cause** of the contamination events.

93. Both personnel that might have acted in some capacity to formally receive the goods were influenced by other events to accept, without question and without proof (including the original paperwork) that what was in front of them was acceptable. Neither had been briefed or trained on their responsibilities, there was no local order or procedure in place and there was nothing in their TORs. Key staff absences, human factors and concurrent events all played a part in influencing their behaviour and as **error provoking conditions**, making the unquestioning acceptance of the deliveries all the more likely and thus **contributing** to making the contamination event more likely.

94. The acceptance of the glycol at the PSD was a **mistake**, but was brought about by the error provoking conditions present at the time.

95. The acceptance of the glycols without paperwork and the assumption made by SNCO Av Fuels when re-identifying the unknown glycol were also **mistakes**. However, both were made under similar influences to those of the PSD Cpl and the latter mistake was the one error that benefitted the entire process as it corrected an earlier error and actually prevented a further contamination incident.

Figure 5 – Fuel supplies cheese model

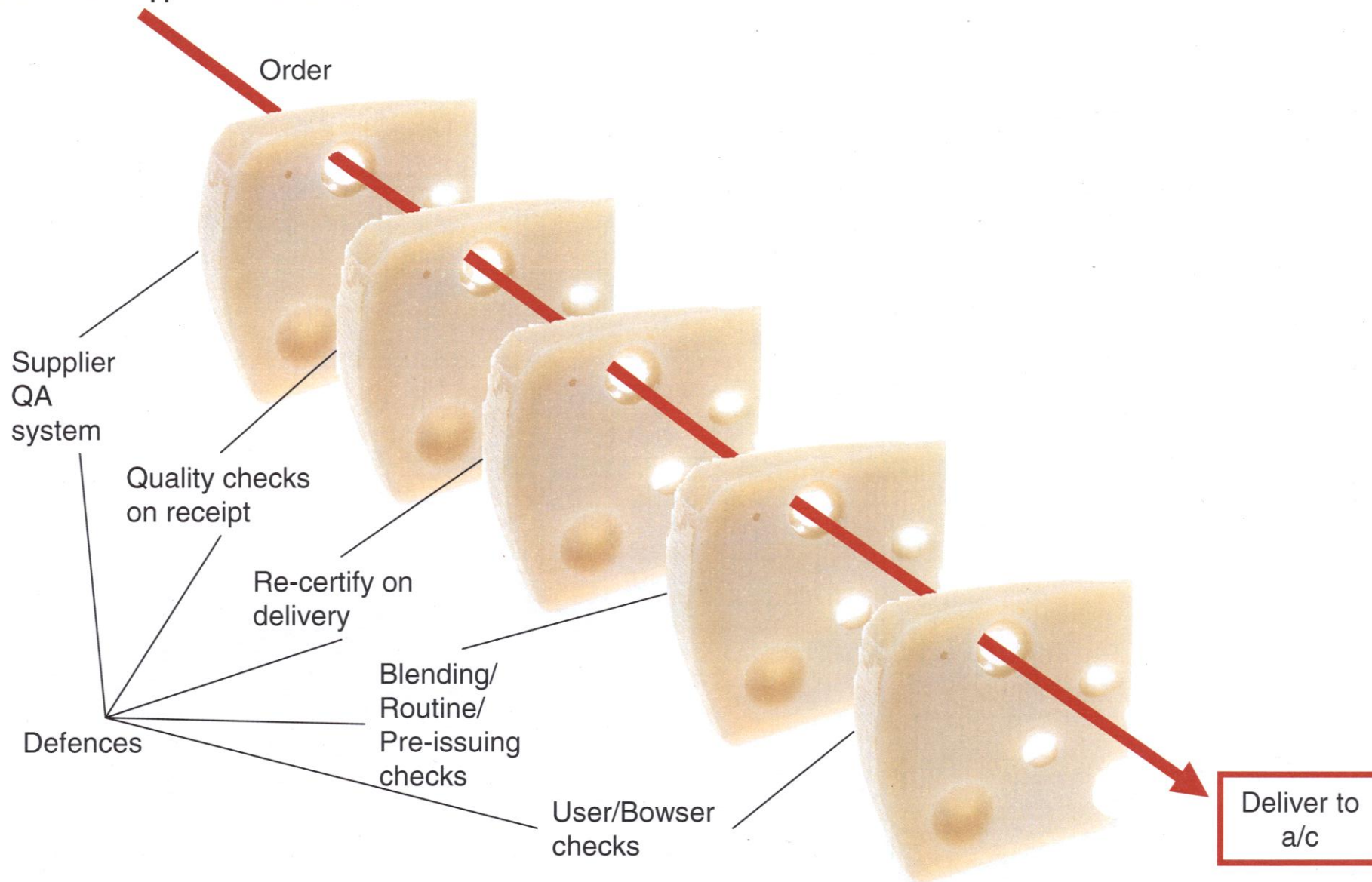




Figure 6 – Packed product model

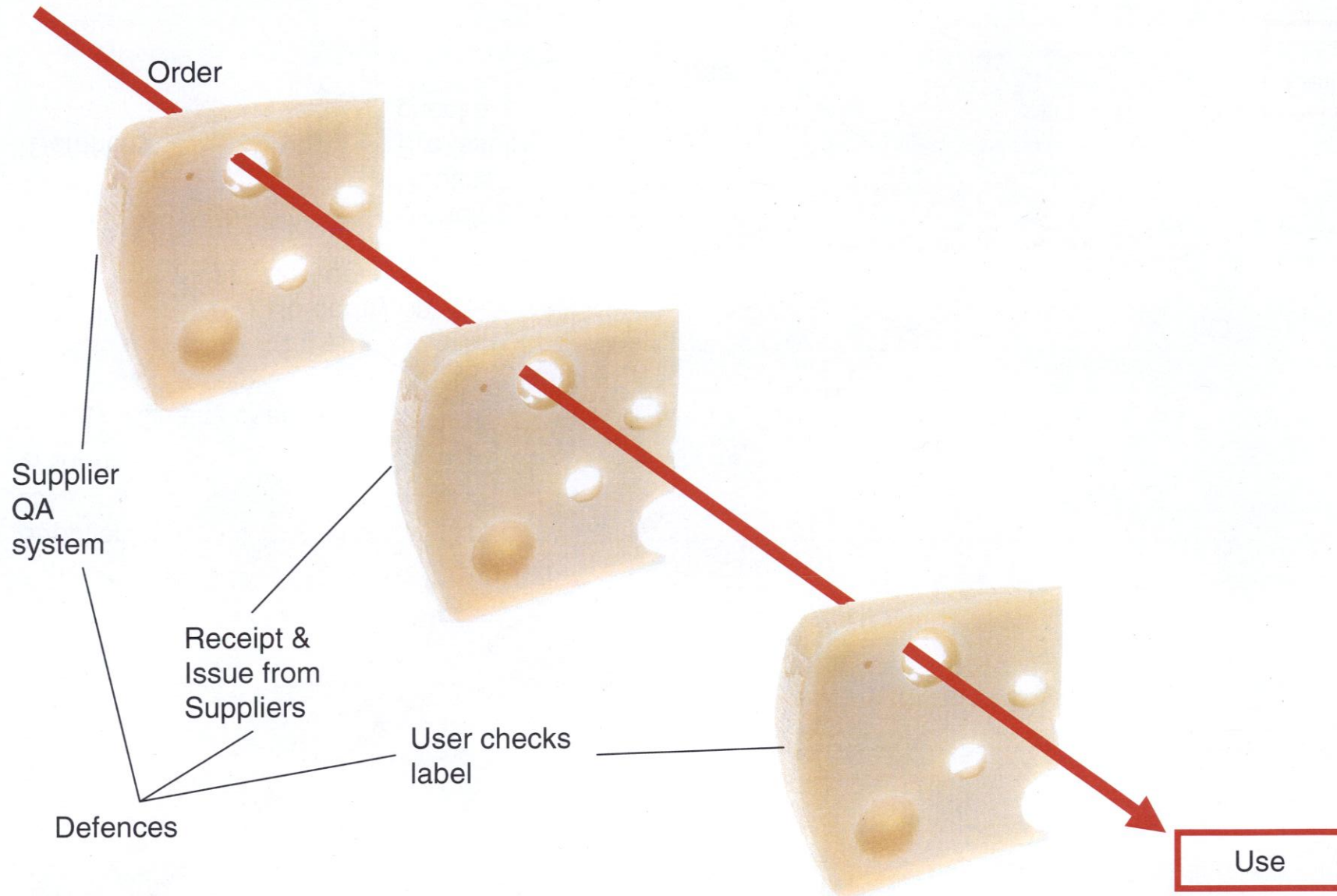
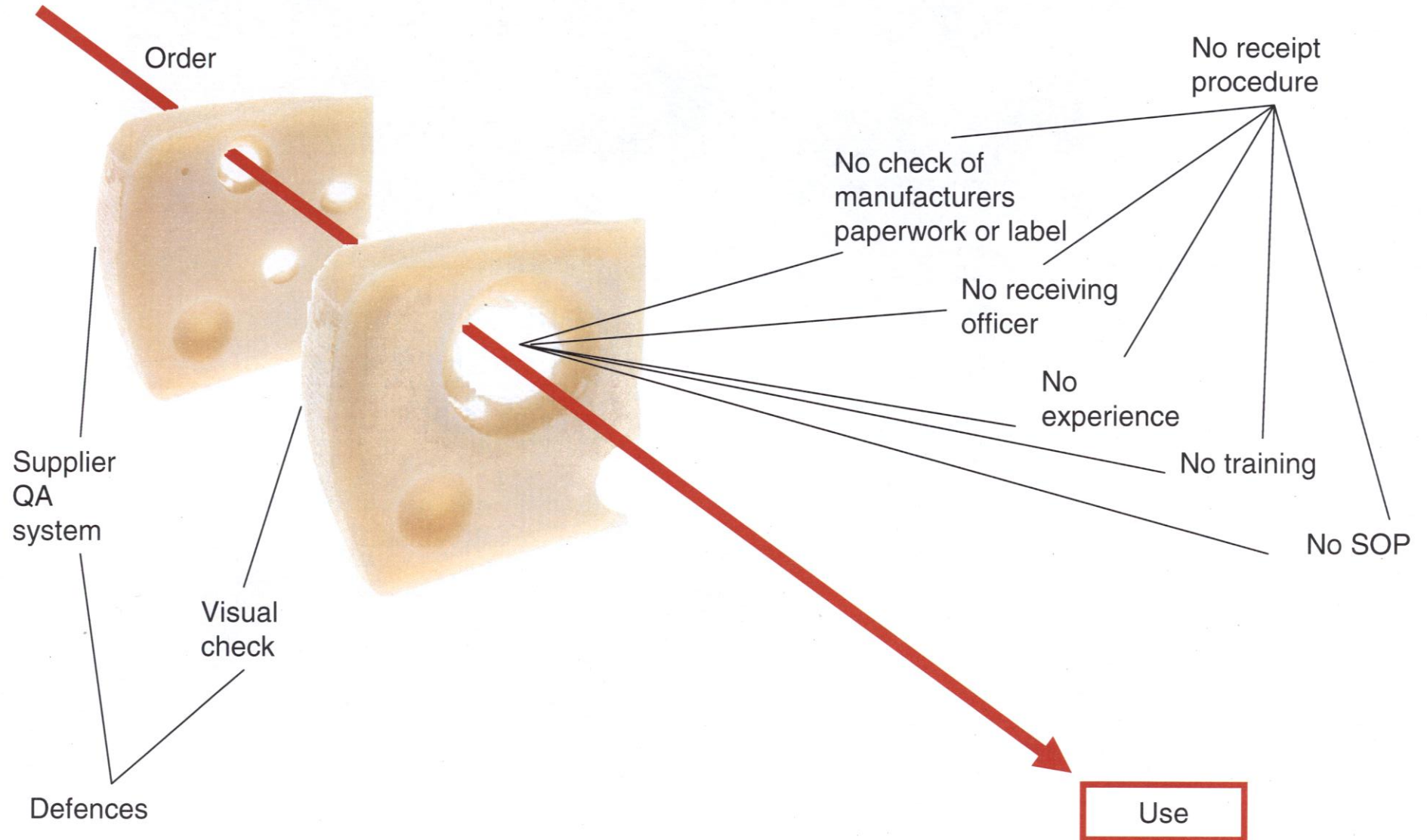


Figure 7 – Glycol model





96. One of the solutions frequently suggested to the Inquiry was that labelling the glycols was the answer to the problem. Clearly, the significant causal factor was the misidentification of the glycols and therefore it would seem sensible to suggest that they should be labelled. Indeed, it was the first practical thing that the Inquiry sought to achieve. However, the misidentification occurred whilst the glycols were moving through the logistics chain where the contents were of no relevance to those handling the glycols. Fundamentally, there should have been someone conducting a comprehensive check against the product and some form of proof of content from the manufacturer before it was accepted for use. This never occurred, so albeit unlikely, it is clearly possible that any label might not be checked either. It might help the logistics system move the containers to the right areas but does not guarantee the contents nor can it guarantee that the same mistakes will not be made again. Of necessity, the labels will need to be removable as the glycols are only leased and are used many times over for multiple products. It cannot be guaranteed that old labels will be removed or new ones will remain affixed over a 3-week sea voyage or a week on the hard-standing in East Cove Military Port. Accordingly, the multiple use of glycol containers makes it imperative that the label does not become the sole means of identification prior to use.

97. JSP 886 Volume 6 Part Chapter 6 Section 3 Article 14 does not detail a sufficiently robust receipt process for fuels oils and lubricants to meet the basic requirements of the generic receipt process nor the principles upon which such a process should be based. Whilst it is entirely acceptable that a process may differ for receiving goods, the Panel considers the generic receipt process provides very sound principles upon which to base the process. These principles should be augmented by the requirement to check original manufacturer's certification as proof of contents against the delivery.

98. The Inquiry was aware that work had already been done in Cyprus to establish SOPs (**Annex MM**) for the management of glycols that include the requirement to check the original manufacturer's certificate of quality against all other identifiable paperwork and container serial numbers.

## RECOMMENDATIONS

- 1.5.9
- 1.5.46
- 1.5.10
- 1.5.11



## JSP 317

## INTRODUCTION

99. JSP 317 is the Joint Service safety regulations governing the handling of fuels and lubricants sponsored by the Fuel and Gas Safety Regulator (FGSR) section of Defence Safety and Environment (DS&E). The JSP gives comprehensive guidance in all areas of the storage and quality assurance of fuels and lubricants either under field conditions or, as in the Falklands Islands, in permanent infrastructure run by Service personnel. In the absence of clear identifiable responsibilities flowing from JSP 886, the Inquiry focussed specifically on the roles and responsibilities of personnel involved in the acceptance of fuels and lubricants, known in the JSP as a receiving officer.

## FINDINGS

100. JSP 317 Volume 4 Part 2 Ch 12 Para 2.12.09 outlines the duties of a Receiving Officer (RO) as follows:

'The RO is responsible for ensuring that the product is supplied in accordance with the contract requirements and that the quality and integrity of the product has not been compromised at or before the point of receipt. They are also responsible for ensuring the product integrity is maintained on receipt into storage.'

101. The Inquiry found that it was not possible to identify an RO in the Falkland Islands as there was no evidence of one being nominated. Owing to the absence of the PSD SNCO, SNCO Av Fuels and FSF&L dealt with the arrival and identification of the glycols. Neither was aware of the responsibility of an RO and neither viewed themselves as responsible. Both assumed that further checks would be completed before the products would be used. In effect, both personnel merely acted as another link in the logistics chain to move a product from one place to another.

102. The PSD Cpl was unaware of the responsibilities of an RO and had received no training or delegation to hold the responsibility. For reasons discussed in the preceding section, the glycol's arrival was effectively ignored. Similarly, the aircraft de-icer glycols arriving at the ICA compound, whilst falling within the intent of the regulation as an additive, were met by SNCO Av Fuels who had no knowledge or training in the role of RO.

103. The Inquiry considers that the JSP must provide sufficient direction and guidance to be certain that local procedures will meet the drafter's intent. An ambiguous statement will inevitably fail to produce the right checks and controls and will fail to engage the training mechanism to ensure the need is understood. Accordingly, the regulations in the JSP must leave the user in no doubt as to their responsibilities. Where the concept of an RO was understood, it was clear to the Inquiry that the responsibility was viewed as applying only to fuels and not to lubricants. This was supported by evidence of a close, professional focus on any bulk movement of fuel from all personnel that the Inquiry spoke to and a commendable attitude to fuel safety engendered in training. However, the same approach did not appear to apply to lubricants and additives.

104. In the same chapter, Article 37 refers to the receipt of bulk lubricant, FSII and AL-34 deliveries from a contractor. It stipulates:

'On arrival all tanks are to be sampled in accordance with Annex A (the general procedures for sampling) and the samples visually examined. If the check is satisfactory, the product and requirements at paragraph 2.2.17 have been implemented (the general preparations for receipt of stock), the product can be transferred to storage. It adds that if water or particulate



contamination is observed, a further sample is to be taken. If the re-sample is satisfactory; the product can be transferred to storage. If the resample is still contaminated, the delivery shall be rejected.'

105. As neither the PSD Cpl nor SNCO Av Fuels were aware of the requirement to act as an RO, it was unsurprising that neither person knew of the regulation and therefore this check was not conducted. Even had they done so, the Inquiry doubts that a visual inspection would have achieved anything other than confirm the product was free from visible contamination. This is not to suggest the check is without merit but it does nothing to confirm the identity of the contents.

106. Accordingly, the Inquiry believes that the JSP should stipulate precisely what checks should be completed before a product may be accepted. No person intended to act, or was nominated to act as the RO so the requirements placed upon an RO in the JSP did not affect the outcome. However, the Inquiry noted that there is no guidance on what paperwork to refer to within those requirements. Prior to reaching any potential RO, VITAL had been used to identify the contents, although this was inappropriate as it is merely a logistics consignment tracking tool. Reliance on VITAL could mean that if an RO had been nominated, they might have been satisfied by the production of VITAL paperwork or the assurances of the logistics team that delivered the product, or even the provision of labels on the glycols. Further, the lack of paperwork supporting the delivery caused no appreciable concern to those receiving the glycols. Even if the lack of paperwork had raised concerns, or the RO had noticed discrepancies in the paperwork, there was no guidance in the JSP on what was required and what to do in the event of any doubts. Neither the RLC nor RAF training organisations presently had any official RO training. Indeed, because the RO paragraph in JSP 317 gave little detailed direction, there was nothing to base any training on.

## CONCLUSION

107. The RO as a concept was not well known. It was not taught on any of the fuels training. It was not detailed in any TORs. It was not delegated. It was not entirely clear that it was intended to apply to anything other than fuels, which was the common perception where the concept was acknowledged. Finally, it neither stipulates the checks required nor outlines recommended actions in the event of a problem. Accordingly, the Inquiry considered that the regulation was a **failed defence** and a **root cause** of the contamination event at the PSD. The Inquiry acknowledges that there will be personnel involved in the receipt of POL items such as aircraft de-icers, who will have very little awareness of JSP 317, hence the equal priority placed on the requirements in JSP 886 to ensure a final check is carried out and is adequate to assure air safety items.

108. The Inquiry has considered whether the absence of SNCO PSD might be considered a causal factor as he was aware of the concept and would have been the de facto RO. However, there was sufficient doubt about the role and the effect an RO would have delivered to conclude that even if one had been nominated and present, the contamination may still have occurred as the regulation only stipulated a visual check that should be applied to receiving bulk additives. As the subsequent visual inspection of the additives during the incident proved, the failure to conduct this check of a sample on receipt did not affect the incident. The SNCO PSD had offered that he would not have done anything differently. Accordingly, the Inquiry found that the absence of SNCO PSD did not contribute to the incident.

109. The failure to conduct visual inspections of the additives on arrival was an **inadvertent contravention** but did not affect the outcome.

110. The Inquiry noted that the lack of clear guidance on the requirements for identification and acceptance of a product **passively contributed** to the incident as a **latent weakness** in a **failed**



**defence.**

111. The Inquiry acknowledges that there has been a deliberate and commendable effort to reduce and simplify the content of the JSP with the principle that greater levels of detail should be provided in local instructions and standard practices to decide appropriate levels of management and scrutiny. However, the Inquiry feels that the position of RO is such a key link in the chain that it is imperative that the regulations fully support and acknowledge this. Furthermore, the responsibility should clearly and unambiguously state principles that should apply in all circumstances. It was clear that much of the confusion arose from the requirement to constantly cross refer to other sections for guidance. Accordingly, the regulations need to be unambiguous and comprehensive.

**RECOMMENDATIONS**

- 1.5.12
- 1.5.13
- 1.5.46



## SECTION 3 - THE CLOUDY FUEL PHASE

## Cloudy fuel and dropping FSII levels

## INTRODUCTION

112. Once the blending process had begun, it became apparent to S&AMS staff that there was something wrong when the FSII levels were low and dropping and the fuel was cloudy on visual inspection. As a result, the fuel in tank 202 was quarantined. Despite this, the fuel was subsequently released as fit for issue and was supplied to aircraft for several weeks. Although a plausible reason for the cloud was quickly established, no root cause was ever identified. No authority with delegated responsibility for airworthiness was consulted and no risk to air safety was considered prior to the fuel's release.

## FINDINGS

113. Test results from fuel samples deliberately contaminated with Ethylene Glycol (EG) conducted by 1710 Naval Air Squadron Materials Integrity Group (1710 NAS MIG) on behalf of the Inquiry were inconclusive and the Panel decided to omit the results from the report. Without formal proof or further controlled testing, it remained that the most likely hypothesis for the cloudy fuel was due to mixing with ICA, which comprises 9.5% water. This cloud or haze may have been as a result of the MEG present, or it may also be wholly or partly due to water present in ICA. Water presents as a haze in fuel in suspension, when it is present at levels in excess of 100 ppm. Accordingly, the level of water in ICA at 9.5%, blended at 800 litres of fuel to 1 litre of ICA, should result in a cloudy sample as the water would be present in suspension at approximately 120 ppm.

114. It is important to note that the first blending operation on 20 Jun 11 resulted in very low levels of contamination reaching Tank 201. 302,258 litres of fuel were blended with 378 litres of FSII. As the glycol had been connected to the blending rig via the temporary tank, it was likely that some FSII was still in the tank, although it had not proved possible to establish how much. Accordingly, this assessment is based on the worst case scenario. **(S26)**

Ignoring the complexities of hydrodynamics and for the sake of ease, it may be assumed that of the 302,258 litres sent through the pipeline, only the last 18,654 litres of fuel to arrive in the tank would have been contaminated with ICA. By volume, this ICA would be approximately 23 litres and assuming an even mix through the entire Tank, it would represent a mere 0.005% of the total volume, resulting in 2 ppm EG and 5 ppb sodium. The water introduced by the ICA would have been 224 ppb, so it is unlikely that this would have been sufficient to turn the fuel cloudy, whether it turns cloudy as a result of MEG or water or both, so there would have been no indications that anything was amiss at the BFI. This fuel was issued to aircraft on 26 Jun 11.

115. The Panel acknowledges that testimony was very clear that routine testing in accordance with laid down procedures during blending operations was conducted. However, written records of test results on both the MPA Pipeline Receipt Logs (**Annex V**) and on the AVTUR FSII F-34 Record of Quality Checks (**Annex W**) were inconsistent. Consequently, there was no record to establish categorically whether a problem was identified during blending operations on 20 Jun 11. Theoretically, testing at the PSD should have shown cloudy fuel in the latter stages as the ICA started to be used, although nothing was recorded or reported during interviews.

116. The blending operation on 28 Jun 11 produced a different result, as 350,435 litres of fuel were blended with 438 litres of FSII and were pushed to Tank 202. As the pipeline was already full of contaminated fuel from the blending operation on 20 Jun, it appeared to be cloudy at the BFI on