DESC Contract No. SP060099D5944

SwRI Contract No. 03.40.50.04371

Report of Site Visits in Support of an Investigation of "Apple Jelly" Contaminant in Military Jet Fuel

Defense Energy Support Center (DESC)
Product Technology and Standardization Division
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Under Subcontract to:
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NOTE

This subcontract report is the compilation of all information obtained during the various site visits conducted under the apple jelly project. While all of the information contained herein is useful, not all of it was ultimately directly applicable to the final apple jelly project report. This is because the subcontractor (C4e) was permitted to conduct its investigation independent of the SwRI laboratory work due to the complexity, scope, and time constraints of this study. The subcontractor was also given this latitude to ensure all available information was collected, compiled, and ready for use if required. Once all the information (both field and laboratory) was assembled, SwRI determined that some of the information was not needed for the project's final report. Most of the information not included in the final report deals with specifics of infrastructure design and operation. The main point to be taken from this overall effort (both field and laboratory) is that fuel storage/delivery systems must be designed and operated in a manner to reduce or eliminate fuel contaminants, especially water. Furthermore, the additional information obtained remains invaluable to those (such as the Air Force and DESC) who may work to correct possible infrastructure problems. For that reason, the subcontract report was not edited, abridged, or revised.

Readers and users of this report should remember that the project final report contains a summary of site visit information and important conclusions from the site visits. Readers of this report should also remember that some of the opinions/information given in this subcontract report are from the subcontractor and site visit team members. These persons have immeasurable experience in fuel and fuel systems and their comments/contributions were (are) invaluable. These comments usually provide important insight to a complicated problem. However, this subcontract report has not been through the same formal revision as the project final report and, as such, the opinions and comments are those of the subcontractor and site visit team members only. The comments/opinions should be taken in context and should not be attributed to the sponsor of this project.

Steven R. Westbrook
SwRI Project Manager

ACKNOWLEDGEMENTS

C4E, Inc., (Consulting for Energy Efficiency and Environmental Excellence), performed this task in association with the Southwest Research Institute. Although too numerous to mention by name, the authors are indebted to the many outstanding fuels managers and personnel at the 32 bases and support locations visited. The authors would also like to acknowledge, thank, and express a special appreciation to Steve Westbrook, Andy Waynick, and Ruben Alvarez of the Southwest Research Institute; Calvin Martin, Martin & Associates; Bud Rodee, DFR-Americas; and Terry Knight, DFR-NE. Their assistance and support were essential in the successful completion of this task. Their comradeship made it an enjoyable experience.

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1.0 EXECUTIVE SUMMARY

The appearance of a dark colored, viscous material known as Apple Jelly (AJ) in military aircraft and within the military fuel distribution system has created safety concerns and multiple problems for fuels personnel. Safety concerns aside, AJ in fuel distribution systems has led to increased filter element changes, increased workload for fuels personnel, and a substantial increase in costs.

There have been documented and undocumented reports of a brown gelatinous substance in aviation fuel since Fuel System Icing Inhibitors were introduced to military aviation fuels in the early 60s. Several agencies have written reports and completed research to identify the cause of the formation of AJ. In July 1999, the Navy Research Laboratory discussed the problem as it relates to the clogging of receipt filter/coalescers during operations with either JP-8 or JP-5. The Air Force Research Laboratory published a report in November 2000 documenting research in AJ formation in military aircraft and the fuel distribution system. Both agencies conducted laboratory research and both reports indicated a potential link between excess water in fuel systems, FSII, and a sodium producing substance, such as the static dissipating additive Stadis 450. Both reports also indicated that injection and filtration points and procedures needed to be reviewed and improvements considered.

When the anomaly was given a name during the late 1990s, the number of reports increased steadily. In January 2001, the Defense Energy Support Center (DESC) contracted the Southwest Research Institute (SwRI) to analyze AJ and fuel containing AJ and to visit locations where AJ had been reported to review processes, survey facilities and equipment, and ascertain the impact of changes in recent years that may contribute to the formation of AJ. In response to a request by AFRL, DESC directed SwRI to review Technical Orders to determine if procedures prescribed by the directives contributed to the formation of AJ. To facilitate the collection of samples from field activities, SwRI developed the following working description of AJ:

> "Apple Jelly is a variably fluid matrix comprising of water, di-EGME, and other components originating from the jet fuel and any additives contained therein. The exact identity of the other components has yet to be well defined but may include metal salts (e.g. sodium, iron, calcium, potassium, and magnesium) of acid corrosion inhibitors, components from static dissipater additives, materials leached from elastomers, or metabolites originating from microbial activity. The color of apple jelly ranges from light amber to reddish-brown."

C4e teamed with SwRI to review technical orders, conduct site visits, and collect field data to identify facility, equipment, and process factors that may contribute to the formation of AJ. The AJ field investigation was a comprehensive analysis of the fuel support system where AJ contamination has been found. Two teams were dispatched to identify the specific location (truck sump, hydrant filter separator, etc.) and work backward through the logistics support system to document variables (materials, designs, equipment, maintenance, and operations) that may contribute to the formation of AJ.

Although AJ has been reported at a few overseas locations, site visits were restricted to the Continental United States.

Investigators determined that all of the bases experiencing significant quantities of AJ had excessive water in the fuel they received or rainwater intrusion into on-base tanks. For the C4e Investigation Team members involved in the project, perhaps the most eye-opening result of our investigation into the AJ problem is a better understanding of the importance and difficulty of keeping JP-8 dry (i.e., minimizing water content). Clearly, during the conversion to JP-8, we* made assumptions based upon the similarity of JP-8 to JP-4, Jet A, Jet A-1, and JP-5 that were not thoroughly thought out. We realized, because of its higher density and lower water separation index measurement, that JP-8 holds more water than JP-4, and for that reason, water removal would be a somewhat slower and more difficult process. However, this difference was never thoroughly addressed when considering facility, equipment and process variables necessary for handling JP-8. The fact that commercial airlines use kerosene fuels very similar to JP-8 and that the Navy uses JP-5, which resembles JP-8 more closely because of the use of Fuel System Icing Inhibitor (FSII) in both fuels, assumptions were made that the existing facilities, equipment, and processes used for JP-4 were satisfactory for use with JP-8. However, these assumptions were made without full consideration of the impact of additives or a complete review of differences between Air Force, Navy and commercial facilities, equipment and processes.

With respect to the design of both fuel handling facilities and equipment, both the Navy and commercial industry have a stronger focus on keeping fuel dry and protecting the integrity of their filtration systems. The use of fixed-roof storage tanks and discharge (suction) lines specifically designed to avoid the intake of water bottoms are two examples. The Navy's use of a three-stage process for water removal (coalescence, separation, and absorption monitors), compared to the one or two-step process used by the Air Force, is another example. In commercial industry, FSII is generally not injected into bulk fuels, but rather is injected at the aircraft, if used at all. Static Dissipater Additive (SDA) is not used in JP-5, nor is it used in Jet A, and its use in Jet A-1 in overseas locations is declining.

SDA was adopted for use in JP-4 during the late 1970s because of electrostatic ignition of fuel vapors within aircraft fuel tanks containing reticulated foam and a number of ground handling fires that were ignited by static electricity. The foam was designed to protect fuel tanks in combat aircraft from explosion when hit by ground fire. The first generation foam was non-conductive and rapid movement of fuel through the foam during refueling or sharp, banking turns, generated sufficient electrical charges to ignite the JP-4 vapors. When this occurred, the foam did its job by preventing serious structural damage to the aircraft, but evidence of soot at the aircraft fuel tank vents and the discovery of chard foam inside aircraft fuel tanks was discomforting for the aircraft operators. Since that time new emphasis was placed on the use of conductive foams that may have resolved

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*Because of the policy and technical roles played by C4e investigators, while in positions of responsibility within the Department of Defense relative to the conversion from JP-4 to JP-8, we have chosen to address these concerns in the first person.

this problem. Furthermore, most aircraft that have reticulated foam also use JP-8+100, and the additional conductivity provided by the +100 additive may be sufficient without the use of SDA. The likelihood of electrostatic ignition of JP-8 in ground handling is also greatly reduced by the use of JP-8, as compared to JP-4, because of the significantly higher flashpoint and lower vapor pressure of JP-8. Consequently, the two key reasons for use of SDA may no longer be applicable, and consideration should be given to eliminating the use of SDA in JP-8.

Eliminating the use of FSII in military turbine fuels would simplify water removal, but, because of design and mission differences between military and commercial aircraft, eliminating the use of FSII is not an option. However, the point of additive injection and improved control over the quantity of additives injected are options that could simplify water removal and, in the long run, reduce costs. For these reasons, and one more to be addressed in the next paragraph, we strongly recommend that the point of additive injection be moved as far forward in the logistics system as is operationally possible.

The other reason we advocate moving the point of additive injection forward is that one of the major lessons learned and documented during Operations Desert Storm and Desert Shield, was that our forces were not prepared to convert commercial Jet A-1 to the JP-8 required by the weapons systems by injecting the necessary additives. The only personnel that accomplished this task with relative ease were the fuels operators from Hill AFB who had previous experience with on-base additive injection. It is a fact of life that, in many locations, our forces will have to rely on commercial fuel and inject the needed military additives to support global operations. While moving additive injection forward would cause some increase in workload at the operating bases, it would help prepare fuels operators for deployment, reduce the cost of additives and filters, and simplify water removal in the resupply systems.

Looking forward to fuels of the future, there are other compelling reasons why additives should be injected on base. New weapons systems will demand increased thermal stability that will likely be provided by special additives, such as the +100 additive. Take the Joint Strike Fighter for example; the heat sink requirement of this aircraft is significant enough that the JP-8+100 fuel must be refrigerated immediately prior to being issued to the aircraft to provide the necessary heat sink without temperature stressing of the fuel. As new, specialized additives are developed there will likely be a need for tailoring fuel differently at some locations to meet the specific needs of the weapons systems supported.

Those bases successful in reducing AJ incidents introduced aggressive water removal programs combined with a reduction in FSII and SDA in fuel receipts. In some instances, FSII an SDA levels were excessive in receipts and injection points were misplaced and ineffective. At some Air Force bases, such as Barksdale, Fairchild, and Grand Forks, there appeared to be a relationship between the increased available tank ullage with reduced fuel inventories, and the presence of water in partially filled cone-roof tanks to the formation of AJ. At these locations, the cone-roof tanks are ineffective in preventing rainwater intrusion. This allows water accumulation on the interior tank walls that can leak past the floating pan or floating-roof seals. When product levels are low, the increased surface area above the floating-roof/pan collects a greater amount of water, which slips past the roof seal into the fuel. This problem is even worse at locations that continue to use floating-roof tanks, including DFSP Ludlow and Edwards AFB. Unfortunately, many of the geodesic dome and floating-roof tanks have been modified with Self-Cleaning tank bottoms, which exacerbates the problem.

The design of the Self-Cleaning fuel storage tanks maximizes the opportunity for fuel-water emulsification and entry into the fuel distribution system. At the expense of fuel quality, this design intentionally sucks free-water/FSII mixtures and particles from bulk tank sumps and pumps it through filter separators not designed to handle additized fuel. The problem is worse at locations where floating-roof tanks or tanks with ineffective geodesic domes have been retrofitted with a Self-Cleaning tank bottom. Typically, these tanks have ineffective product recovery/water removal systems. By comparison, little or no AJ problems have been reported in NATO or commercial aviation fuel tanks. The differences are the use of receipt filtration, fixed-roof tanks, and the effective tank bottom water removal features of the NATO design. At commercial airports, aviation fuel storage tank designs purposefully avoid the intake of tank bottoms into fuel suction (issue) lines, while the opposite is true at Air Force installations.

The size of the issue line on many of the newer hydrant systems at Air Force Bases creates a potential for free-water/FSII and other contamination to settle and accumulate in low points in the hydrant system loop. During peak operations this material can be picked up and forced further downstream in the fuel distribution system. Increased low point draining frequency and seasonal draining--following dramatic temperatures drops that cause water and FSII to drop out of fuel--would aid in reducing this problem. Additionally, some Type III hydrant systems are routinely shutdown at night and over weekends. This further promotes accumulation of water/FSII in low points.

The continued use of old DoD standard filter separator vessels, especially when combined with the self-cleaning tank design, jeopardizes fuel quality and provides a means for AJ to get into aircraft fuel systems. While marginally effective with JP-4, these filter vessels are ineffective with the denser JP-8, and allow the fuel to bypass the water separation stage. API/IP 1581 filter separators have replaced most of the old DoD standard design filter vessels, those that remain should be modified or replaced. Likewise, the DoD standard design coalescer elements under NSN 4330-00-983-0998 used in the old DoD standard vessels and some modified vessels have an off-the-shelf failure rate approaching 40%, regardless of manufacturer. Such vessels and filters continue in use in some fixed facilities, in Oshkosh R-11 refuelers, and in MH2-C hosecarts. Use of this coalescer element should be discontinued.

The thickest, most viscous AJ was found in R-11s equipped with water absorption media filters. These filters were installed at most Air Force locations to guard against potential disarming of the coalescers by surface-active agents contained in the additive used to increase the thermal stability of JP-8 and convert it to JP-8+100. According to industry experts, FSII in JP-8 may pass through these cartridges. In contrast, the Navy uses filter-coalescers that remove most free-water/FSII immediately prior to the water absorption "fuse." The Navy has reported very few AJ problems, which is attributable to the lack of SDA in JP-5 and the Navy's three-stage filtration process. Use of the water absorption cartridges began at the initial JP-8+100 bases during 1996, but was later expanded most of the other Air Force bases during 1999 and 2000--which closely corresponds with the increased reporting of AJ incidents.

Industry officials have recommended changing water absorption cartridges used with fuel containing FSII when the differential pressure reaches 15 psi as opposed to the Air Force limit of 22 psi. We agree that the differential pressure change criteria should be reduced; however, there is strong evidence that the water, FSII, and other compounds extracted from the fuel may be dissolving absorptive materials in the filters. Several bases reported that as temperatures increase the amount of AJ found in filter sumps also increases while the pressure differential across the vessel drops. We suspect that components of SDA and other polar compounds in the JP-8 are extracted as the fuel passes though FSII/water saturated absorption media. Over time, this process changes the nature of the materials trapped in the absorption cartridges. Strong evidence developed by SwRI indicate these chemicals eventually begin to dissolve the absorptive media within water absorption cartridges, allowing it to escape from the cartridge, along with the water, FSII, and polar compounds. The sodium agar in absorptive cartridges is the most likely source of the high sodium content of the most viscous AJ samples which were typically found in the bottom of filter vessels equipped with the water absorption cartridges. If the absorptive materials are dissolved and drained or are washed out of the absorption cartridges, then the use of pressure differential as a means of determining the reliability of the absorption cartridges is highly questionable.

Interestingly, JP-8+100 bases, which were the first Air Force units to use the water absorption media elements, have had surprisingly few incidents of AJ in R-11 filter vessels. Moreover, AJ has not been reported in any of the aircraft that routinely use JP-8+100. We suspect that the detergent and dispersant additives in JP-8+100 keep the entrained water/FSII in suspension and prevent it from agglomerating, settling out of the fuel or being absorbed by the absorption cartridges. The role of the +100 additive in reducing AJ formation merits special study. Furthermore, since the +100 additive increases conductivity, wider use of JP-8 +100 may obviate the need for SDA. At least one of the major filter manufacturers believes that the API/IP Edition 3 coalescer may be effective for use with JP-8+100 in fuel systems with low levels of particulate contamination. Because of the high surface-active nature of SDA, its removal from JP-8+100 would likely aid in enabling the use of the API/IP Edition 3 coalescers as a replacement for the water absorption media cartridges and as a more cost effective alternative than the Edition 4, M-100 series. We recommend further testing to explore this possibility.

The base level Fuels Automated System (FAS) contains a wealth of fuel quality information that can be used to monitor important quality trends; however, most base level personnel do not know how to access and use this information to monitor and manage fuel quality. Improved training and technical guidance is need.

2.0 INTRODUCTION AND BACKGROUND

The appearance of a viscous substance in military fuel distribution systems has caused significant safety concerns and resulted in increased costs and additional labor. The substance, varying in color from light amber to dark reddish-brown and recently dubbed "Apple Jelly" because of its appearance, has been found in fuel system sumps and filter separator vessels of both fixed fuel distribution systems and refueling vehicles. AJ has been reported in the United States as well as other parts of the world. AJ causes frequent premature change out of filter elements and quite possibly disarms filtration systems allowing excess water to travel through the fuel distribution system into aircraft with potential catastrophic results. Initially, the AJ phenomenon seemed to be restricted to the northern tier bases, occurring in the fall and spring and associated with dramatic weather changes. Last year, increased reports of AJ have shown that AJ is not limited to a particular geographical area of the United States, and AJ has been reported in fuel systems at some overseas locations. These increased reports of AJ are also attributed to giving the contamination a name.

A substance matching the description of AJ was documented in the 1950s in tests of an anti-icing additive. When Fuel System Icing Inhibitor (FSII) was added to the military specification for jet fuel in1961, incidents involving "foreign material" in fuel increased. FSII is added to fuel (0.10-0.15 volume percent) to lower the freeze point of water associated with the fuel from +32F to –57F. Both the Navy and Air Force use diethylene glycol monomethyl ether (diegme) as the primary FSII. It is normally injected into fuel intended for military installations at terminals supporting specific bases or at the refinery. In a few cases, FSII is injected at the bases. Concentrations of FSII vary and can be affected by climatic changes. Intended to be soluble in fuel and especially soluble in the free-water accompanying fuel, FSII/free-water mixtures drops out of fuel and collect in sumps, low points, and coalescer housings. A heavy concentration of FSII and water can disarm filter coalescers and lead to the premature failure of water absorbing cartridges. FSII and water were the primary components in AJ reported in filter element housing in various stages of the fuel distribution system.

In July 1999, the Naval Research Laboratory (NRL) published *Final Report on Investigation of the Formation of Brown Gelatinous Precipitate Which Forms in Jet Fuel After Injection of FSII Additive and Possible Corrective Actions*. It specifically addressed receipt filter/coalescers clogging during operations with either JP-8 or JP-5 containing FSII additive. The clogging gel most often occurred when the filter/coalescer water bottoms were not continually drained and had become saturated with FSII, making a solution that was close to 50:50 FSII and water. This changed the water to essentially a very polar organic material, which was capable of extracting the fuel polars with great efficiency. Thus, the filter/coalescer bottoms contained a very high concentration of fuel polars.

The NRL used ASTM D6426, "Standard Test Method for Determining Filterability of Distillate Fuel Oils" to test fuel samples and simulate the formation of gel in the laboratory. The Defense Energy Support Center (DESC) provided fuel samples from locations where the problem had occurred most recently. All fuel samples were completely additized except for FSII. Representative samples of FSII were obtained from different locations. Since FSII has diegme as the major ingredient and appeared to be crucial in the formation of the problem gel, there was a major focus on investigating FSII properties, such as its solubility performance, its solubility as a function of temperature, its purity, its injection and mixing properties, and its effect on filterability after injection.

The report concluded that FSII alone does not cause the problem; however, its presence appears to be a necessary condition for the problem to occur. Furthermore, the problem seems to be more prevalent in JP-8 than in JP-5. JP-8 contains the static dissipater additive (SDA) Stadis 450, while JP-5 does not. This additive represents a potential source of sodium ion content. The formation of the brown gel is highly dependent on small metal cation content, such as sodium. If all the right conditions exist, there is sufficient time to allow diffusion of polar species from fuel to the water/FSII bottoms, temperature change to provide the initial energy needed for gel to form, and finally the presence of sodium or other small cationic species. (Not a complete sentence. I'm not sure where you are going with this. I think this is from the NRL report, lets discuss)

The NRL report made several recommendations. They recommended improving housekeeping practices to eliminate water bottoms, overnight recirculation for the continual removal of free-water, adding FSII at the refinery, adding FSII after the final users receipt filters or at the skin of the aircraft, adding SDA at the skin of the aircraft, and only as necessary before the receipt filters.

In November 2000, the Air Force Research Laboratory (AFRL) published a report entitled, *Evaluation Report On Fuel Distribution Field Problem "Apple Jelly"* and a paper entitled, *C-17 Fuel Sump Samples*. The report discusses several potential causes of AJ and the analysis of eight AJ samples provided by affected bases. The aqueous layer of six of the eight samples were analyzed by gas chromatography and showed a range of diegme from 17-vol % to 60-vol %. The principle (sp?) balance of each sample was determined to be water. They were also analyzed by inductively coupled plasma, and the acid number and pH were also determined for the samples. The results show an inordinately large concentration of sodium. Using X-Ray Photoelectron Spectroscopy (XPS) to analyze all eight samples, AFRL found that the sodium levels were not consistent with contamination from seawater or other salt sources.

After testing an unused water absorption cartridge using XPS, the middle layer of three layers of matting was found to contain sodium agar, apparently as the swelling agent. No conclusions were reached as to whether this was the source of the sodium; however, when a 60/40 diegme/water mixture was introduced, the matting swells and seems to decompose with the addition of the diegme.

Considering the hypothesis that the degradation of diegme may contribute to the formation of AJ, AFRL performed experiments to assess degradation behavior and the products of degradation. Their research led to the conclusion that the addition of an antioxidant such as butylated hydroxy toluene (BHT) may retard the degradation process.

In reviewing the functions of a filter separator, AFRL reminded fuels specialists that an increase in pressure in the vessel is an indication that the filter separator is losing its capacity to remove water and dirt from the fuel. When an excessively high concentration of water and/or icing inhibitor passes through the filter separator, the filter separator is disarmed, rendering it useless in the removal of water and particulates. If this happens, then excess water and dirt move through the fuel distribution system and possibly into an aircraft. AFRL also expressed concern that diegme interferes with filter monitors (does this refer to the water absorption cartridges or the AEL test filter?) giving the appearance that the water content in the fuel is low. If this happens, excess water can pass through the fuel distribution system. Excess water and/or diegme may also cause water absorption cartridges to malfunction and send some of the sodium agar downstream. Once the water concentration drops by dilution in fuel, the agar may plate out on surfaces of the filter element causing the gel-like substance.

The AFRL report also had several recommendations. They included minimizing water in the fuel distribution system, adding additional and better filtration to the fuel distribution systems, determining the source of sodium found in the contaminated samples, adding an antioxidant to diegme that is stored for extended periods of time or stored at elevated temperatures, and conducting research to determine a comprehensive phase diagram for FSII in fuel to determine the source and role of sodium in the formation of Apple Jelly.

In the C-17 paper, AFRL reported on an investigation of AJ in five C-17 aircraft that had vented fuel from one or both vent boxes either in flight or during ground fueling. The C-17 does not have a mechanical float to indicate fuel level, but depends on probes, compensators, and densitometers to determine fuel levels in the tanks. Electrical signals send information to the fuel quantity computer, which calculates the volumetric quantity and ultimately the fuel weight in pounds. Fuel with water concentrations exceeding the specifications of the compensators is believed to cause the compensators to sense low fuel quantity, resulting in an erroneous message to transfer fuel, creating an overflow and a fuel venting situation. Fuel tank sumping is not a requirement on the C-17. The C-17 fuel scavenge feature incorporates water scavenge rakes to pick up water and recirculate it near the aft boost pump pick up. The water is then fed to the engine. This system is designed to prevent ice build up in the bottom of the tank, which can cause pump cavitation. All samples analyzed appeared to be the same AJ type material found in ground handling systems and formation of AJ on the aircraft cannot be ruled out. Boeing engineers are investigating the potential for malfunction of the scavenger system, and the need for FSII on C-17 aircraft is being reviewed.

With growing concern over the AJ problem, the DESC contracted the SwRI to obtain and analyze AJ samples, to conduct field visits to observe facilities and processes, and to identify a probable cause of AJ formation and to recommend ways to prevent the recurrence. C4e partnered with SwRI to conduct field visits to more than 30 affected bases and terminals in an attempt to determine the cause of AJ. In addition, the Air Force

Research Laboratory asked and DESC directed C4e to examine Technical Orders to see if prescribed practices contributed to the formation of AJ. Prior to the field visits, the C4e teams review literature concerning AJ-like contamination in turbine fuels. Additionally, the C4e investigators identified changes that have taken place in military fuels in recent years that many contribute to the increased frequency AJ finds have been reported of the past three or four years. During their site visits, team members were asked to be mindful of these changes and how they might contribute to the formation of AJ. These changes include:

- The conversion from emge to diegme.
- The conversion from JP-4 to JP-8 and JP-8+100.
- The Air Force adopting the cone-down, center sump, self-cleaning bulk storage tank design.
- Use of the API vice the DoD filter separator element.
- Installing water absorption media cartridges on R-11s to accommodate JP-8+100.
- The reformulation of STADIS 450 to promote compatibility with Merox treated product.
- Reduced inventory levels and settling time.
  During the site visits, the C4e teams identified the following concerns as potential contributors to AJ formation:
- Practices to minimize the presence of water in fuel and fuel systems.
- The type and condition of BS&W, product recovery equipment and the process.
- Additive injection locations and procedures.
- The impact of temperature change on the formation of AJ.
- The impact of reduced inventory, tank usage, and settling times.
- The role the self-cleaning tank design plays in AJ formation, if any.
- The role of electrostatic charging.

Keeping aviation fuel clean and dry and within specification is a difficult undertaking. Unlike packaged petroleum products that are manufactured and sealed until use, bulk aviation fuel is often exposed to particulate and water contamination, and potentially chemical contaminates, as it moves through a multitude of transport systems, such as pipelines, tank trucks, barges, and ocean going tankers. Even when fuel is stored in bulk tanks, it can be exposed to particulates, humidity, rainwater, and temperature variations. Whether it is a result of ill-conceived procedures, design, or lack of good housekeeping. All of or some of these factors may contribute to the formation of AJ. Against, this background, C4e staff investigated and reviewed procedures and processes, design criteria, housekeeping procedures, and interviewed individuals at all levels of fuels management. The findings, conclusions and recommendations are presented on the following pages.

3.0 DISCUSSION

3.1. APPLE JELLY FUEL CONTAMINATION INVESTIGATION

Southwest Research Institute (SwRI) has the task of identifying the chemistry of AJ and determining the source of the chemical constituents while C4e is responsible for performing site surveys to identify facility, equipment and process variables that may contribute to the formation. From the previous work completed by the Air Force and Navy Research Laboratories, it is clear that the two principal components in AJ are diethylene glycol monomethyl ether (diegme) and water. Diegme is the Fuel System Icing Inhibitor (FSII) used in JP-8. The purpose of FSII is to lower the freeze point free-water in JP-8 to below the freeze point of the fuel. While the amount of FSII added to JP-8 is a maximum of 0.20 percent (%) by volume, the quantity of diegme in AJ ranges from 17% to 60% with the principal balance being water. FSII is more soluble in water than fuel, and free-water draws FSII out of the fuel. Blends of diegme and water alone do not account for the color or gelatinous nature of some AJ, so other key variables come into play. Because of the similarities between JP-8 and JP-5 and the fact that incidents involving AJ formation in JP-5 seem to be rare, the addition of the static dissipater additive Stadis 450 to JP-8 was identified by NRL and AFRL as a factor that may contribute to the formations of AJ. However, the sodium content of Stadis 450 prior to injection is in the parts per million range and only small quantities of Stadis 450 is injected into JP-8 (again in the parts per million range), the small quantities of Stadis 450 injected into JP-8 gives rise to the question what other sodium sources may be a factor. The AFRL report found that the high sodium levels in AJ were not consistent with contamination from seawater or other known sodium sources. The sodium agar used in water absorption media cartridges as a swelling media was identified as a potential explanation. This, in itself, would not explain the difference in apparent occurrence frequencies between JP-8 and JP-5 because the water absorption cartridges are used with both fuels. However, there is at least one significant facility and one process difference between how the two fuels are handled that may also be contributing factors. First, most JP-5 is stored in fixed-roof tanks, while significant quantities of JP-8 are stored in floating-roof tanks, many with geodesic dome covers. Fixed-roof tanks are far more effective in preventing rainwater intrusion into the fuel than are tanks with geodesic domes and floating-roofs. Second, the Navy generally uses a filter separator to remove free-water/FSII mixtures and particulates immediately before JP-5 passes through the water absorption cartridges, while the Air Force does not. Consequently, in Navy systems, the filter separators would remove significant amounts of water and FSII/water mixtures from the fuel before the fuel reaches the absorption cartridges.

As C4e began its site investigations, the two principal tasks were to identify process and facility equipment changes that may contribute to excessive FSII/water mixtures, and to identify changes that might contribute to the chemical makeup of AJ.

3.2 EXCESSIVE FSII AND WATER IN JP-8 FUEL SYSTEMS

All of the bases reporting significant amounts of AJ were found to have excessive water either in the fuel they received or as a result of rainwater intrusion into on-base tanks. A number of bases that have struggled to overcome AJ problems report that an aggressive sump draining program combined with reducing FSII in fuel receipts have significantly reduced the frequency and amount of AJ experienced. Detailed summaries of the findings at each site visited are provided in Appendices E-1 through E-32. The first site investigations involved Barksdale AFB and the supporting terminal at DFSP Bossier City. We found there are two potential sources of excessive water that could contribute to the formation of AJ at Barksdale. First, the tanks at the Texas Eastern Pipeline Products Company (TEPPCO) terminal at Bossier City are not equipped with a means to drain bottom sediment and water (BS&W) from the tank bottoms prior to transferring the product to Barksdale AFB. Second, rainwater entry into JP-8 storage tanks at Barksdale AFB, and particularly Tank #4 is a significant problem.

The design of the Bossier City tanks is such that each time product is received any BS&W in the center tank sump would be swirled into solution with the incoming product. The lines used to receive JP-8 into these tanks enter from the bottom of the two tanks into a well that is approximately 16 inches deep. The receipt line rises approximately one inch above the tank floor and is capped by a diffuser resulting in the BS&W in the sump being swirled into solution each time new product is received. On the tank drawings, the receipt lines for the two tanks are identified as issue lines. New issues line have been installed and, while no drawing or photographs of the line inside the tanks were available, TEPPCO personnel report that the issue line draws fuel from approximately eight inches above the tank bottom. FSII and SDA are injected downstream of the bulk tanks as the JP-8 is transferred to Barksdale AFB via a 4 inch pipeline that stretches 3.98 miles to the base.

The SDA injection point is two feet upstream of the pump and the FSII injection point is four feet downstream of the pump. Government supplied FSII is stored in a bulk tank which is structured to provide pressure relief to or from atmosphere of a vacuum in excess of four ounces or pressure in excess of 2 ounces. The tank is not equipped with a desiccant to preclude downing moisture from the atmosphere and the FSII in the tank is not sampled for water content. We asked that the QSR draw a sample to be tested for water. The test results indicated that the moisture content of the FSII in this tank was within the specification level. Approximately three feet downstream of the point of FSII injection, the fuel enters a “Coriolas” meter manufactured by Smith Meter Company. The Coriolas has a seven-foot long venturi (approximately 2 inch diameter), which increases the pressure on the upstream side and dramatically reduces the discharge pressure into the four inch transfer line to Barksdale. The pump pressure was noted to be 150 psi and the pressure downstream of the venturi was 50 psi. The four-inch line stretches 3.98 miles to Barksdale AFB where receiving pressure is approximately 4 psi. It is highly unlikely that this arrangement would result in adequate blending of the FSII into the fuel. Because FSII is the most difficult of the additives to blend with fuel, we **recommend that the injection points be switched so that FSII is injected upstream of**

the pump and SDA downstream. Also, the injection system at DFSP Bossier city is old and had no data plate information identifying the manufacturer. In comparison to systems observed at other terminals, **this injection system appears archaic and should be considered for replacement.**

Product samples drawn upstream of the receipt filters at Barksdale AFB during our investigation were cloudy; however, downstream of the filters the product was clear and bright. The base personnel report a history of problems with wide fluctuations in the quantity of FSII and SDA in the fuel. However, laboratory records show that since August 2000, the quantities of FSII in the shipments have been consistently between 0.15% and 0.17% by volume and the fuel conductivity readings range from 250 to 300 CUs. While the amount of FSII is within the specified receipt range of 0.09-0.20 percent, other installations with similar history have found that lowering the amount of FSII to 0.10% to 0.12% may help reduce the occurrence of AJ. Also, reducing fuel conductivity to between 150 CUs and 250 CUs may also help.

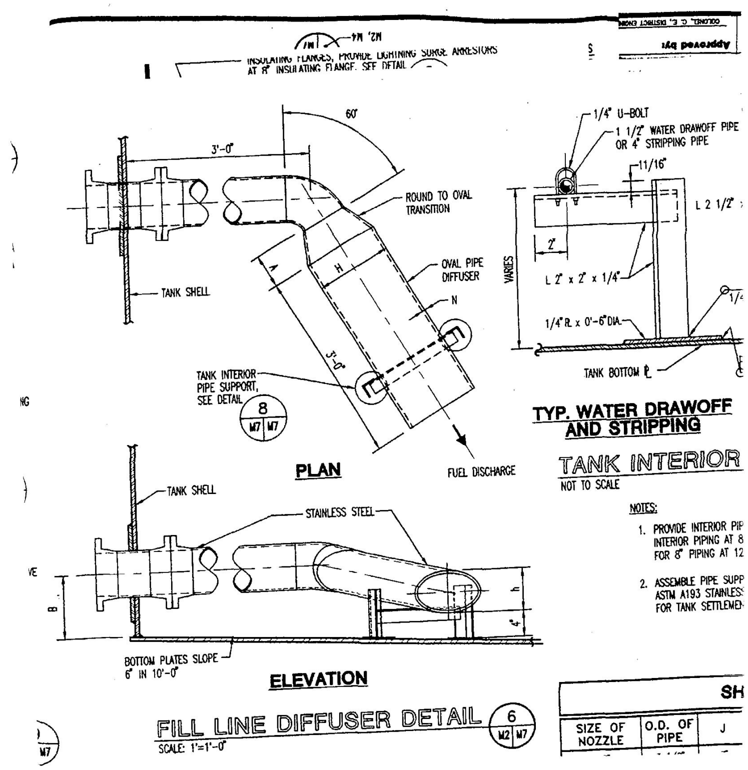
The most significant amount of water in the Barksdale AFB fuel system enters the fuel at Tank #4, a 40,000-bbl tank that has experienced a rim fire, is out-of-round, and leaks badly during periods of heavy rains accompanied by moderate wind. As much as 500 gallons of water have been drained from Tank #4 after periods of heavy rain. The water problem is complicated by ineffective product recovery/water removal systems on several tanks. Ineffective product recovery/water removal systems were identified at a number of locations experiencing AJ. This problem is discussed in detail later in this report. Another factor contributing to the water problem at Barksdale AFB is that inventory capacity significantly exceeds the average inventory. During the site investigations, a number of old floating-roof tanks modified with geodesic dome roofs were found to allow water entry into the tanks through the dome vents during periods of rain accompanied by moderate to heavy wind. When the product levels in the tanks are low the large area of exposed interior tank wall surface facilitates the collection of moisture and allows it to drain from the tank walls past the floating-roof or floating pan seal and into the product content of the tanks. Because of the low inventory requirement at Barksdale AFB, Tank #4 could be removed from service without impacting current mission requirements.

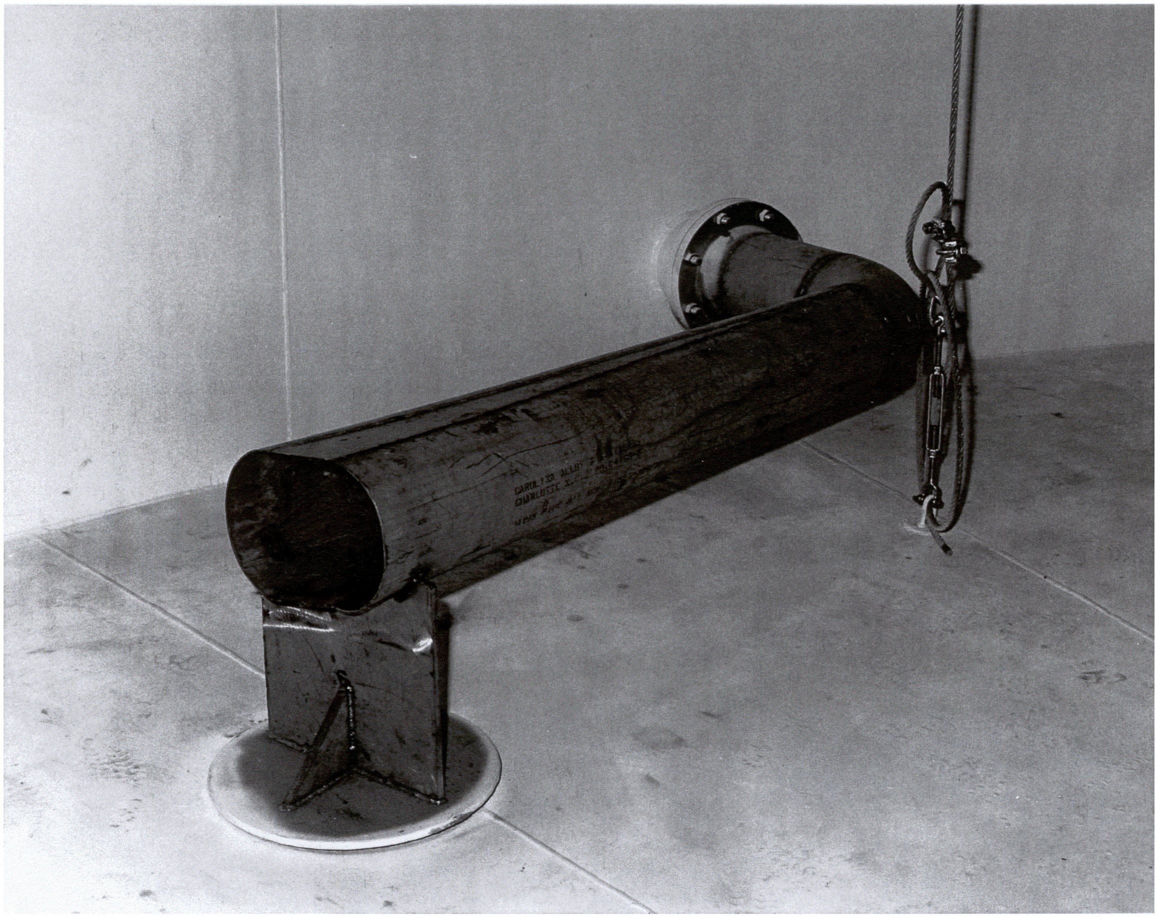
3.3 Fuel Facility Design Factors Contributing to AJ Formation

Several fuel system design deficiencies identified at Barksdale AFB are believed to contribute to the potential for AJ formation and other fuel quality-related problems identified at a number of other bases, including: Otis ANGB, Dover AFB, Edwards AFB, Grand Forks AFB, Beale AFB, Fairchild AFB, McChord AFB, Minot AFB, McConnell AFB and Hill AFB. The design deficiencies include the use of "self-cleaning" fuel storage tanks, the removal or disabling of automatic water drains on filter vessels, ineffective product recovery systems, and the use of over-sized pipes in hydrant system design. In recent years, new construction has included the use of fixed-roof storage tanks. AJ problems are most pronounced where old floating-roof tanks have been modified with the "self cleaning" features because many of these tanks, even when equipped with geodesic domes, allow rainwater entry into the fuel. The design deficiencies are described before continuing with the discussion of on-site investigations to allow the reader to allow the reader to consider these points as they review the site findings.

3.31 Self-Cleaning Tank Design

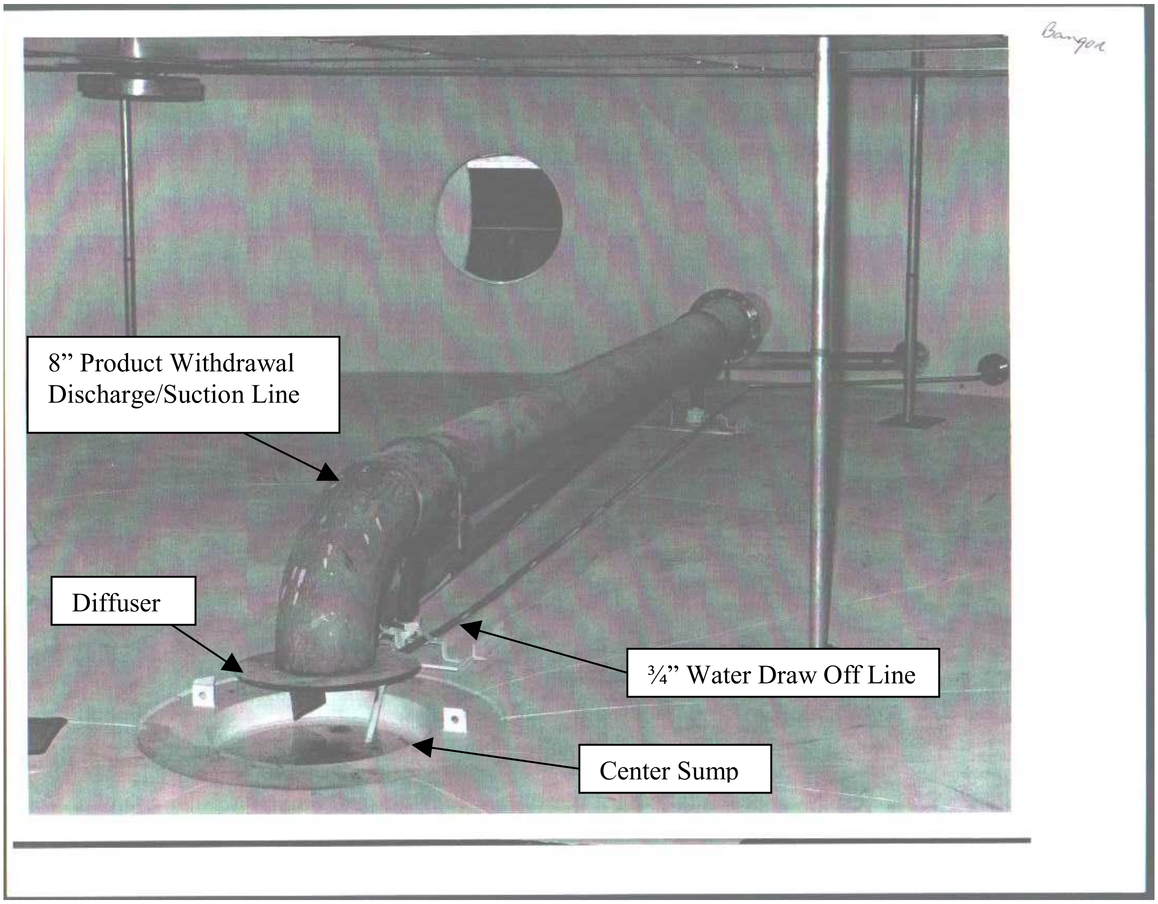
Above ground fuel storage tanks at virtually all of the Air Force and Air National Guard bases visited were built or have been modified to comply with the self-cleaning tank design. The self-cleaning tank design requires a fully epoxy coated tank with, according to T.O. 42B-1-1, a minimum slope of one inch every ten feet to a center sump. (Note: in the drawing below, the slope is 6 inches every 10 feet). The fill line enters the tank wall and is equipped with a 60-degree elbow approximately three feet inside the tank (as shown in the drawing below). This design creates a circular motion inside the tank during receipts to sweep free-water/FSII mixtures and sediment into the tank sump.





Photograph of Tank Inlet at Bangor ANGB.

Generally, a filter separator is installed on the fill (receipt) line. However, the filter separators currently in use at the vast majority of locations were not designed for use with fuel containing FSII and SDA additive. When warm JP-8 is received, the fuel has the capacity to hold significant amounts of dissolved water and suspended free-water. As the fuel cools and settles, this water combines with FSII accumulated in the tank sump. Because the product recovery systems used to drain the sumps are ineffective (discussed below) significant amounts of free-water/FSII blends can accumulate in the tank sumps. The problem is compounded where old floating-roof tanks have been modified for self-cleaning because of rainwater entry into the tank. In most of the existing tanks, the issue (suction) lines are installed directly over the center sump. This allows free-water/FSII mixtures in the tank sump to be picked up by the issue (suction) line. A photograph of the issue line suction nozzle currently in use at Bangor ANGB, ME is shown below.



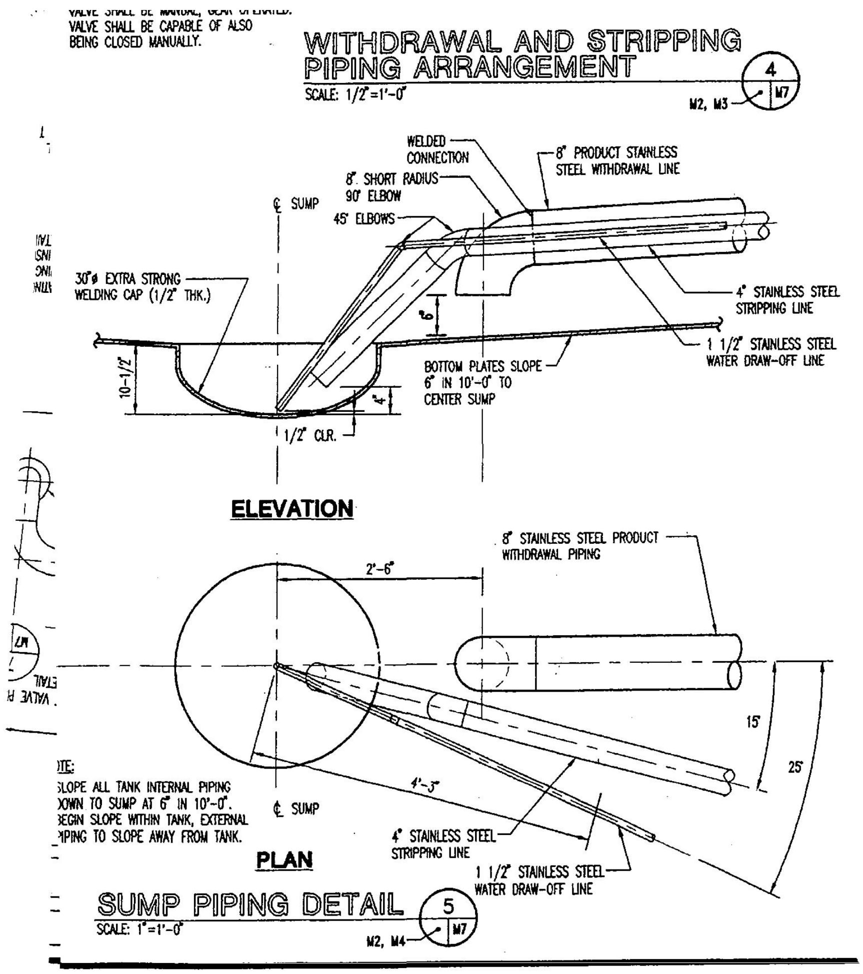
The intent of this design is to reduce the frequency of tank cleaning and reduce the amount of bottom sediment and water/FSII mixtures that require special disposal procedures. The suction line sits directly over and approximately 8 inches above the sump. The flat diffuser on the bottom of the discharge (suction) line helps direct the suction vortex, created by the discharge suction, into the tank sump to clean any water/FSII mixtures and sediment that accumulate in the sump. This design relies on the filter separators to remove water and sediment from the fuel.

The self–cleaning tank design was originally intended for use with fixed-roof operational storage tanks. Under this concept, fuel would be received, settled, drained and transferred through a filter-separator into the self-cleaning operational tanks. Because of the success of this design in reducing cleaning requirements and minimizing tank bottom disposal requirements, the use of this design was expanded to bulk receipt/storage tanks. Another advantage to this design is that it minimizes “unobtainable” tank bottoms, because the discharge line inlet is very close to the tank bottom. However, four factors combine to result in fuel quality being jeopardized by the self-cleaning design. First, many of the self-cleaning tanks are not equipped with effective product recovery (sump drain) systems (discussed below). Second, many geodesic dome roofs are not effective in preventing rainwater entry into the fuel storage tanks. Third, the Air Force relies on the use of automatic tank gauging (ATG) installed near the tank shell to identify the presence of a water bottom in the tank; however, because the tank bottoms slope to the tank center, many of the larger tanks could accumulate thousands of gallons of water before it would reach a level detected by the ATG system. Fourth, the filter separators currently in use are not designed to handle fuels with surfactant additives and water bottoms with high concentrations of FSII. This problem is exacerbated at installations experiencing water entry into on-base tanks because the water removes the FSII from the fuel and the base fuel management personnel must request an increase in the amount of FSII from the supply source to assure the minimum required level of FSII is in the fuel at the time of issue to aircraft. The higher concentration of FSII further contributes to AJ formation in receipt and transfer filter separators because, according to Rick Waite of Velcon Filters, Inc., when free-water contains more than 20% FSII it will pass through the filter separators and water absorption media elements.

Reliance on the filter separators currently in use to remove the free-water/FSII mixtures and sediment to prevent slugs of these contaminants from reaching the aircraft is ill founded. Filter separators at the vast majority of locations were designed for use with "neat" unadditized turbine fuels. The military, and particularly the Air Force, use additives that contain surface-active agents (surfactants) that disarm the ability of these filter separators to coalesce water from fuel. A new API 1581 Edition 4 filter separator has been developed for use with fuels containing surfactants; however, the filter vessels used at many DoD locations have not been qualified for use with the Edition 4 elements. Significant qualification testing and system modifications would be required before the Edition 4 elements could replace all other filter separator elements currently in use. Furthermore, while the Edition 4 elements are apparently an improvement, some filter system experts (including manufacturer representatives) recommend further field experience and testing before the new API 1581 Edition 4 elements are adopted for standard use.

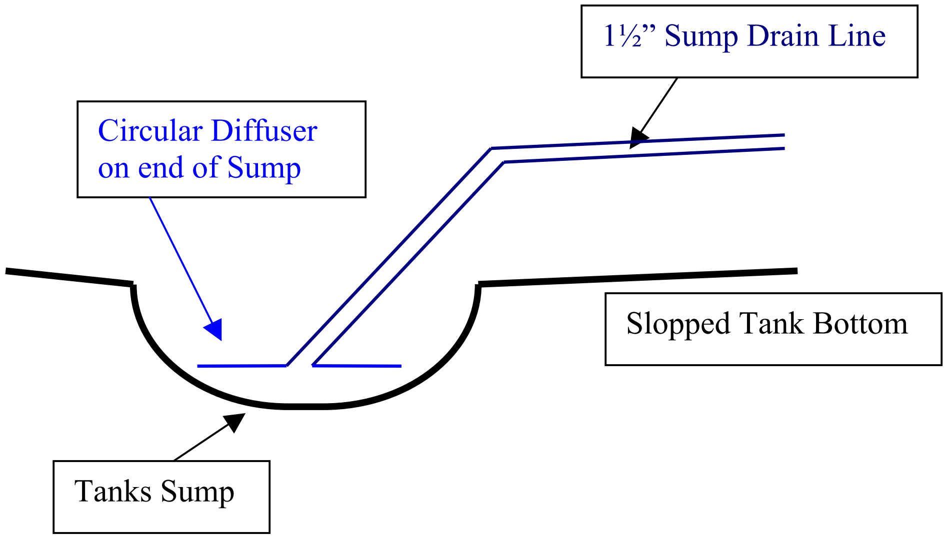
3.32 Recent Improvements to the DoD Standard Tank Design

In a recent change to the DoD standard design, the discharge (suction) line has been offset approximately one foot from the edge of the tank sump and the flat, disc-shaped diffuser has been eliminated (see drawing below). Likewise, in the newer DoD design, the size of the water draw off line has been doubled from ¾ inch to 1 ½ inches line and new systems are provided with a much improved product recovery system consisting of a 2,000 to 4,000-gallon product recovery tank.



These were important improvements but left important problems unresolved. A basic problem is that this design relies on the pressure of fuel above the sump to push the water up and out of the sump through the drain line; however, if the drain line is opened too quickly, the lower density fuel above the FSII/water mixture is drawn into the vortex created by the drain-line, while the FSII/water mixture, because of its higher density surface tension, clings to the sides of the sump wall. The operator draining the line sees fuel being discharged and assumes there is no water in the tank sump. Because many discharge lines are directly over the tank sumps, the FSII/water that was not draining is picked up and forced into the filter separators.

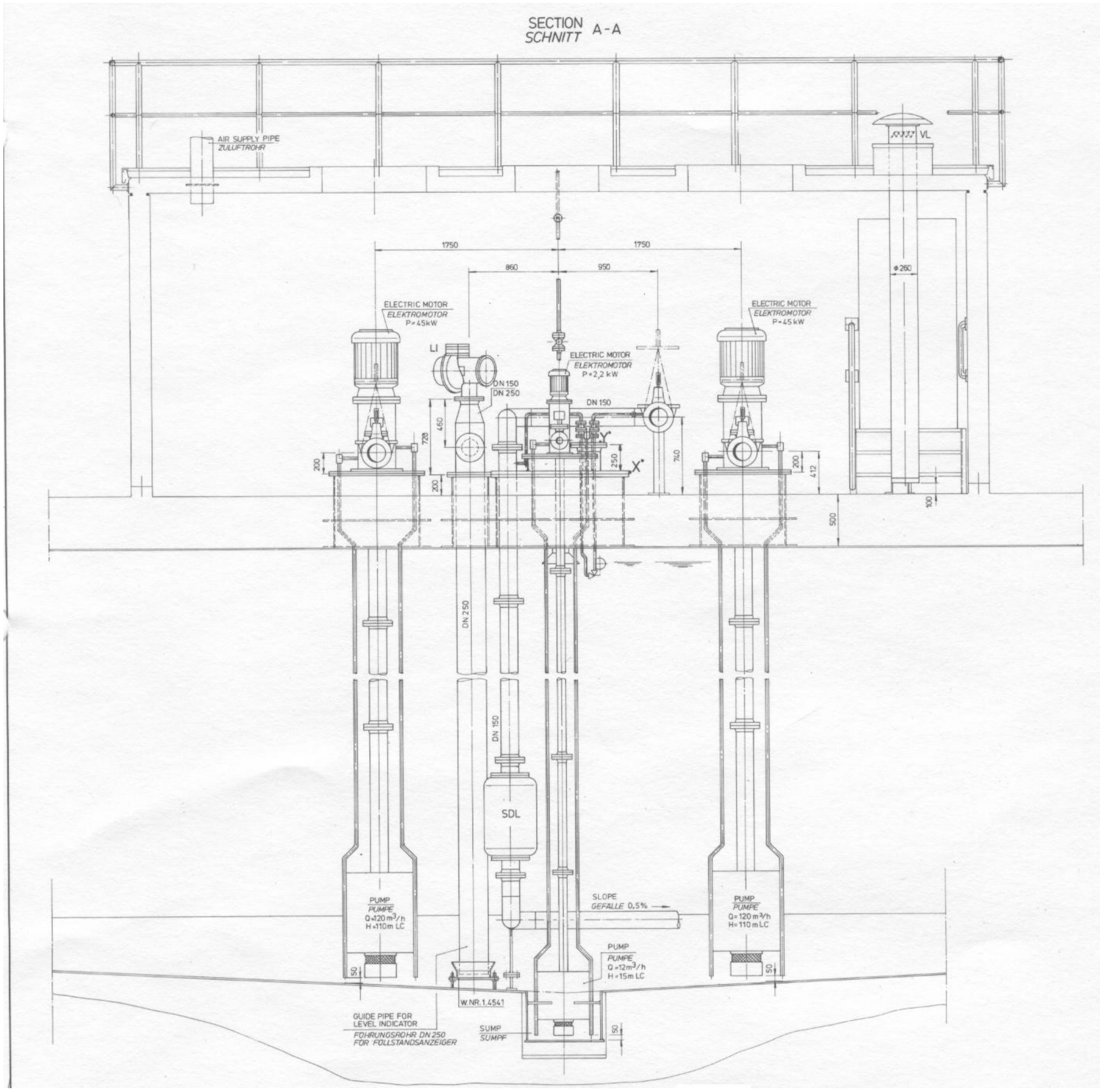
A simple improvement to this design would be to equip the drain line nozzle with a diffuser plate, such as illustrated below. This would allow the drain to draw from the bottom and sidewalls of the sump and help overcome the problem of the FSII/water bottoms being pushed to the side while fuel is forced into the sump drain line.



3.33 NATO Tank Design

While the number of reported AJ incidents has increased dramatically at Air Force installations within the U.S. and more recently in Asia, few if any reports of AJ contamination incidents have been reported in the NATO fuel storage and dispensing systems in Europe. The C4e investigation team believes there are four primary contributing factors that reduce the amount of FSII/water bottoms in the NATO system. First, most NATO tanks are the cut-and-cover design with fixed-roofs that do not permit rainwater entry into the fuel. Second, the NATO tank design is more effective in removing FSII/water bottoms from storage tanks. Third, the discharge lines do not draw directly from the tank sumps. Finally, the point of FSII injection is generally much closer to the point of use than is the case at installations experiencing AJ within the U.S. This final point will be addressed in detail in a later section in this report.

While there are significant design requirements for cut-and-cover tanks that would not be practical for use in above ground storage tanks, some of the design differences help illustrate why AJ has been a significant problem in the U.S. but not within Europe. The use of fixed-roof tanks eliminates rainwater entery into on base storage. The NATO design, shown below, has a tank sump suction pump that is more effective in removing FSII/water mixtures. The suction nozzles of the sump pumps are installed inside the sumps close to the tank sump bottom and walls and, consequently, overcome the greater density and surface tension of FSII/water mixtures facilitating its removal. Furthermore, the two discharge suction nozzles are installed so they do not draw directly from the tank sump.

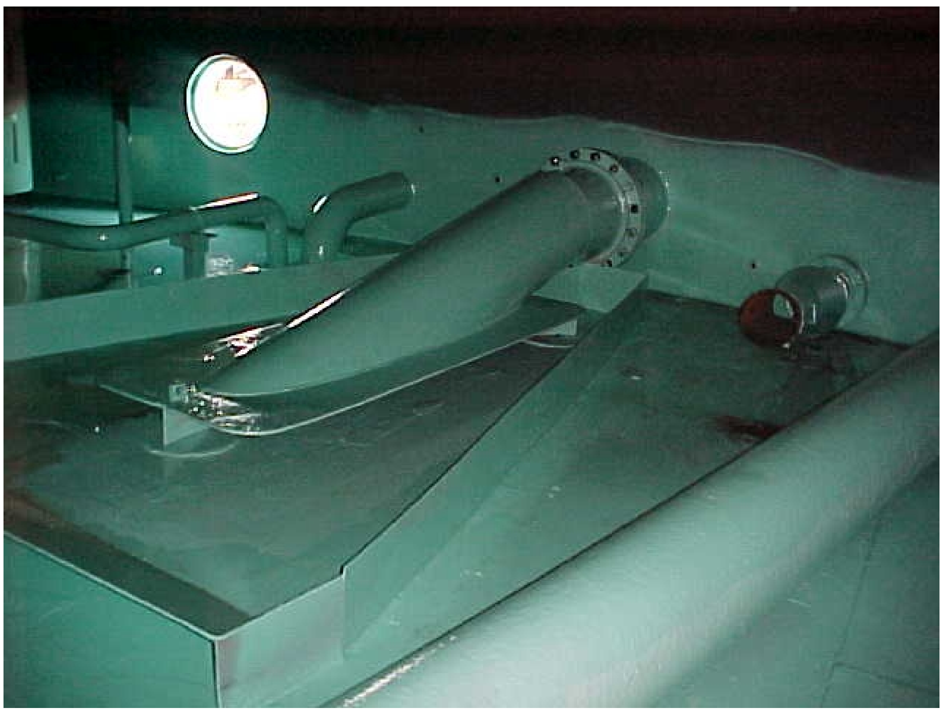


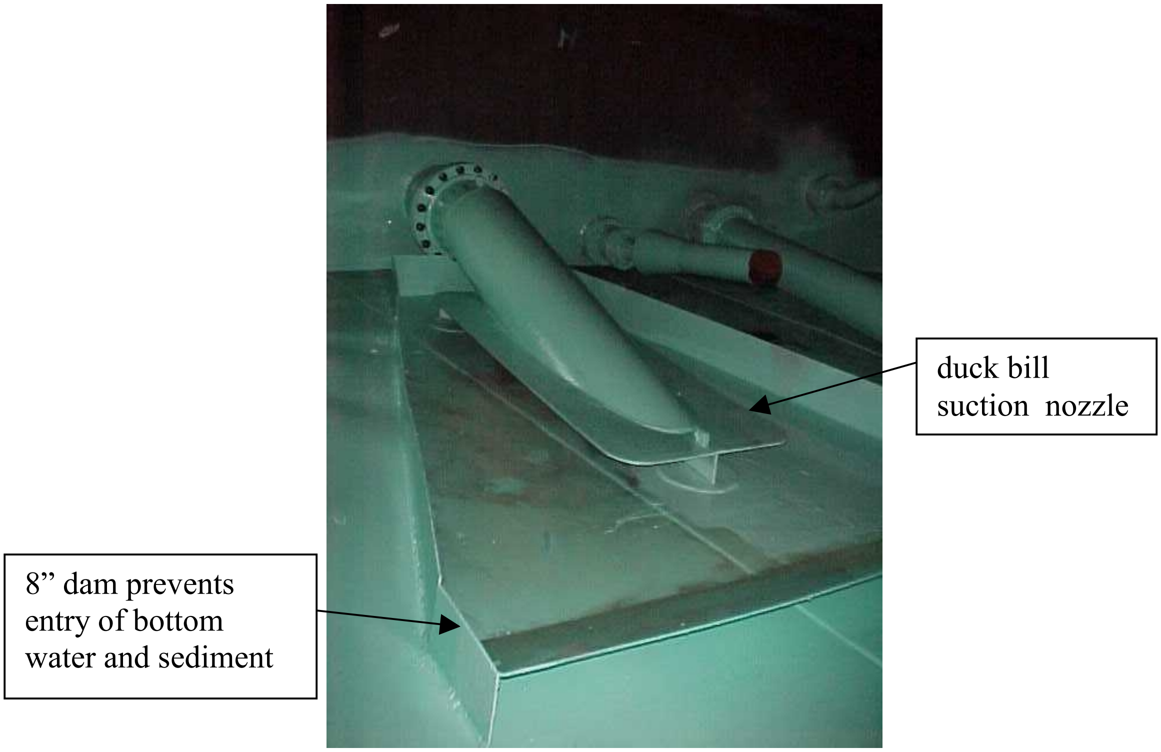
Standard NATO Operating Tank Design

3.34 Commercial Turbine Fuels Storage Tank Design

When comparing the DoD tank design to the designs used for turbine fuel storage tanks at commercial airports and terminals, a significant difference in design philosophy becomes apparent. While there is no single standard design in use at commercial airports and fuel terminals, the various designs that are in use emphasize preventing water from entering the tank discharge line. The use of a “floating suction” discharge line is very common at commercial airports. In this design, the inlet line has a mechanical swivel near the tank wall. Floats are installed at the end of the discharge pipeline, near the suction inlet. The swivel and the floats allow the discharge line to rise and fall with the level of the fuel in the tank. Consequently, the discharged fuel is drawn from the top of the product in the tank rather than from near the tank bottom or sump. This floating suction design was also encountered at several of the commercial terminals that provide JP-8 for use in DoD aircraft.

Another design that is common in commercial fuel storage involves a “duck bill” suction line used in conjunction with an eight to ten inch dam to minimize the amount of water that can enter the suction line. The photograph below shows a duck bill suction line and tank of a recently cleaned epoxy coated tank at DFSP Carteret. The water dam helps prevent the migration of bottom water and sediment toward the suction line and the flat diffuser on the duck bill directs the suction vortex into the dam. The diffuser sits inside the dam and approximately one inch below the top of the dam. Fuel being lighter than water enters from the top of the dam and the water on the tank bottom is kept away from the discharge line suction nozzle.





In another tank design, used in one of the two JP-8 tanks at DFSP Portland, the discharge (suction line) is equipped with a 90 degree elbow that angles up toward the top of the tank, rather than down toward the tank bottom. While this design enhances fuel quality by not vacuuming bottom sediment and water, it significantly reduces usable inventory and “unrecoverable” tank bottoms, since the entry point into the discharge line is approximately 24 inches above the tank bottom. The other JP-8 tank at DFSP Portland uses a floating suction discharge line.

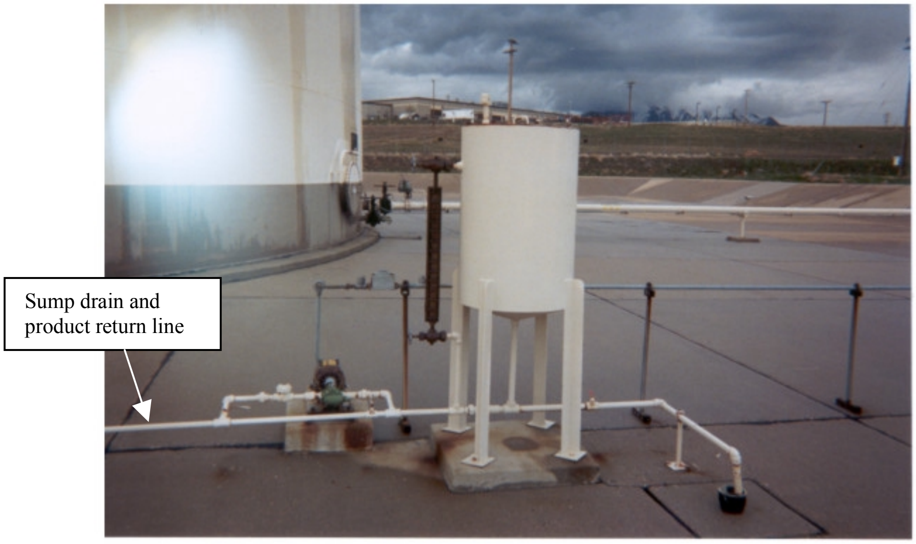
3.35 Floating-Roof Tanks and Geodesic Domes

Geodesic domes have been installed on most of the Air Force floating-roof tanks originally designed for use with JP-4. The primary purposes of the geodesic domes are to prevent rainwater entry into the tanks and to keep snow off the floating-roofs. The installed domes have a wide variety of designs and some appear to be more effective than others. Ineffective geodesic domes are the primary source of water entry into JP-8 at several locations that have struggled with AJ contamination (see the reports on Barksdale AFB, Fairchild AFB, Grand Forks AFB, McChord AFB, Edwards AFB, Beale AFB, Minot AFB, and Otis ANGB provided in the Appendices). The principal design problem is that the dome skirts and tank vents around the exterior sides of the tanks do not keep rain, when accompanied by moderate to high wind, from entering the tanks. The seals on floating-roofs in these tanks are typically ineffective in preventing water running down the interior tank walls from entering the fuel. Low product level during periods of heavy rain and high wind also contributes to this problem. Low product level exposes a greater surface area on the interior tank walls to collect the rain and allow the water to run down the tank wall and between the wall and the ineffective roof seals into the fuel. Fixed-roof tanks are being provided as a standard for new construction and significantly reduce the potential for AJ formation.

Most floating-roof tanks in geographical areas where rain is a common experience have been equipped with domes. (The tanks at DFSP Ludlow are exceptions discussed in detail in another section.) However, floating-roof tanks at some installations located in typically arid regions have not been modified. In recent years, an unusually heavy rainstorm in Albuquerque, NM resulted in a serious water contamination of the JP-8 at Kirtland AFB. Similar problems have been experienced at Luke AFB, AZ. More recently, an unusual rainstorm at Edwards AFB resulted in the draining of over 2,000 gallons of water from two tanks and the associated filter separators, and added a new location to the AJ list. At Edwards AFB, the tank seals on both Tank 28 (10,000-bbl capacity) and Tank 19 (20,000-bbl capacity) are ineffective in keeping the water out of the tanks. Subsequent to this storm, Edwards AFB found AJ contaminants in the transfer filter separator between bulk storage and the hydrant system, as well as in the filter vessel on Kovatch R-11 refuelers. **We strongly recommend that all floating-roof tanks used for the storage of JP-8 be equipped with an effective dome designed to keep rain water out of the tanks even when the rain is accompanied by high wind.**

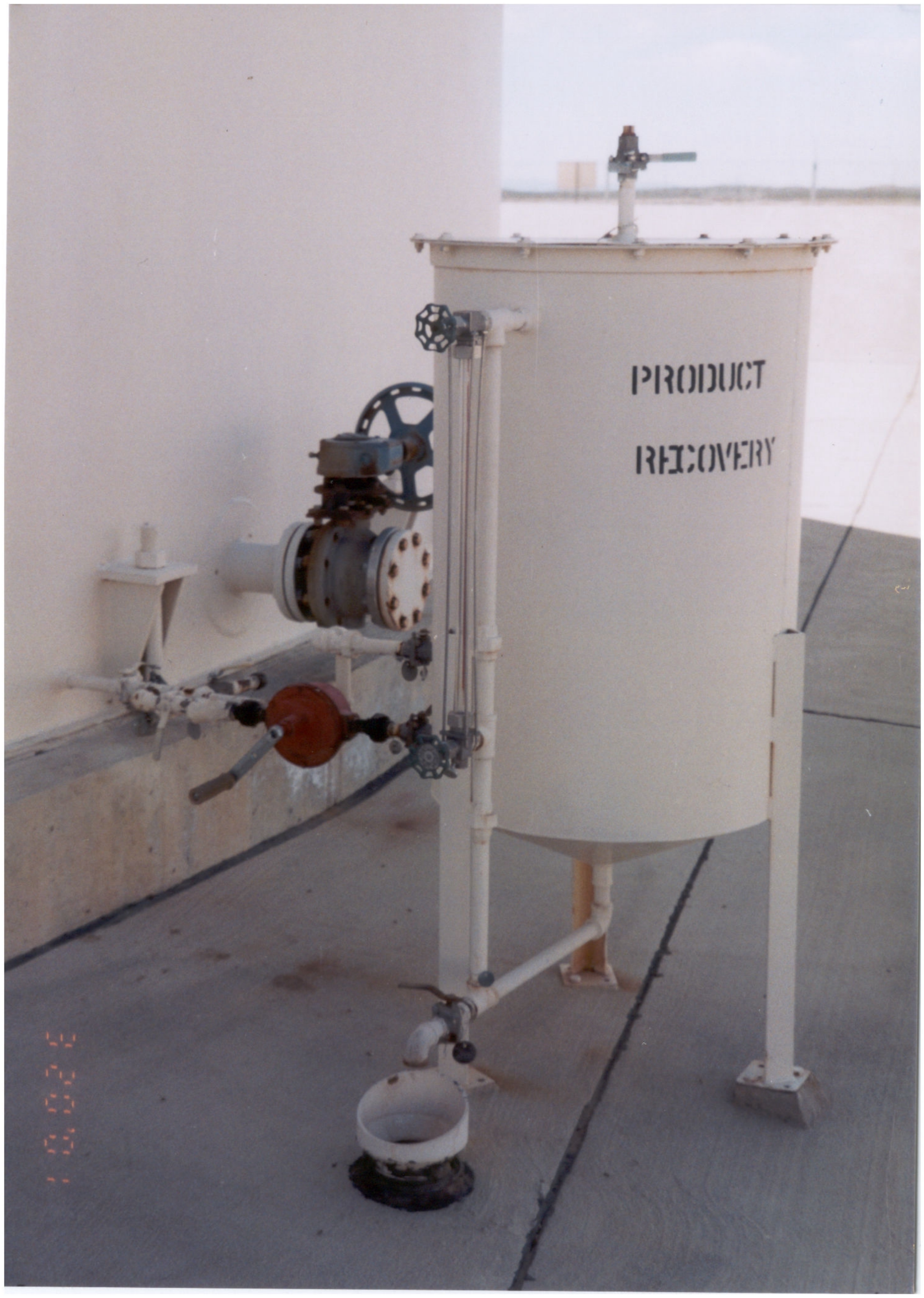
3.36 Bulk Storage Product Recovery Systems

The new DoD design provides for a much improved and environmentally sound product recovery system. However, many of the older design systems, still in use at most bases, are ineffective in draining FSII/water bottom from the storage tanks. Typically, the old floating-roof tanks that have been modified with geodesic domes have the older type product recovery systems that are ineffective in removing FSII/water mixtures from tank bottoms. There are basically three problems with these product recovery systems. First, the small capacity of the recovery tank is insufficient to handle the recovery line fill and any significant quantity of FSII/water or fuel/water emulsion. Second, many of these systems typically have small ¾ inch pipelines, which are ineffective in draining large or small amounts of FSII/water and cloudy fuel mixtures from the tanks. As discussed above, the high surface tension of the water/FSII mixture causes this material to cling to the sides of the sump wall while fuel is drawn into the suction vortex. Because many of these tanks have been modified with a sloped bottom to a center tank sump and discharge line drawing directly from the tank sump, the tank bottom FSII/water mixtures are forced into the filter separators. The third problem is the means provided to return usable fuel from the product recovery system to the tank. In many cases, the return line on the product recovery system is the same line as the suction line. The photograph below, taken at Hill AFB, shows an example of an ineffective product recovery system. Notice that the drain line and return line is the same, which is undesirable because any contaminants remaining in the line are returned to the sump. Also notice that an electric pump is provided to aid in pumping against the head pressure in the tank during product reclamation. Some systems still in use, such as the one at Dover AFB, provide a hand pump for this purpose which are ineffective and contribute to operator neglect of sumps draining requirements. Similar systems are also in use at Barksdale AFB and Beale AFB.

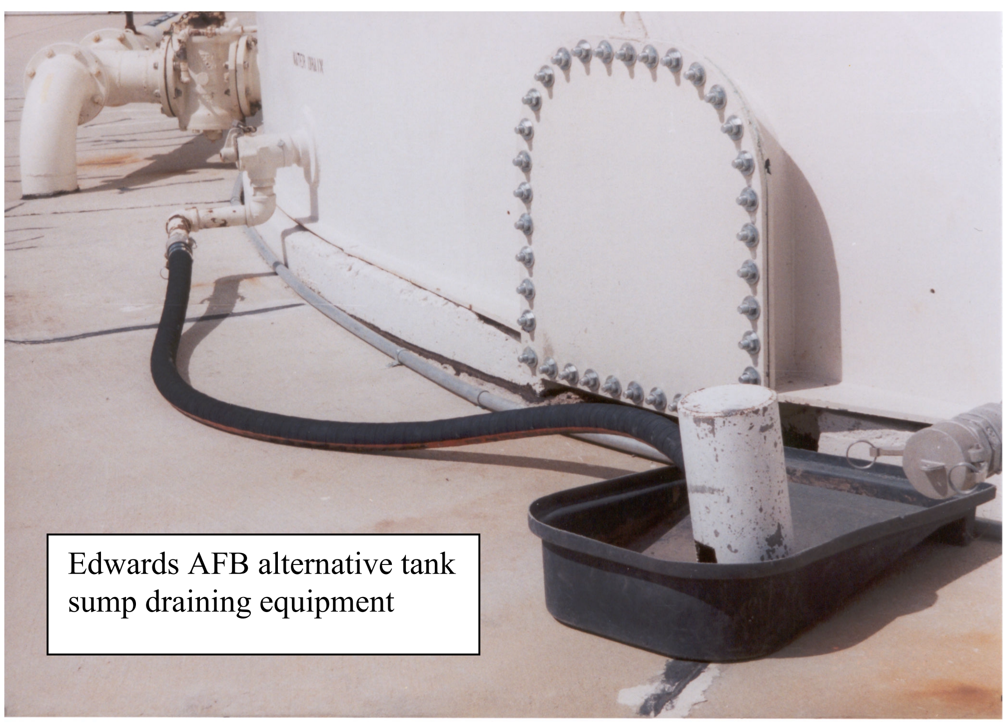


The product recovery system pictured above has been abandoned because of lack of utility and this same tank is currently drained by running a 1 ½” rubber hose across the diked area and into the bowser shown below.

Product recovery systems at Fairchild have also been abandoned in favor of using a bowser, like the one above, to draining tank bottoms. Likewise, the product recovery systems at Edwards AFB (see photo below) has been abandoned in favor of draining BS&W into the containers shown in photographs two and three below.



Edwards AFB alternative tank sump draining equipment



Edwards AFB alternative tank sump draining equipment

3.37 Hydrant System Design

The size of the issue line on many of the newer hydrant systems at Air Force bases creates a potential for contamination to settle and accumulate in low points in the hydrant system loop. The typical design involves the use of a 12" issue line and four 600-gpm pumps. The systems are designed to maintain a constant pressure by automatically turning on additional pumps as fuel flow to aircraft being serviced increases. Flow through these systems, which reaches a maximum flow rate of 6.8 feet per second, seldom develops the turbulence to sweep clean the pockets of FSII/water that settled into low points within the pipeline. Consequently, FSII/water mixtures accumulate in low points during low or no flow conditions. When the accumulations become large enough and the flow rate increases, some of this material can be picked up in the fuel flow.

Technical guidance concerning the draining of these low points is provided in T.O. 37-1-1, "General Operations and Inspection of Installed Fuel Storage and Dispensing Systems." The applicable portions of this technical order are cited and discussed below:

> T.O. 37-1-1, paragraph 6-1: "**GENERAL.** The FMT and CE personnel will review drawings for the fuel systems. Drawings will be checked to determine if drain valves are indicated for all low points in the systems. Low point drains not indicated will be included in the drawings. Where low point drains are not provided, action will be initiated to have them installed when warranted."

> T.O. 37-1-1, paragraph 6-2. "**LOW POINT DRAINING FREQUENCIES.** All low point drain valves shall be operated at least semi-annually when the system is not under operating pressure."

Our investigation did not include verification of compliance with the above T.O. 37-1-1 requirements. However, we are concerned that the large diameter dispensing lines on the Type III, IV and V hydrant systems do not reach turbulent flow conditions sufficient to prevent pockets of FSII/water mixtures from accumulating in low points during normal operations. After sufficient FSII/water accumulates, some of this material can be picked up in the fuel flow during peak operation. The fuel system at Bangor ANGB, ME is a case in point. The fuel system at Bangor has fixed-roof tanks and the most modern design product recovery system, yet AJ is periodically found in flight line servicing equipment, including hydrant-servicing vehicles. The AJ problems at Bangor, as at many other locations, occur simultaneously with a significant drop in ambient temperatures. Since the frequency of AJ occurrence appears to be related to temperature change, we suggest that this section of T.O. 31-1-1 address the need to drain low points in the Fall of the year soon after the temperature of fuel in the operating storage system drops below 40° F. Furthermore, we recommend that draining frequency be increased for low point drains where more than eight ounces of FSII/water mixtures are found during the semiannual draining required by the technical order.

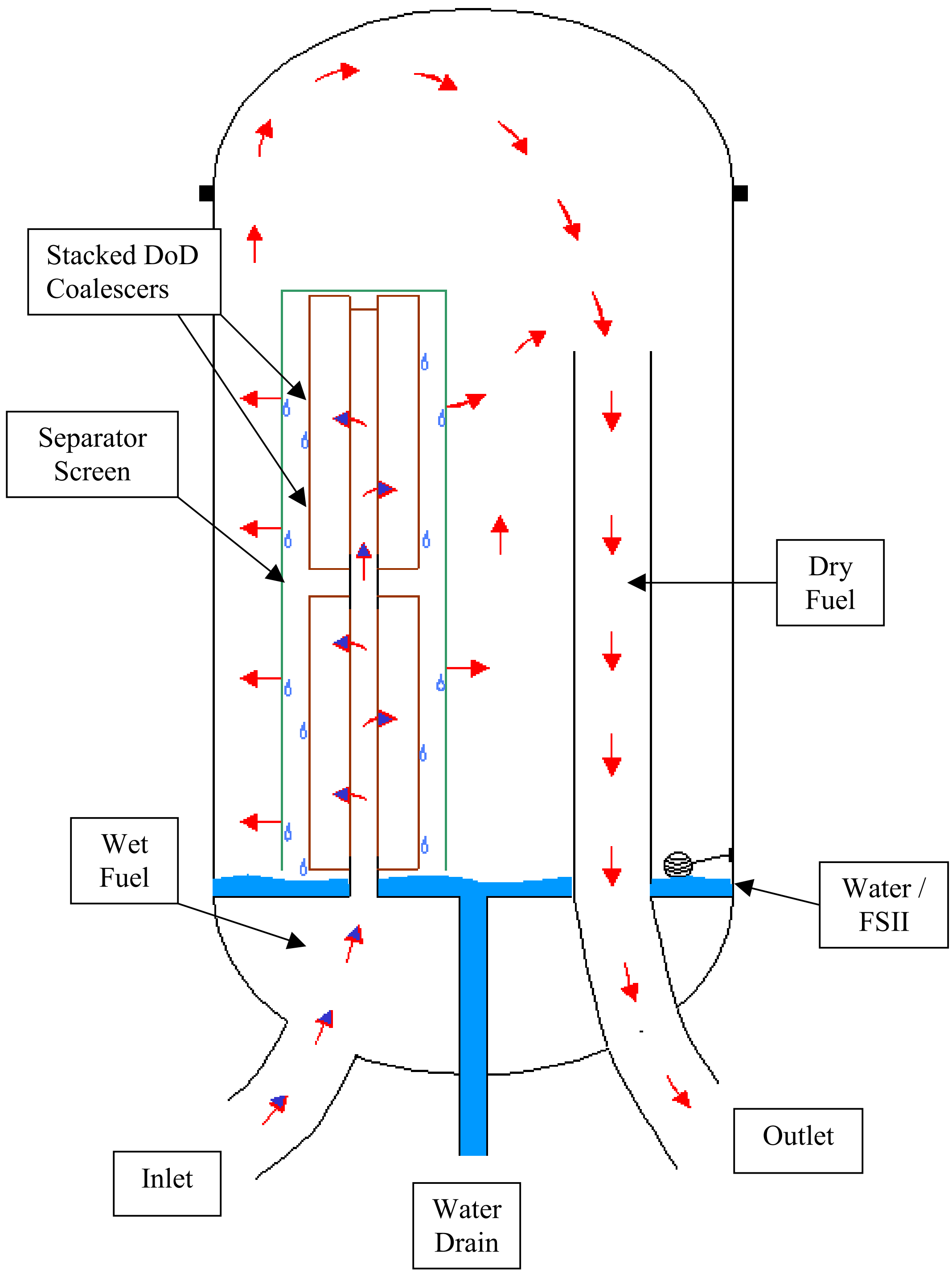
The influence of temperature changes on the accumulation of FSII/water mixtures in hydrant system pipelines merit further study. Seasonal and operational changes impacting fuel temperature can increase the amount of FSII/water entrained within the fuel that settles. The temperature of the fuel entering the pipelines and changes that occur within the pipelines influences the amount of entrained FSII/water than will settle out of the fuel. Some hydrant systems are routinely operated around-the-clock, seven days a week. While others, such as Air National Guard locations are turned off for periods of time. A better understanding of how these changes impact the accumulation of FSII/water in low points at different operating locations would be beneficial in determining conditions that should influence the low point draining frequency and schedule.

Product recovery systems on the filter separators and issue tanks on the newer Type III systems are very effective and provide for automatic draining of water from the filter separator sumps into product recovery systems equipped with a high level shut off and high level alarm systems. The one deficiency is that manual water drains on the filter separator sumps and issue tank sumps do not provide a means whereby the operator can drain the sumps into a bucket or glass jar for visual inspection. Though a sight glass is provided on the drain line, the rapid movement of the sump content through the sight gauge does not allow time for the operator to get a good view of the material being drained. Many of the locations visited that have this newer system have subsequently installed manual drains so they can capture the materials drained from the filter vessel sumps for closer examination.

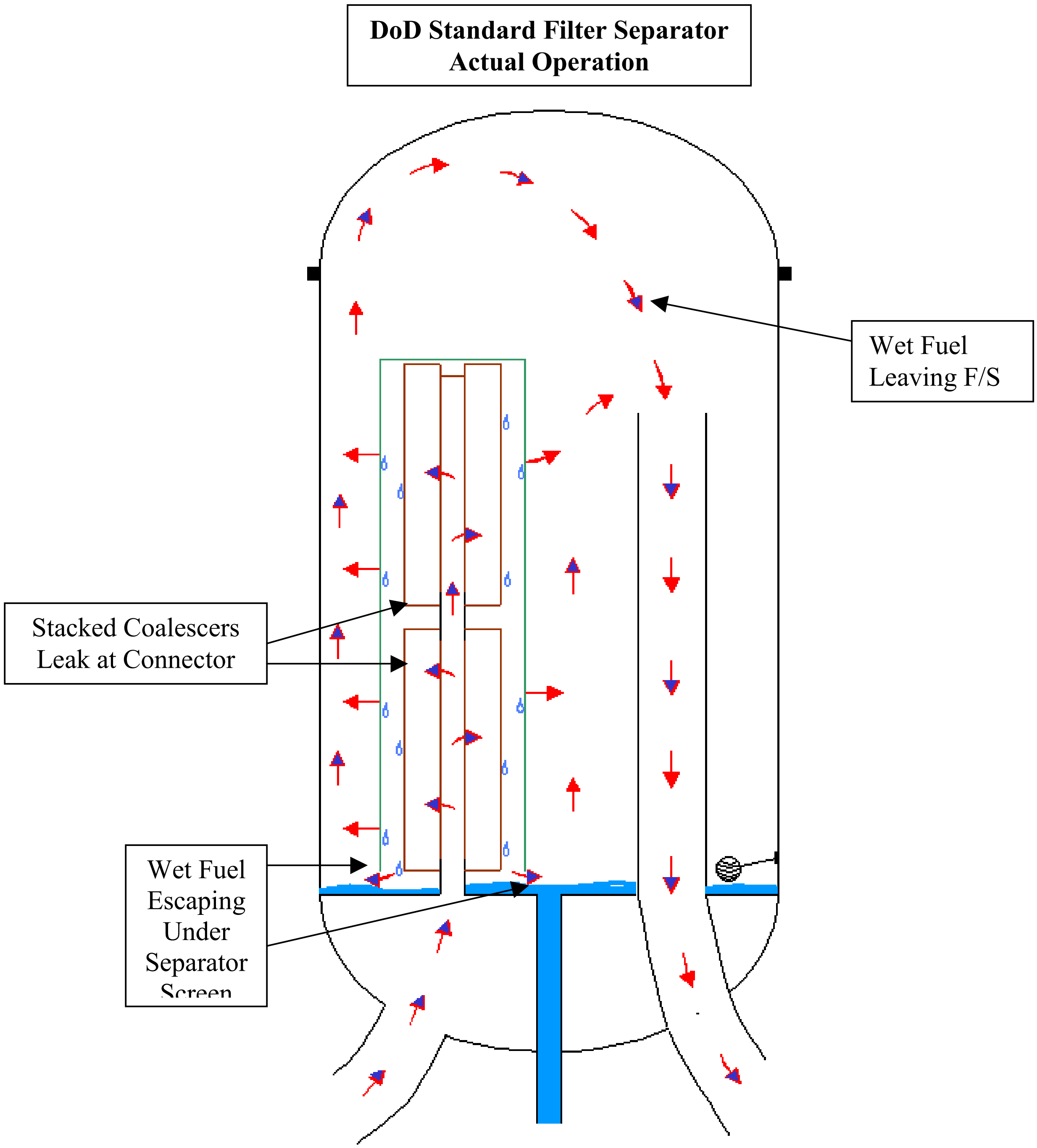
3.38 Filter Separator Vessel Design

Continued use of old DoD standard filter separator vessels, especially when combined with the self-cleaning tank design, jeopardizes fuel quality and provides a means for free-water/FSII and AJ to get into aircraft fuel systems. The DoD F/S design was built for use with JP-4 and was marginal for that application. The design concept of the DoD vessel is presented in the drawing below. Fuel enters the coalescer elements from the inside and flows to the outside. The coalescers cause free-water to form large droplets on the fiberglass sock that covers the coalescers. The water droplets, being heavier than fuel, eventually drop to the bottom of the vessel. A Teflon coated separator screen with a small pore size (70 microns) allows the fuel to pass though but not the large water droplets. The separator screens are open at the bottom to allow the water to flow under the screen to the sump drain. It is our understanding that qualification testing of these vessels was accomplished using a “water leg” in the bottom of the vessel to “seal” the separator so that fuel would not bypass the separator screen by slipping underneath the screen. When water in the bottom of the vessel reaches a certain height, a flow actuated valve opens an automatic water drain. If the water level rises higher, a second position of the float actuates a flow control valve to stop the flow of the fuel. As water is released through the automatic drain and the float is lowered, the flow control valve is opened and the automatic water drain is shutoff.

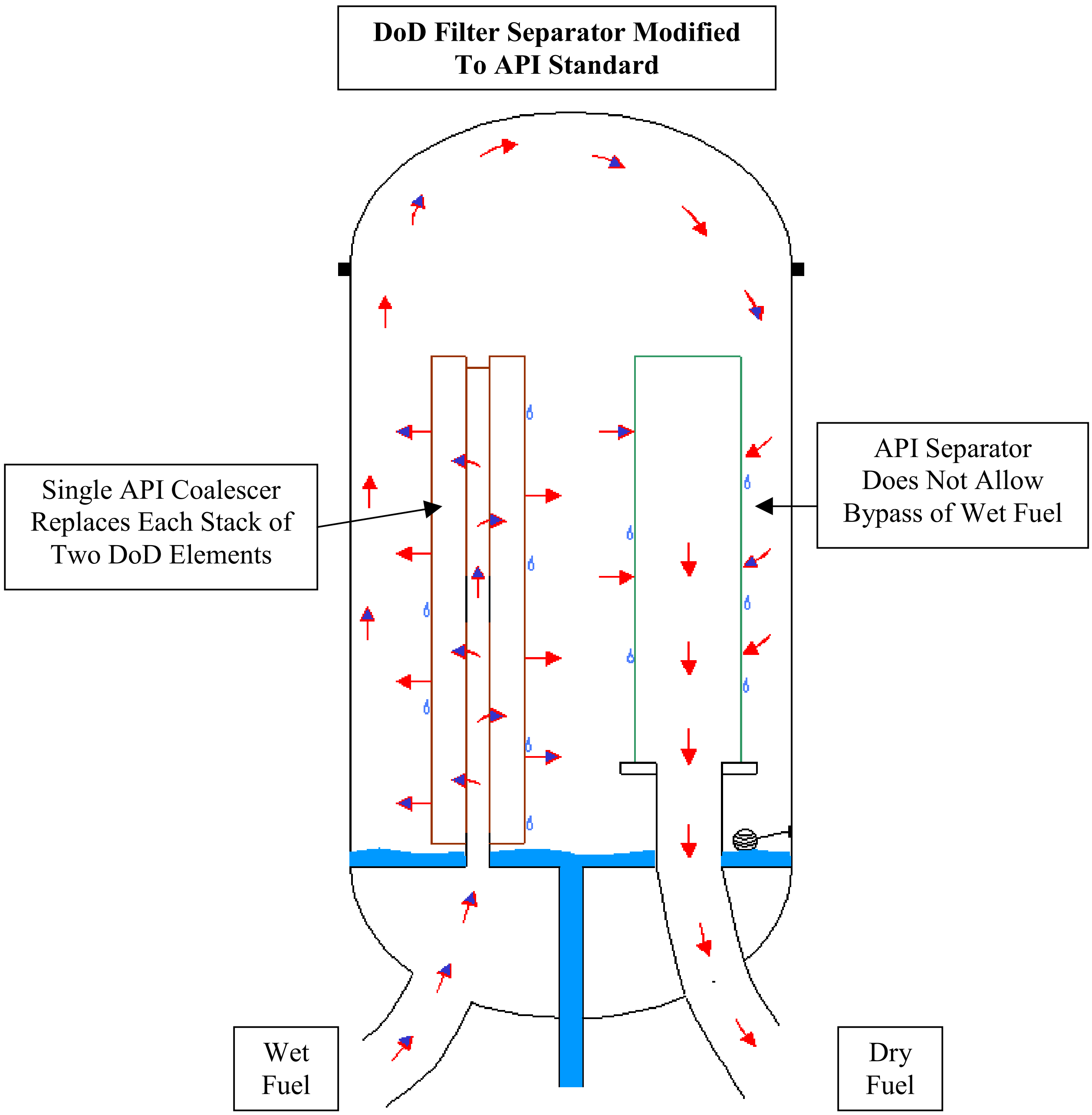
DoD Standard Filter Separator Design Concept



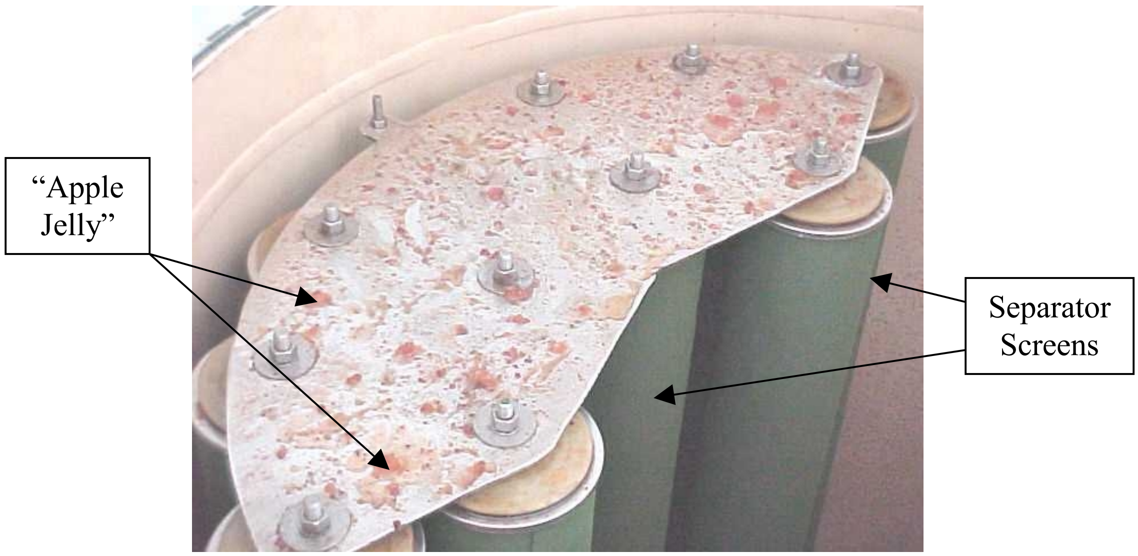
A major problem with this vessel is that a "water leg" is not used to seal the separator screen in normal operational use. Without the water leg, fuel bypasses underneath the separator screen carrying water and AJ with it. When used with naphtha-based JP-4 this design was adequate because of the greater difference in the density between the fuel and water. However, with kerosene-based JP-8 this is not the case. Even with a water leg in the bottom of the vessel, the higher density JP-8 will follow the path of least resistance and some will bypass the separator by flowing beneath the separator screen carrying free-water/FSII with it.



Most, but not all of the DoD F/S vessels have been replaced or modified to meet the API/IP 1581 standard. Minot AFB, Edwards AFB, Beale AFB, McChord AFB, and Hill AFB are all using DoD standard F/S vessels that do not appear to have been modified. In the API vessel, the separator screen is attached directly to the F/S outlet and does not allow bypass. A conceptual drawing of how the API vessel works is provided below.



The photograph below shows gelatinous material reported as "apple jelly" on top of the separator screens in a JP-5 receipt vessel in Kodiak AK. Any assumption that such contaminants would settle to the bottom of a filter vessel and would not reach the discharge line of a DoD design vessel is proven incorrect by this photograph.



To preclude environmental incidents involving the discharge of fuel/FSII/water mixtures, T.O. 37-1-1, paragraph 4-11e(2) directs fuel system operators to "Ensure automatic water drain valves are removed, plugged or made inoperative" on filter separators unless the discharge lines "connect directly to a product recovery tank equipped with an operational high-level shutoff and high level alarm." Likewise, automatic water discharge valves on refueling vehicle filter separators have been removed or made inoperative. Most of the bases visited have instituted very aggressive F/S sump draining procedures that include draining the F/S vessels on refueling trucks, hydrant servicing vehicles, and hose carts twice daily—at the beginning of the day shift and at the beginning of the B-Shift in the evenings. Some bases, such as Barksdale AFB have gone a step further by having their operators drain the fillstand and vehicle F/S sumps each time a truck is filled. These are sound management practices implemented in response to the operating environment they confront.

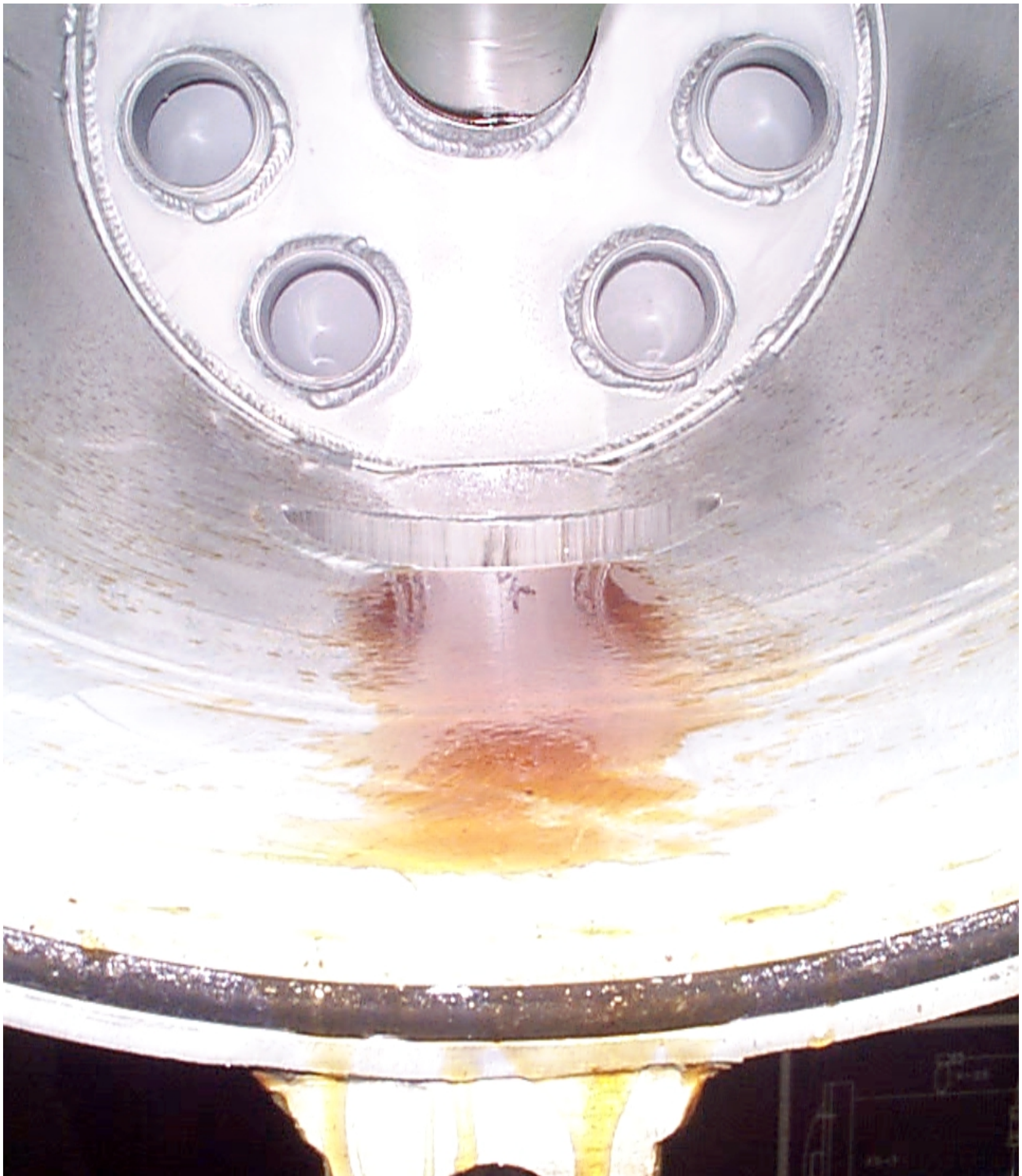
We are concerned about the lack of automatic draining capability on receipt and transfer vessels that filter high volumes of product. This is a particular concern where product is received directly into a self cleaning-type bulk storage and operating tank. Due to a history of excessive water in the receipts, a hay pack dehydrator was recently installed at Beale AFB. Unfortunately, this system makes no provisions for the proper containment and collection of water discharged from the vessel. Normally, when a dehydrator is installed, the separated water discharges into an oil/water separator or a product recovery tank. We were told that the state of California EPA would not approve an oil/water separator.

Similar problems exist at some DFSP support terminals. The conversion of the F/S vessel at DFSP Ludlow to a micronic filter is particularly troublesome given the large quantity of water in the Ludlow JP-8 tanks. At DFSP Port Mahon the F/S vessel drains were blocked with pipe plugs below the drain valves and the vessel air eliminator lines were capped. The Terminal Manager stated that they were blocked to avoid a spill and the associated environmental impact. This type of an arrangement inhibits checking the F/S sumps for water and, if water is allowed to build-up in a F/S sump, the water will be transferred downstream.

3.4 Refueling Vehicle Filters and AJ Formation

During the onsite investigations, it became apparent that some general characteristics of AJ differ depending upon the location in the fuels logistics systems where the AJ materials were found. Materials drained from the sumps of receipt and issue F/S vessels were generally similar in viscosity to a free-water/FSII mixture. The same was true of most materials drained from bulk storage tank sumps and found in the bottom of product recovery tanks. However, the thickest, most viscous forms of apple jelly were found to be associated with the R-11 refueler equipped with water absorption media filters. This type of AJ material is occasionally drained in small amounts from the filter vessel sumps, but is more frequently found in the bottom of the filter vessel, as shown in the photograph below.

(Photo provided by Youngstown ANG)



Filter Separator Vessel on Kovatch R-11
(Photo taken at Barksdale AFB, LA)

Over 93 samples suspected of being AJ were submitted to SwRI by field activities. SwRI categorized these samples into four groups based upon test results or appearance. Materials with a viscosity in the range of a water/FSII blend (equal to or less than 10 cP at 25ºC) were categorized as having low viscosity. Samples having a viscosity of between 10cP and 100cP at 25ºC were categorized as having medium viscosity, while samples with a viscosity greater than 100cP at 25ºC are considered high viscosity samples. In the chart below, samples that have been tested and determined to have high viscosity are identified in red. Intermediate samples are shown in blue. Samples that were too small to be tested but appear to have a high viscosity are identified in orange. (See Appendix B for data on all samples, including those with low viscosity.)

Sample ID	Sample Matrix (Jet-A/JP-8/JP-5/other)	Type of Sample	Sample Location (where sample was taken from in the system)	Base Name	Type Filtration prior to sample
AP-032	JP-8	AJ	Kovatch R-11 97L-069, Tank Sump (12 Dec 00),	Grand Forks AFB	Facet Absorbent Media, model FGI-633SB
AP-044	N/A	AJ	Kovatch R-11, 97L039 refueling unit, (15 Nov 00)	McConnell AFB	Facet Absorbent Media, model FGI-633SB, with Velcon Separators, Part Nr SO-630C
AP-045	N/A	AJ	Kovatch R-11 (no other data unavailable)	McConnell AFB	All R-11s are Kovatch Models (w/Facet Absorbant Elements)
AP-055	N/A	AJ	Oshkosh R-11, 2/12/01 (Found during change water absorb cart.	Delaware ANG	R11 Oshkosh with Facet Absorbant Elements Lot # 98116, Model #CNG440.
AP-056	N/A	AJ	Kovatch R-11 98L0024 Filter housing	Beale AFB, ACC	Kovatch R-11s w/Facet Absorbant Elements (GNG440) since Aug 00
AP-070	N/A	AJ	Oshkosh R-11, 91L-102 filter sump, 12-7-00	Travis AFB, AMC	Water Absorption Media, no info on manufacturer
AP-108	JP-8	AJ	Oshkosh R-11, 91L355, 62°F	Lajes Field, AMC	Water Absorption Media, no info on manufacturer
AP-110	JP-8	AJ	Oshkosh R-11, 91L356, 65°F	Lajes Field, AMC	Water Absorption Media, no info on manufacturer
AP-006	JP-8	AJ	Consolidated refueling units (all Kovatch R-11s)	Maxwell AFB	Facet Absorbent Media model FGI-633-SB, Lot #99104, with Velcon separator model #168FS-Z201, part # 1-63387TB
AP-043	N/A	AJ	Tank water bottom, sample #7 (from product recovery system for Tank #2)	McConnell AFB	No Receipt Filtration

Sample ID	Sample Matrix (Jet-A/JP-8/JP-5/other)	Type of Sample	Sample Location (where sample was taken from in the system)	Base Name	Type Filtration prior to sample
AP-060	JP-8	AJ	Oshkosh R-11, 89L-945 sump, 2-5-01, 68°F	Eglin AFB	Facet Absorbent Media
AP-067	N/A	AJ	Refueling unit filter separator sump, 2-23-01, 9:15am, 36°F, FSII +.25	McGuire AFB	Facet Absorbent Media
AP-080	JP-8	AJ	Oshkosh R-11, 91L69, filter sump, 2/27/01	Edwards AFB	Facet Absorbent Media
AP-081	JP-8	AJ	Oshkosh R-11, 91L69, filter sump, 3/7/01	Edwards AFB	Facet Absorbent Media
AP-082	JP-8	AJ	Kovatch R-11, 96L144, 3-20-01, bottom of filter (element change)	Edwards AFB	Facet Absorbent Media
AP-088	N/A	AJ	Kovatch R-11, 96L186, 1-11-01	Misawa AB	Facet Absorbent Media
AP-096	JP-8	AJ	Oshkosh R-11, 91L69, F/S sump, 2/27/01	Edwards AFB	Facet Absorbent Media
AP-098	JP-8	AJ	Kovatch R-11, 96L144, 3-13-01, 50°F	Edwards AFB	Facet Absorbent Media

Eighteen of the 93 samples submitted were identified as having medium or high viscosity. It is noteworthy that 17 of 18 samples were from filter vessels on R-11 refuelers equipped with water absorption media filters. The fact that the absorption cartridges identified were manufactured by Facet may be less significant, since most of the elements in the field are manufactured by Facet and we have received reports of similar high viscosity AJ finds with Velcon elements.

Use of water absorption media cartridges as a replacement for standard filter coalescer elements began at the Air National Guard locations initially involved in the JP-8+100 program during 1995 and 1996.[1] Coalescer elements in these vehicles were replaced by water absorption cartridges to guard against potential disarming of the coalescers by surface active agents (surfactants) contained in the Betz-Dearborn SpecAid (+100)

[1] For the sake of objectivity, the reader should be aware that C4e and two of its principal investigators working this AJ investigation were involved in the development of the Air Force JP-8+100 implementation plan and the initial installation of the water absorption media elements and +100 additive injection equipment. C4e also provided training of personnel at Air National Guard installations involved in the JP-8+100 program during 1996-1998 time frame, and performed assessments of the impact of the use of JP-8+100 on aircraft maintenance by comparing pre-JP-8+100 maintenance data with requirements following the conversion to JP-8+100.

additive used to increase the thermal stability of JP-8. Due to concerns that JP-8+100 might be defueled from transient aircraft at virtually any Air Force location, the Air Force required the replacement of standard coalsecer elements throughout its R-11 refueling vehicle fleet. This replacement effort began during the summer of 1999 and continued through 2000. The increase in reported AJ findings since 1999 is largely associated with the use of the water absorption cartridges. Most, but not all of the installations visited in connection with the AJ investigation, had completed the replacement of coalescer elements with water absorption elements. (Westover ARB, the one exception, had received water absorption media cartridges but had not yet installed them.)

The time frames that water absorption cartridges were installed at the bases visited are shown below.

Installation	Date Water Absorption Media Filters were Installed
Hill AFB	Sept – Oct 1999
Bangor ANGB	November 1999
Barksdale AFB	February 2000
Dover AFB	July 2000
Beale AFB	August 2000
Bradley ANGB	Fall 2000
Fairchild AFB	December 2000
Pease ANGB	June-October 2000
Niagara ANGB	September 2000
Grand Forks AFB	June 1999
McChord AFB	June-October 2000
McConnell AFB	June-July 2000

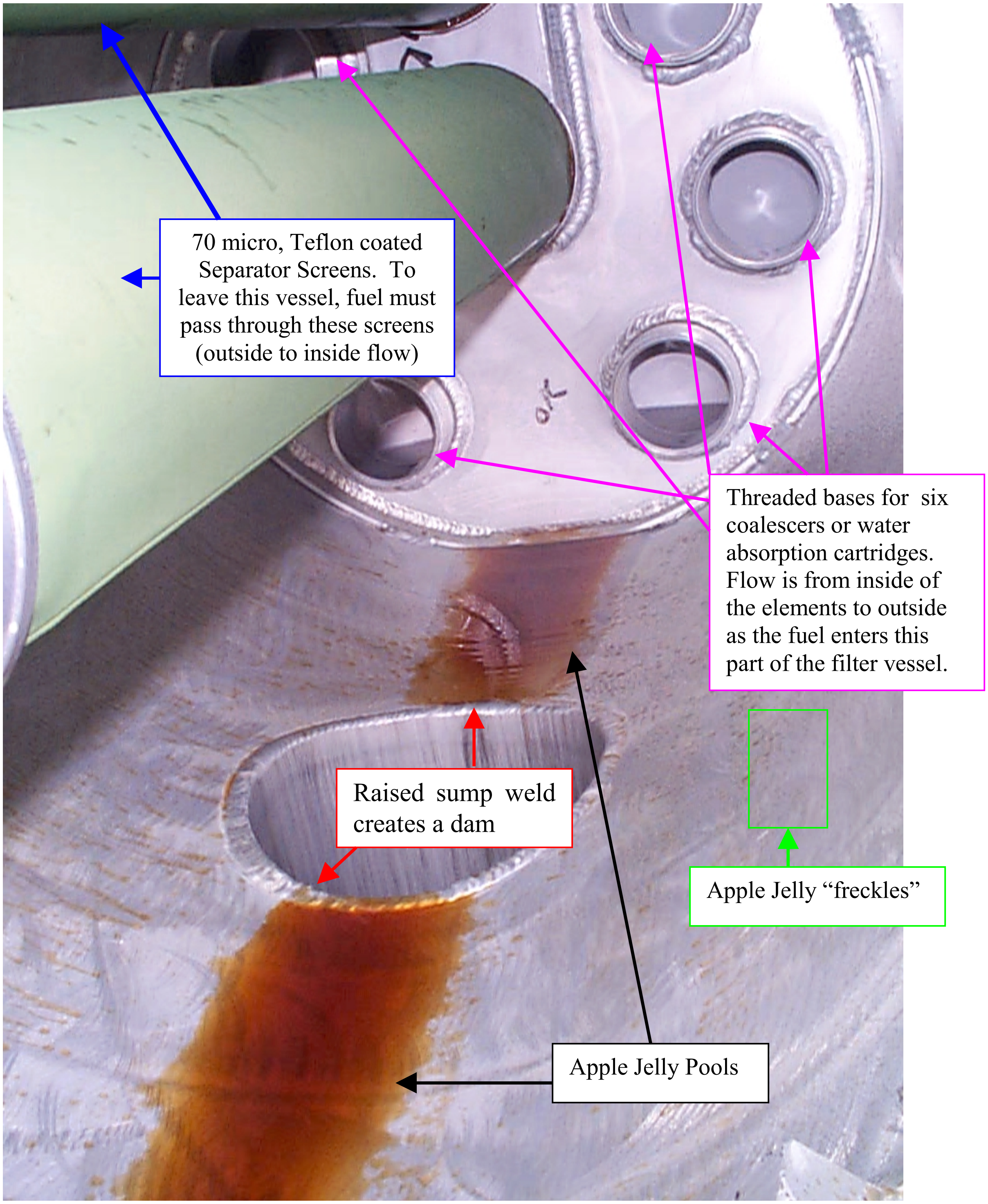
Otis ANG Base – Special case – was using +100 then stopped facility maintenance

Quonset ANGB – Special case – was on +100 then stopped

In discussions with Rick Waite, Velcon Filters, Inc., we learned the API/IP-1583 specifications "do not cover the operation and performance of this type of equipment in fuels containing Fuel System Icing Inhibitor (FSII)" because of the deleterious effect of FSII on water absorbing cartridges. (The quoted statement is contained in the 1.1 SCOPE section of API/IP-1583.) In commercial applications, there is little or no use of water absorption media cartridges with fuel that is pre-mixed with FSII. Most of the Jet-A fuel in the U.S. is not pre-mixed with FSII. At commercial airports FSII is generally injected downstream of the final filter. However, JP-5 and JP-8 are pre-treated with the FSII. While there have been numerous reports of AJ and excess water downstream of some Air Force water absorption cartridges, to our knowledge the Navy has not reported similar experiences. There are two key differences between Air Force and Navy processes which may explain why the Navy has not had similar AJ experiences. First, the Navy uses filter-coalescers to remove most free-water/FSII mixtures immediately prior to the separate water absorption vessels. In effect, the Navy refueling vehicles use a three-stage process (coalescence, separation, and *then* an absorption monitor) while Air Force R-11 refuelers use only a two-step process (absorption and separation). In short, if a water slug containing 20% or more FSII reaches a Navy refueler, most of the FSII/water is probably removed in the F/S vessel through coalescence and separation. However, in the USAF refuelers, a water slug with more than 20% FSII goes directly to--and may go through--the water absorption cartridges. The second difference between the Air Force and Navy experience is that the Air Force uses SDA (Stadis 450) and the Navy does not. This point is addressed in detail later in this paper.

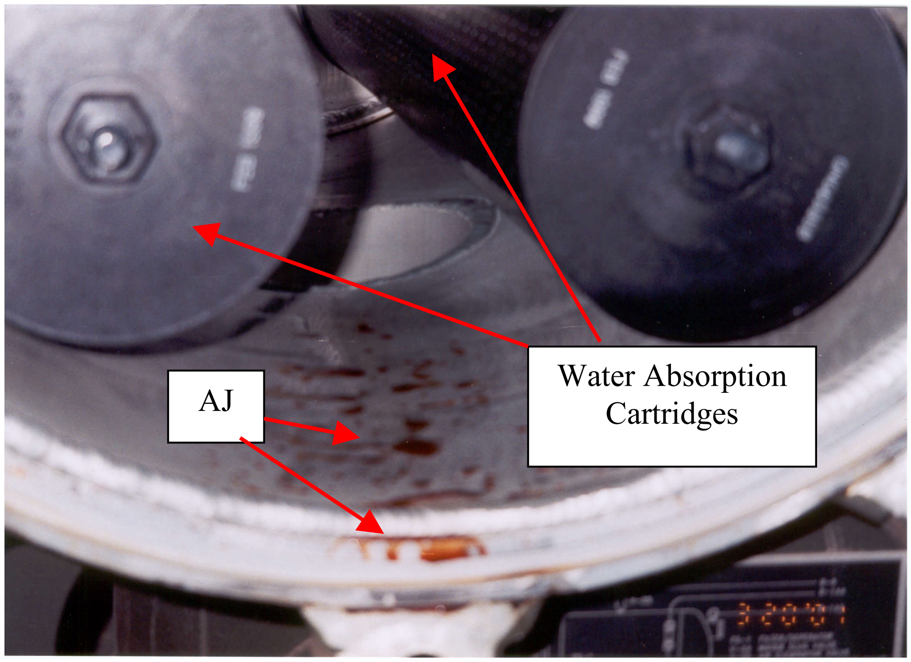
Kovatch R-11s are equipped with API/IP 1581 qualified filter vessels, manufactured by Beta Systems. These filter vessels were originally equipped with six coalescer elements and two separator screens. As a result of the JP-8+100 program, water absorption cartridges have replaced the six-coalescer elements but the two Teflon coated, stainless steel separator screens remain in the vessel. Separator screens are designed to keep water that has been coalesced into large droplets from passing through the separator screen. The water droplets, being heavier than fuel, settle to the bottom of the vessel and drain into the sump where the material can be removed through the sump drain. The separator screen on the API filter vessel used on the Kovatch R-11, if functioning properly, prevent any fuel from leaving the vessel without passing through the separator screen. In the Kovatch R-11, a considerable amount of AJ particles are trapped in the vessels by an interior weld, which attaches the sump to the vessel. This weld creates a dam that prevents a significant amount of the free-water/FSII or AJ mixtures from draining into the sump. **We recommend that the design criteria for filter vessels be changed to specifically prohibit the use of an interior weld that could serve as a dam to collect and prevent free-water/FSII or AJ from reaching the vessel sump.**

There is evidence that some AJ may pass through the Kovatch separator screens. During the AJ investigation team visit to Edwards AFB, the Quality Control Specialist observed orange specs on a single element monitor filter membrane that had the appearance of AJ when examined under a microscope. The sample had been drawn downstream of the filter vessel of Kovatch R-11 # 96L-144.



Filter Separator Vessel on Kovatch R-11
(Photo taken at Barksdale AFB, LA)

There is another type of separator made of a white synthetic material that may be more effective than the Teflon coated separators currently in use in the Kovatch R-11 F/S vessels. The new, disposable, white synthetic separators have a 300x300 mesh (rather than 200X200) and smaller pore size of 40 microns, verses 70 microns for the screens shown above. Also, the Teflon coated, stainless steel separators are easily damaged (small dents result in water leaks) and frequently leak at the seams. For these reasons, we **recommend testing of the disposable white synthetic separator as a potential improvement over the separator currently in use on the Kovatch R-11.**

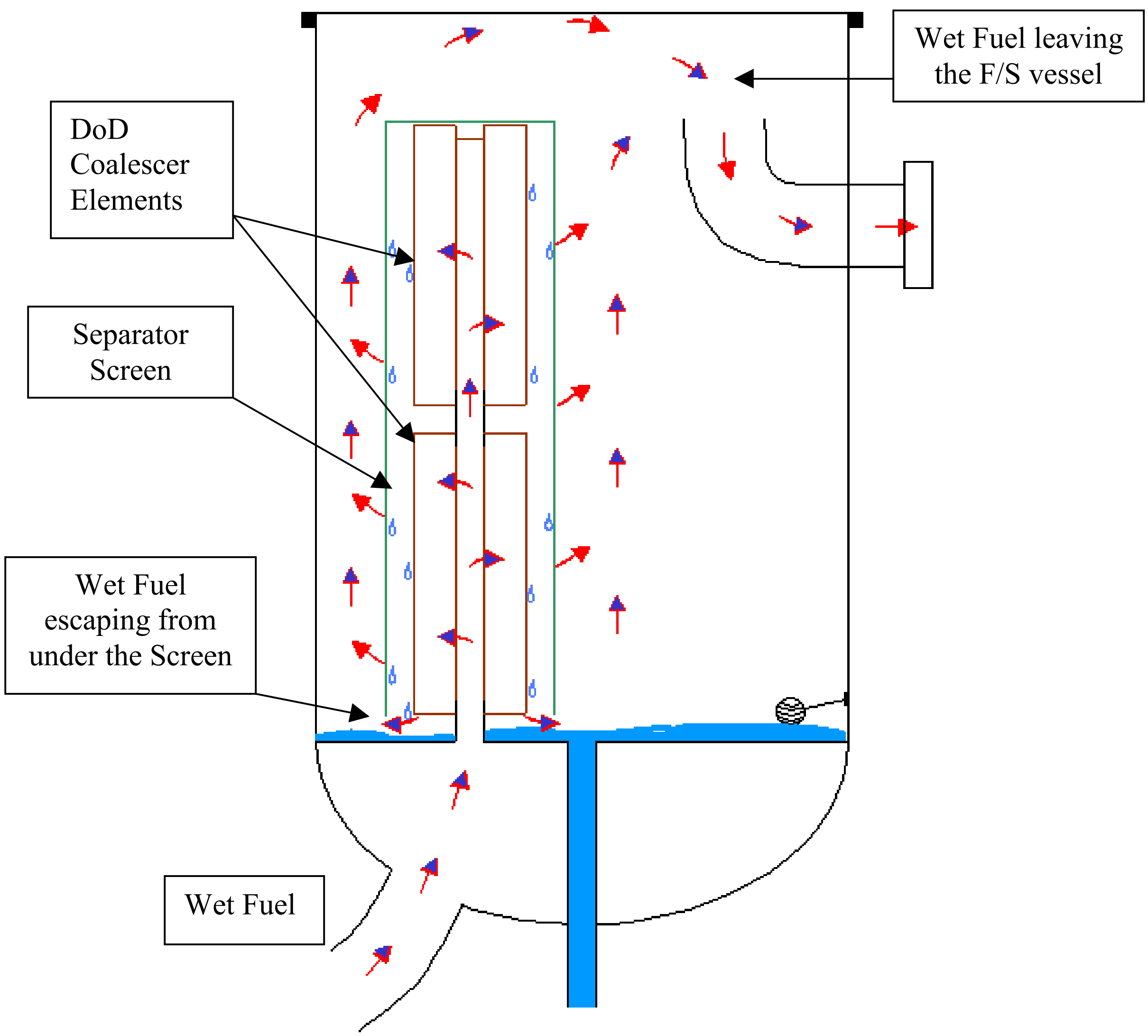


Filter Separator Vessel on Kovatch R-11
(Photo taken at Edwards AFB, CA)

While the smaller pore size might prevent or help reduce the amount of AJ that passes downstream of the Kovatch R-11 filter vessel, use of this tighter separator in the Oshkosh R-11 would likely increase the amount of AJ that could find its way to aircraft. **We do not recommend the new separator for use in the Oshkosh R-11.**

The Oshkosh R-11s were built prior to 1992, while Kovatch R-11 production began in 1996. The Oshkosh R-11 filter vessels were built using a standard DoD design that has since been abandoned in favor of API/IP Standard 1581. The DoD vessel design was used for both vehicle and fixed facility F/S vessels. This design was adequate when used with JP-4; however, it is inadequate for use with JP-8. Most—but not all—of the fixed facility DoD design F/S vessels have been replaced or modified, as describe below; however, because of a slight design difference the same type modification has not been considered practical for the Oshkosh R-11 filter vessel.

In the Oshkosh DoD filter vessel, the separator screens slip over each of the fifteen-stacked sets (two per set) of coalescer elements. The separators are open to allow the water droplets to leave the separator and settle to the bottom of the filter vessel where it can be drained. As is the case with DoD standard vessels used in fixed facilities, wet fuel can escape separation by passing under the separator screen. Because of the high density of JP-8, wet-fuel is more likely to follow this escape route as it is the path of least resistance. The location of the discharge line, which exits out of the side of the vessel, complicates modifications that would upgrade the Oshkosh vessels to meet API standards. In the representation below, the red and blue arrows indicate wet-fuel while the red arrows indicate dry-fuel. The point of this illustration it to show that wet-fuel escapes below the separator screen allowing wet-fuel to be issued to aircraft.

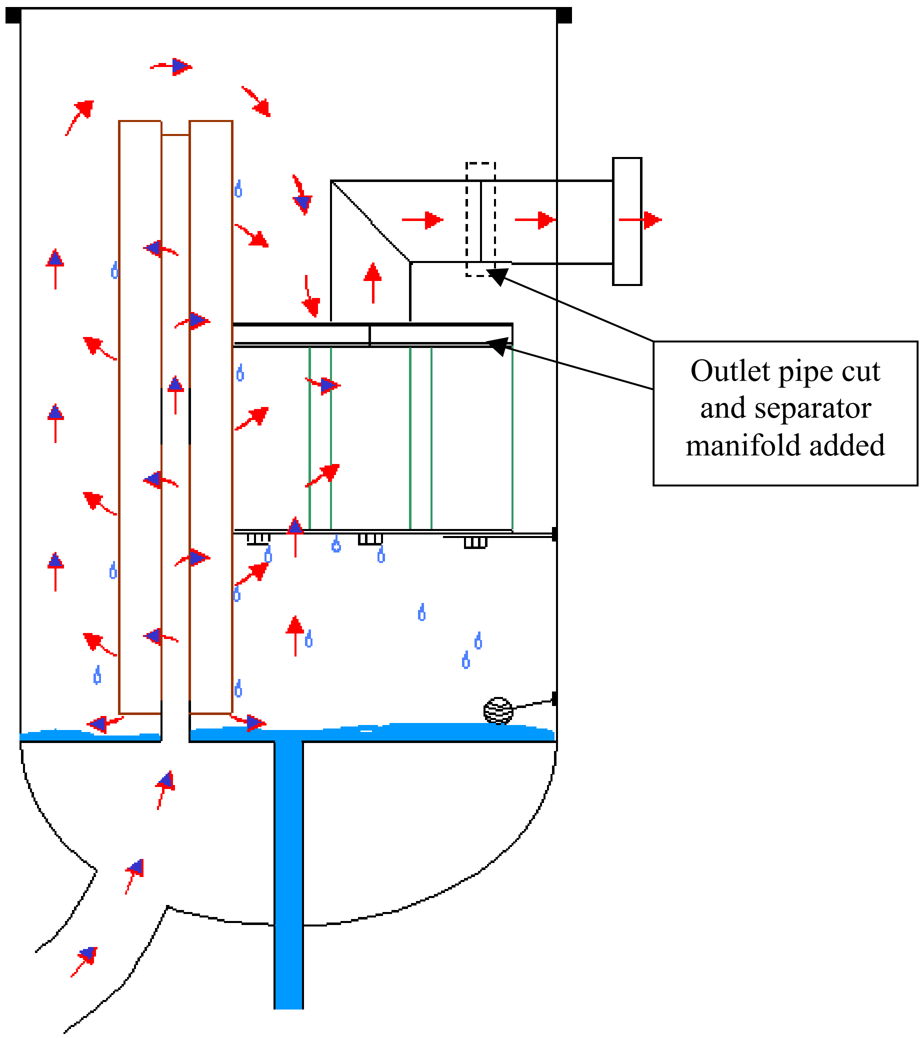


The rationale for considering the separator screens as optional when water absorption cartridges are used is that the cartridges would absorb the free-water in the fuel, thus there should be no free-water to be separated after the fuel passed through the absorption cartridges. A modification kit made by Gammon Technical Products, Inc., is available to permit use of the water absorption cartridges without the separator screens. This modification holds the coalescer cartridges in place without the screens. Since we now know that AJ, and probably water with high concentrations of FSII, escapes through the water absorption elements, the use of a separator screen appears to be important even with coalescer cartridges. However, even with the separator screens installed in the existing separators on the Oshkosh R-11 refuelers, we believe a considerable amount of wet JP-8 will escape under the separator screen.

This DOD vessel design was satisfactory for use with JP-4. Soon after the initial delivery of the Oshkosh R-11s, the Air Force Fuels Technical Assistance Team tested sixteen R-11s by injecting water upstream of the filter and conducting AEL water measurements down stream of the vessel. All vessels tested passed with JP-4--the product the Oshkosh R-11s were designed to support. However, knowing that the Air Force was considering converting to a Kerosene-based fuel, one Oshkosh R-11 was tested with JP-5 during this testing effort and it failed. Because of the higher density of JP-5 (and JP-8), the fuel follows the path of least resistance and a significant portion passes through the opening at the bottom of the separator carrying water or AJ with it. Tighter separator screens in the Oshkosh DoD vessels are likely to increase the amount of bypass.

However, Gammon Technical Products has developed a modification kit that converts the similar DoD vessels on R-5 and R-9 refuelers to meet the API/IP Standard 1581, Edition 3. Commercial refueling companies that purchased the old R-5s and R-9s from salvage for use at commercial airports use these modification kits to bring the refuelers up to commercial standards. We contacted Gammon Technical Products and learned that they have not been asked to design a similar kit for the Oshkosh R-11s but believe they could do so. A copy of the correspondence received from Gammon Technical Services is provided as Appendix F. A conceptual representation of the modification of such vessels is shown below.

Proposed Modification of Oshkosh R-11 F/S Vessels to meeting API 1581



In this modification, the outlet line is cut to permit installation of a manifold to hold the separator screens installed in such a way as to preclude bypass.

The poor reliability of the NSN 4330-00-983-0998 coalescer elements used in the DoD vessels is a related problem that could be resolved by this modification. Testing of new elements by both the Air Force and Navy have shown a high likelihood of failure, regardless of the manufacturer. We recommend that all vessels using the NSN 4330-00-983-0998 elements be modified to comply with API Standard 1581.

3.5 When Do Water Absorption Cartridges Become Unreliable?

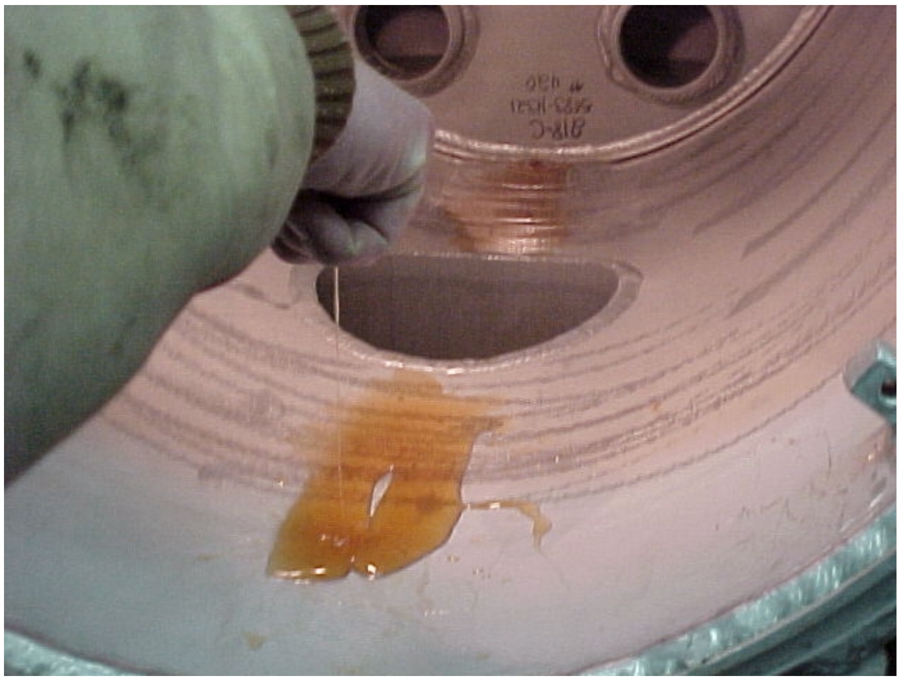
Velcon Filters representatives, maintain that absorption media cartridges when used with fuel containing FSII, should be changed when the differential reaches 15-psi, rather than the 22-psi limit currently followed by the Air Force. **We concur with this recommendation.** Furthermore, if in fact the materials captured by the water absorption media attacks that media causing it to dissolve and drain from the cartridges when temperatures rise, then differential pressure becomes highly suspect as a measure of performance for these elements. Since most of the water absorption elements are changed based upon a differential pressure criteria, rather than time in service, other alternatives should be considered. Several alternatives are proposed below:

- The use of API Edition 3 or API Edition 4 elements should be considered in lieu of the water absorption elements on R-11 refuelers. Velcon personnel maintain that particulate content of the API test protocol is unreasonably high and they believe the API Edition 3 filter coalescer elements would be effective when handling JP-8+100 when particulate contaminants are at a level commonly encountered in Air Force fuel systems. We recommend that this contention be tested and considered as a possible alternative to use of the water absorption media elements. One point of CAUTION: because of the cleansing action of the +100 additive, we would caution against the use of the Edition 3 element if the +100 additive is injected into the storage or hydrant system tanks. Most bases using the +100 additive inject downstream of the fillstand filter.
- Another alternative would be to inject the +100 additive downstream of the filter vessel on the R-11s.
- Whether the choice is to continue use of the water absorption media cartridges or to use API coalescers, and regardless of the point of +100 additive injection, we recommend the Oshkosh R-11 vessels be modified to provide a separator stage that complies with API Standard 1581.
- Another option would be to continue use of the water absorption cartridge but inject FSII downstream of the filter vessel on the R-11 refuelers.

We recommend that DESC and the military services perform or commission a study to determine the best course of action regarding filtration used on JP-5/8 refueling equipment and additive injection points.

3.6 Possible Role of Stadis 450 in AJ Formation

The thick, viscous AJ found in the R-11 sumps has caused alarm and spread the name "Apple Jelly" widely throughout the Air Force Fuels Management community. Consequently, the term "Apple Jelly" has been indiscriminately applied to any discolored mixture of free-water/FSII mixture drained from any Air Force tank or filter vessel sump.

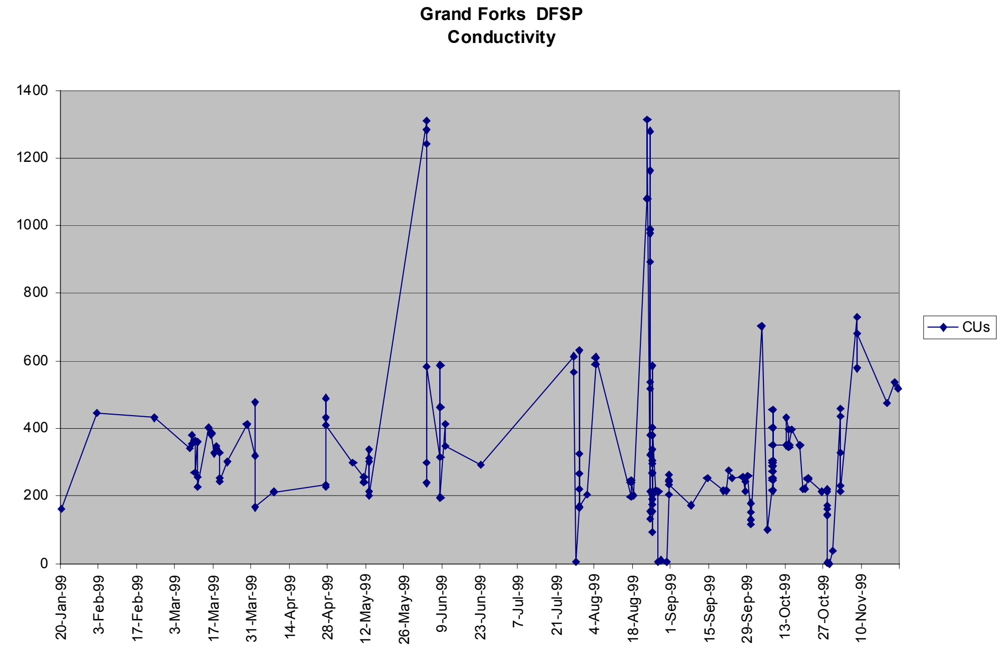


Filter Separator Vessel on Kovatch R-11
(Photo taken at Youngstown ANGB, OH)

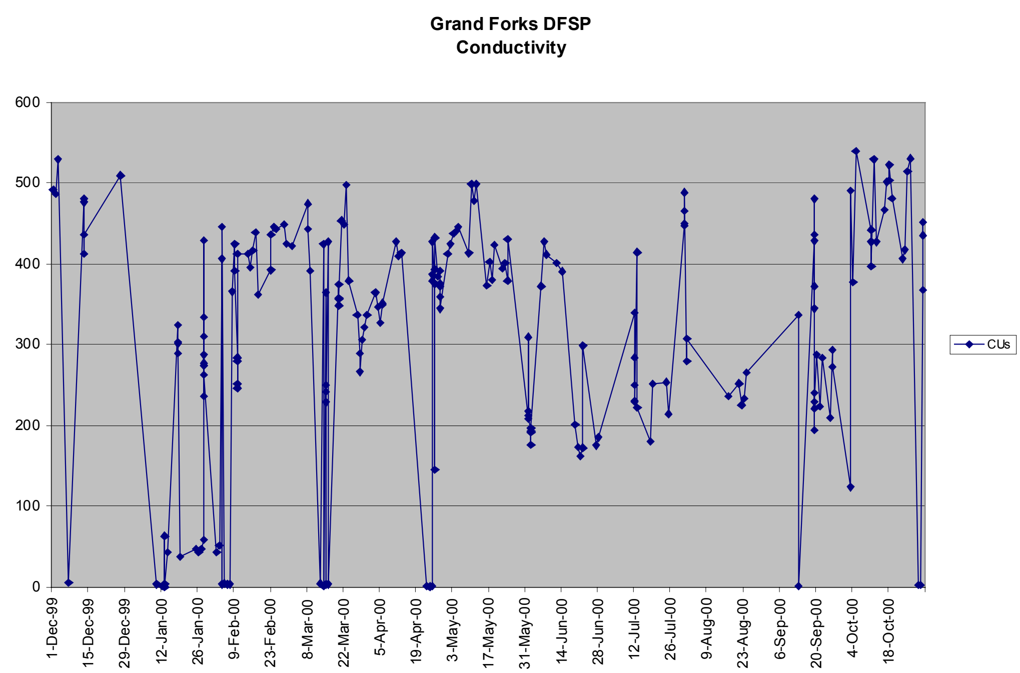
A significant amount of materials drained from tanks, receipt F/S vessels, and transfer F/S vessels is the normal mixture of free-water/FSII mixtures that settle or is coalesced and separated out of JP-8 following transfer or a marked drop in temperature. Water/FSII mixtures are heavier and somewhat more viscous than JP-8 and are quickly labeled "Apple Jelly." However, it is apparent that something else is happening in the water absorption cartridges that change the free-water/FSII mixtures resulting in a thickening process that yields the highly viscous materials seen in the R-11 filter vessels.

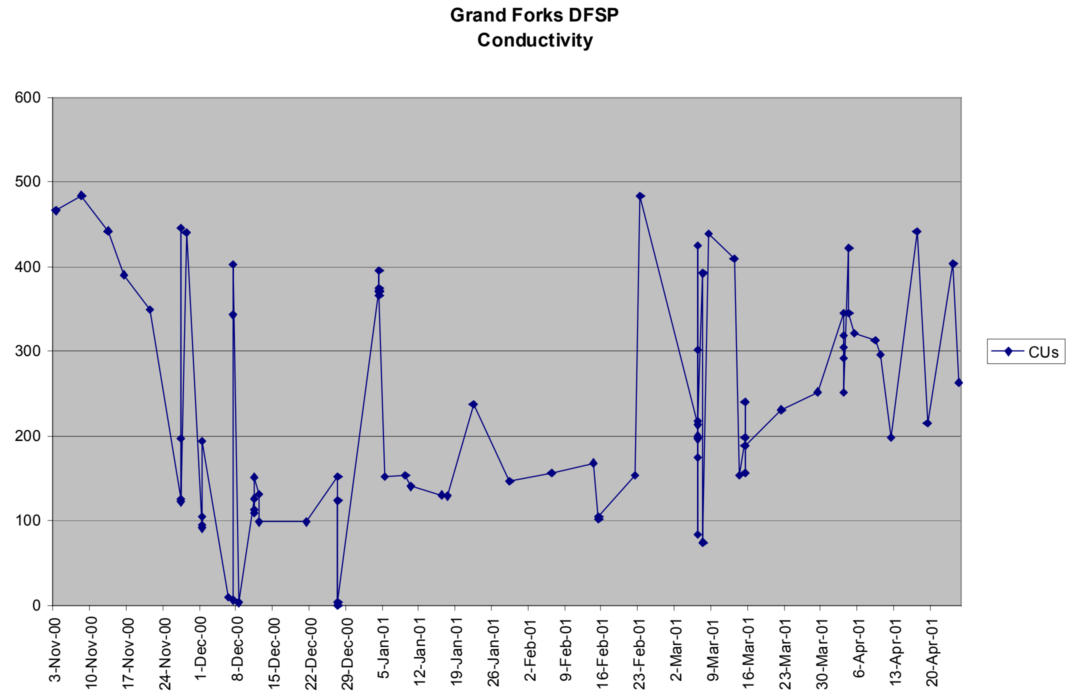
Unlike the coalescing elements, the role of the water absorption elements is to capture and hold water. The material used in these cartridges is much like the material used in prefabricated baby diapers (such as Pampers). As the water absorption elements capture the free-water/FSII mixture, the nature of the filter changes as it accumulates increasing amounts of the water/FSII, which is capable of extracting polar compounds from the fuel as it passed through the elements. In effect, the absorption cartridges become "more efficient filters" and "less discriminate." These elements were designed to extract water from fuel but, as they accumulate water/FSII mixtures, they become less discriminate and also extract other materials from the fuel as it passes though the cartridges. The static dissipater additive, which is high in polar compounds, is suspected as a contributing factor in the development of high viscosity AJ. Some components of SDA and other polar compounds in the fuel may be extracted from the fuel as it passes though FSII/water saturated absorption media. Over time, this process changes the nature of the materials trapped in the absorption cartridges. Eventually, these chemicals may begin to dissolve the water absorptive media within the elements, allowing it to escape from the cartridge, along with the water, FSII, and polar compounds. Since the absorptive materials in the cartridges contains sodium agar this could account for the high sodium content of the most viscous AJ samples. Preliminary findings by SwRI indicate AJ may get its color bodies from Stadis 450. FSII and water are both clear prior to and after mixing, while SDA has a dark brown caramel color.

Stadis 450 may also play a role in the color and viscosity of free-water/FSII mixtures drained from tanks and filter coalescer vessels. This may account for differences in the viscosities of materials found in these locations. In tank truck deliveries where multiple compartments are in use, T.O. 42B-1-1 permits the addition of Stadis 450 through one of the dome hatches into a single compartment in a sufficient quantity for the entire cargo. Stadis 450 blends more readily with JP-8 than does FSII. However, when fuel conductivity at a base becomes too low, extra Stadis 450 may be added to help bring up the conductivity level of product in storage on base. We are unaware of any work to assess the impact of high concentrations of Stadis 450 on receipt filters. It is possible, in high concentration, and particularly in fuel with a high content of emulsified water and FSII, that a significant portion of the Stadis 450 may be coalesced out of the fuel along with the free-water and FSII. The procurement specification for JP-8 conductivity established a minimum level of 150 CUs and a maximum level of 450 CUs. Because the conductivity of Stadis 450 is temperature sensitive, the use limit allows a wider conductivity range of 50 CUs to a maximum of 700 CUs. However, at some locations the conductivity level of fuel varies erratically exceeding both the minimum and maximum use limits. The charts below plot the conductivity test results at DFSP Grand Forks over the period from January 1999 through April 2001 and show dramatic swings in the test results ranging from 0 to 1,300 CUs.



Test results during 1999 (above) shows that fuel conductivity frequently exceeded both the minimum and maximum use limits, the graph for the year 2000 (see below) show improvement in controlling the upper end of the conductivity limits but the results are still very erratic, and results below the lower use limit were frequently experienced. Results during the first four months of 2001 show significant progress in controlling fuel conductivity levels.



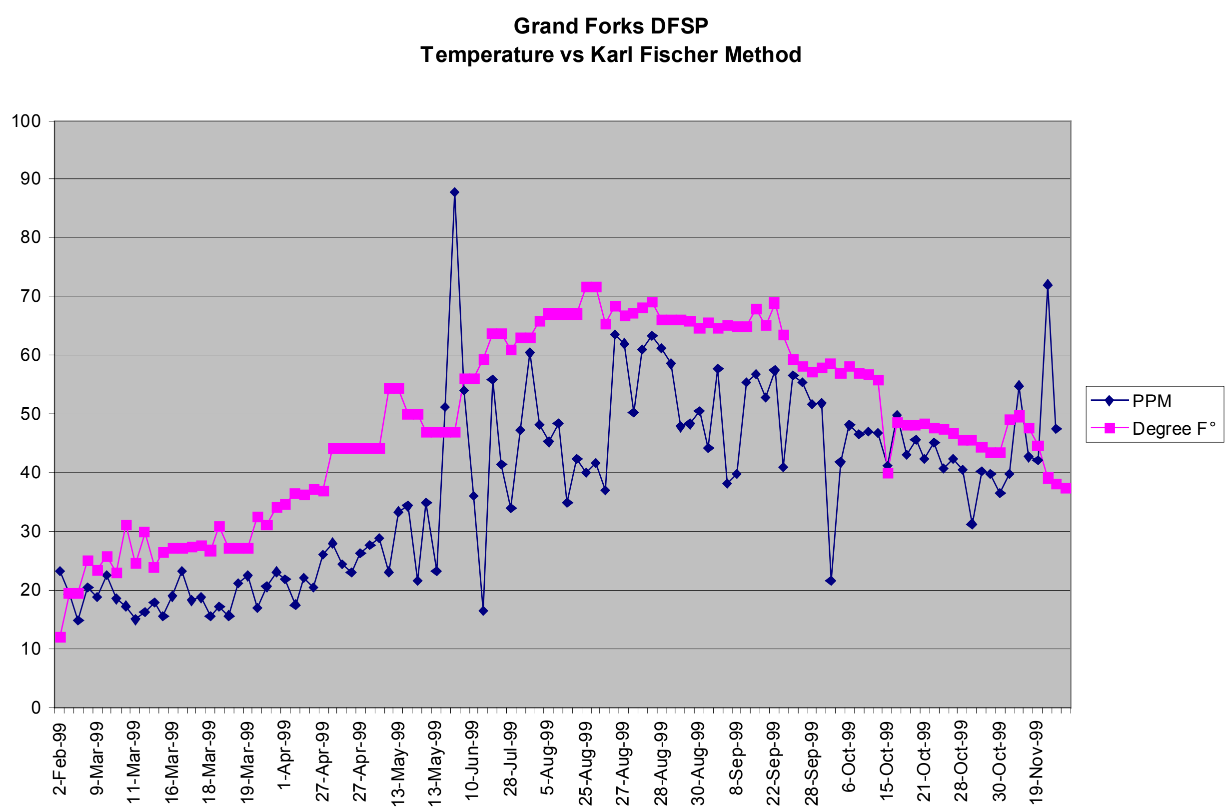


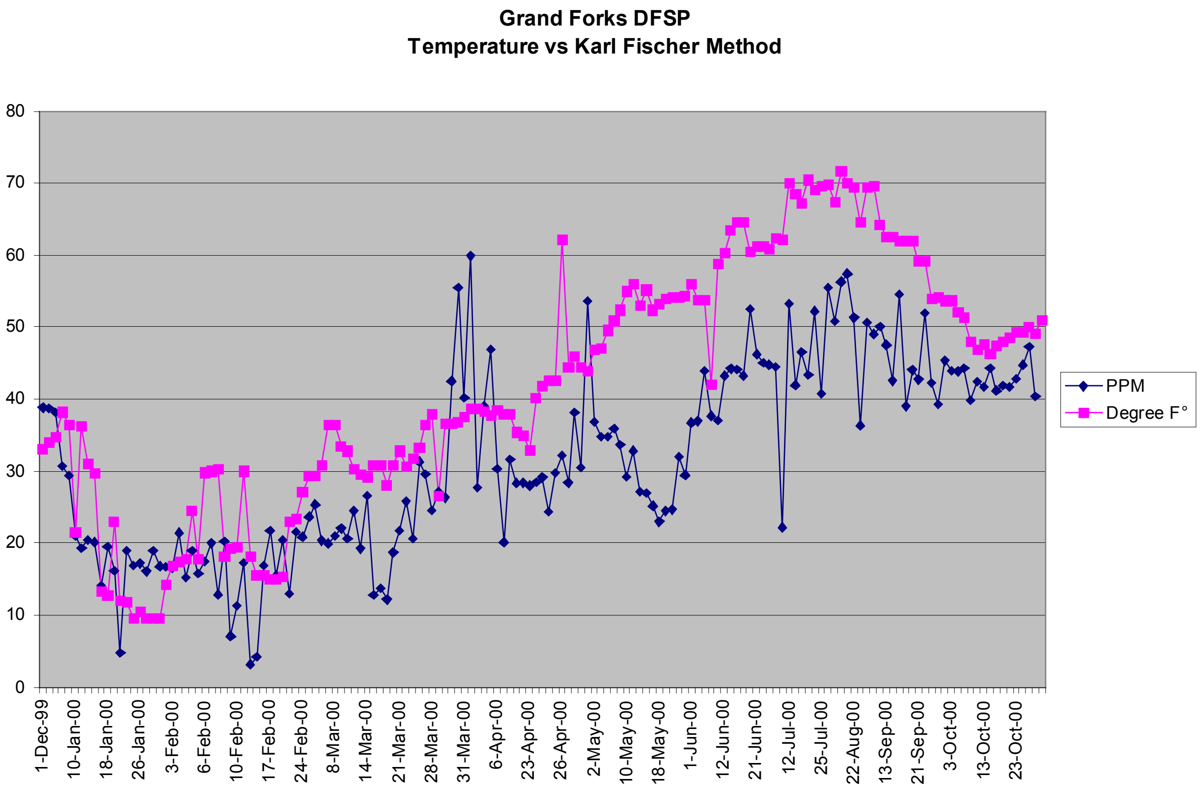
The reported incidents of AJ findings in receipt filters correspond closely with temperature drops during the transition from fall to winter. Those same temperature drops reduce the fuel conductivity levels generating a requirement of an increased dose of Stadis 450. Increased SDA dosages would hit the receipt F/S vessels at the same time the dissolved water is being released from the cooling fuel. The combination of increased SDA dosage and the increased amount of free-water/FSII mixtures being removed by the receipt F/S vessels may account for the dark color of the free-water/FSII mixtures drained from receipt and transfer F/S vessel and tank sumps.

At Fairchild AFB, we measured the conductivity of a sample, drained from a storage tank sump. Fuel from the sample was separated from the free-water/FSII (BS&W) and tested separately. The fuel had a conductivity level of 3,000+ while the free-water/FSII reading exceeded 4,000 CUs.

3.7 The Impact of Temperature Changes on AJ Formation

One of the puzzling issues associated with the AJ phenomena is that it is associated with a marked change in temperatures. Reports of AJ from the field are associated with significant temperature decreases, as well as significant temperature increases. It is easy to understand why a significant temperature drop would increase the amount of free-water/FSII in fuel systems, because the lower temperatures reduces the ability of the fuel to hold free and dissolved water. As temperatures drop and dissolved water is released as free-water, the newly freed water absorbs FSII from the fuel and is coalesced out of the fuel or settles to the bottom of the tanks. The correlation between fuel temperature and the ability of the fuel to hold water is clearly demonstrated in the two graphs below. These graphs contrast the Karl Fisher test method result for total water (in parts per million (ppm)) in the fuel at DFSP Grand Forks against the fuel temperature at the time the sample was taken.





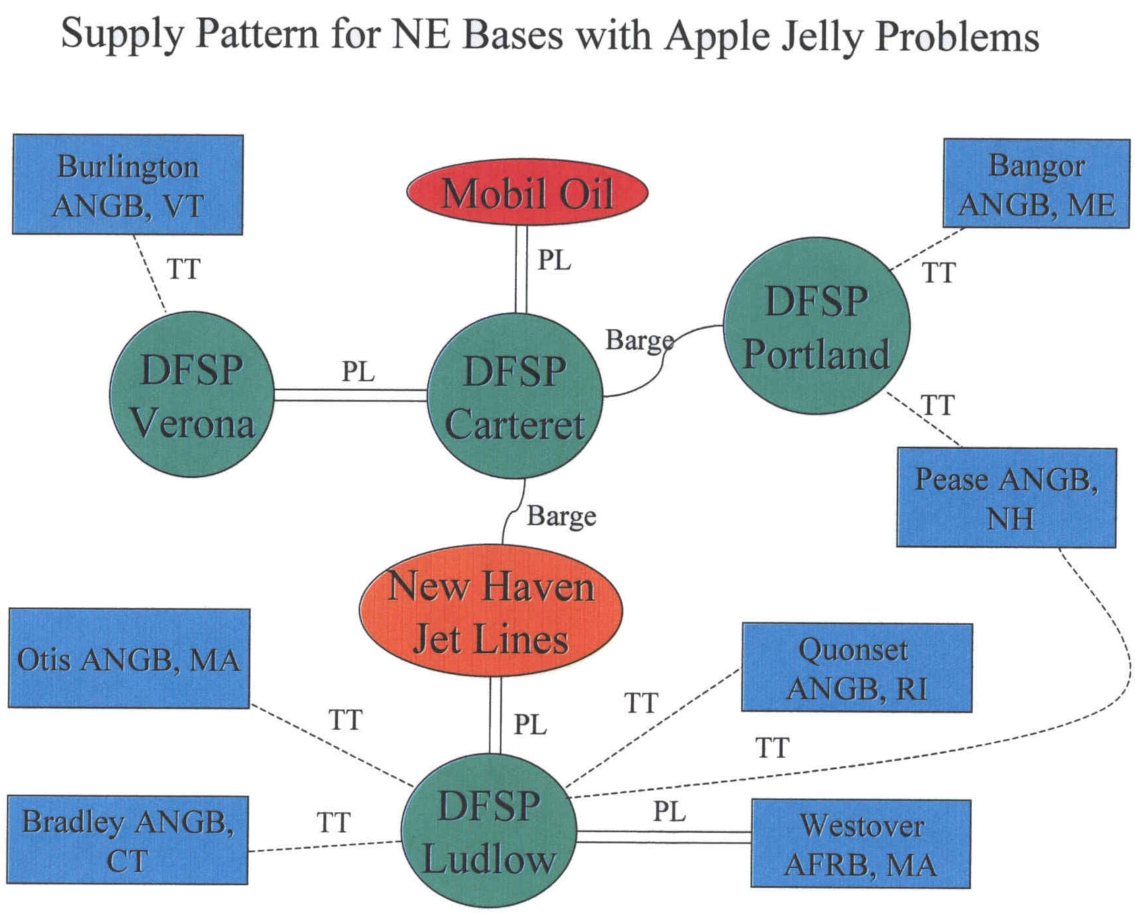
But what causes AJ to increase when temperatures rise? We know that when temperatures are below the freezing point of water, fuel requires less FSII because there is less exposure to water that removes FSII from the fuel. DFSP Ludlow, for example, does not add additional FSII to fuel during the winter months. However, as ambient temperatures rise above 32°F, the amount of water in the form of rain able to enter floating-roof tanks or tanks with geodesic domes increases. The increased amount of water in the fuel requires an increase in the amount of FSII in order to maintain the specification requirements.

There are, however, another phenomena that appear to occur as temperatures rise: free-water/FSII and the other compounds extracted from fuel as it passes though the water absorption cartridges are released as temperatures rise. We believe this is because of the direct correlation between temperature and viscosity of these materials. At Grand Forks AFB, Fuels Managers found that after parking R-11 refueling vehicles inside heated stalls, significant amounts of AJ would be drained from the filter sumps the following morning. When the same vehicles were parked outside the next night and a group of different vehicles were place in the heated stalls, no AJ was found in those R-11 parked outside, but AJ was be drained from the sumps of the other R-11s parked in the heated stalls. Furthermore, filter vessel differential pressures decreased on vehicles parked inside the heated stalls. Fuels Managers at Grand Forks have taken advantage of this phenomena by intentionally parking R-11s that are approaching the differential pressure (DP) change criteria inside the heated stalls to lower the R-11 filter vessel DP in order to "extend" the life of the water absorption element. If the free-water/FSII trap in the water absorption media is extracting other materials from the fuel and is attacking the absorptive media itself, as we believe may be the case, the practice of warming the filter vessels to lower the DP probably does nothing to "extend the life" of the cartridges. In fact, we are concerned that the drop in differential pressure, if caused by a loss of free-water/FSII **and absorptive materials** from the cartridges, would invalidate the usefulness of differential pressure as a means of detecting when the elements have become ineffective in protecting aircraft from fuel contamination. Consequently, **we recommend against the practice of warming filter vessels as a means of extending their useful life.**

Increased temperature also appears to play a role in AJ production with filter vessels containing coalescing elements. In a heated pumphouse at Bangor ANGB, ME, the hydrant system filter coalescer vessel that sits directly below the heater produces the most AJ. At Otis ANGB and Bradley ANGB system repairs that precluded the use of heated pumphouses appeared to reduce the amount of AJ drained from filter vessels. Grand Forks AFB personnel intentionally turned the heat off in one of their pumphouses to determine the impact and concluded that when F/S vessels were not heated, AJ was not found in the vessel sumps. The only feasible explanation for this phenomenon that we have identified is that at cold temperatures the filter coalescing media may retain some of the free-water FSII mixture that is released from the filter coalescer material as the F/S vessel is warmed. Because of the sticky nature of this substance, we suspect that it may cling to outer coalsecer socks at cold temperatures and be released as the vessel warms enough to lower the viscosity of the AJ to the point it will flow.

3.8 SITE VISIT SUMMARIES

Rainwater entry into on-base tanks is a major factor in AJ formation at many locations. This problem is compounded by ineffective product recovery systems (sump drains) and the self-cleaning tank design that suck BS&W into the tank issue line. Further, the use of filter separators that were not designed to handle fuel with additives and the continue use of defective F/S vessels built to the old DoD standard all contribute the excessive water and AJ contaminates. This is best illustrated by a discussion of process and facilities at terminals and the supported bases where problems were identified. Within the Northeastern United States, DFSP Ludlow contributes to AJ problems at a number of installations. Conversely, other Northeastern DFSPs within the same logistics support system consistently supply clean dry fuel: these include Portland, New Haven, and Carteret. The chart below shows the fuel distribution pattern for bases in the Northeast.



3.8.1 DFSP Ludlow

Serious deficiencies in facilities at DFSP Ludlow are major contributing factors to high incidents of AJ occurring at a number of Air National Guard locations in the Northeastern

States. DFSP Ludlow receives fully additized JP-8 via pipeline shipments from DFSP New Haven, which receives its fuel via barge from DFSP Carteret. From DFSP New Haven, the fully additized JP-8 is moved through a Buckeye operated multi-product pipeline that also transports #2 fuel oil, gasoline, kerosene, and Jet A fuels. Pipeline time from New Haven is approximately 12 to 13 hours and moves at a rate of 2,000 bbls per hour. Pipeline drag reducer (PDR) is used in the pipeline that supplies Ludlow. The use of PDR normally starts in December to meet the increased demand for heating oils. PDR is injected at New Haven but "not within two hours before or two after a JP-8 or other aviation fuel shipment." When asked about the controls to insure against the accidental injection of PDR, a pipeline company representative reported that there had been one such incident, but Buckeye identified the error and cut the contaminated JP-8 product into a diesel tank.

DFSP Ludlow stores only JP-8. The JP-8 is not filtered on receipt. DFSP Ludlow has two dedicated storage tanks with 55,000-bbl capacities; however, the safe fill level is restricted to 41,000 bbls because of the small capacity of the tank dikes. The low product level results in increased surface area for water accumulations that leak past the floating-roof seals and into the JP-8 stored in the tanks. This storage system was originally built by the Air Force to support Westover AFB and was later sold to the Buckeye Pipeline Company. The steel, above ground, floating-roof tanks have flat bottoms and a fixed discharge (suction line) that is approximately one foot above the tank bottom. The bottom of Tank #2 is epoxy coated and Tank #1 is scheduled for cleaning, epoxy coating and installation of a cone roof. The terminal manager reported that they always maintain a one-inch water bottom in both tanks. **Approximately 5,000 gallons of water bottoms are removed from the two tanks 3 to 5 times a year**. The most water drained from the two tanks at any one time totaled 5,300 gallons. A vacuum truck is used to draw the water bottoms from the tank sumps. According to the terminal manager, the procedure involves draining the tank bottoms until the "black gunky stuff ends, and the product becomes milky." Water bottoms are dark amber. The all-level samples prior to receipt on the day of the visit (February 22, 2001) was clear and bright; however, the post receipt sample was cloudy.

Though SDA and FSII are injected at DFSP Carteret, DFSP Ludlow must re-inject the additives because exposure of the JP-8 to excessive water leaches out the FSII. Stadis 450 is added as necessary to increase the conductivity level as the product is pumped into the tanks. SDA is blended with JP-8 in a ratio of 1 to 9 and is stored in a 50-gallon tank. They attempt to achieve 200 CU reading. When bases request an increase in additive levels, the additional additive is often added directly into the delivery trucks through one of the domes on the top of the tank. FSII is injected in the issue line upstream from the pump by use of a Hammond's turbine injector. They attempt to achieve an FSII level of 0.12%. The FSII is stored in a steel tank that is not equipped with a drier. They were in the process of refilling the FSII tank, which was last filled during April of 2000. Drums of FSII are stored outside, on end rather than horizontal. The tops of the drums were covered with water because it had been raining. Additional FSII is rarely injected at DFSP Ludlow during the cold winter months. This is because of the minimal exposure to rainwater intrusion during period of freezing temperatures.

An American Bowser F/S vessel is installed in the issue line; however, this vessel has been modified for use of micronic filters only. Velcon 2 micron filter (F0629PLF1) elements are used (12 elements per bank of filters) on the issue line for trucks and the pipeline. The elimination of coalescer elements from this vessel many have been to reduce the cost of frequent replacement given the amount of free-water/FSII mixtures in the tanks. The truck fill rate is 900 gpm for a single truck and 1,000 gpm for two trucks. They pump JP-8 to Westover ANGB by pipeline at a rate of 15,000-bbl/hr.

Team members climbed both bulk tanks. Snow and ice had accumulated on the top of both floating-roofs. Removal of the snow and ice is hampered by the safe fill capacity that is restricted to 75 percent of the tank capacity—the top tank shell is too high to throw the snow over. The floating-roof on one tank appeared to list at approximately 5 degrees because of the uneven distribution of the snow and ice accumulation. This is an unsafe condition. Rainwater entry into the tank is facilitated by the limited fill capacity and the tilt of the roof, which interferes with the floating-roof seal. Because of the tilting position of the roof, we did not climb down onto the roof to examine the seal. The terminal manage/operator (only person assigned to the terminal) was on this roof attempting to shovel the snow/ice to the center of the roof to balance the weight. When descending the second tank, an open-ended 55-gallon drum of florescent "lime green" antifreeze was observed near the floating-roof drain. (If the floating-roof drain is leaking, this may have been the source of the "lime green" material drained from the receiving F/S sumps at Pease AFB. If rock salt or some other form of sodium is used to melt the snow and ice on the floating-roof, and the roof drains do leak, this could explain the high sodium content in AJ samples from Pease ANGB reported by the Air Force Research Laboratory. The terminal manager, who was very forthcoming in responding to all questions, denies the use of sodium to melt the snow. A more probable explanation was provided by DFSP Carteret where we learned that the Department of Transportation mandated the use of green dyed water to pressure test the Colonial Pipeline during December 2000, and some JP-5 and JP-8 receipts following those injections has a slight green tint.)

DFSP Ludlow routinely supplies six installations that were included in the onsite AJ investigations. These included Pease ANGB, Otis ANGB, Westover AFB, Bradley ANGB, Quonset Holland ANGB, and NAS Brunswick. All of these locations, with the exception of Quonset Holland ANGB and NAS Brunswick report periodically draining AJ-like material from their receipt F/S sumps and, less frequently, from issue F/S sumps.

3.8.2 Pease ANGB

JP-8 is delivered to Pease AFB by tank trucks from DFSP Ludlow and DFSP Portland. Pease Personnel reported that the JP-8 from DFSP Portland is always clear and bright, while JP-8 received from DFSP Ludlow is often cloudy. Some of the deliveries from DFSP Ludlow are so cloudy that one cannot see the bottom of the delivering tank truck. Pease personnel also reported that they "never" have a problem when receiving tank trucks from DFSP Portland. After receiving from DFSP Ludlow, dark contaminants are drained from receipt vessels, generally starting in late October and early November when fuel temperatures drop to 40°F or below. The materials become lighter in color as the winter progresses. Receipt filter vessels are inside a heated pump house and the elements changed at approximately 11-month intervals because of excessive differential pressure. Issue filters are changed every three years, and they report they have never drained AJ-like materials from the pump-house issue F/S vessels. All fixed facility F/S vessels are within a heated pump house. The receipt temperature during January ranges from a high of 33°F to a low of 28°F, with an average 30°F. During August, the temperatures range from a high of 85° F to a low of 65° F, with an average of 65°F to 70°F. The JP-8 is stored in two fixed-roof tanks with floating pans. One has a 12,500-bbl capacity, and the other has a 10,500-bbl capacity. The tanks are the self-cleaning design with the bottom sloped to the center with the suction line over the sump. The BS&W drain line is a three-inch line that empties into a 4,000-gallon product recovery tank. Reclaimed product is pumped through the F/S back into the bulk tank. Pease AFB has three R-11 refuelers, one Oshkosh and two Kovatch. They also have three HSV-12 hydrant servicing vehicles. An aggressive sump draining program and a newer designed product recovery system has enabled Pease AFB personnel to prevention the migration of AJ to the aircraft servicing vehicles and equipment. We believe the AJ problems at Pease AFB are primarily attributable to the problems identified at DFSP Ludlow for three reasons. First, the AJ is primarily drained from receipt F/S sumps. Second, problems are associated with deliveries from only one of two suppliers. Third, storage tanks at Pease all have fixed-roofs, which eliminates rainwater intrusion. Fourth, the product recovery system at Pease ANGB is newer and much better than most other sites visited.

3.8.3 Otis ANGB

AJ is routinely experienced at Otis ANGB from October through April and is primarily found in the receipt F/S sumps. Fuels personnel have been successful containing AJ to their receipt and pump house issue vessels since March of 1999. During March of 1999, they had to change all of the elements in their refuelers and the receipt and issue vessels after being overwhelmed by AJ. They were routinely draining AJ from their receipt F/S vessels until January 2001 when they changed their receipt filtration mode due to a major tank construction project. Product is delivered to Otis ANGB from DFSP Ludlow. Otis ANGB has two 600-gpm horizontal F/Ss and two 600-gpm horizontal issue F/S vessels. The heated pump house, which houses the receipt and issue F/S vessels, was recently taken out of service due to major tank construction. An R-14 Air Transportable Hydrant Refueling System (ATHRS) F/S unit was placed in service outside in the climatic elements for the fuel receipt and issue filtration. No further incidences of AJ have been experienced since placing the R-14 in service. Under normal operating conditions, a Hammond Injector Model 800 injects JP-8+100 into a 4-inch truck fillstand pipeline downstream from the pump house. During the tank construction project +100 additive has been suspended. Otis ANGB had Facet M-100 elements on hand at the time of our visit, which they plan to install in their receipt and issue F/S vessels upon completion of the construction project. The Facet M-100 elements are API 1581, 4th Edition elements that were designed specifically for use with JP-8+100 and may be more effective than any elements used previously. The Otis bulk storage system consists of two forty-year old steel ASTs. Tank #15 has a capacity of 19,000 bbls and has a geodesic dome that was leaking badly until recently. The dome has been repaired and the water problems have apparently been resolved. Tank #16 has a fixed-roof and a capacity of 1,300 bbls. The product recovery systems on the operating tanks are inadequate due to poor design in effectively removing water from the tanks. A major construction project will replace the existing system. Otis ANGB has five Oshkosh and two Kovatch R-11s equipped with Facet absorption elements. The water absorption elements in the refuelers seem to be holding up well since the fleet-wide change following the contamination incident in March 1999. We believe the recent AJ problems at Otis ANGB are also attributable to DFSP Ludlow, though earlier problems were probably cause by rainwater intrusion into the tank with the leaky geodesic dome. Hopefully, recent repairs have resolved those problems.

3.8.4 Westover ARB

Westover occasionally drained AJ-like material from the receipt filter, prior to the construction of the two 20,000-bbl bulk receipt tanks. The AJ contamination occurred between late fall and early December. Following the completion of the two bulk receipt tanks, Westover discontinued the use of receipt filters and has not experienced further AJ occurrences. The same filter separators previously used for the receipts are now used to filter the JP-8 transferred to operating storage. The new receipt tanks are generally settled at least 24 hours. The sumps are drained prior to transfer to the operating storage system through piping directly connected to a new product recovery system. The settling and draining of these tanks prior to coalescence, removes the FSII/Water mixture that is the principle constituents of AJ. Westover personnel reported finding AJ in the receipt filters prior to Desert Storm and afterwards, but not during the period of heavy product movement in support of Desert Storm activities. Since Desert Storm, they report finding AJ on four occasions.

Westover receives JP-8 via pipeline from DFSP Ludlow. The pipeline from Ludlow to Westover is an eight-inch line and static line fill of 29,600 gallons. Product receipts range in temperature from 32°F to 35°F during January, and from 60°F to 66°F during August. Westover has three R-11s (one Oshkosh and two Kovatch) four HSV-12s, and two MH2C (Type II) hose carts. The R-11 refueling trucks were equipped with standard coalescer elements at the time of the site investigation (February 2001), though water absorption cartridges were on hand for installation during the next filter change.

The Westover product recovery system is one of the better systems observed during the onsite investigations. The two new bulk tanks have geodesic domes that were well engineered and built. The ability to settle receipts for 24 hours prior to during transfer to the operating hydrant tanks combined with an excellent product recovery system are the principle reasons why Westover has not experience AJ in recent years. Reclaimed JP-8 is pumped back into the bulk storage through a filter/separator. The fact they had not installed water absorption cartridges prior to our visit may have spared them problems with high viscosity AJ in R-11 refuelers.

3.8.5 Bradley ANGB

DFSP Ludlow supplies JP-8 by tank truck to Bradley ANGB. Bradley experienced AJ last winter in their pumphouse receipt and issue F/S vessels. The pump house is equipped with a heater normally operated with the thermostat set around 50 degrees F. Heat is required in the pump house to prevent a water main and an emergency eyewash station from freezing. This fall, the heater failed and was not repaired until mid-December. When the heater was out of service, a portable Herman Nelson H1 heater was used in the pump house for heat. With the heater out of service, there has been no reappearance of the AJ. There is some speculation that a reduction in the pump house temperature might have played a role in the disappearance of AJ.

JP-8 is shipped from the Ludlow DFSP in dedicated tank trucks with a transient time of 45 minutes. During the winter, product receipt temperatures range from 20°F to 30°F. Bradley has two 300-gpm vertical Quantek vessels with Velcon coalescers for receipts and two 600 gpm vertical Quantek vessels with Velcon coalescers for issues.

Bradley ANGB has two steel **fixed-roof** ASTs that were constructed in 1993. This relatively new system has some design features that are helpful in fuel handling, such as the product recovery water drain system from the operating tanks. This system consists of one underground collection tank, with a capacity of 2,000 gallons. The product recovery tank is connected to both bulk storage tanks and is used to receive water and cloudy fuel from the tank sumps via a three-inch drain line. After separation, the fuel is pumped back through the receipt F/S to the operating tanks. The product recovery tank is gauged for water using a plumb bob, tape and water finding paste. They have four Oshkosh R-11s with Facet absorption media elements, installed during the fall of 2000. Here again, the primary AJ problems occur during filtration of receipts from DFSP Ludlow.

3.8.6 Quonset Holland ANGB

Quonset Holland ANGB receives JP-8 from DFSP Ludlow and periodically finds foreign matter in the receipt F/S sumps. The average driving time for the tank truck deliveries is 2¼ hours. FSII levels currently average 0.115% at time of receipt with a fuel conductivity range from 184 CUs to 244 CUs and an average of 210 CUs.

Quonset Holland ANGB has two vertical F/S vessels with coalescers for fuel receipts and a vertical vessel with coalescers for issues. There are two 2,500-bbl above ground steel tanks with **fixed-roofs** and floating pans. The tanks are 100% epoxy coated. The two product recovery systems are inadequate due to poor design. Operating personnel have had to resort to draining water into buckets and carrying it to a product container for settling, and recovering product after water separation. Quonset Holland ANGB has three Oshkosh R11s with Facet absorption media elements. A Hammonds Model 800 injector is normally used to inject the SpecAid (+100) additive into a 3-inch pipeline downstream of the issue filters. The unit has temporarily suspended JP-8+100 injection pending a final decision from the ANG Bureau regarding C-130 units.

The Fuels Superintendent feels the material drained from the receipt and issue F/S vessels is normal BS&W and not "Apple Jelly." Therefore, Quonset Holland ANGB has not reported AJ findings. Since DSFP Ludlow supplies JP-8 to Quonset Holland ANGB and is suspected as a principal source of AJ found in receipt and issue F/S vessels at a number of installation in the Northeast, why hasn't Quonset Holland ANGB found AJ contamination in their system? We believe several factors come into play. First, the definition of AJ has been open to interpretation by the bases. We suspect similar materials drained at other locations are reported as AJ by those locations. Second, the thickest, most viscous form of AJ contamination is more easily seen in Kovatch R-11 refuelers--all three R-11s at Quonset Holland ANGB were manufactured by Oshkosh. Third, bases that have used the water absorption media in R-11 refuelers for the longest period are those (like Quonset Holland ANGB and Otis ANB) involved in the JP-8+100 program. As we review the reported incidents of AJ findings in refueling vehicles, there is an extremely low occurrence of AJ findings in R-11 that handle JP-8+100 fuel. Furthermore, there are no reported findings of AJ in JP-8+100 aircraft fuel systems. This may be because the detergent and dispersant additives in JP-8+100 keeps AJ particles from agglomerating and keeps the small AJ particle in suspension. While Otis ANGB, has reported finding significant amounts of AJ in receipt and issue F/S sumps, they only experienced AJ in their R-11 on one occasion in March of 1999 when massive amounts of AJ "overwhelmed" the base.

3.8.7 NAS Brunswick

DFSP Ludlow delivers JP-8 via tank truck to NAS Brunswick. The fuel is received through two 600-gpm F/S vessels manufactured by M.E. Industries. The vessel model number is VFCS-C-6N38SB-3630T2N. Each of these vessels contains six coalescer elements, P/N CC-N38SB, and three separator screens, PN CS639T2N. After the fuel passes through one of the receipt F/S vessels, it passes through an M.E. Industries "Fuel Quality Monitor," model # M2030V600 containing water absorption cartridges. The receipt F/S vessels drain automatically to a product recovery tank, so the operators do not see what is drained from the receipt filter sumps.

The fuel storage tanks have **fixed-roofs** and cone bottoms that slope to center sumps. They have two issue F/S vessels that are identical to the receipt vessels described above with the exception that the sumps are do drained automatically. The issue F/S sumps are directly connected to a product recovery system via a ¾ inch pipe. The only visual observation of materials drained from the sump is through a site glass installed in the sump drain line. After the fuel passes through the receipt F/S vessel it goes through a "Fuel Quality Monitor" as described above.

NAS Brunswick personnel report that during the winter of 1998-1999 they did drain some AJ-like material from their F/S sumps. At that time, the FSII content of the fuel was running from 0.18% to 0.22%. After the FSII content was reduced to approximately 0.12%, they no longer noticed any of the thick dark liquid.

The NAS Brunswick fuel handling process differs from the process at Air Force/ANG bases supported by DFSP Ludlow in two ways. First, NAS Brunswick uses a three-stage filtration process (coalescence, separation, and absorption) at each filtration step. The Air Force uses either coalescence and separation (in fixed facilities and hydrant servicing equipment) or a single absorption phase on R-11 refueling trucks. Second, the receipt filters automatically drain to a product recovery system with no manual drain to allow the operator to examine materials drained from the sumps, while Air Force facilities supplied by Ludlow have installed manual drains that permit close visual examination

3.8.8 DFSP New Haven, CT

DFSC Ludlow receives its JP-8 via Pipeline from DFSP New Haven, CT. In turn, DFSP New Haven receives fully additized JP-8 from the Carteret DFSP by dedicated jet fuel barge approximately every three weeks to once a month. Transient time via barge is approximately eight hours. The New Haven receipt tank is sampled following each receipt. An all-level sample is taken, in addition to the barge retain sample, for laboratory B-1 level testing. The fuel is not filtered at the barge off-load terminal nor is the fuel filtered during receipt or issue from the tank.

The fuel is transferred through a dedicated line from the tank to Buckeye's multi-product pipeline for shipment to the Ludlow DFSP. The Buckeye multi-product pipeline from New Haven to Ludlow is approximately 90 miles long and the average pumping rate is 3.3 miles per hour. The JP-8 is buffered in the multi-product pipeline with Jet A fuel. The JP-8 is sampled at the start and middle and one hour before finish of the transfer.

The one 60,000-bbl Motiva above ground steel tank with a geodesic dome is located in the New Haven Buckeye terminal complex. The 60,000-bbl tank is equipped with two sumps and 1½-inch water drain valves. The discharge line is offset from the tank sumps by approximately forty feet. The single, common receiving and discharge line is equipped with a "piccolo tube" diffuser and extends 30 feet from the tank wall toward the center and descends from 25 to 21 inches from the bottom. All diffuser orifices are located on the top of the diffuser. (This arrangement minimizes turbulence in the tank and reduces the chance of BS&W contamination of the issued product.)

3.8.9 DPSP Portland

Like DFSP Ludlow, DFSP Portland also supports Pease AFB. Since Pease AFB reported that they drain AJ from receipt F/S vessels when receiving deliveries from Ludlow, but not when receiving from Portland, comparison of the two DFSP provides an informative contrast. DFSP Portland receives JP-8 via spot charter barges where the fuel is transported in uncoated mild steel tanks. Most JP-8 has historically been received from the Sun Oil Marcus Hook Refinery PA, though some has come from DFSP Carteret (primarily refined at Mobil Oil Houston). Sun Oil did not re-bid on the most recent contract. JP-8 is received through a dedicated line from the pier into two above ground, **fixed-roof** bulk tanks. One tank has a 55,000-bbl capacity and the other a 90,000-bbl capacity. Within the past three years, mild steel secondary tank bottoms have been installed in the tanks. The new tank bottoms are 10" above the old bottom at the tank center and slope to 6" at the outer edge. The fill and discharge lines are separate. Tank #4 is equipped with a floating suction line that draws fuel 14" above the tank bottom at the lowest point. The other JP-8 tank, Tank #5, has a discharge suction line that extends approximately eight to ten feet into the tank and draws fuel at a point approximately 24-inches above the tank bottom. The entry into this suction line differs from the Air Force tank design in that the elbow curves toward the top of the tank rather than the bottom. The suction line is baffled at the end having the effect of widening the vortex created by suction. This design minimizes turbulence and the potential of drawing bottom sediment and water into the suction line. The water sump is some forty feet away from the discharge line. Water is removed from the tanks twice each year through a 1½-inch drain line. While the tanks have two drain lines only, one drain line is used per tank because tank "settling has result in a slight pitch of the tank floor." On average the product turns over every 30 days. Significant cooling occurs during transfer of the product to the Portland DFSP. For example, this past August product was loaded at 95°F and had cooled on the Barge to 56°F just prior to discharge. The temperature of product in storage during August ranges from 60°F to 70°F. During January, the product temperature reached a low of 10 degrees, but averages approximately 29°F with a high temperature of 33°F. When issued, the product is pumped through two separate vessels, one for micronic filtration and the other for coalescence. The maximum flow rate through the vessels is 1,100 gpm. FSII content of the product is fairly consistent at 0.13%, while the product conductivity ranges from 150 CUs in the winter to 350 CUs during the summer months. The Portland DFSP does have a 6,000-gallon stainless steel FSII tank equipped with a dryer vent. Injection capability is provided via an injector manufactured by Gates City. The tank is empty and has not been used in recent years. They do have five drums of FSII on hand, which they have had stored in a warehouse for three-years.

Product is filtered through separate filter and coalescer vessels. Both are equipped with Velcon elements. The filter vessel contains 11 filter elements and the coalescer vessel contains 22 coalescer elements. There have been three filter changes since the beginning of the contract period (once in August 1999, again on October 28, 2000, and most recently on December 7, 2000). The changes occurred based on differential pressure.

The Portland DFSP ships solely by tank truck. A visual sample, and laboratory analysis for FSII, CU, and API gravity are taken each morning. Samples are retained for a 15-day period. Tank trucks loaded at Portland go to Pease (50 minutes), Bangor (2.5 hours), Brunswick (45 minutes), and several Army National Guard units.

The major differences between the facilities at DFSP Portland ME and DFSP Ludlow, is that Portland stores JP-8 in fixed-roof, rather than floating-roof tanks; and that Portland provides coalescer removal of water, while Ludlow has modified its filter separator vessel to remove the coalescers and uses only micronic filters. Because Portland's fixed-roof tanks do not allow rainwater intrusion into the JP-8, they are not faced with the need to re-inject FSII and SDA.

3.8.10 Bangor ANGB, ME

Bangor ANGB receives product primarily from DFSP Portland. While Bangor ANGB has found small amounts of AJ in hydrant system F/S vessels and flight line servicing equipment, they have not experienced AJ problems in their receipt filters since changing from DFSP Searsport (now closed) to DFSP Portland as its major supplier. During pipeline receipts from DFSP Searsport, and especially toward the end of the pipeline use during late1997, "dark" contamination occurred frequently. At that time, it was believed that the dark materials were the result of pigging the pipeline to prepare it for closure.

Materials with an "AJ-like" appearance were first found in the receipt filter during a filter change driven by a rapid rise in the filter differential pressure.

Since converting from pipeline receipts to tank truck receipts during 1997, Bangor ANG base found approximately one quart of AJ in one of the two hydrant system filter vessels in their Type III hydrant system. These two F/S are located within an enclosed pump house along with all the other F/S vessels. The temperature in the pump house is maintained at approximately 55 degrees during the winter (though operators occasionally turn up the thermostat). One unique feature about the vessel (designated as H-2) where AJ was found is that it sits directly beneath the overhead heater for the building.

A small amount (a few tablespoons) of AJ-like material that "flowed like mercury" was found in the filter vessel of one of the four assigned R-11 refueling trucks (Kovatch, Serial # 98L59), during change from coalescer elements to water absorption type elements. The R-11s were equipped with water absorbing elements during November 1999. The other three R-11s, manufactured by Oshkosh, and have vertical filter vessels built to use the old standard DoD NSN 4330-00-983-0998 filter coalescer elements. All of the R-11s were equipped with water absorption elements manufactured by Facet during November 1999.

AJ was also found on several occasions in one of the three assigned HSV-12 hydrant-servicing vehicles (Serial #98L76). On each occasion, a small amount (a few tablespoons) of AJ was found while draining the filter vessel the morning following a day of unusually heavy use. At that time, the HSV-12 were parked in a heated barn over night. The HSV-12s are now parked outside and no AJ has been identified recently. Beta Systems manufactured the F/S on 98L76, during the 4th quarter of 1997, Model # 182FS2001, and Serial # 182F-049. This vessel uses three coalescers and two separator elements. They have not observed any AJ-like material from either of the two older model HSV-12s that are equipped with Velcon vessel, Model # HV2856YTSR, that use seven coalescers (I-65688TB) and two separators (99-848V).

The Bangor ANGB receives JP-8 via tank trucks (not dedicated to JP-8) that are filled at Portland DFSP. The trucks travel approximately 130 miles. Receipt temperatures during January average 34 degrees and reached a low of 28 degrees. During August, fuel temperatures are consistently 75 degrees. The product is filtered upon receipt via two vertical API standard filter-separators vessels, manufactured by M.E. Industries; the vessels are epoxy-coated steel. The F/S vessels are drained following each receipt. The filter vessels are drained through a ¾" line equipped with a circular sight gauge. The Bangor ANG personnel have modified the sump drain to include a manual drain. No fuel receipt quality problems have been experienced since changing from pipeline to truck receipts during 1997. The pipeline receipts originated from Searsport DFSP and traveled 27 miles from the DFSP to the base. Bangor receives an average of six tank truck deliveries per day. They have the capability to offload three trucks simultaneously. A single truck can be offloaded within 35 minutes. The truck offloading system is equipped with two positive displacement pumps. The offload procedure results in pumping a significant amount of air as the tank trucks nears empty and while evacuating the discharge lines. The fuel is received through the receipt F/S into two above ground 10,000-bbl tanks. They store and issue approximately 800,000 gallons per month.

The two 10,000-bbl tanks ASTs were built in 1993/94 and placed into service during 1994. The tanks have **fixed-roofs**, floating-pans, and are fully epoxy coated. The tanks are the “self-cleaning” design with the tank bottoms slopped to the center and the suction line directly over the tank sump. Bottom water is drawn out of the sump through a ¾ drain line (inside the tank) with a one-inch line outside the tank. The sump drain extends to within one inch of the bottom of the sumps. When draining the tank sumps, fuel is first drained into a bucket for a visual examination. If there is no BS&W seen in the bucket, the fuel is pumped through the receipt F/S and back to the tank for approximately two minutes and monitored through a pipeline sight gauge. The filter vessel sump drain lines empty into a 2,000-gallon underground product recovery tank. Sight gauges on the hydrant and truck fill stand F/S sump lines are used to monitor the product, and manual drains have also been installed and are used daily. The product recovery system is equipped with a two-inch return line that moves JP-8 from the product recovery tank, through the receipt F/S, back to the bulk tank. A 50-gpm pump powers the return line.

The Bangor ANGB Type III system was installed during 1994 at about the same time they converted from JP-4 to JP-8. All F/S vessels are located within a heated pump house. Two F/S vessels are used for hydrant issues and two support the refueling truck fill stand. The Type III system is turned off at the end of the day and restarted the following duty day. The Type III system has a 10-inch pipeline loop. Considering that AJ has been found primarily in issue filters and flightline servicing equipment following periods of refueling heavy activity, it seems most likely that the AJ results from entrained and free-water/FSII mixtures settling from the fuel as it cools in the storage tank and hydrant system pipeline. Once these materials accumulate in system low-points they are subject to being picked up at time when flow rates increase above normal to support a surge of activity.

FSII content is fairly consistent at 0.12%, with the low of 0.10% and a one time high of 0.14% by volume. Conductivity ranges between 100-160 CUs during the winter months and 250-300 CUs during the summer months. The few experiences with AJ at Bangor are attributable to the dramatic cooling of fuel that occurs with the onset of winter, which causes the dissolved water to precipitate out of the fuel. The water collects FSII and the discharge line that sits directly over the bulk/operating storage tank sump sucks the BS&W out of the sump and pushes it to the filter-separators. Bangor ANGB is one of the few locations that have reported finding AJ in HSV-12 servicing vehicles, and we are concerned over the possibility that AJ-like materials accumulate over time in low points within the hydrant system and are being picked up during surge operating conditions.

3.8.11 DFSP Carteret

DoD products handled by DFSP Carteret include JP-8, JP-5, and F-76. Carteret was activated as a new DFSP following the closure of DFSP Stanton Island in 1999. As DFSP Stanton Island tanks were drawn down in preparation for closure, we understand that significant amounts of AJ-like materials were found and may have contributed to the

AJ problem in the Northeast during the late 1990s. JP-8 is shipped to Carteret neat via a multi-product pipeline operated by the Colonial Pipeline Company from breakout tanks in Linden, NJ. Four, **fixed-roof**, steel, tanks constructed in the 1940s are dedicated to JP-8 storage. Since December 2000, unfiltered, neat JP-8 is received into Tank 100 (capacity 92,000 bbls) and additized in a tank-to-tank transfer to Tanks # 125 and 126 (capacities 23,000 bbls each). Unadditized JP-8 is filtered as it enters Tank # 44 (capacity 74,000 bbls) which is used primarily to fill barges and occasionally tank trucks. Receipt batches are limited to a maximum of 75,999 bbls. Three tanks are dedicated to storing JP-5, Tanks # 25-1 and 25-2 constructed in 1955 and Tank # 63, constructed in 1942. JP-5 is additized as it leaves the pipeline and enters Tank 63. Carteret also has tanker and barge capability and supplies fuel to DFSPs New Haven and Portland by barge and DFSP Verona by pipeline.

Tank # 100, the JP-8 primary receipt tank, has an epoxy-coated floor and epoxy coating 3 1/2 feet up the sides. It also has an eight-inch water dam around the suction line that has a duckbill six inches from the bottom. The discharge (suction) line and receipt line are separate and the suction line is fixed. The tank was last cleaned in May 1999, when the epoxy coating was applied. Tank # 44 is also coated similar to Tank # 100 and has a discharge line 18-inches from the bottom of the tank, positioned in the center, with a diffuser on the end and slots on the side. The tank sump is approximately 35 feet away from the discharge line. The 18-inch receipt line is also used to fill barges. An eight-inch line connects the tank to the tank truck loading rack. When Tank # 125 was last cleaned in March 1999, the coating was unacceptable and had to be sandblasted. The floor and walls are mild steel. The fixed discharge line is a duckbill approximately three feet from the side with a water dam six-inches from the floor. The tank sump is approximately four feet from the discharge line. Tank # 126 is similar to Tank #125.

FSII is stored in an 11,000-gallon tank with a nitrogen blanket. Since December 2000, both FSII and SDA is injected by the same Hammonds 2000D-40-1M injectors after it leaves Tank # 100 at a concentration of 0.11 to 0.13 for FSII and 200-250 CUs for SDA. The FSII concentration was traced from DFSP Carteret to New Haven with no significant loss of FSII evident.

There have been no reports of AJ since the terminal was activated; however, the appearance of a lime green tint in fuel receipts, especially JP-5, has been frequent since the Department of Transportation mandated the use of green dyed water to pressure test the pipeline in December. Water is removed as needed when gauging indicates the need. BS&W is removed by using a vacuum truck. An immediate sample and all-level sample are taken and tested on all inbound and outbound shipments. A B-1 sample is taken on receipts after the fuel in the receipt tank has settled for a day.

DFSP Carteret was a focal point of our investigation as it is the “common denominator” that supplies the other DFSPs in the Northeast. Our two teams working the Northeast military bases independently joined together for the on-site investigation of DFSP Carteret. We were pleasantly surprised by the quality of the facilities and management and very impressed by Joe Fish, the local QSR.

3.8.12 DFSP Jacksonville

Jacksonville has received fuel (JP-8) primarily from the Sun Refinery, Marcus Hook, PA. On occasion, product may also be received from DFSP Yorktown and DFSP Baltimore. JP-8 is primary received by dedicated barge, the Bay Trader, on contract to the government, although spot chartered barges may be used periodically. Travel time by barge is about 4.5 hours from Marcus Hook, 30 hours from Yorktown and about 8 hours from Baltimore. JP-8 is fully additized when received at DFSP Jacksonville. The terminal has the capability of adjusting additive levels as barges are discharged should this be required. Product is received dry and there are no water problems. Tanks are drained as required based on water finding paste, but very infrequently.

The terminal has a total of 12 tanks but only 8 are in use for JP-8. All are above ground steel tanks equipped with **fixed-roofs** and internal floating pans. Four tanks have bottoms, which slope to the side and 4 bottoms slope to the center. Tanks are cleaned every 5 years. Product in tanks #1, #2, and #5 is rotated at least every 6 months, tanks #4, #9 and #10 every 1 to 1.5 months and in tanks #11, #12 (used to load barges) product is rotated weekly.

Product is shipped to McGuire AFB through a dedicated pipeline and loaded in tank trucks (non-dedicated) for shipment to various other locations. Product is filtered when shipped by pipeline and trucks. Shipping time to McGuire AFB varies from 8 to 12 hours depending on the batch size. Filter changes average about every 15 million gallons.

DFSP Jacksonville personnel reported they experienced a very small amount of AJ in the pipeline F/S to McGuire about 3 or 4 years ago.

3.8.13 McGuire AFB

McGuire AFB was selected as a site to visit because it had no history of Apple Jelly contamination. The plan was to contrast the facilities and handling process with locations that have experience AJ contamination to identify potential differences. However, just prior to our visit, McGuire AFB fuels personnel discovered a jelly-like substance in the sump of Kovatch R-11 # 97L0165. The substance drained from the sump had a foamy appearance, as though a lot of air was mixed with the product. It had a pinkish brown tint and had the appearance of a chocolate/strawberry milkshake. The appearance of the sample did not change significantly while sitting in the laboratory or even after it had been shipped to SwRI. The unusual appearance of the sample is attributable to the unique circumstances that led to the discovery. This particular R-11 had been recently used to flush four 100-foot sections of hose while preparing a Forward Area Refuel Point (FARP) cart for deployment. The hoses, which had been in storage for three years at McGuire AFB, had been pressurized with water to 150 psi, drained and were flushed by connecting the one end to the single point nozzle and the other to the bottom-loader of the R-11. Five hundred gallons of fuel were circulated through each of the hose section; then the content of the hoses was evacuated into the R-11. They allowed 97L0165 to sit over night to allow the water to settle and discovered the “Apple Jelly” contamination while draining the sump the following morning. The R-11 was equipped with Facet water absorption elements, installed during July 2000. The hoses were not available for inspection because they had been deployed with the FARP cart. Very little information was available about the manufacture or materials in the hose. The ambient temperatures during the two-day period that encompassed the flushing of the hose and the discover of the "AJ" range from 23°F to 28°F with wind chill factors of 1°F to 16°F.

A second incident occurred on February 27, 2001, when a F/S vessel shutdown during a transfer between hydrant systems. Some dark materials were drained from the filter sump. The filter elements had been in service for 35 months and an apparent water slug shutdown the F/S. AJ was not found during an internal inspection of the F/S. After examining the materials, the C4e team members concluded it was normal BS&W because it did not have a heavy viscous nature. Later in our investigation, once SwRI published its broad definition of AJ and after seeing a number of similar samples of material considered "AJ" in the field, we should have considered this material to be AJ within the SwRI definition.

McGuire AFB receives fuel via a dedicated six-inch, eleven-mile pipeline from DFSP Jacksonville. McGuire is capable of receiving 648,000 gallons per day. A new tank truck off-loading facility will increase receipt capacity to 1.3 million gallons per day when it is completed. A pipeline modification, scheduled for completion in October 2001, will route both pipeline and tank truck receipts directly to the BRAC hydrant system bypassing bulk storage. C-Station, used primarily for storage and as a fillstand, has six 25,000-gallon tanks and two fillstands.

McGuire has three 450,000-gallon floating-roof tanks with geodesic dome but these tanks have been out of service for maintenance and repair since prior to their conversion from JP-4 to JP-8. Construction of a two million-gallon storage tank is scheduled for fiscal year 2002/2003.

The primary storage is the two Type III Hydrant Systems. The KC-10 hydrant system (BRAC) has two 1million-gallon tanks with five 600-gpm pumps and delivers up to 2,400 gpm. It also has two fillstands that can sustain six R-11s per hour. The C-141 Hydrant System (DLA) is located within Bulk Storage and has two 850,000 gallon tanks with four 600-gpm pumps that deliver 2,400 gpm. They also have Type II system with six 50,000-gallon tanks, three laterals with five outlets on each with a flow rate of 600 gpm. If one of the systems became inoperable, the system can be configured so that one hydrant system can service all spot with a reduced capacity. McGuire AFB has twelve R-11s with water absorption elements installed in June-July 2000, six HSV-12s, and five MH2-C Hose Carts.

3.8.14 DFSP Port Mahon

Port Mahon experienced AJ during December 2000. On two occasions, they drained cloudy fuel from the F/S sump and got a dark material that was suspected to be AJ. This experience coincided with a drop in temperature and occurred at the same time that Dover AFB was experiencing AJ problems in their receipt F/S sumps.

The Delaware Storage and Pipeline operates the Port Mahon DFSP for the primary support of Dover AFB. Occasionally, tank trucks are loaded for destinations directed by DESC to relieve temporary shortages or resupply delays. There are **eight fixed-roof** storage tanks for JP-8: four 30,000-bbl tanks, three 96,000-bbl tanks and one 25,000-bbl tank**. Tank #5 is a floating-roof tank but has been modified with a geodesic dome cover**. The suction and discharge into tank #5 is typical of the other tanks. The single 8 inch suction line goes 30 feet into the tank, turned down 90 degrees, coming to within 3 ½" off the tank floor. The tanks are cleaned on a three-year cycle, and tank #5 was last cleaned in 1999. This 96,000-bbl tank was constructed in Aug 1964.

Product is received at Port Mahon by barge from Sun Oil, Marcus Hook, PA (75%) and Baltimore DFSP Terminal (25%). The US Coast Guard limits barge size to 13,000 bbls because of the shallow bay. Eight to ten barges per month are received at Port Mahon. Product received normally has all the needed additives for JP-8, though additional SDA can be injected at Port Mahon if needed.

There are two 1,200-gpm vertical F/S vessels installed on the outbound lines. The vessels are Model # VFCS-C-12N38-5636TN2. Both vessels are API 1581, Group II. Class B. **It was noted during the walk around that the F/S drains were blocked with pipe plugs below the drain valves and the vessel air eliminator lines were capped.** The Terminal Manager stated that they were blocked to avoid a spill and the associated environmental impact. This modification arrangement inhibits checking the F/S sumps for water and relies on the internal float mechanism to stop the flow of fuel if the vessel sump becomes full. The internal float shutdown have a history of failure allowing water to be transferred downstream of the F/S vessel.

DFSP Port Mahon supports Dover AFB. The only AJ experience at both locations occurred during a ten-day period in December 2000. The fact that eight of the nine JP-8 storage tanks have-fixed-roofs may explain the infrequency that excessive free-water/FSII mixtures (AJ) have been found at Port Mahon or Dover AFB. The one modified floating-roof tank with the geodesic dome cover, and a suction nozzle directed toward the tank floor and sitting only 3½ inches above the floor might explain the AJ experience during December 2000; however, we were unable to confirm whether or not this tank was on issue. While some rainwater may have entered this tank, the drop in temperature that coincided with the discovery of AJ indicates that dissolved and entrained water/FSII mixtures separated from the fuel and settled to the tank bottom as a result of the temperature drop. This, of course would happen in fixed-roof, as well as dome roofed tanks. Given the design and position of the intake nozzles, the free-water/FSII mixture would have been picked up by the discharge line and pushed to the F/S vessels.

3.8.15 Dover AFB

Dover AFB experienced AJ only during a ten-day period in December 2000. During this time, AJ was frequently drained from the sumps of receipt F/Ss #1 & #2, which are installed in a heated pump house. When the problem occurred, the ambient temperature had dropped from 40 to 20ºF. It was also noted that slugs of water were coming through the F/S, and they were experiencing high AEL water readings. Pete Shields, Bulk

Storage Supervisor, reported that the F/S pressures decreased during the temperature drop from a high of 11-psi to a low 5-psi differential pressure. After the temperature went back up, the differential pressure also went back up. Kevin Hughes, LFM Foreman, was prepared to change the elements, and he verified this condition. They removed the F/S tops and inspected the vessels internally. Finding nothing wrong, they reinstalled the tops and placed the vessels back into service.

Product at Dover is received from the Port Mahon DFSP, which is approximately five miles away. Fuel is transferred from Port Mahon to Dover through two 6-inch dedicated pipelines. The pipelines run approximately five miles from Port Mahon to Dover AFB. The normal transfer rate is 35,000 gallons per hour (gph) and during an upsurge, a boost pump is utilized that will increase the flow to 51,500 gph. The fuel is filtered at Port Mahon outbound to Dover. Line displacement time to Dover from Port Mahon is three hours. Pipeline receipts from Port Mahon are not filtered upon receipt and transfer from the bulk tanks. Dover AFB issues an average of 300,000 gallons of fuel per day. The FSII content of the fuel received and issued at Dover is normally 0.13% to 0.14 % on receipt and is normally 0.12% to 0.13% upon issue. (Perhaps the FSII level could be reduced without creating a problem.)

Dover AFB has three above ground steel tanks used to store JP-8. Two of the bulk storage tanks are equipped with floating-roofs with geodesic covers. The third tank is an above ground steel tank with fixed-roof and floating pan. This 55,000-bbl was tank built in1971. It is equipped with a product recovery system with hand pump and ¾ inch line for water removal.

Dover AFB has three Beta, two Tri-State and one Page AVJET Hydrant servicers. The frequency of F/S element changes on this equipment averages three years and the changes are based upon the maximum use life. No AJ has been encountered in these hydrant servicers. They have nine R-11 refuelers that are equipped with absorption media elements. The Facet elements were installed in July 2000, and no problems have been encountered. Fuels Management at Dover has implemented an aggressive water-draining program. Operators drain the sumps of the refuelers and hydrant servicers at checkpoint and at the second shift change daily. Personnel report that they are not seeing anything abnormal.

There are two-Type III constant pressure hydrant systems installed at Dover. The F/Ss have API 1581, Group II, Class B, and 3rd edition elements. The first filtration occurs during transfers to the two Type III constant pressure hydrant systems. Each hydrant system has two receipt and re-circulation F/S vessels and five issue F/S vessels. Each hydrant system is equipped with two above ground steel fixed-roof 10,000-bbl operating tanks. The suction discharge lines in all four tanks are positioned within the tanks directly above the sumps. Again, the product recovery systems are equipped with ¾ inch lines. The four hydrant operating tanks are 100 percent epoxy coated and are equipped with three-inch diameter stripper lines. During surge operations, as much as 600,000 gallons of fuel per day may be issued, primarily by hydrant systems.

3.8.16 DFSP Grand Forks

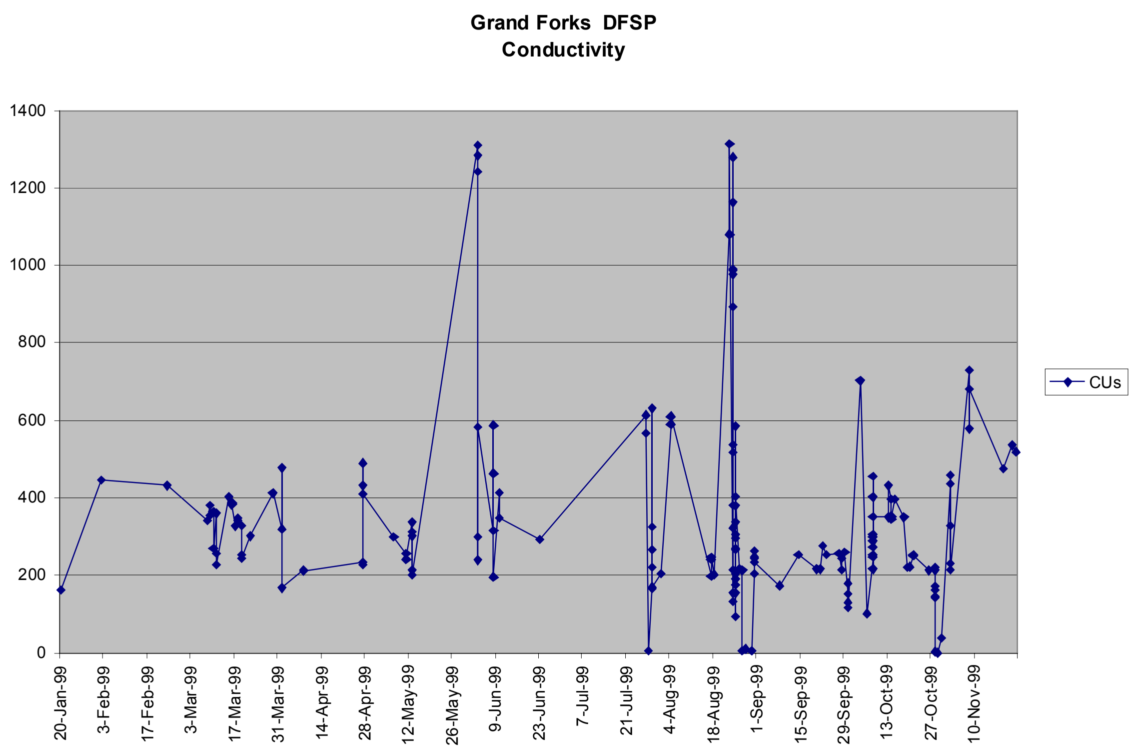
DFSP Grand Forks receives JP-8 from Conoco's Ponca City, OK Refinery via a multi-product (jet fuel, diesel fuel, and gasoline) pipeline operated by Williams Pipeline. Pipeline Drag Reducer (PDR) is used in some of the pipeline product movements, but not JP-8. Because of the line fill in this pipeline, it takes approximately three weeks for a shipment to reach DFSP Grand Forks. DFSP Grand Forks receives a "heart cut" of the pipeline shipment, based on API gravity readings. The transmix at the front and end of the batch is not separated as transmix but is reportedly blended with "other" products. Grand Forks DFSP has two 1959 vintage 55,000-bbl steel tanks, and two 80,000-bbl tanks, also built in 1959. The floor of the tanks are epoxy coated and the coating extends three-feet up the tank walls. The tanks have **floating-roofs with geodesic dome covers**. The roof drains have been removed. The tanks slope to the center and are equipped with 2" bottom sediment and water (BS&W) drain lines. The tanks are drained weekly and after each receipt. Tank receipt and discharge lines are separate. The discharge (suction) lines are fairly close to the BS&W sumps. The distances range from 17" to 43".

During January, product receipt temperatures range from 33° to 35°F, while the temperature of JP-8 in storage ranges from -2° to +20°F. During August, receipt temperatures range from 65° to 69°F, while storage temperatures range from 65° to 70°F. **The JP-8 is not filtered** during receipt at DFSP Grand Forks and **it is not filtered during transfer** to Grand Forks AFB. **We recommend that filter coalescence be added to the DFSP Grand Forks system upstream of the point where FSII is injected into JP-8 issues.**

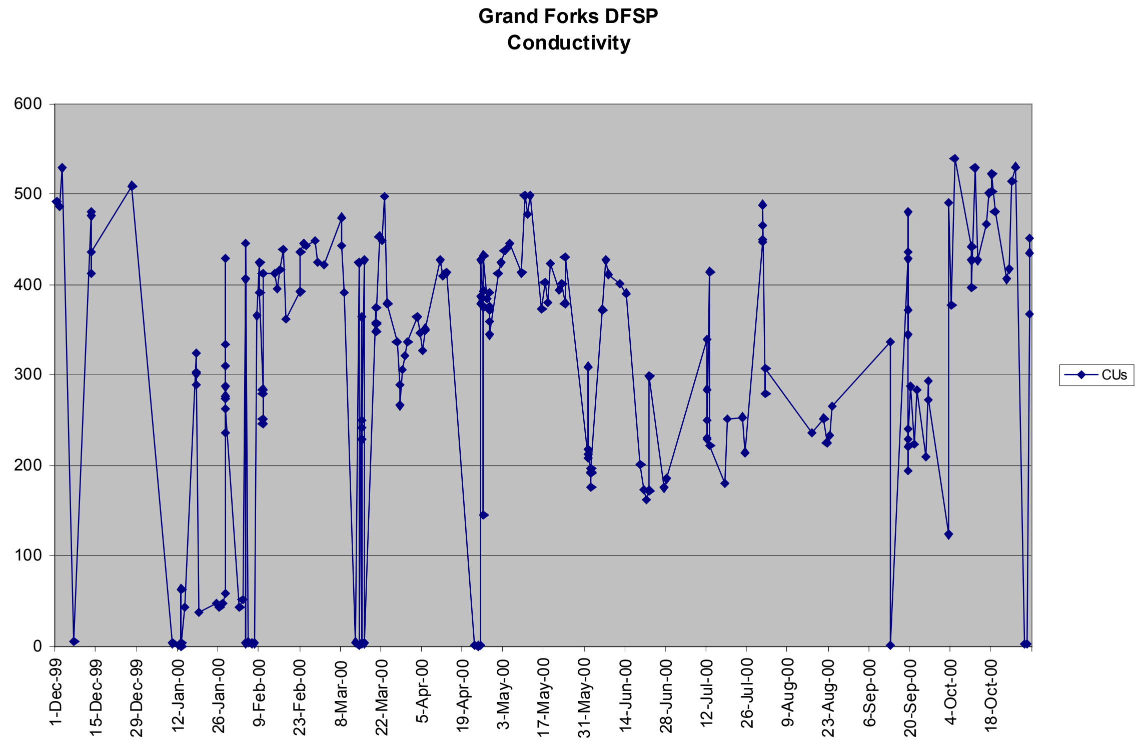
SDA and FSII additives are injected using Hammond injectors (six model 6T-4L for the truck fill stand and a model 1400 for the pipeline). The same injection unit injects both additives. A 6" pipeline, which operates at 500 gpm, supplies the fillstands. The transfer pipeline to Grand Forks AFB is an 8" line with an average pumping rate of 650 gpm and a 210-psi average operating pressure (300 psi max). STADIS 450 is received in 55 gal drums and is blended with JP-8 at a ratio of 20 parts JP-8 to 1 part of STADIS 450 in a 27.5 gal tank. The JP-8 retain samples (fully additized) are used to dilute the STATIS 450. FSII is received by bulk from Ashland Distribution Co. and is stored in a 6,353 gal tank. The tank is equipped with a desiccant dryer, and the FSII turns over every six months. The DFSP personnel work hard to maintain a 0.11% FSII injection ratio and keep meticulous records. FSII test results show a range from 0.10% to 0.12%. They report that the Hammonds injectors are not completely reliable and require constant monitoring. Fuels Management personnel at Grand Forks AFB report that the quantity of FSII in prior years averaged 0.14%. They also stated that following the reduction of FSII to 0.12% and greater attention to removing water bottoms they have seen less AJ.

Tank truck deliveries are also made from DFSP Grand Forks to military activities in Minnesota (6 to 8 hours transit time), North Dakota (up to 4 hours transit time), Wisconsin (8 hours) and South Dakota (up to 15 hours driving time, which requires an over night stop). Trucks are not dedicated but each truck is inspected and the manifolds drained prior to loading.

Due to the work of the DESC Apple Jelly Tiger Team and William Pulley, the QSR for this area, a tremendous amount of data has been collected concerning JP-8 and operations at DFSP Grand Forks. Fuel quality data and temperature information have been extracted from this data and are presented in graphic form in Appendix E-20. Historical fuel conductivity data for the period from January 1999 through April 2001 is present in the three graphs below. Note that the conductivity test results of JP-8 ranged wide and erratically throughout this period. For instance, during 1999 tests results frequently exceeded both the upper and lower ends of the specification limits. This may have been a result of the difficulty regulating the additive injectors, mentioned above.



Test results during 2000 (see charts below) show improvement in controlling the upper end of the conductivity limits but the results are still very erratic. Results during the first four months of 2001 show significant progress in controlling fuel conductivity levels.


Grand Forks DFSP
Conductivity
600
500
400
300
200
100
0
1-Dec-99
15-Dec-99
29-Dec-99
12-Jan-00
26-Jan-00
9-Feb-00
23-Feb-00
8-Mar-00
22-Mar-00
5-Apr-00
19-Apr-00
3-May-00
17-May-00
31-May-00
14-Jun-00
28-Jun-00
12-Jul-00
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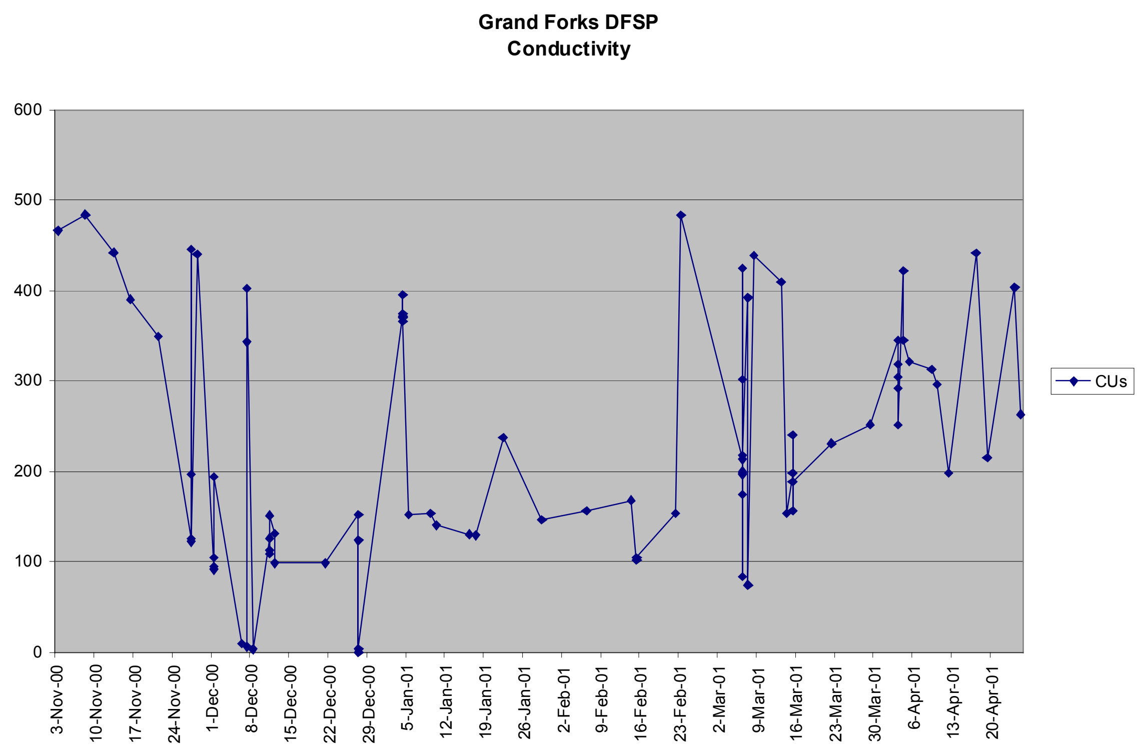
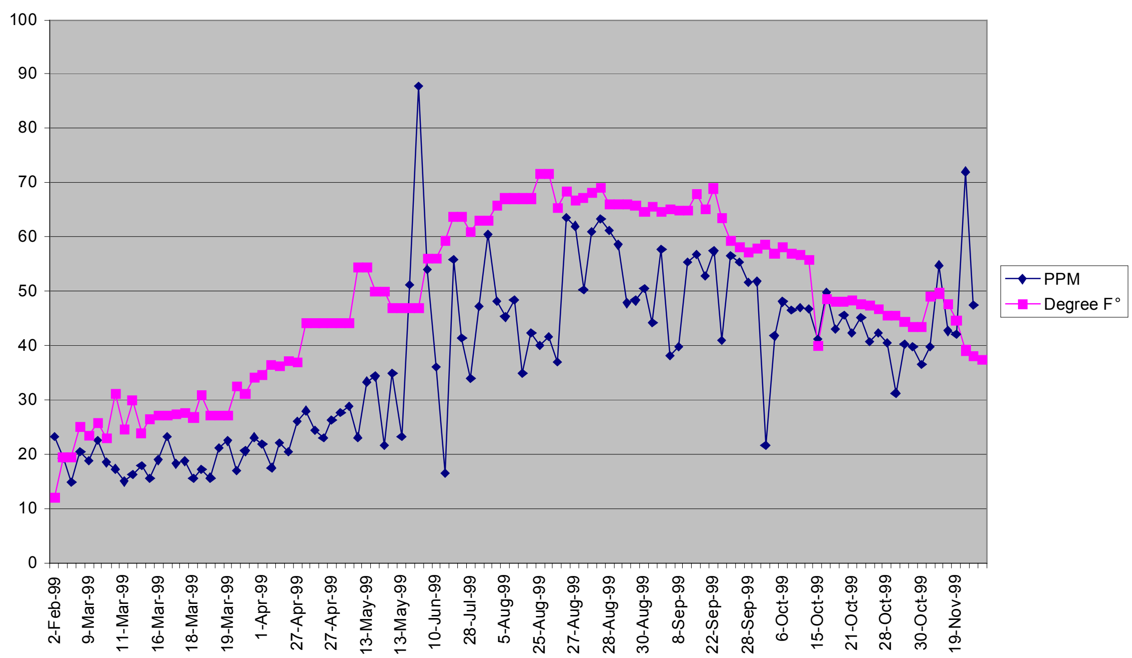
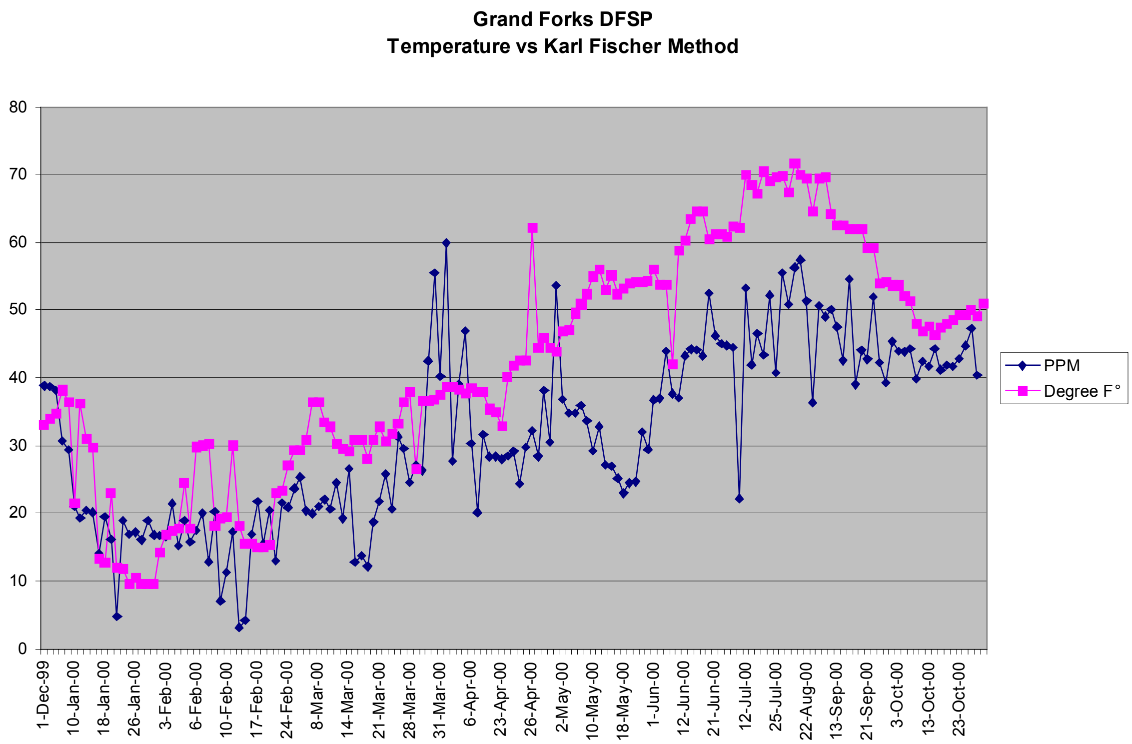
9-Aug-00
23-Aug-00
6-Sep-00
20-Sep-00
4-Oct-00
18-Oct-00
CUs

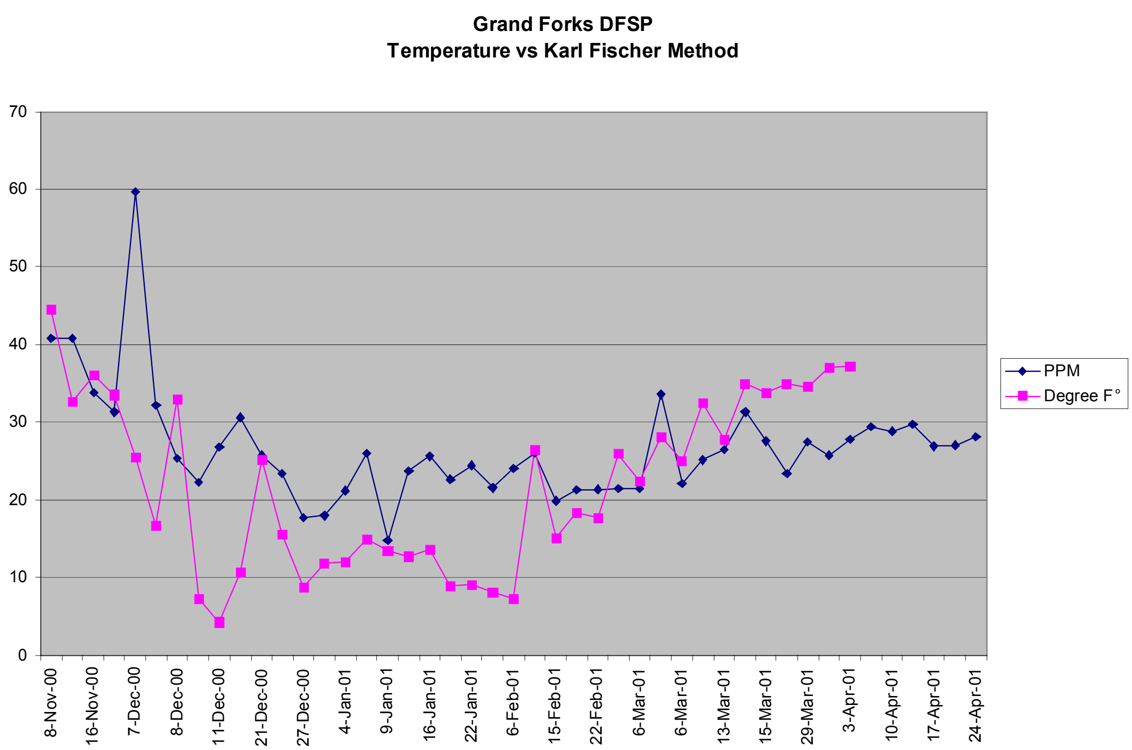

Grand Forks DFSP
Conductivity
600
500
400
300
200
100
0
3-Nov-00
10-Nov-00
17-Nov-00
24-Nov-00
1-Dec-00
8-Dec-00
15-Dec-00
22-Dec-00
29-Dec-00
5-Jan-01
12-Jan-01
19-Jan-01
26-Jan-01
2-Feb-01
9-Feb-01
16-Feb-01
23-Feb-01
2-Mar-01
9-Mar-01
16-Mar-01
23-Mar-01
30-Mar-01
6-Apr-01
13-Apr-01
20-Apr-01
CUs

Water content, using the Karl Fischer Method, along with the temperature of the fuel at the time the samples were taken are shown below. An important factor in AJ phenomena is that seasonal changes resulting in changes in fuel temperature play an important role in AJ formation. The results of the Karl Fischer tests, when compared with the fuel temperature at the time the sample was drawn, clearly show the extent that warm JP-8 holds more water than cold fuel. Consequently, as the seasons change from fall to winter and a significant drop in fuel temperatures occur, free and dissolved water come out of the fuel and settle to the tank bottoms or is more easily separated from the fuel by coalescence. This is the primary reason that the most AJ in both frequency and quantity occurs during the temperature drops that accompany the transition from fall to winter.

Grand Forks DFSP
Temperature vs Karl Fischer Method




Grand Forks DFSP
Temperature vs Karl Fischer Method
0
10
20
30
40
50
60
70
80
1-Dec-99
10-Jan-00
18-Jan-00
26-Jan-00
3-Feb-00
6-Feb-00
10-Feb-00
17-Feb-00
24-Feb-00
8-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
31-Mar-00
6-Apr-00
23-Apr-00
26-Apr-00
2-May-00
10-May-00
18-May-00
1-Jun-00
12-Jun-00
21-Jun-00
12-Jul-00
25-Jul-00
22-Aug-00
13-Sep-00
21-Sep-00
3-Oct-00
13-Oct-00
23-Oct-00
PPM
Degree F°


Grand Forks DFSP
Temperature vs Karl Fischer Method
0
10
20
30
40
50
60
70
8-Nov-00
16-Nov-00
7-Dec-00
8-Dec-00
11-Dec-00
21-Dec-00
27-Dec-00
4-Jan-01
9-Jan-01
16-Jan-01
22-Jan-01
6-Feb-01
15-Feb-01
22-Feb-01
6-Mar-01
6-Mar-01
13-Mar-01
15-Mar-01
29-Mar-01
3-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
PPM
Degree F°

3.8.17 Grand Forks AFB

Grand Forks AFB has been plagued with AJ for the past three years. It was worse three years ago but they continue to struggle with periodic occurrences. The very first occurrence was in receipt F/S 1 and 2 at Bulk Storage. These two receipt F/S vessels also yielded the largest amount of AJ, ranging from 2 quarts to 15 gallons. The second largest amounts are found in F/S #1 though #8 within the Type III Hydrant System, with amount ranging from 1 quart to 2 gallons. The third largest amount comes from Tank # 3 and Tank # 4, which are above ground floating-roof tanks with **geodesic dome covers**. From 2 quarters to 2 gallons are periodically drained from the sumps of these two tanks. The smallest amount comes from R-11 refueling units with 2 milliliters usually found in the F/S sump. The first occurrence this past fall was on October 16, 2000. Grand Forks AFB occasionally finds AJ in the transfer F/S and AJ is frequently found in R-11s parked in the four heated stalls over night. Base personnel noted this phenomenon and conducted an experiment during December 2000 and January 2001 that involved moving the trucks inside the heat storage for several days, then outside, then back inside. AJ was drained from the sumps while inside, but no AJ was drained from trucks kept outside overnight. They also conducted a similar experiment with the transfer pump house by turning the heat off for a period of time, and then back on. When the heat was on, AJ was produced. When the heat was off, no AJ was drained from the sumps. Base personnel reported that they take advantage of this phenomenon to reduce the differential pressure on vessels approaching the 25-psi differential pressure change criteria of the elements. They report that the Air Force has provided a waiver to extend the use of water absorption elements from the 22-psi differential pressure change requirement to 25-psi. On vehicles approaching the 25-psi limit, they frequently park those R-11s inside to allow the water absorption media to drain. This lowers the differential pressure and "extends the life" of the elements. It also results in the accumulation of AJ in the filter sumps.

JP-8 is shipped via pipeline to Grand Forks AFB from the DFSP at Grand Forks. Product is filtered as it is received through a Facet CDCS-D-7K39SB-1-2S636FM element located in Facility 511. As fuel is issued, it passes through a transfer/issue station located in Facility 50l and is filtered by a Bowser 1838 F/S vessel.

Grand Forks AFB receives JP-8 into two steel, epoxy-coated ASTs. One tank has a 30,000-bbl capacity and the other is a 25,000-bbl tank. Both were constructed in 1958. The tanks have floating-roofs and geodesic dome covers. The geodesic domes do not have a complete seal against the tanks and during periods of heavy rain and high winds, water enters the tank by blowing up under the skirts on the geodesic domes. They have an active project to extend the skirts of the geodesic domes to preclude water entry into the tanks. The tanks slope to the center, and the discharge (suction) lines are located approximately 15" from the bottom of the BS&W sumps. Product in these tanks is turned over every two to three days. During January, product storage temperatures ranged from 11ºF to 22°F. The base reports that inventory levels had dropped by 45% over last two-three years. On average, only 50% of the existing capacity is currently in use.

The base has seven Oshkosh R-11 refuelers, and one Kovatch R-11. All are equipped with water absorbent elements manufactured by Facet (NSN 4330-010-439-2314, and PN 3 FGI 6335B. Grand Forks AFB also has four HSV-12s with Facet CA56-35B-51 coalescing elements. Because the HSV-12s tend to leak when taken from a warm environment to a cold environment, the HSV-12s are primarily (except for maintenance) parked outside rather than in the heated facility. No AJ has been found in the HSV-12s. Grand Forks has a Type II and a Type III System.

Receipt AEL samples show that product averages 3 ppm of water. FSII levels run between .10 and .11. Base personnel report that the occurrence of AJ was greater three years ago and at that time FSII level averaged 0.14%. Conductivity readings currently range between 200 CUs and 300 CUs; temperature variation is reported as the key factor.

3.7.18 BP/AMOCO Mandan Refinery

The Mandan BP/AMOCO Refinery refines various grades of petroleum product, diesel fuels, heating fuels, gasoline, commercial jet A and JP-8. The crude oil is North Dakota sweet crude, Williston Basin. This crude is sometimes green in color and has API gravity between 41 and 42. They have on occasion purchased from Canada but have not done so in the last few years. The refinery capacity is 60 thousand barrels per day. The JP-8 is straight run distilled from one tower with no cracking or blending, however the JP-8 does pass through a salt dryer. There is a change from summer to winter grade diesels and #2 oil, but there is no change to the JP-8 process.

The refinery has three dedicated storage tanks. Tanks #757 and #717, constructed in 1954, are 43 MBBL steel, ASTs with **floating-roofs** and are used for truck rack loading. Tank #726 is a 96,000-bbl steel AST tank with a floating-roof and is used primarily for pipeline shipments. The roof is equipped with a flex-line roof drain. The sump wells are 18-inches deep and tanks are drained prior to issue or when rain or water intrusion is suspected. The receipt line extends straight 18 inches into the tanks with no loops or turns. It is offset from the suction line by 20 feet. The tanks floors are epoxy-coated extending three feet up the sides. A three-inch diameter sight glass is used to visually observe the removal of water from the tank sumps. The laboratory supervisor reported that all water removed is clear with no discoloration. Storage tanks are drained after quality acceptance and before issue to customers. No water gauging is performed and quantity determination is by meter. The JP-8 contract requires storage tanks to be cleaned every 5 years.

Tank #726 is connected directly to the multi-product pipeline that feeds the BP/AMOCO terminal located in Morehead, MN. The refinery makes 20,000-bbl batches for pipeline shipment once per month because of the small capacity of the Morehead terminal. Side sample taps are affixed to all storage tanks, however since tank #726 is never full all samples are obtained from a goose neck located 12-inches from the 3 inch water drain line. JP-8 is filtered from the refinery through a clay filter and two paper filters prior to entering storage tanks. All JP-8 shipped by pipeline contains one additive, corrosion inhibitor/lubricity (CI) additive. The Morehead terminal injects FSII and SDA.

The refinery ships to Minot AFB twice per week by tank truck. FSII and SDA are injected at the tank truck loading rack. The FSII injector is manufactured by GATE-PAC, model, EI 2007-1. Setting is at 0.10% to 0.15% as per specification requirement. FSII storage tank is 10,000 gallons equipped with a dryer. FSII is received by tank tuck from EquaStar, located in Bay Port, TX. The SDA injector is a GATE-PAC, Model, EI 0755-1, and the FSII tank has 500-gallon capacity. The tank trucks load at 600-gpm, not allowing for much turbidity. The JP-8 passes through a F/S vessel as tank trucks load.

3.8.19 Minot AFB

Minot AFB initially experienced AJ during 1995, soon after the conversion from JP-4 to JP-8. More recently Minot has experienced AJ on 16 separate occasions from December 1 through March 14. AJ was found seven times each in issue F/S #2 and issue F/S #3, once in tank #4 product recovery, and once in a hose cart. Since October 2000, Minot has received JP-8 from the Mandan refinery by tank truck. The average travel time from the loading point to receipt is 3 hours. They report receiving significantly less water in the fuel from Mandan than was the case when they were supplied by DFSP Grand Forks. All JP-8 is filtered upon receipt through a Facet, SS636FF vessel. During January, product receipt temperatures range from 28° to 13°F, while the temperatures of JP-8 at the time of issue ranges from 34° to 11°F. During August, receipt temperatures range from 81 ° to 65 °F, while storage temperature ranges from 76° to 67°F. JP-8 received at Minot AFB contains all additives upon receipt. The base has two types of receipt F/Ss: Facet, SS636FF/CC-K388B1, and Faudi separators, F.7-965 8806796 that are being tested at Minot for the sake of comparison. Personnel reported no significant difference between the Faudi coalescers and the NSN 4330-00-983-0998 coalescers ordered from stock. Issue/hydrant F/S vessels use Velcon separators, S0630VA, and NSN 4330-00-983-0998 coalescers manufactured by Velcon.

Minot Base Fuel Personnel are aware of the FSII, water and temperature combination causing a possible problem with AJ. A policy letter implemented a rigorous plan for water removal from all units and storage tanks. All systems and storage tanks are drained at the beginning of each shift. AJ occurrences have lessened since the adoption of the new procedures; however, small amounts are found almost daily. All above ground bulk storage tanks are 100% epoxy coated, modified floating-roof tank with **geodesic dome** covers. Tank bottoms slope to the center where a ¾ inch line to the sump well is located to remove BS&W. The issue (suction) line is 12 inches from the bottom and is located in the same area as the sump drain. During warm weather, the bulk tanks are drained for water daily through the product recovery system. After settling, the product is pumped back to the tank with a hand pump. During cold weather, the hand pumps freeze and tanks are drained manually into a jerry can, which are emptied into bowsers. Minot AFB stores 50,000 bbls of JP-8 and 3,500 bbls of JP-4. JP-4 is available to assist engine starts during cold winter months. The JP-4 is stored in a one fixed-roof tank. No AJ problems have been experienced with JP-4.

Minot AFB has seven Oshkosh R-11 refuelers and seven MH2C hose carts. They also have a Type II hydrant system with three independent pumphouses. They expect to break ground for a new Type III hydrant system during fiscal year 2002.

When JP-8 was received in August from DFSP Grand Forks, the FSII levels were between 0.11% and 0.14%, averaging 0.12%. From March 5 through March 21, JP-8 received from AMOCO Mandan, ND, FSII levels were from 0.12% to 0.16%, and averaged 0.14%. On March 21, the day of our visit the FSII concentration was 0.16%. SDA additive concentration levels in August averaged 263 CUs; however, throughout January of 2001, the SDA averaged 445 CUs. Reducing the concentrations of FSII and STADIS 450 may help reduce AJ occurrences at Minot AFB.

3.8.20 McConnell AFB

McConnell AFB has experienced Apply Jelly in a clear white form. The substance appears to be thick and gummy. This substance is quite unique and may be the result of a refinery process. A sample was sent to Southwest Research for analysis.

Four KC135s have found Apply Jelly in 2 main tanks after reports of fuel gauge problems. Two of the incidents were within a week of each other. All four aircraft had refueled at another location prior to reporting the problem to aircraft maintenance. The AJ found in the aircraft fuel cells was not as thick as the material drained from the fuel F/S mentioned above. During pre-flight inspection, KC-135 sumps are drained and crews report never having observed AJ. Aircraft fuel cells contain ribs with water outlets located at the bottom of the ribs, and the Apply Jelly seems to have difficulty draining through the outlets. Fuel cells must be entered and wiped out by hand. The KC-135 is equipped with three fuel pumps. The main fuel pump pressure is 35 psi. This pump feeds the low-pressure pump, which increases the pressure to 125 psi. The low-pressure pump feeds the high-pressure pump that increases the pressure to 450 psi at idle, and +1000 psi at full speed. The KC-135 is equipped with a filter bypass system that allows fuel to the engines if the fuel filters would become clogged. However, if the main cargo pump becomes clogged, fuel could not reach the engine. This may be unlikely because of the size of the intake and outlet of the main cargo pump.

The Air National Guard uses the same JP-8 from the same system as McConnell AFB and has not experienced any AJ. The ANG has the Oshkosh R-11 refuelers. Boeing engineers have reported a problem with AJ in their refuelers to the McConnell AFB Fuels Flight. Boeing loads their truck at the same location as the ANG at the McConnell AFB.

McConnell has established a more aggressive policy to remove water from the fuel system as a means to reduce the occurrences of the AJ.

JP-8 is received by dedicated pipeline from the CONOCO terminal approximately 1½ mile from the base. Tank trucks are received twice per year to exercise the truck receiving system. Pipeline receipts are usually scheduled for Wednesdays and are normally 614,000 gallons. After start-up, it takes about ten minutes to displace receipt lines. JP-8 is not filtered upon receipt, though the fuel is filtered as it leaves the CONOCO terminal. Tanks and F/S sumps are drained for water at each shift change, and tanks are drained each day while temperatures are below 55 degrees F. The FSII receipts range from 0.105% to 0.125%. Fuel conductivity averages 260 CUs, as measured by

McConnell AFB. Fuels Management has requested that the FSII maximum level be reduced to 0.11%.

All tanks are 100% epoxy coated. Tanks are above ground steel with **geodesic domes** and floating-roofs. Two 35,000-bbl tanks were constructed in 1950, and two 10,000-bbl tanks in 1998. These tanks slope to a center sump, which has ¾-inch water drain line. With one exception, suction lines extend to the center on a slight angle parallel with the tank floor, approximately 18-inches from bottom. There are no elbows on the suction line and the inlets are directly over the sump. Tank #1, a 35,000-bbl tank, is the exception in that the suction line has an elbow that is angled away from the sump.

McConnell has ten R-11 Kovach refuelers, a Type II and a Type III hydrant fueling systems and four Beta HSV-12s.

3.8.21 CONOCO Pipeline Company

JP-8 is supplied to the CONOCO terminal by multi-product pipeline from Ponca City, OK. The product is sampled upon receipt and tanks are equipped with side taps for representative sampling. The contractor obtains all samples. All transmix is diverted into one of the CONOCO tanks to be blended with commercial product. JP-8 is stored in three dedicated, above ground, steel tanks. Storage tanks are epoxy coated, bottom and 1 1/2 feet up the sides. Tank bottoms slope to the edge and are equipped with water sump drains. Tank #1259 has a common receipt and issue line. It is a flat bottom tank equipped with four sump drains, one at the center and three around the edge. Tank #202 receipt line extends 5 feet into the tank and the suction line is 10 inches from the bottom with a ninety-degree elbow; the line is equipped with a vortex diffuser. Tank #1258 suction line extends 12-inches into the tank and is set on a pedestal 10-inches off the bottom. Sump wells are from 18 inches to 3-feet deep. Water draw-off lines are 2-inches in diameter. Storage tanks are cleaned at 5-year intervals in accordance with contract requirements. The terminal has three FSII tanks, one 4,000-gallon and two-2000 gallon tanks. The SDA tank has a 15 gallons capacity. The filter is equipped with 6-Velcon elements, FO-644 PLF. There are 7-Velcon coalescing elements, I-644 85 TB and three screens, SO 636 PV.

Water is removed after each receipt and all water is drained through the oil-water separator. **Their procedure is to drain the sumps until "the brown color turns clear."**

FSII and SDA are injected into a 6-inch receipt line during receipt, after the product passes through a 0.5-micron filter. After injection, the product travels through nine 90-degree elbows before entering the tank. Receipt pressure is 25 psi. The injector is a GATE-PAC manufactured by Milton Roy. **The FSII injector enters the JP-8 receipt line and is flush with the inside surface of the JP-8 receipt line**. SDA is blended 9 to 1 and is also injected into the receipt line as described above. The FSII concentration has been lowered to 0.11% at the request of McConnell AFB Fuels Management. The FSII receipts range from 0.105% to 0.125%. Fuel conductivity averages 260 CUs, as measured by McConnell AFB.

Fully additized prior to shipment and normally settled for 4 days, JP-8 is shipped to McConnell AFB by dedicated pipeline. Pipeline shipments are filtered through the same .5-micron filter and coalescing elements as fuel receipts. Approximately 16 ounces of AJ-like materials are found in the separator unit each time the elements are changed. Element changes are based on differential pressures. Pipeline shipments to McConnell normally take 26 hours to complete.

3.8.22 Edwards AFB

Edwards AFB first experienced AJ on January 31, 2001. When sampling R-11 refueler 96L-144 using a single filter monitor, the Quality Control Specialist observed orange specks on the filter membrane. When observed under the microscope, the specks appeared to be AJ. *Note that this event is the first reported detection of AJ being identified in a quality test performed downstream of the final filtration before fuel enters the aircraft*. Subsequent use of the refueler resulted in collecting samples of AJ from the F/S sump. Upon the differential pressure reaching the maximum, the refueler was put in maintenance for element change. Visual examination of two samples of the material from this refueler appeared to be AJ to both team members. In one sample the material adhered to the bottom of the container while the other sample was in a fluid state. The base has also observed a limited amount of AJ from Oshkosh R-11 refueler 91L-69. This refueler is being monitored and the differential pressure has not increased. The base sent samples to SwRI along with a sample from one of the filter elements removed from Kovach refueler 96L-144. The two R-11 refuelers, 96L-144 and 91L-69, and the transfer F/S between bulk storage and the hydrant systems are the only locations where AJ has been found. One of the refuelers has a horizontal F/S and the other has a vertical F/S.

On March 13th, prior to our arrival, the differential pressure on refueler 96L-144 was recorded as 4 psi @ 400 gpm during re-circulation through the F/S. During recirculation of 20,071 gallons of fuel on March 19th, while on our visit, the differential pressure was recorded as 1 psi @ 400 gpm. After this re-circulation, about ¼ inch of AJ was collected in a quart jar from the F/S sump drain. The starting fuel temperature was 74ºF, and upon completion of the transfer, the temperature of the fuel was 81ºF. The differential pressure decrease is somewhat puzzling. One possible explanation is that the circulating fuel is washing AJ out of the elements and into the sump. The same refueler was used on March 20th to transfer another 15,107 gallons through the F/S. The starting fuel temperature was 57ºF, and the fuel temperature upon completing the transfer was 67ºF. The differential pressure upon completion of the transfer was 2 psi @ 400 gpm which was an increase from the pressure on March 19th. Mr. Carr, the Liquid Fuels Maintenance Foreman, invited us to look at the elements removed from the transfer F/S between bulk storage and the hydrant systems. We examined a number of these elements and selected one that had an orange discoloration along the bottom portion of the element. This element was cut open and a sample of the orange material was removed for microscopic examination. Under the microscope, the material appears to be AJ. This material was shipped to SwRI for further analysis.

All products, except JP-8, are received by tank truck. JP-8 is received by pipeline from DFSP San Pedro by way of the Kinder Morgan Pipeline (KMP) to Carson (better known as Watson

Station) breakout point. Product leaves Watson Station breakout point via KMP to Colton. Here it splits and goes to March AFB or Luke AFB or to CAL/NEV breakout tanks which are across the street at Colton. Product then leaves Colton in the CAL/NEV line for Las Vegas. As product travels to its primary destination, Las Vegas, small batches (5000 – 6000 bbls) are heart cut at Adelanto into tanks for subsequent shipment to Edwards AFB. The 6-inch pipeline from Adelanto to Edwards provides a receiving rate of 21,000 gph at Edwards. The average receipt quantity at Edwards is 100,000-120,000 gallons and requires 5 – 8 hours. Pipeline displacement time from Adelanto to Edwards is 23.5 hours; therefore, it takes an average of 3 or 4 receipts to completely displace the line.

Adelanto has two 20,000-bbl floating-roof tanks and one 25,000-bbl tank both with geodesic domes. This location is completely automated. FSII and SDA are injected into the small batches (5,000 – 6000 bbls) of product for later shipment to Edwards after completion of B-1 testing.

Fuels issues vary considerably at Edwards depending on the aircraft testing in progress. At times defuels exceed issues. The average daily issues are normally about 75,000 gallons. Defuels primarily involve home station aircraft.

Edwards has two above ground JP-8 bulk tanks. Tank #19 has a capacity of 20,000-bbl and tank #28 is a 10,000-bbl tank. **Both tanks are equipped with floating-roofs without covers. Seals on both tanks are in bad condition and tank #19 is out of round. After a recent heavy rain 2,000 gallons of water were removed from the two tanks and associated fill stand F/S sumps**. Tank #19 has floating suction verified by drawings. Tank #28 was reported to also have floating suction, however drawings were not available to verify this. **On tanks #19 and #28, the ineffective product recovery systems have been abandoned and removed.** The tanks were retrofitted with 1½-inch valves and hoses that adapt to their 600-gallon bowser for a more effective system of removing water and emulsion from the tanks. Fuel is not filtered upon receipt, and the first filtration occurs as the product is transferred to hydrant operating storage. The transfer F/S uses American Bowser vessels with the old style DoD NSN 4330-00-983-0998 elements manufactured by Velcon, which are also used in the Type I and III hydrant system F/S vessels. The bulk storage area has the capability to load refuelers but is rarely used due to travel distance.

The three 8,000-bbl JP-7 tanks have suction lines directly above the center sump and are equipped with inadequate product recovery systems. It was noted that these tanks have sections of fiberglass-reinforced pipe and one flange has a small seep. FSII levels averaged 0.11% in storage and at time of issue with a fuel conductivity history range of 70-110 CUs. When tested for fuel moisture content, one refueler had 5-ppm water with AJ.

Edwards AFB has eighteen R-11 refuelers (one Kovatch, seventeen Oshkosh) and five hydrant servicing vehicles (HSV–12s). Water absorption elements replaced the coalescer elements in the refueling trucks beginning in September 1999. Two trucks are dedicated for use of JP-8+100, though the quantity used is small. The +100 additive is injected at the truck fill stand.

Hydrant System 1 (facility 1724) has four 50,000-gallon horizontal cylinder tanks sloped to the sump end. Three are used for JP-8 and one for JP-4. This facility is used primarily to fill 95% of the refuelers at Edwards. There are 3 Bowser, 2 Gil, and 1 American Pipe and Steel F/S vessels with the old DoD style elements manufactured by Velcon.

The Type III system has minimum use. It has two 12,000-bbl fixed-roof operating tanks. Product recovery systems equipped with hand pumps, ¾-inch lines and small (approximately 30-gallons) product recovery tanks. This system has minimum utilization because helicopters occupy the hydrant outlets, precluding access to the outlets by large aircraft. There are 2 Gil V-600 and 3 Gil V-1200 F/S vessels with the old style elements manufactured by Velcon.

3.8.23 Kinder Morgan Holding Tank Facility

The breakout tank that supports Beale AFB is a 30,000-bbl holding tank. The tank is a flat bottom, **floating-roof tank without cover**. The tank has a floating suction line attached to the floating-roof. Product is received from the Rocklin breakout tank that is used for aviation and diesel fuels. The KMP pipeline from Rocklin to Erle Junction is 8 inches and from Erle Junction to Beale is 6 inches. Transit time is 9 hours with product moving at about 5 mph providing a receiving rate of 1,350 bbls/hr into the KMP holding tank BE1. Product is filtered upon receipt through a Warner Lewis Model HP-1000 horizontal vessel rated at 1,000-gpm. This is a micronic filter primarily used for particulate and does nothing for water removal. Tank BS&W is drained into a 6,000-gallon wastewater tank. Wastewater is drained prior to each receipt and after heavy rains. The water drain line is equipped with a visa-flo gauge and draw off valve for water/fuel interface monitoring. The wastewater tank is emptied about twice each year.

SDA is aspirated in the concentrated form into the line and tank-heal at the beginning of each receipt, proportional to the expected quantity of the receipt. FSII is proportionally injected into the line using a Milroyal model MRI-69-113S17 injector as the product is received into the holding tank. This injector is equipped with a Rockwell Meter which measures the quantity of FSII injected and is then compared with the before and after stick readings on the 6,000-gallon FSII tank. The FSII tank (BE-A1) has a pressure vacuum relief and breaths to the atmosphere. The FSII tank is replenished on average twice each year through DESC contract delivery by tank truck.

3.8.24 Beale AFB

During November 2000, Beale AFB found a gel-like substance when draining the F/S sump of Kovatch R-11 97L-358 on two occasions. On December 1, 2000, checkpoint personnel noticed globs of AJ coming from the F/S sump on R-11 refueler 98L-005. This was followed by periodically obtaining 50 ml trace quantities of AJ. Absorption media elements were installed in the refuelers during August 2000.

On December 13, 2000, traces of AJ contaminant were found in the F/S sump on MH-2C # 81W0104. Since there were no replacement elements available, the housing was cleaned and the hosecart was returned to service. On December 13, 2000, two other hosecarts (81W0109 and 81W0111) were opened and examined and no evidence of AJ was found.

On January 2, 2001, hosecart 81W0104 was re-inspected (filters removed) and 700 ml of AJ was found inside the vessel near the sump. The 700 ml sample from the hosecart along with AJ found in the sump of R-11 97L171, were forwarded to the Mukilteo Laboratory for analysis. Test results were received on January 17th for R-11 97L038 and hosecart 81W0104. The Mukilteo Laboratory reported that the samples contained FSII and water. No other constituents were identified. Interestingly, FSII made up 75.7% of the R-11 sample and only 38% of the hosecart sample. The R-11 sample was described as the "truest form of AJ" that they have seen at the Mulilteo Lab.

JP-8 for Beale is refined at ARCO, Ferndale, WA and tendered into DFSP Selby at Crocket, CA. From there it enters the Kinder/Morgan Pipeline (KMP), passing through their Concord, CA terminal and on to their Rocklin, CA terminal. From Concord it enters KMP's Chico, CA pipeline onto Erle Junction where it is cut over to Beale AFB. It then goes into KMP's 30,000-bbl tank located next to Beale tank farm. Once the product passes quality testing, tank lockouts are removed and Beale is then able to draw from the tank as needed. Additives (FSII and SDA) are injected into the line where it comes out of the ground, prior to passing through a 10 micron Velcon horizontal filter and on into the KMP tank. The fuel also passes through a metering device just after leaving the filter chamber then on to the tank inlet that ends in a mixing nozzle. The tank has a **floating-roof.** The FSII additive tank and injector pump are about 50 feet from the injection point.

Beale normally receives about 100,000 gallons of JP-8 twice a week. Issues are 25,000 to 30,000 gallons per day.

Inventory minimum levels were increased in December 2000, therefore, smaller and more frequent receipts are required. Settling times between receipts are less. Due to a history of water in the receipts, a haypack dehydrator was installed January 5, 2001, but the system is not operational. The contractor has not yet released it to the US Air Force. This system makes no provisions for the proper containment and collection of water discharged from the vessel. Normally, when a dehydrator is installed, the separated water discharges into an oil/water separator. We were told that the state of California EPA would not approve an oil/water separator.

When discussing this issue with the LFM Supervisor, MSgt Grygierczyk, he explained the dehydrator would shutdown when receiving excessive water. When shutdown occurs, operating personnel will have to drain the vessel into barrels for disposal as hazardous waste. The LFM Supervisor is developing start up tests and procedures, and working directly with Kinder Morgan Pipeline personnel to determine if the system functions as designed. On the initial attempt to pump through this system, the Kinder Morgan automated system shut the pumps off due to inadequate flow through the vessel. The flow was reduced from 735 gpm to 235 gpm when the dehydrator was placed on line. MSgt Grygierczyx is confident that the flow control valve on the dehydrator will allow him to adjust the system to a flow that will not decrease the incoming flow rate through the 4 inch line, which is 735 gpm.

The JP-8 fillstand at bulk storage has one Facet F/S model number VFCD-D-6N39SB-3S630FD. Elements required are six CA43-3SB coalescers and three SS330FD separators.

There are two operational 15,000-bbl tanks (#10 and #11) both of which have geodesic domes and floating pans. **Due to design of the geodesic domes, blowing rain penetrates the vents on the skirts of the domes**. The vents are louvered, approximately four feet wide and surround the periphery of the tank. Both tanks have cone-down bottoms with center sumps and the discharge suction lines are positioned directly above the sumps. The tanks are equipped with product recovery systems, which discharge directly through about 1½-inch lines into 30-gallon product recovery tanks. Collected water and fuel are drained into a 600-gallon bowser for separation and proper disposal. Tank water drains are inspected daily and drained as needed.

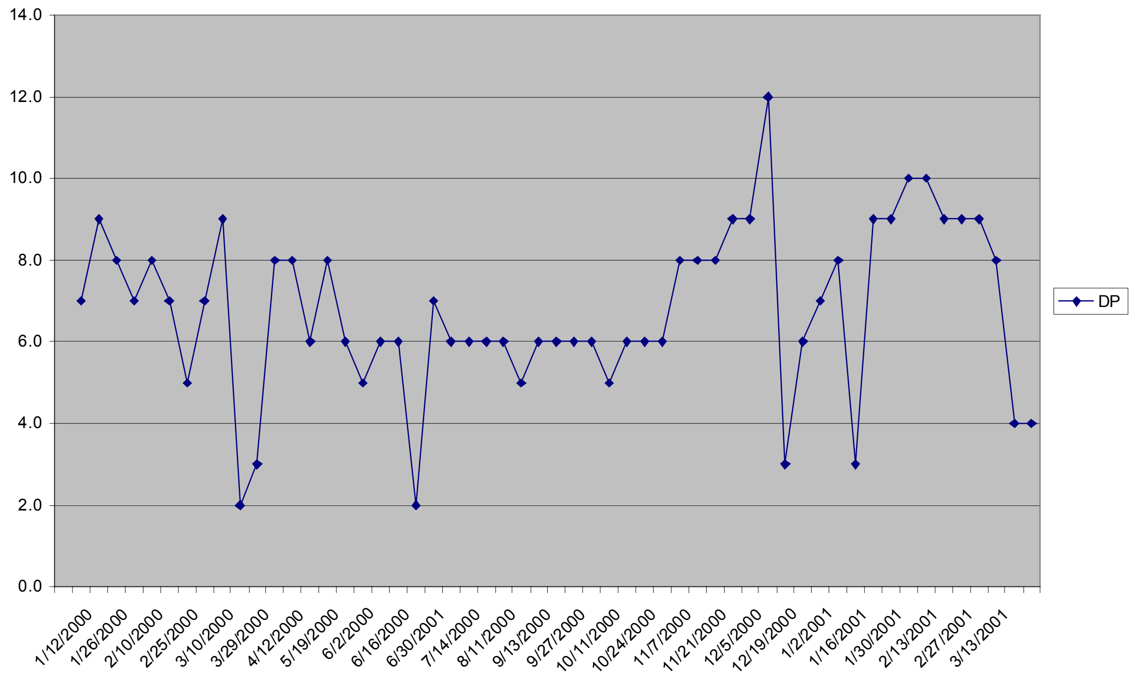
A third tank, #14, has been inoperative since 1996 and is programmed for extensive repair including a new bottom. This is a 10,000-barrel tank. Upon completion of this project, the availability of this tank should reduce the frequency of receipts and will accommodate greater settling time.

Beale AFB has four Kovatch R-11s and one Oshkosh R-11 in JP-8 service, as well as eight MH2C hose carts, which have NSN 4330-00-983-0998 filter elements. Five R-11 refuelers are used for JPTS support, three Oshkosh and two Kovatch.

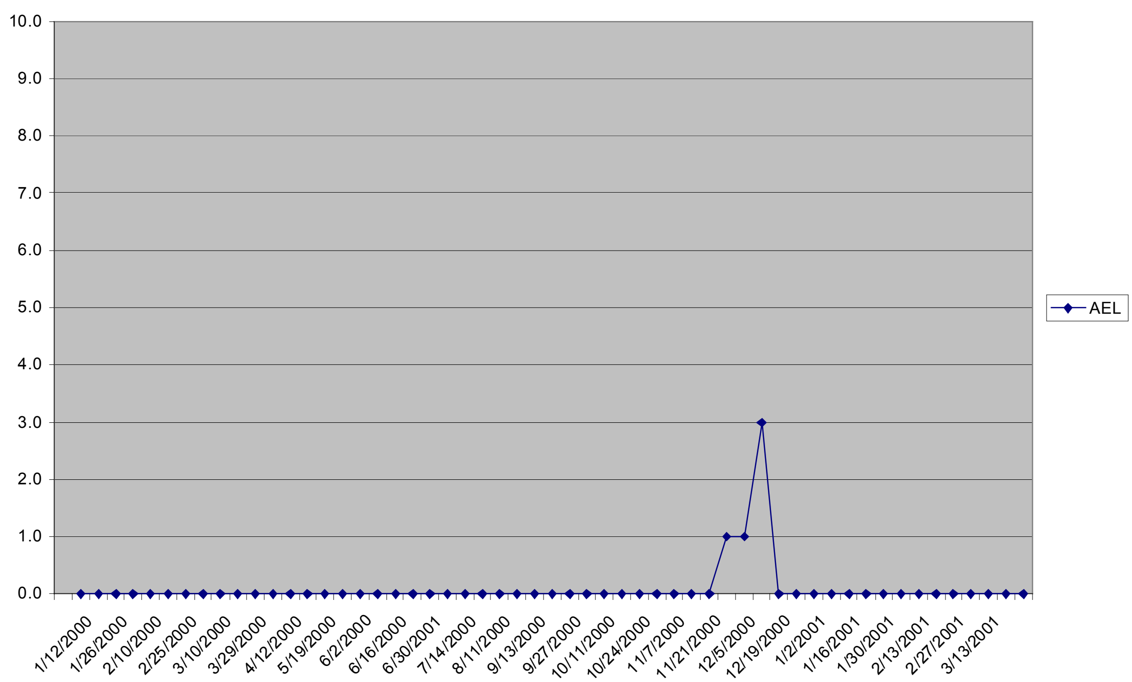
Products stored at Beale AFB are JP-8 and JPTS. There are three above ground steel JPTS tanks in the bulk storage area. These tanks have fixed dome roofs and there are no vents that allow rain to penetrate the tanks. These tanks are equipped with product recovery systems that facilitate removal of any water present in the tanks from condensation etc. Delivery of JPTS is by 20,000-gallon railcars. Prior to off loading the railcars, they are inspected for water and any water found is drained. Beale AFB personnel report they have not experience any problems AJ in JPTS.

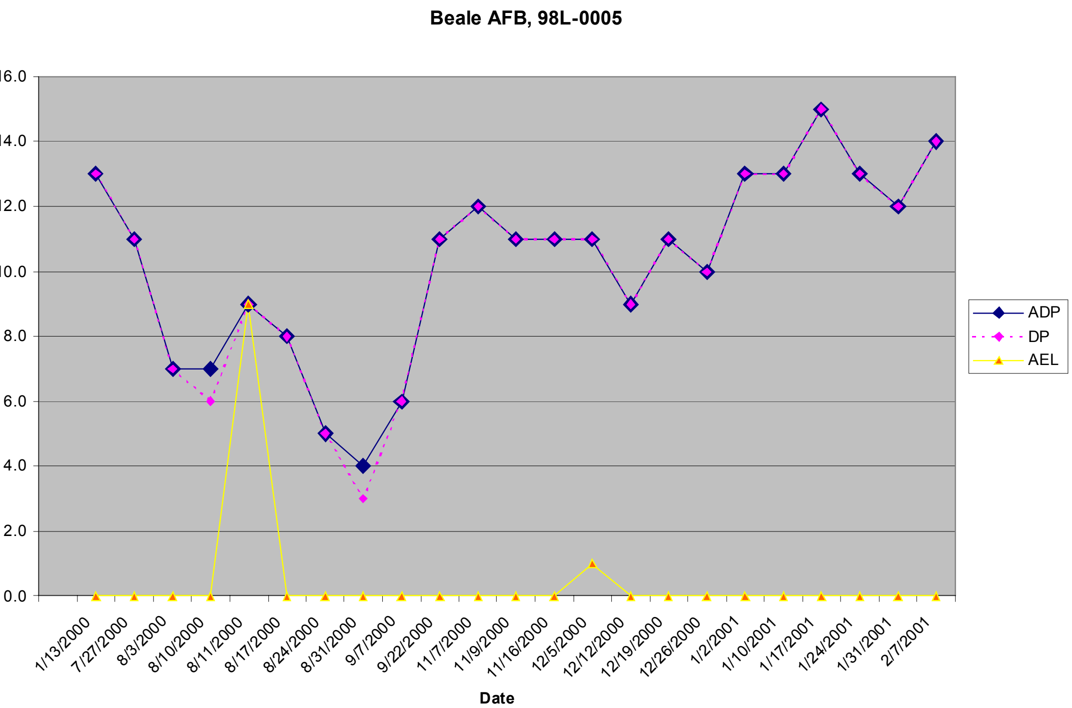
Data on FSII and CU test results with associated temperatures were downloaded from the FAS system. This information has been entered into graphs. A few of these graphs are presented below; others are presented in Appendix E-27. Note that even slight increased in AEL test results of free-water content is followed by an increase in differential pressure. While that would be expected, the drop in differential pressure that follows surprises us. That may indicate that the free-water content is washing AJ materials out of the absorption elements.

Beale AFB, CA 97L-0358 DP

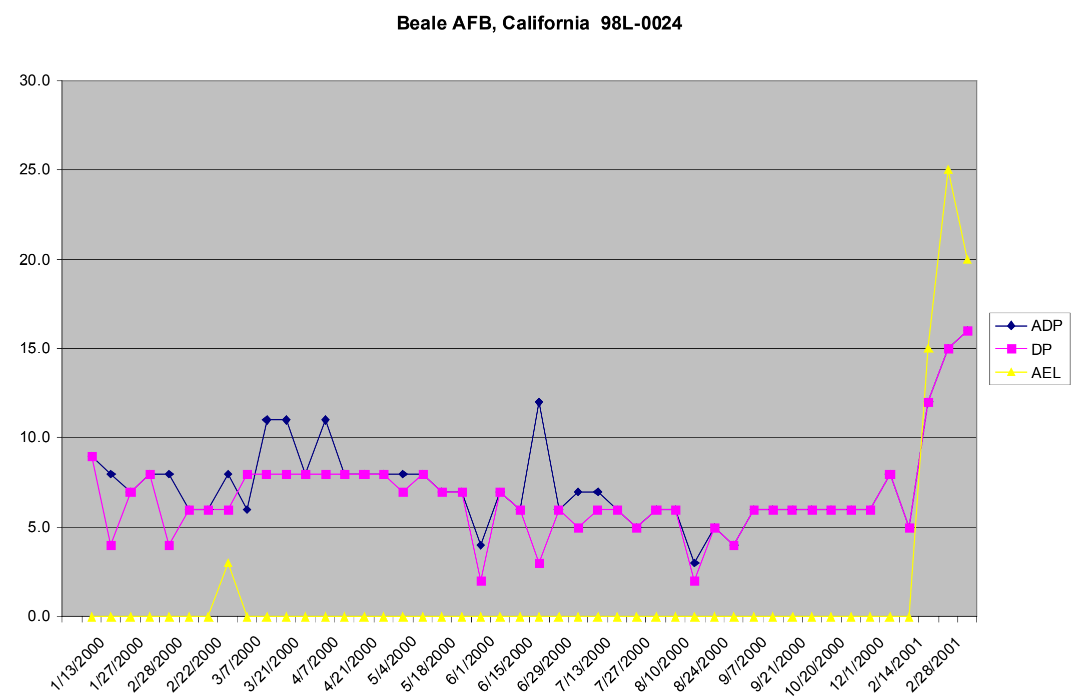


Beale AFB, CA 97L-0358 AEL





Beale AFB, 98L-0005
ADP
DP
AEL
Date



Beale AFB, California 98L-0024
ADP
DP
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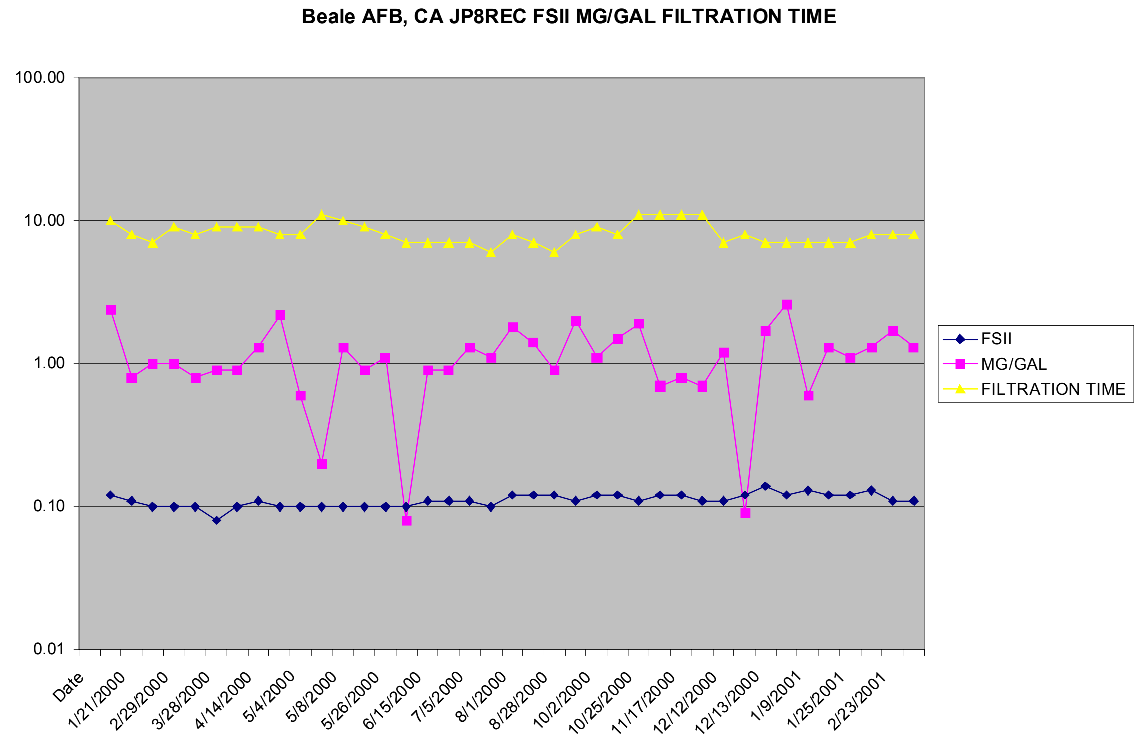


3.8.25 Fairchild AFB

Fairchild AFB first encountered AJ on December 13, 2000, after differential pressures on the filter-separators of four Kovatch R-11 refuelers rapidly increased. In addition, AJ was drained from the cargo tank sump (upstream of the F/S) from one truck. The R-11 refuelers were equipped with **Facet water absorption media elements during June 2000**. The AJ was traced back to bulk tank #4, where they drained two or three quarters of AJ each day for several days. Following a transfer between Tank #4 and Tank #1 (20,000-bbl), AJ was also identified in Tank #1. Tanks #1 and #4 both have center-down cone bottoms with the suction lines located immediately above the bottom, sediment, and water sumps. Storage operators report that following heavy rainstorms, it is not unusual to drain 30 gallons of water from Tank #4. Little water is found following product receipts. An active tank and vehicle sump-draining program has significantly reduced the amount of AJ drained from bulk tanks and vehicles, though AJ continues to be found periodically.

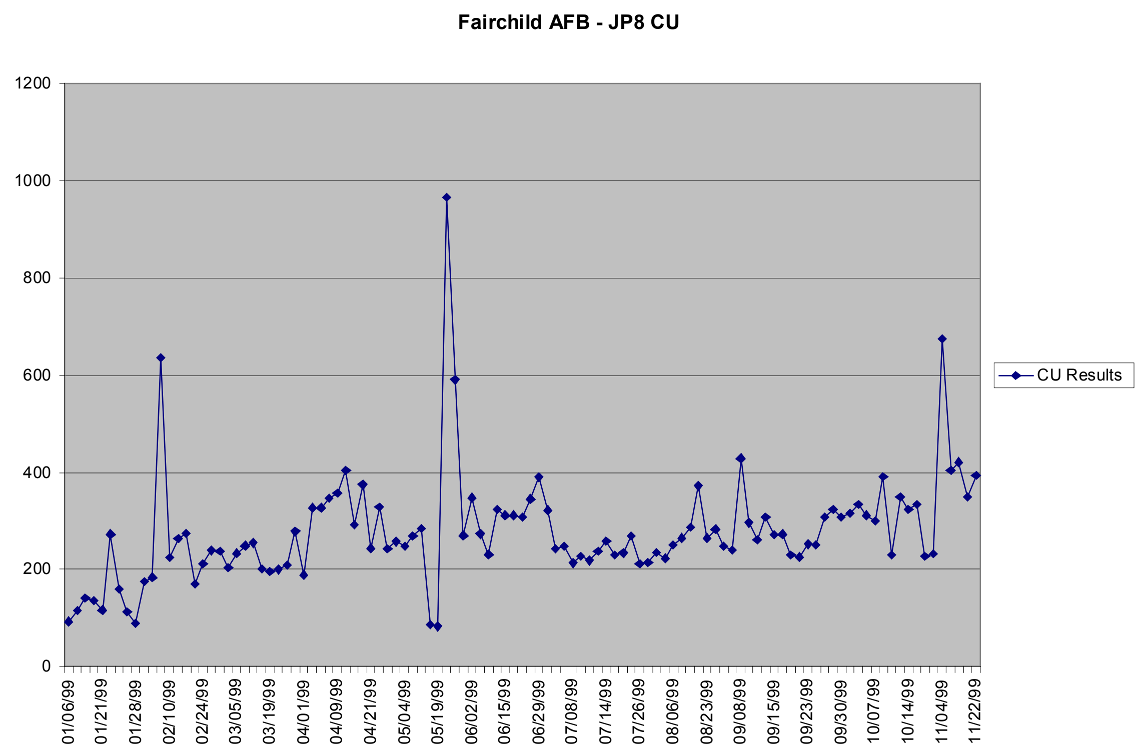
JP-8 receipts range from 10,000 to 20,000 bbls. The JP-8 is moved by barge from DFSP Portland OR where it is loaded on barges that travel up the Columbia River for approximately 35 hours prior to arrival at DFSP Pasco. It takes about 12 hours to off load a barge into Chevron's 30,000-bbl tank at Pasco, WA. After the tank has settled approximately a day and a half, the tank is sampled. Following certification, the product is scheduled into the Chevron pipeline for delivery (approximately 150 miles and 60 hours later) to the Chevron Detection/Injection point. At this point the fuels passes through two filter separators used simultaneously, in parallel. FSII and SDA are injected approximately 25 feet downstream of the F/S. There is no breakout tank at the Chevron Detection/Injection station, and the fuel moves directly into bulk storage at Fairchild AFB. The JP-8 moves though the Chevron Detection/Injection station at a rate that ranges from 16,800 to 31,500 gph through a six-inch pipeline. The above ground FSII storage tank is not equipped with moisture control (such as a desiccant or nitrogen blanket) but has a standard vacuum pressure vent and breathes to the atmosphere. The Government owned deliveries of FSII (6,000 tank trucks) are sampled at the loading point, but FSII in the Chevron tank is not sampled. FSII and SDA are injected with Gates City Injectors. The points of injection are approximately 10 inches apart. The Chevron facility is an automated station, though it is manned during receipts. It is an attractive station, constructed in 1996, and appears to be well maintained and managed. A continuous, automated sample is extracted from each receipt. The Chevron station manager, Dave Otto, reports that Pipeline Drag Reducer is not used for any product moved through the Chevron line.

The bulk storage at Fairchild AFB consists of two fixed-roof 20,000-bbl tanks. One is equipped with a vapor recovery dome. In addition, there is a 5,000-bbl tank, and a 30,000-bbl floating-roof tank with a geodesic dome designated as Tank #4. **The geodesic dome on Tank #4 is ineffective in keeping water from entering the tank.** The floating-roof in Tank# 4 leaks due to an ineffective tank seal that permits water to enter the fuel. FSII from the tank water bottoms was identified as damaging the epoxy around the tank perimeter. A project to make significant repairs to the three largest bulk storage tanks is at 35% design and badly need to resolve the AJ problem at Fairchild. This project will replace the floating pans in two tanks and the floating-roof in Tank #4. The 5,000-bbl tank will be removed. The product recovery system is ineffective and should be reviewed for possible inclusion in this project. We also recommend that the positioning of the product suction lines in these tanks be reviewed to insure that bottom sediment and water is not easily picked up and forced into the F/S**. Our investigation indicates that water does not readily settle from JP-8. While we realized that this would be the situation because of the higher density of JP-8 (as compared to JP-4) we now are concerned that the problem of water retention within JP-8 is far more serious than we previously believed. Alternative methods of water removals, such as the use of a centrifuge (typically used by the Navy in the handling of JP-5 on board ships) or smart use of "haypack" dehydrators, should be explored.**

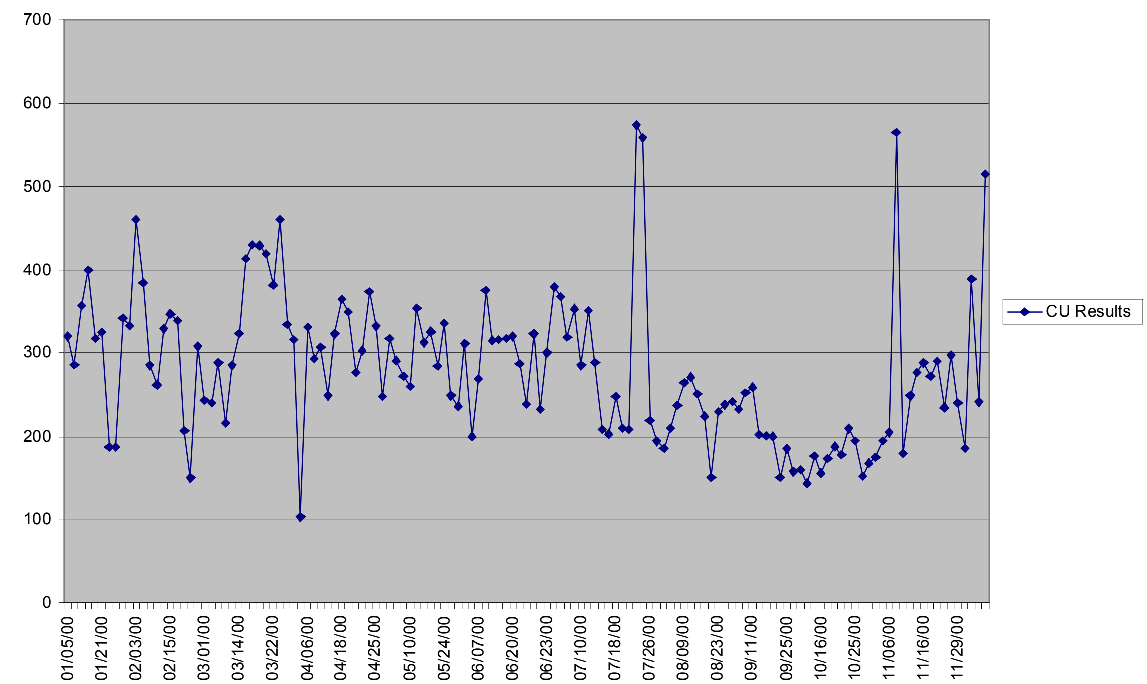
Fairchild has 10 assigned R-11 refuelers, 6 Kovatch and 4 Oshkosh. Water absorption (JP-8+100) elements were installed in these refuelers during the period from June through December 2000. There are five hydrant servicers, 3 R-12Cs and 2 R-12s. The R-12C does not have defuel capability.

Fairchild AFB has a Type II and a Type III hydrant system. Hydrant System A is a Type II system with 10 each Bowser 842 vertical F/S vessels used to issue to a truck fill stand and KC-135 aircraft. This system is being replaced with a Type III system that is currently under construction. We drew a sample from the sump of the F/S with widest differential pressure spread over the last 30 days (3-12 psi) and found the sample to be clear and bright with no indication of free-water or AJ. Hydrant System B is a Type III system with seven horizontal API Group II, Class B, 600 GPM vessels. The F/S vessels were manufactured by Facet (CFCS-D-7K395B-1-2 636FM) and use seven CA38-35B coalescer elements and two SS636FF separator elements. Two F/S vessels are used to filter transfers from bulk storage and five are used for hydrant issues. These F/S are flow rated at 600-gpm and are all the same model and manufacturer. The hydrant systems are normally used to refill JP-8 refuelers in lieu of traveling to the bulk storage area.

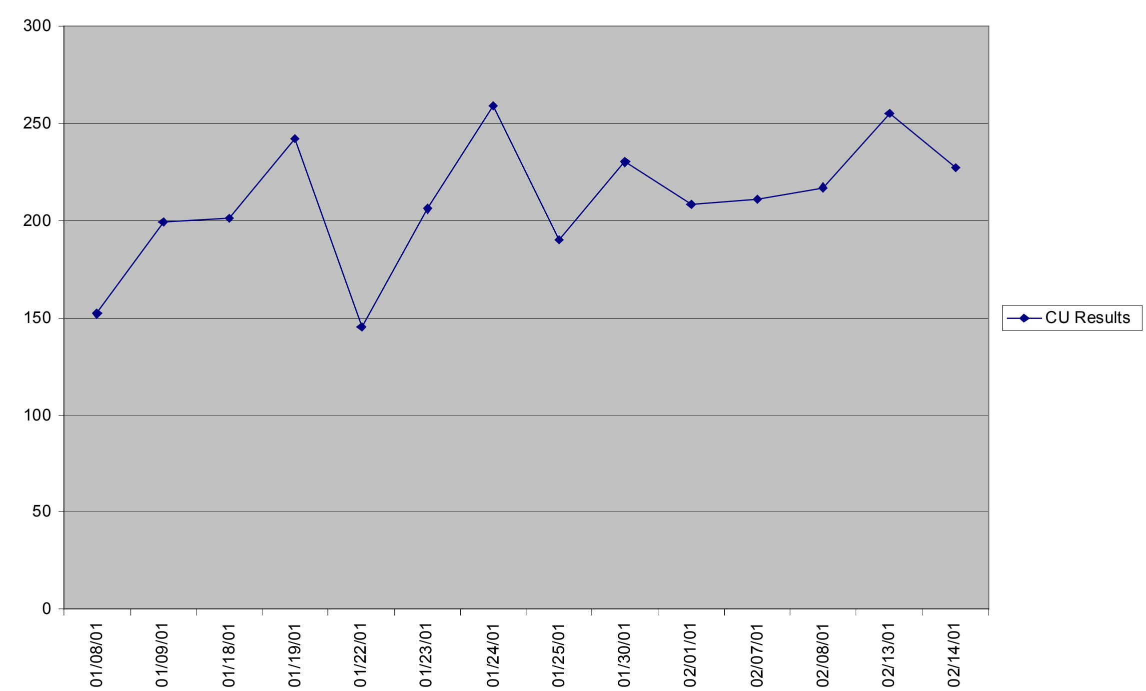
In general terms, the fuel is received clear and bright. FSII readings on receipt range from 0.09% to 0.15% and conductivity ranges from 219 to 560 CUs. Additionally, we measured the conductivity of an AJ sample that was stored in the fuels laboratory. Fuel from the sample was separated from the AJ and tested separately. The fuel had a conductivity level of 3,000+ while the AJ reading exceeded 4,000 CUs. Data on FSII and SDA test results with associated temperatures were downloaded from the FAS system. This information is provided in graphic form below.

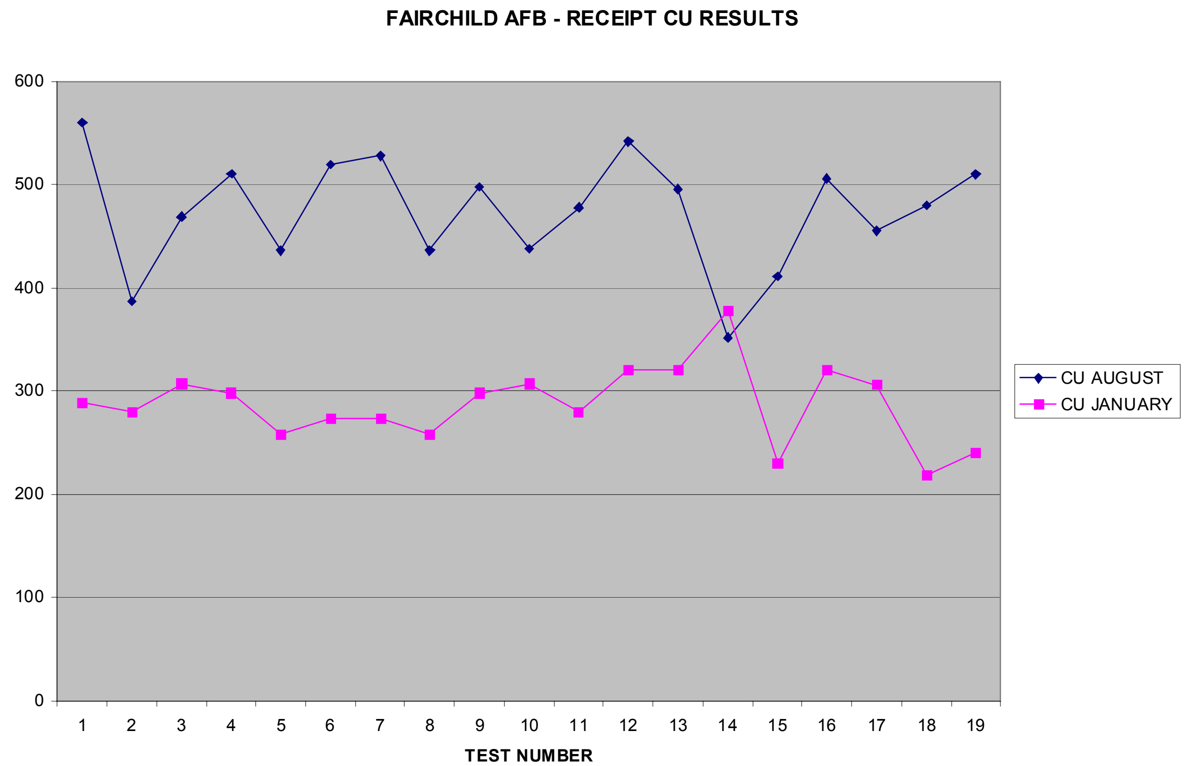


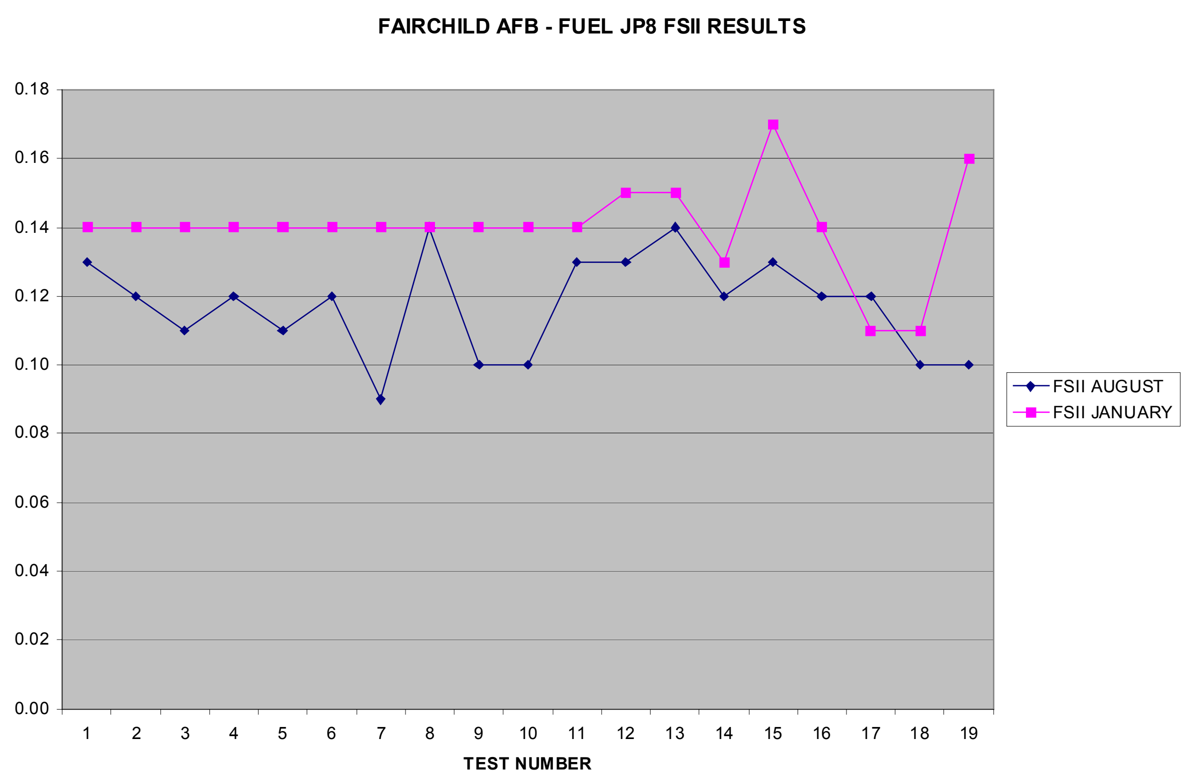
Fairchild AFB - JP8 CU



Fairchild AFB - JP8 CU




FAIRCHILD AFB - RECEIPT CU RESULTS
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
TEST NUMBER
CU AUGUST
CU JANUARY


FAIRCHILD AFB - FUEL JP8 FSII RESULTS
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
TEST NUMBER
FSII AUGUST
FSII JANUARY

3.8.26 US Oil & Refining Company

US Oil & Refining Company, which supports McChord AFB, refines 36,000 bbls of North Slope Alaska crude each day. They produce gasoline, kerosene, diesel, bunker fuels, and asphalt. The production yields about 10,000 bbls of vacuum gas oil a day. From this, they produce Jet A for Boeing and JP-8 for McChord. Jet fuel is manufactured continuously and they ship two to three times per week. The increased demand for JP-8 at McChord has pushed the refinery to the limit and they operate at maximum capacity. During 1996, US Oil bought the Buckeye pipeline that historically supplies McChord AFB. The constructed a one-mile section of 6-inch diameter pipeline to connect the refinery to the old Buckeye line. The Buckeye pipeline previously pushed product from barge deliveries at the port to McChord. There was a history of water problems during this period, which seems to have been abated with the direct line from the refinery.

U.S. Oil produces a straight run jet fuel, and they use a "Merichem" caustic for removal acid and color bodies. The Merichem process does not require a water wash. Salt towers are used to extract moisture. Following caustic treatment, the fuel passes through two clay beds that are installed in series. An anti-oxidant is injected downstream of the clay filters, and the product is then held in one of the two 30,000-bbl tanks for Quality analysis and certification. Corrosion Inhibitor (Unicor J), Fuel System Inhibitor, and Static Dissipater Additive are injected as the product is put into the dedicated pipeline for transfer to McChord. A Blend-Pak Plus Injector System made by Gates City Equipment, Atlanta, GA is used to inject the additives. Injected quantities are metered and closely monitored, and the system shuts down automatically when variances are unacceptable. No filter separator is provided for pipeline transfers, **though F/S vessels are provided at the truck rack where Jet A is loaded for Boeing.** Bottom water and sediment are drained from the tanks "religiously" prior to each pipeline shipment. Only 60 feet of the 14.5-mile pipeline is above ground. Pipeline drag reduce (PDR) is not used in this dedicated JP-8 supply line, though it was not clear whether or not it is used in the movement of Alaskan crude.

3.8.27 McChord AFB

The first encounter AJ at McChord AFB occurred during the fall of 1999 when AJ was noticed in the fillstand F/S vessel at bulk storage. There are three Warner Lewis horizontal filter vessels installed on the bulk storage fillstands. These are the old DoD standard vessel with Banner NSN 4330-00-983-0998 elements. (These vessels should be modified or replaced.) Mr. Terry Brown, Bulk Storage Supervisor, said when they noticed the substance, he didn't realize what it was and learned later that it was likely AJ. This experience motivated the Bulk Storage personnel to implement an aggressive tank bottom water-draining program beginning the fall of 2000. They drain or perform a product recovery after every receipt and twice a week minimum on inactive tanks. This effort is likely the reason why no AJ has been seen in the F/Ss downstream of the bulk tanks since the fall of 1999. However, on 13 February 2001, the receipt F/S on the six-inch pipeline from the US Oil and Refinery was overwhelmed with a dark brown sticky substance. There are two 600-gpm API 1581 Group II Class B Facet horizontal F/S installed on the receipt line at the custody transfer point. Mr. Brown explained that the

F/S differential pressure began increasing on each of the last three receipts, which were 7,000 bbls each. The F/S vessels are in parallel and are rotated every other receipt. When the differential pressure reached the maximum allowable of 15 psi, the F/S vessels were shutdown, and upon removing the elements from the first vessel, operating personnel found the elements completely coated with the dark brown sticky material. The elements from the second vessel, which had also reached the maximum on differential pressure, were not completely covered, as was the case with the elements from the first vessel. An element from the first vessel having an abundance of the dark brown material was forwarded to the US Air Force Fuels Laboratory at Wright Patterson for an analysis. A second element was provided to the product supplier, the U.S. Oil & Refining Company. No finding had been reported at the time of our visit.

During our visit to the U.S. Oil & Refining facility, they recovered one of the filter elements containing the dark brown, tar-like substance from storage in their laboratory. With their permission, we cut a swatch of material from the element for forwarding to the SwRI laboratory. We examined the element in great detail and attempted to dissolve the substance with hot water without any luck. We were unable to come to any conclusion concerning the substance. In its original liquid state, the heavy liquid penetrated the pleated paper filter and lodged in the outer coalescer sock portion of the element. It is assumed that a portion of the material washed through the element during the three 7,000 bbl transfers, as the differential pressure increased steadily.

Approximately 80% of the JP-8 product is received from US Oil and Refining via the 6-inch pipeline. This is a dedicated pipeline that extends from the refinery to McChord AFB, a distance of approximately 14.5 miles. The remaining 20% of product comes from the Manchester DFSP and is delivered by tank truck. Tank trucks are received from Manchester three days a week. The pipeline-receiving rate is 435 gpm and the hydrant transfer rate is 1,000 gpm. Two or three pipeline shipments are received each week. Product is received with an average temperature of 46ºF in January and an average temperature of 69ºF in August. The average FSII receipt content ranged from 0.10 to 0.14% with an average of 0.12%, and the fuel conductivity ranged from 68 to 128 CUs in January with an average of 76 CUs and from 119 to 193 CUs with an average of 137 CUs in August.

McChord AFB has four above ground steel tanks equipped with floating pans and geodesic domes. **Tank #A-5, a 12,000-bbl tank, has a leaking geodesic dome. Because of frequent rainstorms and high winds in the Tacoma area, removing water from this tank is often a daily chore.** The capacities of the four tanks are 5,000 bbls, 12,000 bbls, 17,000 bbls and 20,000 bbls, providing a total capacity of 54,000 bbls. Bulk Storage personnel monitor these tanks closely for water. As an example, on the March 28, 2001, 60 to 70 gallons of a milky emulsion was removed from the leaking tank #A-5 while a total of 300 hundred gallons were removed from the other four tanks. It was reported that most of the water removed was entrained water in a fuel emulsion.

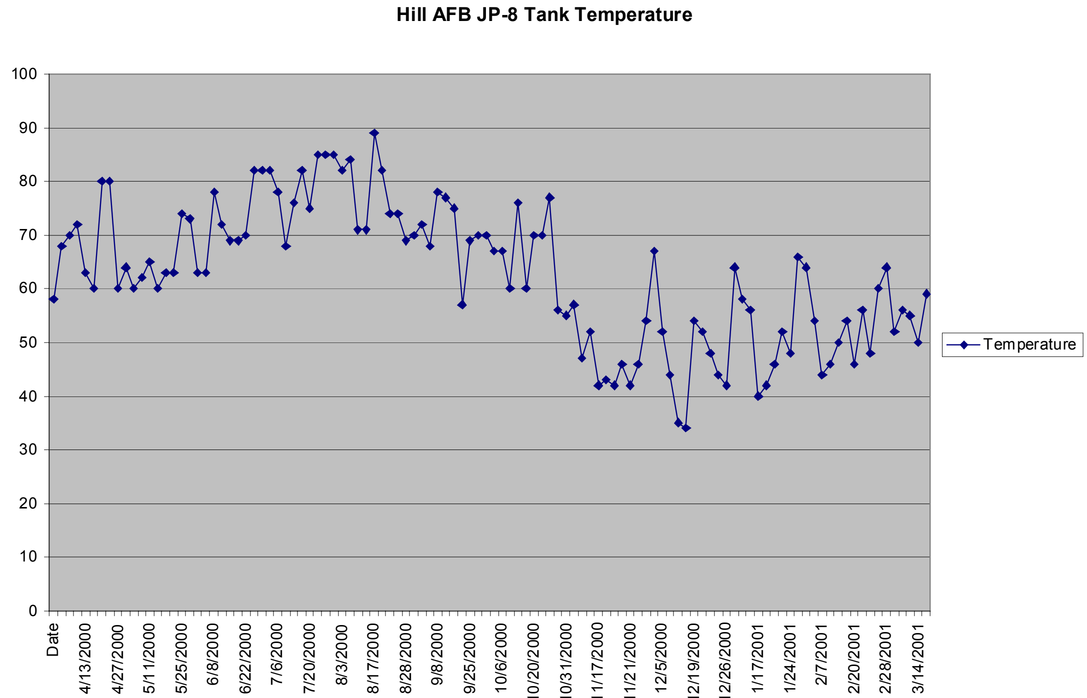
This system has an automatic tank gauging system that measures water at the datum plate near the side of the tank. All four tanks were reported as having cone-down bottoms with a 7% slope. The suction lines are located directly above the center sumps. For the largest tank, it would require 9,000 gallons of water to reach the ATG system; consequently, this system no value for the early detection of water in bulk tanks.

McChord AFB has ten R-11 refuelers (5 Kovatch and 5 Oshkosh) and four R-12 Hydrant Servicers assigned. Absorption media elements were installed June 2000-October 2000.

Two Type III constant pressure hydrant systems are used primarily for support of wide body aircraft. Each system has two above ground 10,000-bbl operating tanks. Tanks M-3 and M-4, completed two years ago, do not have the typical suction line over the sump. It was also noted, that the pump room in one system is without heat. The hydrant system supervisor reports that no heat in the pump room is better because of the reduction in thermal expansion when the systems are inactive.

3.8.28 Hill AFB

The first "recent" finding of AJ at Hill AFB occurred during late December 2000, following a lull in flying activities resulting from "snow days" and the Christmas break, when small amounts of AJ were found in the filter housing of Kovatch R-11 refuelers (98L079 and 98L080) following a rapid increase in filter differential pressure. Water absorption media elements were in use and high differential pressures cause premature requirement to change elements in other trucks, including Oshkosh R-11, though no AJ was observed in the other refuelers. The weather during December cycled from very cold to warm with rain and then to very cold again. The JP-8 is refined at the Sinclair refinery in Wyoming at temperature above 40°F degrees during the Winter and cools as it is transported by truck through the mountain passes to as low as 20°F upon arrival at Hill AFB. A graph below showing bulk tank temperatures indicates fuel in bulk fuel in bulk storage generally warms to above forty degrees; however, there was a period during mid-December 2000 when bulk JP-8 temperatures dropped below 40°F.

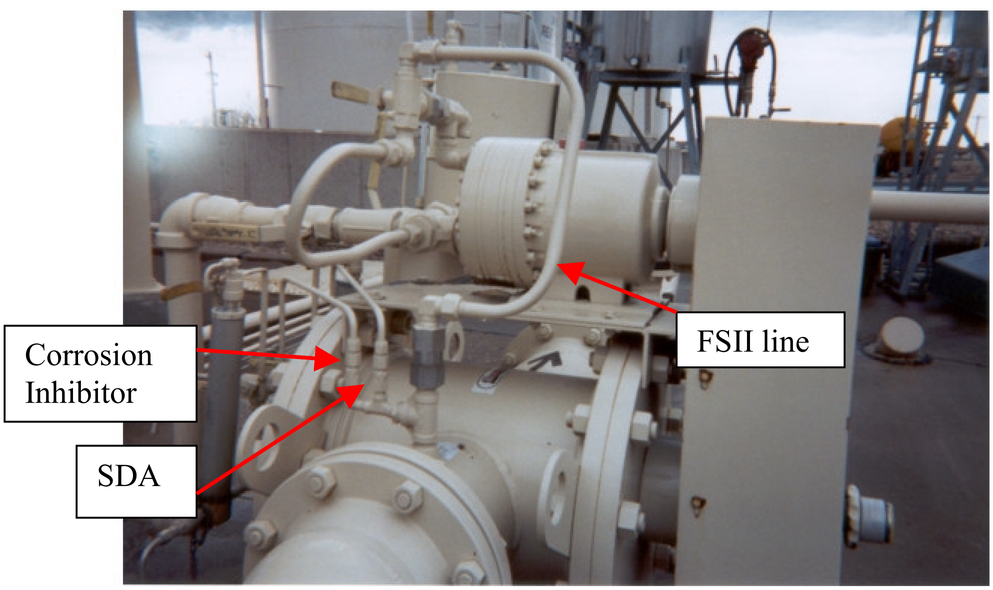


A couple of years earlier when receiving by pipeline, personnel who had been at Hill AFB reported that they frequently saw AJ-like material; however, the fuel received by tank truck from the Sinclair Refinery in Wyoming is cleaner and drier.

JP-8 is received at Hill AFB without filtration, though a filtration system is currently being installed. Hill AFB normally receives eight to ten 7,000-gallon tank trucks that are pulling 3,000-gallon tank wagons. The product originated from the Sinclair Refinery in Rawlins, Wyoming, and as mentioned above, is subject to significant cooling during winter transport though the mountains that separate Wyoming and Utah. During the period of the visit, Hill was receiving approximately 18 trucks and tank wagons per day to support a flying surge to make up for lost time earlier during the winter. The additional workload clearly strained the available storage manpower.

Once each six months, Hill AFB receives JP-8 by pipeline to exercise that receipt mode. The pipeline is a 6-inch diameter line that comes from the Chevron Refinery near Salt Lake City. While no pipeline drag reducer (PDR) is used in this line, it was reported that the Pioneer Pipeline from Sinclair's Rawlins Refinery, which does use PDR in diesel movements, connects to the Chevron line and provides approximately 100,000 bbls of Jet A to Delta Airlines at the SLC Airport each month. Additionally, fuel is occasionally pumped from SLC Refineries through the Chevron Pipeline to Pasco, Washington. Hill AFB is unique in that three additives are injected on base as the fuel is received: Corrosion Inhibitor, SDA, and FSII. Prior to injection, the fuel is filtered through one of two clay filters (manufactured by Eaton Metal Products). These on-base clay filters are set in parallel and only one of the two filters is equipped with a pressure differential gauge.

The three additives are injected using a Hammonds injector (model # D25XFCPHHHC / 1400-D25-1S-1S). The three additive streams are manifolded into a common nipple prior to injection, in effect mixing the additives prior to injection. The three additives enter the pipeline upstream of the paddle wheel that powers the injector pistons. While there are no specific indications of problems at Hill AFB resulting from the use of a single injection point for the three additives, the more common and recommended procedure is to inject the additives at three separate points.



Neither of the two FSII storage tanks is equipped with moisture control, such as a desiccant or nitrogen blanket. Fuels personnel did not know the pumping rate nor the inside diameter of the pipeline information needed to compute a Reynolds Number or flow rate at the point of injection.

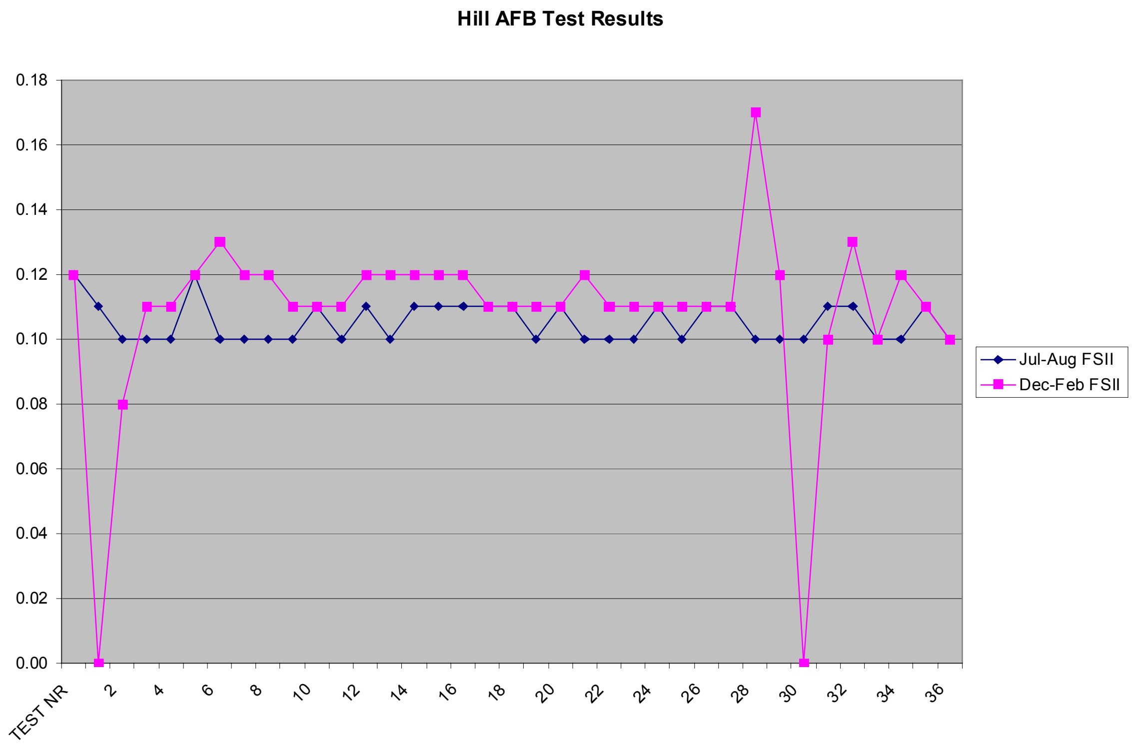
JP-8 is stored in four bulk tanks. The two largest (a 25,000-bbl tank and a 55,000-bbl tank) have fixed-roofs with floating pans. The two smaller tanks (an 18,000-bbl tank and a 12,000-bbl tank) have geodesic domes with floating-roofs. All four tanks have the self-cleaning design sloped to the center with the suction line directly over the sump, and fully epoxy coated. The BS&W drains or product recovery systems are totally ineffective and have been abandoned. Water is drained into a bowser through a long hose that goes over the tank dike. The sump of the tank designated as the issue tank is drained daily and the other tanks are drained weekly. Samples were taken from the bowser connected to the issue tank. The first one-quart sample, drained from the low point was a yellowish mixture of water and FSII, with no fuel interface. A drum thief was used to obtain a more representative sample. The fuel phase of the latter sample was unusually yellow, though the water phase seemed unremarkable. A thin layer of substance at the fuel water interface appeared typical of microbial growth. Major Dave Sonntag took this sample for testing to the bioenvironmental health laboratory.

Two 40,000-gallon, horizontal tanks (Tanks # 39 and #40), which receive from bulk storage without filtration, supply the truck fillstands. Storage operators usually drain from one pint to one quart of “orange colored water” from the tanks each morning. A sample was taken from the low point drain during our afternoon visit was found to be clear and bright. The fill stands are equipped with two vertical F/Ss (manufactured by Keene Corporation, model #330 V600 manufactured in 1974). These F/S vessels use the old DoD elements, FSN 4330-00-983-0998. This old style element was marginally effective for use with JP-4 and is ineffective for use with JP-8. The filter vessels should be replaced with API qualified vessels.

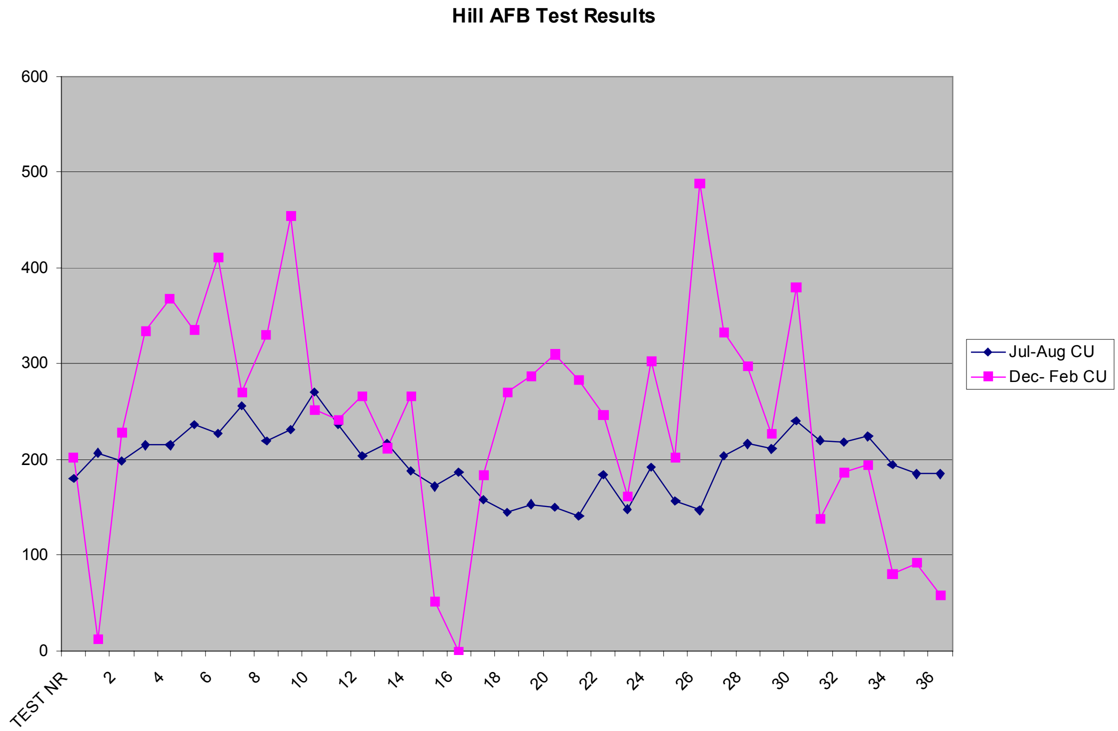
Currently, this is the first filtration that JP-8 delivered by tank truck is subjected to before it enters the flight line refuelers. Most of the jet fuel issued by Hill AFB is JP-8+100. The +100 additive is injected downstream of the fillstand F/S vessels.

Hill AFB has fifteen assigned R-11 refuelers. Seven of these are 1989 model Oshkosh refuelers, three are 1991 model Oshkosh refuelers, and the remaining five are Kovatch 1998 vintage refuelers. According to Fuels Management personnel, AJ has only been found in the 1998 Kovatch model R-11. However, the refueling vehicle maintenance manager stated that he finds AJ in the filter vessels of all the refuelers. Since his records showed that he had recently changed the filters elements in a Kovatch R-11, #98L083, he was asked if we could examine the filter element. The filter showed no evidence of AJ; however, what was a matter of concern is that the element was the filter coalescer type (63387TB) and not a water absorption type. This situation is exacerbated by the fact that refueler 98L083 is a designated JP-8+100 truck. Water absorption elements should be used for this application in accordance with T.O. 42B-1-1 because JP-8+100 disarms coalescer elements. The elements change information was reviewed for all fifteen vehicles and it appeared that one other R-11 (98L081) might have the old coalescer type elements based on the change dates in the automated maintenance record. Later, it was determined that the elements, whichever type, had been changed earlier, but the automated report had not been updated. Water absorption elements were apparently installed in most of the R-11 refuelers during September and October of 1999. Since that time, the records reflect that two Oshkosh and three Kovatch R-11 experience premature filter failure (9 months or less installed time).

A visual sample was drawn from one truck at the beginning of the delivery and was found to be clear and bright. A review of product receipt records for 216 deliveries showed that FSII levels on receipt range for 0 to 0.17%, with the vast majority (>90%) being 0.10% to 0.12%.



Conductivity levels range widely from 0 to 499 CUs, though the average appeared to be in the low 200 CU ranged.



The JP-8 at Hill AFB is relatively dry. Less than 4% of 814 samples reviewed showed any water at all in the AEL testing of flight line refueling equipment. Five of the 814 samples failed having from 15 ppm to 20 ppm of water. Approximately, 15,000 to 20,000 gallons of JP-10 are downgraded to JP-8 each year. Hill AFB personnel also reported that they had an unusual experience a year or so ago with filtration time test failures. Fuel samples that had set in the laboratory for a short period failed filtration time dramatically (test would run out of time) but if samples of the same fuel were allowed to set over night they would pass the test the following day. Settling time or perhaps gradual warming seemed to be the significant factor, since fuel setting for a short period and warmed rapidly failed the test. During this period, fuel was loaded at the Sinclair Refinery at 44°F and cooled significantly during transport to 20°F by the time it arrived at Hill AFB.

Hill AFB provides depot level maintenance for F-16, A-10, and C-130 aircraft. We visited the Bioenvironmental Health Office and spoke with Karen Thompson, the Safety Office and spoke with Augie Pierman. We learned that a contaminated sample had recently been taken from a Puerto Rico ANG C-130. We were able to obtain the sample, which contained three-phases of material: a fuel top, an unremarkable water/FSII bottom (with some type of sediment), and what appeared to be a microbial layer at the fuel-water interface. We visited the C-130 engine shop and spoke with Doug White, and the C-130 depot maintenance area and spoke with Phil Younger. All of the above individuals where shown a “classic” sample of AJ (from one of the Hill AFB R-11 refuelers) and all unanimously reported that they had never seen similar materials inside aircraft.

3.8.29 NAS Corpus Christi

Though a small operation with two 6,000-bbl tanks, NAS Corpus Christi has an aggressive fuel filtrations program. The fuel is filtered upon receipt into Tank #1. After settling and draining any bottom water and sediment, the fuel is transferred from Tank One through a filter separator and then through a water absorption monitor into Tank #2. As the fuel is issued from Tank #2 to the fillstand it is filtered once again through the separate filter separator and water absorption monitors. The two **fixed-roof** storage tanks have inverted cone bottoms. Fuel is drained manually into a bucket to check for water and then placed in the fuel reclamation tank. Doss Aviation provides along side fuel servicing aircraft using a fleet of new Isometrics built Refueling trucks. These are equipped with Beta Systems filter vessels that use the I-63887TB coalescers and the SO-6336S separators, and provide the fourth filtration prior to the fuel entering aircraft.

NAS Corpus Christi has no history of AJ. While it may be argued that this is because it is located in a warm climatic area, temperatures do drop into the 30ºF range on some occasions. There are two other key difference common to most Navy turbine fuel storage facilities that may be a factor is precluding AJ formation at NAS Corpus Christi. First, the product is stored in fixed-roof tanks that are not subject to rainwater intrusion. Second, the fuel goes through multiple, three-stage filtrations (coalescer, separation, and absorption).

3.9 Additive Injection

From the AFRL and NRL reports as well as early findings by SwRI, it is apparent that FSII, SDA, and perhaps CI all play a role in AJ formation. During the site investigations it was frequently reported that the amount of AJ found has a direct relationship with the amount of FSII and SDA in the fuel. Generally, when FSII levels and fuel conductivity are toward the higher end of the authorized levels, the amount of AJ experienced is greater. When these levels are reduced the amount of AJ also declines. Consequently, we recommend consideration be given to reducing the upper limits of these two additives. As a minimum effort, we recommend efforts to manage the FSII concentration to 0.12% or below on base. The conductivity level target should be to maintain the fuel on base at a level of 250 CUs or lower.

The requirement for all additives should be reviewed with a view toward elimination or minimization. SDA was initially used in JP-4 to preclude the electrostatic ignition of fuel vapors. Given the higher flashpoint and lower vapor pressure of JP-8, and the use of more conductive reticulated foam in aircraft fuel tanks make them less prone to in-tank fires, consideration should be given to whether SDA can be eliminated. In either case, the elimination of SDA at locations using JP-8+100 may be practical because the +100 additive increases fuel conductivity. Also, few locations using JP-8+100 have reported AJ downstream of the point of injection. The +100 additive appears to afford some protection to the water absorption cartridges, probably because it keeps some amounts of entrained water/FSII in suspension and allows it to pass through the absorption media and the aircraft fuel systems.

SDA and CI require dilution prior to injection. During our visits to sites that inject these additives, we noticed that the dilution ratios are very low. The amount of concentrated SDA required in JP-8 rarely exceeds 1.5 ppm. When SDA was introduced during the late 1970s, there were few injectors in use within DoD. The concentrated SDA was diluted with 9 parts of fuel to one part SDA. The amount of fuel used in this dilution was held to the minimum because often it was necessary to hand carry the diluted additive to the top of above ground tanks where the additive was introduced through the gauging hatch—the lower the dilution ratio, the less weight to carry to the top of the tank and fewer trips. When injectors were later introduced, operators continued to use the 9/1ratio. The majority of the injectors in use at DoD facilities within the CONUS are manufactured by Hammonds Technical Services, Houston TX. The Hammonds Injectors use small 1S pumps for the injection of SDA and CI. Therefore, the injector pump stroke must be set on the extreme low end to avoid over injection of the additive. Like all mechanical equipment, injection pumps do not perform at maximum efficiency or accuracy on the low or high end of their range. As an example, when injecting a 9/1 dilute, a maximum of 15 ppm would be required. This means that the stroke adjustment is at a maximum of 10 on a scale of 100. We recommend that SDA be diluted a minimum of 20/1 which requires a stroke adjustment of 20 to achieve an injection rate of 30 ppm. This will help prevent over and under injection of SDA.

The injection of CI presents very much the same problem. The normal concentration of CI would be a maximum of 23 ppm and a minimum of 9 ppm using one of the 13 corrosion inhibitors listed on the Qualified Products List. Most operators inject around 15 ppm of the CI. This small amount requires a pump stroke adjustment at 10 or 12 on the Hammonds injector, which is on the extreme low end of the pump range. Since only a small amount of corrosion inhibitor is required typically the injector supply line from the additive tank is a small tubing line. This further compounds the accuracy of injection because CI has a viscosity similar to 30 weight motor oil and during cold months the additive flows much slower through the small supply line. Consequently, the dilution of corrosion inhibitor with one part turbine fuel prior to injection is recommended. The diluted mixture can then be injected at 30 ppm which will increase injector accuracy while overcoming the viscosity problem encountered by the small supply line, especially during winter months.

There are other factors that need to be considered to ensure adequate blending of additives. These include the positioning of injection points on the pipeline relative to pumps and filters, the positioning of the injector quill within the pipeline, and whether or not the fuel flow though the pipeline achieves turbulent flow. For example, at DFSP Bossier City SDA was injected upstream of the pump while FSII was injected downstream. Since FSII does not blend with JP-8 as readily as SDA, it would make more sense to inject the FSII prior to the pump to gain the benefit of mixing caused by the pump. Conversely, FSII should always be injected downstream of a filter separator because of the need to eliminate as much water as possible prior to injection of FSII. The lower the water content of the fuel, the less FSII required to maintain the required 0.07% level for into aircraft servicing. Injection quills should extend to the center of the pipeline so the additive enters the center of the fuel stream rather than being injected at the inside edge of the pipeline. At the CONOCO Pipeline Terminal in Ponca City OK, we were told that the injection inlets were flush with the inside wall of the pipeline, which would interfere with adequate blending of additives into the fuel.

Another critical factor in ensuring adequate blending of additives is whether the fuel flow, at the point of injections and further downstream, is laminar or turbulent. Turbulent flow provides a mixing action that facilitates distribution of the additive throughout the fuel. A "Reynolds Number" is used to determine flow conditions. The Reynolds Number is a correlating factor that allows predicting flow characteristics for fluids. Generally, liquids flow smoothly when they have low Reynolds numbers – a parameter that takes into account the fluid density, viscosity, and velocity as well as the dimensions of the conduit. Low Reynolds Numbers indicate linear, turbulence-free streams. For JP-8 a Reynolds Number greater than 2,000 indicates the flow would be turbulent and, consequently, facilitate the blending of additives.[2]

[2] Researchers at the California Institute of Technology have found that, at the juncture of a water filled microfluidic channel and another channel containing an oil mixture, interactions on the boundary between the two fluids results in nonlinear flow and complex, crystalline trains of droplets. By varying the relative fluid pressures, the researchers could create elegant water droplet sequences, ranging from simple strings to elaborate helical and ribbon like structures.

For our purposes the Reynolds Number is derived by the following formula:

Rn = (pDv)/ H

Where Rn = Reynolds Number

P =density
D = inside diameter of the pipeline (one foot section)
V = velocity
H = viscosity

We do not have the test results showing the full range of viscosity and density of the JP-8 shipments handled at each facility. For the purpose of calculating the Reynolds Number we used an average viscosity of 8 and an average density of 800.

The Reynolds Numbers for sites visited by the AJ investigation team are as follows:

Injection Activity	Reynolds Number	Type Flow
TEPPCO, Bossier City		
2" Meter Venture	Rn = 2,400	Turbulent
4" Pipeline	Rn = 1,960	Laminar
DFSP Carteret	Rn = 8,600	Turbulent
BP/AMOCO Mandan Refinery	Rn = 4,080	Turbulent
DFSP Grand Forks		
Truck Rack	Rn = 3,420	Turbulent
Pipeline	Rn = 3,280	Turbulent
CONOCO	Rn = 4,740	Turbulent

We recommend that technical guidance, educational literature, and/or contract modifications be used to improve the understanding and management of additive injections activities.

While improving the understanding of activities involved in additive injections would help improve additive injection ratios and ensure proper blending of additives, the most effective way to improve additive injection, reduce the amount of additive required, and reduce the impact of additives on water removal is to move the point of injection as far forward as possible. Ideally, in terms of minimizing the impact of additives during filtration, the additives should be injected at the skin of the aircraft, particularly if water absorption media filters continue to be used in the R-11s. If this is not practical, we recommend, as a minimum, that the injection points be moved so that FSII is injected immediately after the base receipt filters and immediately prior to entry into the fuel storage system, provided the storage systems consist of fixed-roof tanks or geodesic dome tanks that are effective in precluding rainwater intrusion, are equipped with effective product recovery systems, and the discharge line does not draw directly from the tank sumps. For storage systems that do not meet these criteria, the truck fillstand or operating storage for Type III systems would be our "fall back" recommendation. Furthermore, we recommend SDA be injected on the servicing equipment (HSV-12s, R-11 refuelers, or MH-2 hosecarts). Special consideration would be required for unique systems designs (Type IV and Type V hydrant systems), such as pantographs and in-shelter systems typically used overseas. Where JP-8+100 is in use, we recommend injection on the servicing equipment or at the fillstands.

The above recommended injection points are provided as for initial points of discussion. Significant additional research and site-specific considerations would be needed prior to making final decisions.

3.10 REVIEW OF AIR FORCE TECHNICAL PUBLICATIONS

During the course of our investigation, C4e was tasked to review Air Force technical publication to identify possible changes that could help resolve AJ contamination. T.O. citations and quotations are shown in blue below and our comments and recommendations are in black.[3]

3.10.1 COMMENTS ON T.O. 42B-1-1

T.O. 42B-1-1, paragraph 3-7:

a. Aviation fuel received into bulk storage must be allowed to settle for a minimum of two hours prior to issue/transfer. In case of emergency, the product may be transferred in less than two hours provided this is approved by the MAJCOM Fuels Division. Tanks of non-ferrous material epoxy-coated interiors and incoming filter separators do not require a settling time….
b. When product is received directly from suppliers, simultaneous receipt and issue from the same tank, other than Type III, Type IV and Type V hydrant systems, is prohibited.

Prior to the conversion from JP-4 to JP-8, the settling time requirements for fuel receipts was one hour per foot with a minimum of three hours following each receipt. Because the density of JP-8 is higher than JP-4, water settles out of JP-8 more slowly; therefore, reducing the settling time for JP-8 is counterproductive. The decision to relax the settling time was influenced by the adoption of a new tank design, which required tanks to have an inlet filter separator, be epoxy coated, and have a one-inch slope per ten feet to a center sump. Because of new environmental requirements and the desire to minimize tank cleaning and tank bottom waste, the discharge (suction) line for these tanks was placed directly over the sump to keep the tanks clean. This was done at the expense of product quality because any water/FSII mixtures and sediment that does settle from the fuel is picked up by the discharge line and pumped to the filter separators. Filter separators currently in use at the vast majority of locations were designed to filter "neat" or "unadditized" turbine fuels. The military, and particularly the Air Force uses a package of additives that contain surface active agents (surfactants) that disarm the ability of these filter separators to coalesce water from fuel. A new API 1581 Edition 4 filter separator has been developed for use with fuels containing surfactants); however, there is doubt on the part of some experts regarding the effectiveness of the new API 1581 Edition 4 elements. Furthermore, the Edition 4 elements have not been qualified for use in many of the various filter separator housings in use within the Air Force. In a recent change to the DoD standard design, the discharge (suction) line has been offset by

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[3] As one of the C4e Principal Investigators for this project previously served as the OPR for T.O. 42B-1-1 and wrote the most current version of that T.O., we feel it is appropriate that we recommend changes based upon what was learned during this investigation.

approximately one foot from center sump. While most of the tanks at the military installation that have experienced apple jelly were constructed before this design change was made, we question how much of an improvement the offset represents.

T.O. 42B-1-1, paragraph 3-19a:

(3) ….When a fillstand is supplied from a tank or tanks that receive fuel from on-base storage, the filter separator downstream of these tanks can be omitted providing all of the following conditions are met:

We do not consider the elimination of a filter separator between an operating tank and a truck fillstand to be advisable. The assumption that fuel transferred from on-base storage has minimal water and other contaminates is faulty. During our visits to several bases that have experienced AJ contamination, we found several tanks that allowed rainwater entry into the on base storage (see the reports on Barksdale AFB, Fairchild AFB, Grand Forks AFB, McChord AFB, Edwards AFB, Beale AFB, and Otis ANGB provided in the Appendices.) This problem is exacerbated by several other changes to the Air Force fuel systems during recent years. First, most bases rely on the automatic tank gauges, installed since the mid-1990s, and product recovery systems to detect water bottoms in their tanks. T.O. 37-1-1, paragraph 3-12 on gauging states: "When available, Automatic Tank Gauging (ATG) is the primary method of fuel tank inventory control." The problem with reliance on the ATG system is that it is generally installed near the tank wall and measures product at the outer perimeter of the tank interior, which is the top edge of the sloped tank bottoms. Because of the slope-to-center tank bottom design, larger tanks could accumulate several thousand gallons of water before it would be detectable by the automatic tank gauges. Positioning the discharge line directly over or near the center sump virtually guarantees that any FSII/water and sediment that has settled from the fuel will be picked up and pumped into the filter separators.

If the policy of eliminating fillstand filter separators is to stand, we recommend, as a minimum, the following changes:

(a) The tank has an inlet filter separator
[Change to read: The tank has an inlet API 1581 filter separator equipped with an automatic sump drain which drains into a product recovery system equipped with an operating high-level shutoff and high-level alarm.]
(b) The tank is 100% internally coated.
[Change to read: "The tank is 100% internally coated and, if above ground, has a fixed-roof. Geodesic dome roofs are prone to leak and do not qualify as a fixed-roof tank.]
(c) Slope above or below ground vertical tank bottoms to a center sump. [Change to included the following: The discharge (suction) line must be positioned to preclude entry of materials from the tank sump into the discharge line.]

(d) Slope above ground horizontal tanks toward the opposite end of the pump. The slope must be a minimum of 1 inch per 10 feet. [Recommend changing the slope requirement be increased to 6 inches per 10 feet. Because of the high surface tension of free-water/FSII mixtures, a slope of 1 inch per 10 feet is inadequate.]

(e) All piping and components downstream of the tank to the truck fill nozzle must be of non-corrosive material. [Change to: All piping and components from the tank inlet filter separator to the storage tank and from the storage tank to the truck fill nozzle must be of non-corrosive material.]

(f) Piping must not exceed 300 feet between the tank discharge and truck fill nozzle.

[Consider including the following: the tank must not have a history of allowing rainwater intrusion. Such intrusion can be facilitated by a geodesic dome that allows rain to enter the tank, particularly when accompanied by moderate to strong winds, and an ineffective seal on a floating pan or floating-roof. Rainwater intrusion is exacerbated with such tanks when the product level is frequently and significantly lower than the safe fill capacity.]

T.O. 42B-1-1, paragraph 3-20

g: "….Final filtration vessels equipped with water absorption media cartridges have a maximum DP of 22 PSIG at the maximum rated flow of the vessel."

[Change: "22 PSIG" to "15 PSIG" and added: "The vessel must have a separator stage." Velcon Filters experts advise against use of water absorption media cartridges at differential pressures above 15 PSIG for fuels containing FSII.

T.O. 42B-1-1, paragraph 5-4d:

2(c) The SDA limits at the point, time and temperature of delivery into or out of the NATO pipeline system (NPS) are as follows (Ref: STANAG 7036):

Grade	Symbol	IN	OUT
JP-8	F-34	50-600	50-700
Jet A-1	F-35	50-450	50-450

The point of quoting the above conductivity requirement is that we recommend lowering the maximum conductivity level for JP-8 to 450 CUs for receipt and use. Since a lower top end is achievable with Jet A-1, which is very similar to JP-8, we believe it is also achievable with JP-8. Laboratory testing conducted by SwRI indicates that SDA may play an important role in the formation of high viscosity AJ.

3.10.2 COMMENTS ON T.O. 37-1-1

T.O. 37-1-1, paragraph 4-11e

(2) Ensure automatic water drain valves are removed, plugged or made inoperative. Automatic water discharge valves and lines on filter separators that meet USAF standard design criteria shall not be removed or made inoperative. The automatic water discharge valve and line on filter separators that meet USAF standards connect directly into a product recovery tank equipped with an operational high level shutoff and high level alarm. On filter separators that do not meet USAF design criteria, the automatic water discharge valve and line shall be removed or rendered inoperative.

The design of new filter separators at most of the bases visited did not include provisions for a manual drain that would permit the filter separator sumps to be drained manually into a glass jar for visual inspection. These systems are equipped with glass sight gauges, which is a less satisfactory mean of checking filter separator sumps. Recognizing this, several of the Air National Guard installations visited, that have experienced problems with AJ fuel contamination, have installed manual drains to permit a more effective means of examining materials in the filter separator sumps.

> T.O. 37-1-1, paragraph 6-1: "**GENERAL.** The FMT and CE personnel will review drawings of the fuel systems. Drawings will be checked to determine if drain valves are indicated for all low points in the systems. Low point drains not indicated will be included in the drawings. Where low point drains are not provided, action will be initiated to have them installed when warranted."
>
> T.O. 37-1-1, paragraph 6-2. "**LOW POINT DRAINING FREQUENCIES.** All low point drain valves shall be operated at least semi-annually when the system is not under operating pressure."

Our investigation did not include verification of compliance with the above T.O. 37-1-1 requirements. However, we are concerned that the large diameter dispensing lines on the Type III, IV and V hydrant systems do not reach turbulent flow conditions and that pockets of FSII and water mixtures could settle out of fuel and accumulate in low points during normal operations. During peak operational demands, such material could be picked up in the fuel flow. Since the frequency of AJ occurrence appears to be related to temperature change, we suggest that this section of T.O. 31-1-1 address the need to drain low points in the Fall of the year, soon after the temperature of fuel in the operating storage system drops below 40° F.

3.10.3 COMMENTS OF T.O. 42B1-1-14, FUELS FOR USAF AIRCRAFT

This Technical Order has a basic date of 15 August 1979 and was last changed (Change 17) on 15 October 1995. The Technical Order shows JP-4, a fuel no longer in use except at a very few unique locations, as the primary fuel for the vast majority of Air Force and Army turbine engine aircraft. While JP-8 is listed as an alternate fuel for most of these aircraft (along with JP-5, Jet A, Jet A-1, and Jet B), there is no mention of JP-8+100. This technical order needs to be updated.

4.0 CONCLUSIONS

For the C4e Investigation Team members involved in the project, perhaps the most eye-opening result of our investigation into the AJ problem is a better understanding of the importance and difficulty of keeping JP-8 dry (i.e., minimizing water content*)*. Clearly, during the conversion to JP-8, we* made assumptions based upon the similarity of JP-8 to JP-4, Jet A, Jet A-1, and JP-5 that were not thoroughly thought out. We realized that, because of its higher density, JP-8 holds more water than JP-4, and for that reason, water removal would be a somewhat slower and more difficult process. However, this difference was never thoroughly addressed when considering facility, equipment and process variables necessary for handling JP-8. The fact that commercial airlines use kerosene fuels very similar to JP-8 and that the Navy uses JP-5, which resembles JP-8 more closely because of the use of FSII in both fuels, assumptions were made that the existing facilities, equipment, and processes used for JP-4 were satisfactory for use with JP-8. However, these assumptions were made without full consideration of the impact of additives or a complete review of differences between Air Force, Navy and commercial facilities, equipment and processes. With respect to the design of both fuel handling facilities and equipment, the Navy and commercial industry have a stronger focus on keeping fuel dry and protecting the integrity of their filtration systems. The use of fixed-roof storage tanks with discharge (suction) lines specifically designed to avoid the intake of water bottoms are two examples. The Navy's use of a three-stage process for water removal (coalescence, separation, and absorption monitors), compared to the one or two-step process used by the Air Force, is another example. In commercial industry, FSII is generally not injected into bulk fuels, but rather is injected at the aircraft, if used at all.

SDA was adopted for use in JP-4 during the late 1970s because of electrostatic ignition of fuel vapors within aircraft fuel tanks containing reticulated foam and a number of ground handling fires that were ignited by static electricity. The foam was designed to protect fuel tanks in combat aircraft from explosion when hit by ground fire. The first generation foam was non-conductive and rapid movement of fuel through the foam during refueling or sharp, banking turns, generated sufficient electrical charges to ignite the JP-4 vapors. When this occurred, the foam did its job by preventing serious structural damage to the aircraft, but evidence of soot at the aircraft fuel tank vents and the discovery of chard foam inside aircraft fuel tanks was discomforting for the aircraft operators. Since that time new emphasis was placed on the use of conductive foams that may have resolved this problem. Furthermore, most aircraft that have reticulated foam also use JP-8+100, and the additional conductivity provided by the +100 additive may be sufficient without the use of SDA. The likelihood of electrostatic ignition of JP-8 in ground handling is also greatly reduced by the use of JP-8, as compared to JP-4, because of the significantly higher flashpoint and lower vapor pressure of JP-8. Consequently, the two key reasons for use of SDA may no longer be applicable, and consideration should be given to eliminating the use of SDA in JP-8.

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* Those of us responsible for policy and technical guidance at the time of the conversion from JP-4 to JP-8.

Eliminating the use of FSII in military turbine fuels would simplify water removal; however, because of design and mission differences between military and commercial aircraft, eliminating the use of FSII is not an option. Nevertheless, advancing the point of additive injection and improving control over the quantity of additives injected are options that could simplify water removal and, in the long run, reduce costs. For example, DFSP Ludlow receives fully additized JP-8 but must reinject FSII and SDA because of excessive water exposure, before the JP-8 is shipped to the bases. Multiple injections of additives add costs and complicates water removal down the line. For these reasons, and one more to be addressed in the next paragraph, we strongly recommend that the point of additive injection be moved as far forward in the logistics system as is operationally possible.

The other reason we advocate moving the point of additive injection forward is that one of the major lessons learned and documented during Operations Desert Storm and Desert Shield, was that our forces were not prepared to convert commercial Jet A-1 to the JP-8 required by the weapons systems by injecting the necessary additives. The only personnel that accomplished this task with relative ease were the fuels operators from Hill AFB who had previous experience with on-base additive injection. It is a fact of life that, in many locations, our forces will have to rely on commercial fuel and inject the needed additives to support global operations. While moving additive injection forward would cause some increase in workload at the operating bases, it would help prepare fuels operators for deployment, reduce the cost of additives and filters, and simplify water removal in the resupply systems.

There are two traditional arguments against on-base additive injection. The first is the contention that personnel are not skilled in additive injection and the bases are not manned for this task. The very fact that these same personnel must be relied upon to inject additives in field operations reveals the error of such logic. The second argument is that the fuel must be additized and tested before it goes to the aircraft. Existing technologies for control and monitoring additives injection provides sufficient control, and additives are routinely and successfully injected at the aircraft in commercial operations.

Looking forward to fuels of the future, there are other compelling reasons why additives should be injected on base. New weapons systems will demand increased thermal stability that will likely be provided by special additives, such as the +100 additive. Take the Joint Strike Fighter for example; the heat sink requirement of this aircraft is significant enough that the JP-8+100 fuel must be refrigerated immediately prior to being issued to the aircraft to provide the necessary heat sink without temperature stressing of the fuel. As new, specialized additives are developed there will likely be a need for tailoring fuel differently at some locations to meet the specific needs of the weapons systems supported.

The emphasis on minimizing BS&W to reduce tank-cleaning workload though the use of self-cleaning tanks realizes savings at the expense of fuel quality. This practice relies on filter vessels and elements that are already compromised, because they were not designed for use with additized fuels, to remove BS&W. This combined with ineffective product recovery systems and poorly designed geodesic dome tanks or floating-roof tanks, seriously threatens fuel quality and potentially jeopardizes flight safety. Where excessive free-water/FSII (low viscosity AJ) is frequently found in the receipt filters, the problem can be traced back to excessive water from the supply source and the injection of high levels of FSII and SDA. Of course, since water extracts FSII and some SDA materials from JP-8, water contamination causes the need to increase additive injection to maintain the level of additives required. There is a direct correlation between the amount of FSII and SDA in the fuel and the development of AJ contamination. Improved additive injection management can help ameliorate the AJ problem.

Interestingly, bases that drain large quantities of free-water/FSII (low viscosity AJ) from receipt filters generally do not have excessive AJ problems in their distribution systems--if they are blessed with fixed-roof tanks with an effective means to drain BS&W. Invariably, base fuels operators experiencing AJ upon receipt have instituted aggressive sump draining programs that contain the problem. Where significant quantities of free-water/FSII (low viscosity AJ) are found in on-base tanks and transfer filters, the cause was usually traced back to floating-roof tanks or tanks with ineffective geodesic domes that allow rainwater intrusion into the fuel. Some of these older fuel storage systems rely on use of filter vessels designed to the old DoD standard. These vessels were marginally effective with JP-4 and are ineffective when used with JP-8. Likewise, coalescer elements under NSN 4330-00-983-0998 used in the old DoD standard vessels and some modified vessels have an off-the-shelf failure rate approaching 40%, regardless of manufacturer. Such vessels and filters continue in use in some fixed facilities, as well as in the few remaining R-9 refuelers and MH2-C hosecarts.

AJ is experienced in fixed-roof tanks in small quantities when fuel temperatures drop sharply. Temperature impacts the ability of JP-8 to absorb and hold water. Where significant temperature drops occur, entrained water/FSII and dissolved water are released from JP-8. These materials settle to the tank bottoms. The automated tank gauging systems--that have replaced the use of the tape, bob, and water-finding paste--measures fuel and water bottoms at the high end of the sloped tank bottoms; therefore, free-water/FSII will go undetected unless it is present in quantities reaching thousands of gallons. If the tanks have not recently received fuel and the operators have become complacent about draining the sumps because the fixed-roof tanks are normally dry, the free-water/FSII mixtures are sucked out of the self-cleaning tanks by the fuel discharge (issue line) and pumped toward the aircraft. Even if the operator does drain the sump, if it is not done properly the free-water/FSII will remain in the tank. Tank draining must be taught as an art form. The drain line must be opened slowly at first too avoid creating a vortex that will draw fuel into the line while the higher surface tension of the free-water/FSII holds it to the sides of the sump. When the drains are opened to quickly and the line draws fuel rather than the water bottom, fuels operators are tricked into believing tanks are dry when they are not.

Intermediate and high viscosity AJ is usually found in the sumps of filter vessels that contain water absorption media cartridges. These cartridges replaced coalescers in the R-

11 refuelers because of the JP-8+100 program. These cartridges are designed to absorb and hold water. The water in JP-8 absorbs FSII. The FSII changes the nature of the filter element, making it less discriminate in the materials absorbed from the fuel. As the free-water/FSII attracts polar compounds from the SDA and perhaps from aromatics in the fuel, the materials begin to attack and dissolve the absorptive media in the filters creating a high viscosity material. When cold fuel warms, the viscosity of the AJ material is reduced allowing the AJ to drain from the water absorption cartridges. Most of the high viscosity AJ material probably settles to the bottom of the filter vessel and into the sump; however, there is evidence of AJ being found downstream of the filter vessel on a Kovatch R-11 refueler. Because of the ineffective design of the Oshkosh R-11 filter vessel, we would expect this to be a more significant problem with these refuelers, and may explain why less AJ seems to be found in the Oshkosh R-11 filter sumps.

Industry officials have recommended changing water absorption cartridges used with fuel containing FSII when the differential pressure reaches 15 psi as opposed to the Air Force limit of 22 psi. We agree that the differential pressure change criteria should be reduced; however, there is strong evidence that the water, FSII, and other compounds extracted from the fuel may be dissolving absorptive materials in the filters. Several bases reported that as temperatures increase the amount of AJ found in filter sumps also increases while the pressure differential across the vessel drops. We suspect that components of SDA and other polar compounds in the JP-8 are extracted as the fuel passes though FSII/water saturated absorption media. Over time, this process changes the nature of the materials trapped in the absorption cartridges. Strong evidence developed by SwRI indicate these chemicals eventually begin to dissolve the absorptive media within water absorption cartridges, allowing it to escape from the cartridge, along with the water, FSII, and polar compounds. The sodium agar in absorptive cartridges is the most likely source of the high sodium content of the most viscous AJ samples which were typically found in the bottom of filter vessels equipped with the water absorption cartridges. If the absorptive materials dissolve and drain or wash out of the absorption cartridges, then the use of pressure differential as a means of determining the reliability of the absorption cartridges is highly questionable.

Interestingly, JP-8+100 bases, which were the first Air Force units to use the water absorption media elements, have had surprisingly few incidents of AJ in R-11 filter vessels. Moreover, AJ has not been reported in any of the aircraft that routinely use JP-8+100. We suspect that the detergent and dispersant additives in JP-8+100 keep the entrained water/FSII in suspension and prevent it from agglomerating, settling out of the fuel or being absorbed by the absorption cartridges. The role of the +100 additive in reducing AJ formation merits special study. Furthermore, since the +100 additive increases conductivity, wider use of JP-8 +100 may obviate the need for SDA. At least one of the major filter manufacturers believes that the API/IP Edition 3 coalescer may be effective for use with JP-8+100 in fuel systems with low levels of particulate contamination. Because of the high surface-active nature of SDA, its removal from JP-8+100 would likely aid in enabling the use of the API/IP Edition 3 coalescers as a replacement for the water absorption media cartridges and as a more cost effective alternative than the Edition 4, M-100 series.

Our recommendations on ways to resolve these problems are provided in the following pages.

5.0 RECOMMENDATIONS

- Recognize that the prevention of rainwater intrusion and the removal of water from JP-8 is more demanding and more important that it was with JP-4. Fuel handling facilities, equipment, and processes should be re-engineered based upon that recognition.

- Educational materials should be developed for field personnel to foster a better understanding of how and when to remove water from fuel systems. For example, fuel systems operators need a better understanding of the impact of sharp temperature drops on water accumulation in tank sumps, and they need to appreciate the importance of draining fuel system low point, especially following significant temperature changes and prior to surge operations. They also need to know how to properly drain tanks.

- Fuel specification requirements should also be reviewed with an eye toward reducing the number and amount of additives required. Use limits for FSII and SDA should be reduced regardless of changes to the JP-8 specification.

- The practice of adding SDA through a delivery truck dome hatch into a single compartment in sufficient quantity for the entire truck or multiple trucks should be prohibited.

- The +100 additive in JP-8+100 imparts conductivity to the fuel and the use of JP-8+100 minus SDA should be studied as an alternative to JP-8 with the SDA additive.

- Additive injection should be moved as far forward within the logistics system as possible.

- Additive injection technical procedures, educational materials, and/or contract modifications should be developed to provide specific guidance about injecting additives and managing additives to keep them fresh and dry. The proper storage of additives, dilution ratios, selection criteria for the point of injection, the use of injection quills that inject in the center of the pipeline, and the importance of turbulent flow should also be addressed.

- Prior to injecting additives, and particularly FSII, the fuel should be put through a water removal process, such as filter separators (with coalescer elements) or haypack filters.

- Once additized, JP-8 should be:
    - o Stored in fixed-roof tanks or tanks with geodesic domes that are effective in preventing rainwater intrusion. Floating-roof tanks without a watertight geodesic dome should NOT be used to stored additized JP-8.
    - o Where geodesic dome tanks are used, emphasis should be given to keeping the tank full to minimize inside wall condensation that can accumulate and drain into the fuel.
    - o The JP-8 storage tank bottom should slope to a sump and equipped with and effective water removal/product recovery system.
    - o Bulk storage tank sumps should be drained at least weekly, following each receipt, and following dramatic temperature drops, and prior to product transfers. This practice should be applied to all storage tanks containing additized JP-8, including tanks at intermediate terminals.
    - o Tank issue line should not draw BS&W or product from tank sumps, and consideration should be given in the design of issue lines (such as floating suctions or a duck bill with a water dam) that avoid drawing from tank bottoms and sumps.
- When JP-8 is transferred between terminals and bases, inventory levels should be sufficient to allow adequate settling time. The settling time goal for normal operations should be set at 24 hours. During periods of surge operations, adequate storage space and inventory should be provided to permit a 6 to 12 hour settling period.
- All filter vessels built to the old DoD standard should be modified or replaced with vessels conforming to API standards. These include filter vessels in fixed facilities, on R-9 and Oshkosh R-11 refuelers, and on MH-2C hosecarts.
- Vessels using NSN 4330-00-987-0998 filter coalescer elements should be modified to use API/IP 1581 Edition 3 or Edition 4 elements and the use of NSN 4330-00-987-0998 elements should discontinued.
- Find and adopt an alternative to the use of water absorption media in any remaining R-9 and in R-11 refuelers. We recommend these vessels be modified to meet API/IP 1581 standards. A test of API/IP 1581 Edition 3 elements with JP-8+100 and fuel containing low levels of particulate contamination may yield a less expensive solution than use of the more costly, and yet-to-be-proven M-100 series of the Edition 4 standard. Bases with epoxy-coated storage tanks, stainless steel piping, and API/IP 1581 qualified

filtration systems at truck fillstands may be able to use the Edition 3 filters in refueling vehicles without compromising the coalescers. However, deployment requirements may require an assumption of high particulate content for some equipment.

- Ensure filter separator design criteria prohibits the use of an interior weld that works as a dam to prevent free-water/FSII mixtures from entering the separator sumps, as is the case on the Kovatch R-11 refuelers.

- Recommended changes to Technical Orders identified in Section 3.10 should be considered for adopted.

- The base level Fuels Automated System (FAS) contains a wealth of fuel quality information that can be used to monitor important quality trends; however, most base level personnel do not know how to access and use this information to monitor and manage fuel quality. Recommend that training be developed and provided to foster a better understanding of the usefulness of this important and powerful tool.

6.0 APPENDICES

APPENDIX A

LIST OF ABBREVIATIONS USED

AEL	Aeronautical Engine Laboratory
AFRL	Air Force Research Laboratory
AFRES	Air Force Reserve
AJ	Apple Jelly
ANG	Air National Guard
API	American Petroleum Institute
bbl	Barrel (measurement consisting of 42 gallons)
BS&W	Bottom Sediment and Water
C4e	Consulting for Energy Efficiency and Environmental Excellence, Inc.
CU	Conductivity Unit
DESC	Defense Energy Support Center
Diegme	diethelyne glycol monomethyl ether
FAS	Fuels Automated System
F/S	Filter Separator
FSII	Fuel System Icing Inhibitor
GPM	Gallons Per Minute
HSV	Hydrant Servicing Vehicle
JPTS	Jet Propulsion Thermally Stable
LFM	Liquid Fuels Maintenance
MBBL	One Thousand Barrels
MH-2C	Hosecart used with Type II Hydrant System
NRL	Navy Research Laboratory
PDR	Pipeline Drag Reducer
POC	Point of Contact
ppm	Parts Per Million
psi	Per Square Inch
QAR	Quality Assurance Representative
QSR	Quality Surveillance Representative
R-9 and R-11	Types of fuel servicing tank trucks
SDA	Static Dissipating Additive
Stadis 450	Brand Name of SDA
SwRI	Southwest Research Institute

APPENDIX B

BASE MATRIX

Apple Jelly Investigation Base Matrix	Barksdale AFB	Bangor ANGB	Pease ANGB	Westover AFB	Niagara AFRES	Otis ANGB	Quonset ANGB	Bradley ANGB	McGuire AFB	Dover AFB
1. Has this activity experience AJ:	Yes	Yes	Yes	Yes	Yes	Yes	Yes?	Yes	?	Yes
In the receipt filter/separator (F/S)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Receipt F/S Elements Type	API	API	API	998	API	API	API	API-3		
In Storage Tank Prod Recovery Systm	Yes	Yes	Yes	No	Yes	Yes	No	No	No	
In Transfer F/S	No	N/A	N/A	No	Yes	Yes	N/A	N/A	No	
Transfer F/S Element Type	No	N/A	N/A		API	API	N/A	N/A		
In Type III Issue F/S	No	Yes	No	No	Yes	N/A	N/A	N/A	No	
Type III F/S Element Type	No	API	API	API	API	N/A	N/A	N/A		API
In HSV-12 F/S	?	Yes	Yes	No	No	N/A	N/A	N/A		
In Truck Fillstand F/S	No	Yes	No	No	No	Yes	No	Yes	No	
Truck Fillstand F/S type		API	API	API	API	API	API	API		
In R-11 (Kovatch) F/S	Yes	Yes	No	No	No	Yes	No	No	?	No
In R-11 (Oshkosh) F/S	No	Once	No	No	No	Yes	No	No	No	No
R-11s use water absorption elements	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Manufacturer Facet=Fac Velcon=Vel	F & V	Fac	Fac	n/a	Fac	Fac	Fac	Fac	Fac	Fac
In sample downstream of final F/S	No	No	No	No	No	No	No	No	No	No
In Base Assigned Aircraft	No	No	No	No	No	No	No	No	?	No
MH2C Hosecarts	n/a	n/a	No	No	N/A	N/A	N/A	N/A		
Are F/S w/AJ in heated facility	No	Yes	Yes	Yes	Yes	Yes	N/A	Yes	N/A	Yes
R-11s in heated facility? S=some	No	S	No	No	No	No	No		No	No
Does facility heating contribute to AJ	n/a	Yes	?	?	?	Yes	N/A	Yes	N/A	
Is +100 additive injected at this location	No	No	No	No	No	Yes	YES	No	No	No
2. Nature of AJ Samples Tested by Swri										
High Viscosity (HV) (>100cP)	Photo	-	-	-	-	-	-	-	-	-
Medium Viscosity (MV) (10-100 cP)		-	-	-	-	-	-	-	MV	-
Low Viscosity (LV) (10cP or less)	LV	LV	-	-	LV	-	-	-	LV	-
Sample Source										
Kovatch R-11 F/S Sump	Photo	LV	-	-	-	-	-	-	MV/LV	-
Kovatch R-11 Main Tank Sump	-	-	-	-	-	-	-	-	-	-
Oshkosh R-11 F/S Sump	-	-	-	-	-	-	-	-	-	-
Oshkosh R-11 Main Tank Sump	-	-	-	-	-	-	-	-	-	-
HSV-12 F/S Sump	LV	LV	-	-	-	-	-	-	LV	-
Fillstand F/S	-	-	-	-	-	-	-	-	-	-
Transfer F/S	-	-	-	-	-	-	-	-	-	-
Storage/Hydrant Tank	-	LV	-	-	-	-	-	-	-	-
Product Recovery System Tank	-	LV	-	-	-	-	-	-	-	-
Type Elements										
Water absorption, Facet (F), Velcon (V)	F	F	-	-	-	-	-	-	F	-
API Elements	-	-	-	-	-	-	-	-	-	-
DoD Standard Element (0998)	-	-	-	-	-	-	-	-	-	-

Bulk Tank Water Drain	-	-	-	-	-	-	-	-	-	-
Product Recovery System Tank Bottoms	-	LV	-	-	-	-	-	-	-	-
3. Excessive Water in Fuel Sytem	Yes	?	No	No	Yes	Yes				Yes
Fuel Cloudy at Upon Receipt	Yes	?	Yes	Yes	Yes	Yes				
Rain Entry into on Base Tankage	Yes	No	No	No		Yes				
Ground water entry into tank	No	No	No	No	No	No				
In Fuel at time of receipt	Yes	?	Yes	Yes	Yes	Yes				Yes
Ineffective product recover/H2O removal system	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No		Yes
Self cleaning tank design	Yes	Yes	Yes	Yes	N/Y	N/Y				Yes
AEL Water Content - highest		5								>20
AEL Water Content - average		<5								>10
AEL Water Content - lowest		0								0
4. History of FSII Content										
Highest FSII receipt sample	100%	0.14	0.24		0.11		0.12	0.1		0.14
Average FSII receipt content	0.16	0.12	0.12		0.11	0.09	0.11	0.1		0.13
Lowest FSII receipt content		0.1	0		0.1		0.11	0.09		0.1
Has lowering FSII reduced AJ?	Yes		Yes			Yes	-			
5. History of high Conductivity		No								
Highest CU reading - August		300	450	140				300		
Average CU reading - August			300					275		
Lowest CU reading - August		250	220					250		
Highest CU reading - January		160	680		490		244	130		
Average CU reading - January			350		403		209	110		
Lowest CU reading - January		100	180	110	316		184	100		
Has reducing SDA reduced AJ										
6. Product Receipt Temperatures										
Highest Temp - August			85F	66F						
Average Temp - August		75F	70F	64F						
Lowest Temp - August			68F	60F						
Highest Temp - January			33F	35F	33F		58F	30F		40F
Average Temp - January		34F	30F	34F 29F	28F		49F	20F		39F
Lowest Temp - January		28F	28F	32F	22F		40F	25F		20F
7. Receive product from the following										
DFSP Bosier City via pipeline	Yes	-	-	-	-	-	-	-	-	-
DFSP Ludlow via Tank Truck	-	-	Yes	Yes	Yes	Yes	Yes	Yes	-	-
DFSP Ludlow via Pipeline	-	-	-	Yes	-	-	-	-	-	-
DFSP Portland via Tank Truck	-	Yes	Yes	-	-	-	-	-	-	-
DFSP Jacksonville	-	-	-	-	-	-	-	-	Yes	-
DFSP Port Mahon	-	-	-	-	-	-	-	-	-	Yes
8. Products Downgraded to JP-8	JP-10	-	-	-	-	-	-	-	-	-

Apple Jelly Investigation Base Matrix	Grand Forks AFB	Minot AFB	McConnell AFB	Edwards AFB	Beale AFB	Fairchild AFB	McChord AFB	Hill AFB
1. Has this activity experience AJ:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
In the receipt filter/separator (F/S)	Yes		No	n/a	n/a	n/a	YES	n/a
Receipt F/S Elements Type	API	API	n/a	n/a	n/a	n/a	API	n/a
In Storage Tank Prod Recovery Systm	No	No	Yes	No		Yes	No	No
In Transfer F/S	Yes	Yes	?	Yes	Yes		No	n/a
Transfer F/S Element Type	API	API	API	998	API		No	n/a
In Type III Issue F/S	API	Yes		No	API	Yes	No	n/a
Type III F/S Element Type		API			API	API	No	n/a
In HSV-12 F/S	Yes	n/a	No	No	No	No		n/a
In Truck Fillstand F/S						?	Yes	No
Truck Fillstand F/S type						?	998	998
In R-11 (Kovatch) F/S	Yes		Yes	Yes	Yes	Yes	No	Yes
In R-11 (Oshkosh) F/S	Yes							No
R-11s use water absorption elements	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Manufacturer Facet=Fac Velcon=Vel	Fac	Note	F & V	Fac	Fac	Fac	Fac	Fac
In sample downstream of final F/S	No	No	No	Yes	No	No	No	No
In Base Assigned Aircraft	No	No	Yes	No	No	No	Yes	No
MH2C Hosecarts		No	n/a		Yes	No	No	
Are F/S w/AJ in heated facility	Yes	Yes	Yes	No	No	No	No	No
R-11s in heated facility? S=some	Yes	Yes	No	No	No	No	No	No
Does facility heating contribute to AJ	Yes	No	No	No	No	No	No	No
Is +100 additive injected at this location	No	No	No	Yes	No	No	No	Yes
2. Nature of AJ Samples Tested by Swri								
High Viscosity (HV) (>100cP)	HV	-	HV	-	HV	-	-	Visual
Medium Viscosity (MV) (10-100 cP)	-	-	MV	-	-	-	-	-
Low Viscosity (LV) (10cP or less)	LV	-	LV	LV	LV	LV	-	-
Sample Source								
Kovatch R-11 F/S Sump	HV	-	HV	LV	HV	-	-	HV
Kovatch R-11 Main Tank Sump	-	-	-	LV	LV	-	-	-
Oshkosh R-11 F/S Sump	-	-	-	-	HV	-	-	-
Oshkosh R-11 Main Tank Sump	-	-	-	-	-	-	-	-
HSV-12 F/S Sump	-	-	-	-	-	-	-	-
Fillstand F/S	-	-	-	-	-	-	-	-
Transfer F/S	-	-	-	-	-	-	-	-
Storage/Hydrant Tank	-	-	MV	-	-	LV	-	-
Product Recovery System Tank	LV	-	LV	-	-	-	-	-
Type Elements								
Water absorption, Facet (F), Velcon (V)	-	-	-	F	F&V	-	-	-
API Elements	-	-	-	-	-	-	-	-
DoD Standard Element (0998)	-	-	-	-	-	-	-	-

Bulk Tank Water Drain	-	-	MV	-	-	-	-	-
Product Recovery System Tank Bottoms	-	-	-	-	-	-	-	-
3. Excessive Water in Fuel Sytem	No	No	No		Yes	Yes	No+	?
Fuel Cloudy at Upon Receipt	Yes	No	No	No	?			No
Rain Entry into on Base Tankage	Yes	No	No	Yes	Yes	Yes	Yes	?
Ground water entry into tank	No	No	No	No	No	No	No	No
In Fuel at time of receipt	3PPM	3PPM	No	?	Yes	?	?	No
Ineffective product recover/H2O removal systm	?	?	No	Yes	Yes	Yes	Yes	Yes
Self cleaning tank design	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AEL Water Content - highest								20
AEL Water Content - average	3PPM	3PPM						<1
AEL Water Content - lowest								0
4. History of FSII Content								
Highest FSII receipt sample	0.13	0.15	0.14		0.14	0.15	0.14	0.17
Average FSII receipt content	0.11	0.11	0.11		0.11	0.12	0.12	0.11
Lowest FSII receipt content	0.09	0.09	0.08					0
Has lowering FSII reduced AJ?	Yes							
5. History of high Conductivity				No	No	Yes	No	No
Highest CU reading - August		378		110	202	560	193	240
Average CU reading - August	250	263		90	196	474	137	169
Lowest CU reading - August		179		70	191	411	119	76
Highest CU reading - January		618	378		234	378	128	488
Average CU reading - January		427	230		?	286	76	261
Lowest CU reading - January		290	164		?	219	68	86
Has reducing SDA reduced AJ		?			?	?	?	
6. Product Receipt Temperatures								
Highest Temp - August		81	91.6	89F	85F	80F	70F	
Average Temp - August		71	85.2	81F	80F	76F	68F	
Lowest Temp - August		65	80.2	80F	75F	69F	68F	
Highest Temp - January		49	41	62F	56F	41F	48F	
Average Temp - January		40	36.3	59F	56F	36F	46F	
Lowest Temp - January		25	28	57F	56F	34F	45F	
7. Receive product from the following								
DFSP Grand Forks via Pipeline	Yes							
DFSP Grand Forks via Tank Truck		Yes						
Conoco Terminal, Ponca City			Yes					
					JP-10			

8. Products Downgraded to JP-8

APPENDIX C

TERMINAL MATRIX

Apple Jelly Investigation Terminal Matrix	DF SP Bossier City	DF SP Ludlow	DF SP Portland	New Haven Jet Lines	DSFP Carteret	DF SP Jacksonville	DSFP Pot Mahon	DF SP Grand Forks	AMOCO Refinery	CONOCO Terminal
1. Do some customers have AJ problems	YES	YES	YES	YES	YES	No	YES	YES	New	YES
2. Do all customers have AJ problems	YES	No	No	No	No	No	?	No	?	n/a
3. Do customer think it comes from here	YES	YES	No	No	No	N/A	YES	YES	?	YES
4. Has this activity experience AJ	No	YES	No	No	No	No	YES	No	No	YES
In the receipt filter	N/A	N/A	N/A	No	No	No	No	N/A	No	No
In the receipt filter/separator (F/S)	N/A	N/A	N/A	No	No	No	No	N/A	No	N/A
From Tank sump drain	N/A	YES	No	No	No	No	No	No	No	No
From Issue filter	N/A	N/A	No	No	No	No	No	N/A	No	No
Issue filter/separator (F/S)	No	N/A	No	No	No	No	YES	N/A	YES	No
5. Excessive Water in Fuel System	?	YES	No	No	No	No	YES	YES	YES	No
Rain Entry into Terminal Tankage	No	YES	No	No	No	No	No	YES	YES	No
Water in fuel at time of delivery	?		No	No	No	No	YES	No	N/A	YES
Ineffective tank sump draining	YES	YES	?	No	No	No	YES	No	No	YES
How often is water drained?	Never	3 MO	6 MO	?	?	?	?	Wkly	Wkly	6 MO
6 Self cleaning tank design	YES	No	No	No	No	No	No	YES	No	No
7. Is JP-8 received w/ FSII & SDA	No	YES	YES	YES	No	YES	YES	No	No	No
8. Are SDA & FSII blended here	YES	YES	No	No	YES	No	SDA	YES	YES	YES
For Tank Truck Shipment	No	YES	YES	No	YES	No	Yes	YES	YES	YES
For Pipeline/Barge Shipment	Yes	YES	No	No	YES	No	Yes	No	No	No
Is this the initial blending	YES	No	N/A	N/A	YES	No	No	YES	Yes	YES
Is this additional blending	No	YES	N/A	N/A	No	YES	YES	No	No	YES
Is Injection Upstream of pump	No	YES	N/A	N/A	No	YES	YES	YES	No	YES
Is injection Upstream of filter	No	YES	N/A	N/A	YES	YES	YES	N/A	No	YES
Is flow Laminer (L) or Turbulent (T)	L	?	N/A	N/A	T	N/A	?	T	T	T
FSII storage protected from moisture	No	No	YES	N/A	YES	N/A	N/A	YES	YES	No
Is Hammonds Injector used	No	YES	No	N/A	YES	No	No	YES	No	No
Is Gates City Injector used	No	No	Yes	N/A	No	No	No	No	YES	YES
Other Type Injector	YES	No	N/A	N/A	N/A	No	YES	N/A	N/A	N/A
9. History of Excessive FSII in JP8 storage	N/A	?	?	No	?	?	?	No	No**	Yes
Highest FSII Reading in Storage	N/A	?	?	?	0.13	?	?	N/A	N/A	0.15
Average FSII Reading	N/A	?	0.13	?	0.11	?	?	N/A	N/A	0.14
Lowest FSII Reading in storage	N/A	?	?	?	?	?	?	N/A	N/A	0.13
Has lowering FSII Helped	N/A	?	N/A	?	?	?	?	N/A	N/A	?
10. History of high Conductivity	N/A	?	?	?	?	?	?	YES	No	?
Highest CU Reading	N/A	?	350	?	300	?	?	550	N/A	?
Average CU Reading	N/A	?	?	?	250	?	?	250	N/A	?
Lowest CU Reading	N/A	?	150	?	200	?	?	0	N/A	?
Has reducing SDA reduced AJ	?	Yes	?	?	?	?	?	Yes	N/A	?

Apple Jelly Investigation Terminal Matrix	DFSP Bossier City	DFSP Ludlow	DFSP Portland	NewHaven Jet Lines	DSFP Carteret	DFSP Jacksonville	DSFP Pot Mahon	DFSP Grand Forks	AMOCO Refinery	CONOCO Terminal
11. Type of Storage Tanks										
Above Ground (AST) - Fixed Roof	Yes	No	Yes	YES	YES	YES	Yes 8	No	YES	YES
AST - Geo-dome w/floater	No	No	No	YES		No	Yes 1	YES	No	No
Below Ground	No	No	No	No	No	No	No	No	No	No
Are Tanks dedicated to Jet Fuel products	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Are tanks used for multiple products	No	No	No	No	No	No	No	No	No	No
12. Tank Floor										
Flat or essentially flat	No	YES	No	No	?	No	?	No	No	No
Slop to center sump	YES	No	No	No	?	Yes 4	?	YES	No	No
Slop to edge	No	No	Yes	YES	YES	Yes 4	YES	No	YES	YES
Effective water drain system	No	No	No	No	No	No	No	YES	?	?
13. Epoxy Tank Coating	none	Some	none	YES	YES	None	None	YES	YES	YES
Tank floor only	No	No	No	No	No	No	No	No	YES	No
Tank floor and lower wall	No	Yes 1	No	YES	YES	No	No	YES	No	YES
Tank floor and walls (100%)	No	No	No	No	No	No	No	No	No	No
14. Issue (suction line)										
Issue and receipt through same line	YES	?	No	No	No	No	No	No	No	YES
Suction line draws from sump	YES	No	No	No	No	No	No	?	No	No
Height of suction inlet from tank floor		?	?	24"	6"	18"	12"	41"	?	>9.5"
Suction designed to minimize H20 intake	YES	YES	YES	YES	YES	YES	YES	?	YES	YES
15. Water drain/product recovery		None				None				
Sump draining equipment effective	No	No	No	No	No	No	No	?	?	?
Water drained following each receipt	No	No	No	YES	No	No	?	Yes	?	YES
Water drained daily (prior to transfers)	No	No	No	No	No	No	?	Yes	?	No
Water draining procedures effective	No	No	No	No	No	No	No	?	?	?
16. Receipt Modes										
Dedicated Pipeline	No	No	No	No	No	No	No	No	N/A	No
Multi-product pipeline	YES	YES	No	No	YES	No	No	YES	N/A	YES
Tanker/Barge	No	No	YES	YES	No	YES	YES	No	N/A	No
Truck	No	No	No	No	No	No	No	No	N/A	No
Rail Car	No	No	No	No	No	No	No	No	N/A	No
Is receipt conveyance dedicated to jet	No	No	No	YES	No	No	No	No	N/A	No
17. Shipping Modes										
Dedicated Pipeline	YES	YES	No	No	No	YES	YES	YES	No	YES
Multi-product pipeline	No	No	No	YES	YES	No	No	No	Yes	No
Tanker/Barge	No	No	No	?	YES	No	YES	No	No	No
Truck	No	YES	YES	YES	YES	YES	YES	YES	YES	YES
Is receipt conveyance dedicated to jet	No	No	No	No	No	YES	?	No	No	N/A
18. Product rotation--weeks for turnover	?	?	4 wks	4wks	2wks	?	?	?	N?A	1 mo

APPENDIX D

ALL SAMPLE MATRIX

Sample ID	Sample Matrix (Jet-A/JP-8/JP-5/other)	Type of Sample (Fuel/Apple Jelly/DIM E/other)	Sample Location (where sample was taken from in the system)	Base Name	Additional Information
AP-071	JP-8	Fuel	Coalescer #1, 2-27-01, sump sample	Atlantic Product Services	1 quart, rec'd 3/14/01
AP-072	JP-8	Fuel	Coalescer #2, 2-27-01, sump sample	Atlantic Product Services	1 quart, rec'd 3/14/01
AP-035	N/A	AJ	N/A	Barksdale AFB	500 mL jar
AP-036	N/A	Fuel	N/A	Barksdale AFB	1 gal. can
AP-075	N/A	AJ	HSV 12 filter sump	Barksdale AFB	1 quart jar, rec'd 3/16/01
AP-076	N/A	AJ	HSV 12 filter sump	Barksdale AFB	1 quart jar, rec'd 3/16/01
AP-056	N/A	AJ	Kovatch R-11, 98L024 Filter Separator	Beale AFB	125 mL jar, rec'd 3/9/01, AJ temp 53°F
AP-091	JP-8	Fuel	Kovatch R-11, 98L024 from Y strainer, 3-5-01	Beale AFB	1 gal can, rec'd 3/27/01
AP-092	JP-8	Fuel	Kovatch R-11, 98L024 from Y strainer, 3-5-01	Beale AFB	1 gal can, rec'd 3/27/01
AP-112	N/A	AJ	Kovatch 97L005	Boise ANG	500 mL, rec'd 4/10/01
AP-004	JP-8	Fuel	CB-J-2-007, Tank No. 2, hose/nozzle sample, fuel delivery date Jan 18, 2001	Camp Bullis	1 gal. Plastic jug rec'd 2/15/01
AP-055	N/A	AJ	Refueling unit, 2/12/01	Delaware ANG	125 mL jar rec'd 3/5/01
AP-118	N/A	AJ	Base Sample # 0101436	Dover AFB	500 mL, rec'd 4/12/01
AP-078	JP-8	Fuel	Oshkosh R-11, 91L96, F/S sump 3-6-01, Facet elements	Edwards AFB	1 gal can, rec'd 3/23/01
AP-079	JP-8	AJ	Oshkosh R-11, 91L69, F/S sump 3-21-01, Facet elements	Edwards AFB	125 mL, rec'd 3/23/01
AP-080	JP-8	AJ	Oshkosh R-11, 91L69, F/S sump 2-27-01, Facet elements	Edwards AFB	125 mL, rec'd 3/23/01
AP-081	JP-8	AJ	Oshkosh R-11, 91L69, F/S sump 3-7-01	Edwards AFB	125 mL, rec'd 3/23/01
AP-082	JP-8	AJ	Kovatch R-11,96L144, F/S sump during element change, Facet elements	Edwards AFB	500 mL, rec'd 3/23/01
AP-083	JP-8	Absorption Media Element	Kovatch R-11,96L144, F/S sump during element change, Facet elements	Edwards AFB	1 L, rec'd 3/23/01
AP-093	JP-8	AJ	Oshkosh R-11, 91L69, 3/5/01, Facet elements	Edwards AFB	1 qt jar, rec'd 3/27/01
AP-094	JP-8	AJ	Oshkosh R-11, 91L69, 3/2/01, Facet elements	Edwards AFB	1 qt jar, rec'd 3/27/01
AP-095	JP-8	AJ	Kovatch R11, F/S Sump, Facet elements	Edwards AFB	1 qt jar, rec'd 3/27/01
AP-096	JP-8	AJ	Oshkosh R-11, 91L69, 3/8/01, Facet elements	Edwards AFB	1 qt jar, rec'd 3/27/01
AP-097	JP-8	AJ	Kovatch R-11,96L144, F/S sump, 2/1/01, Facet elements	Edwards AFB	1 qt jar, rec'd 3/27/01
AP-098	JP-8	AJ	Kovatch R-11,96L144, F/S sump, 3/13/01, Facet elements/ 50 degF	Edwards AFB	1 qt jar, rec'd 3/27/01

Sample ID	Sample Matrix (Jet-A/JP-8/JP-5/other)	Type of Sample (Fuel/Apple Jelly/DIM E/other)	Sample Location (where sample was taken from in the system)	Base Name	Additional Information
AP-099	JP-8	AJ	Kovatch R-11,96L144, F/S sump, 3/13/01, Facet elements	Edwards AFB	1 qt jar, rec'd 3/27/01
AP-100	N/A	Absorption Media Element	FACET, Refueler 96L-144, sample #12	Edwards AFB	filter media, rec'd 3/27/01
AP-101	N/A	Filter Media Element	Transfer filter separator 5-1, Velcon PN #0998	Edwards AFB	filter media, rec'd 3/27/01
AP-117	N/A	AJ	Oshkosh R-11, 91L69, 4/5/01, scooped from bottom during Facet element change	Edwards AFB	500 mL, rec'd 4/12/01
AP-060	JP-8	AJ	Oshkosh Unit 89L-945 sump, 2-5-01, 68°F	Eglin AFB	1 L jar, rec'd 3/9/01
AP-061	JP-8	AJ	Oshkosh Unit 89L-945 sump, 2-15-01, 65°F	Eglin AFB	1 L jar, rec'd 3/9/01
AP-122	JP-8	AJ	Kovatch 98L-061 Sump	Eglin AFB	500 mL, rec'd 4/12/01
AP-123	JP-8	AJ	Oshkosh Unit 89L-945 sump, 2-15-01, 65°F	Eglin AFB	1 L, rec'd 4/12/01
AP-124	JP-8	AJ	89L-945/Separator, 2-5-01, 61°F	Eglin AFB	1 L, rec'd 4/12/01
AP-125	JP-8	AJ	89L-945, outside temp, 57°F	Eglin AFB	500 mL, rec'd 4/12/01
AP-126	JP-8	AJ	89L-945/Separator, 57°F outside temp	Eglin AFB	1 L, rec'd 4/12/01
AP-127	JP-8	AJ	89L-945/Separator	Eglin AFB	1 L, rec'd 4/12/01
AP-128	JP-8	AJ	89L-945	Eglin AFB	500 mL, ,rec'd 4/12/01
AP-014	N/A	AJ	Rect. Tank 13 B, Area C	Ellsworth AFB	500 mL jar sampled 2/14/01, tank temp 42°F, AJ temp temp 54°
AP-015	N/A	AJ	Rect. Tank 13 B, Area C	Ellsworth AFB	500 mL jar sampled 2/14/02
AP-016	N/A	AJ	Receipt Tank 13 B, Area C, light sample	Ellsworth AFB	1 gal. Can, tank temp 42°F, AJ temp 59°F
AP-017	N/A	AJ	Receipt Tank 13 B, Area C, dark sample	Ellsworth AFB	1 gal. Can, tank temp 42°F, AJ temp 59°F
AP-018	N/A	AJ	Receipt Tank 13 B, Area C	Ellsworth AFB	125 mL jar, AJ temp 54°F
AP-019	N/A	AJ	Receipt Tank 13 B, Area C	Ellsworth AFB	125 mL jar, AJ temp 54°F
AP-020	N/A	AJ	Receipt Tank 13 B, Area C	Ellsworth AFB	125 mL jar, AJ temp 54°F
AP-021	N/A	AJ	Issue tank pumphouse #5, Filter Sep. #4	Ellsworth AFB	125 mL jar, AJ temp 58°F
AP-022	N/A	AJ	Issue tank pumphouse #5, Filter Sep. #4	Ellsworth AFB	125 mL jar, AJ temp 58°F
AP-023	N/A	AJ	Issue tank pumphouse #5, Filter Sep. #4	Ellsworth AFB	125 mL jar, AJ temp 58°F
AP-073	-	Stadis 450 Static Dissipator Addtitive	Drum Sample	Exxon Mobil Refining & Supply	1 quart bottle conductivity improver, rec'd 3/20/01

Sample ID	Sample Matrix (Jet-A/JP-8/JP-5/other)	Type of Sample (Fuel/Apple Jelly/DIME/other)	Sample Location (where sample was taken from in the system)	Base Name	Additional Information
AP-074	-	Deicer - DIEGME	Inbound T/C T/T Monitor	Exxon Mobil Refining & Supply	1 quart bottle , rec'd 3/20/01
AP-077	-	Nalco 5403 Jet Corrosion Inhibitor	Inbound T/C T/T Monitor	Exxon Mobil Refining & Supply	1 quart bottle, rec'd 3/21/01
AP-024	JP-8	Fuel	Continuous, N/A	Fairchild AFB	1 qt. jar, continuous sample
AP-025	JP-8	Fuel	Continuous, N/A	Fairchild AFB	1 qt. jar, continuous sample
AP-026	JP-8	Fuel	Continuous, N/A	Fairchild AFB	1 qt. jar, continuous sample
AP-027	JP-8	Fuel	Continuous, N/A	Fairchild AFB	1 qt. jar, continuous sample
AP-028	JP-8	AJ	Composite, Fuels hydrants/storage	Fairchild AFB	1 qt. jar composite
AP-029	JP-8	AJ	Composite, Fuels hydrants/storage	Fairchild AFB	1 qt. jar composite
AP-030	JP-8	AJ	Composite, Fuels hydrants/storage	Fairchild AFB	1 qt. jar composite
AP-031	JP-8	AJ	Composite, Fuels hydrants/storage	Fairchild AFB	1 qt. jar composite
AP-003	JP-8	Fuel	FSH-J-1-007, Tank No. 1, hose / nozzle sample, fuel delivery date July 2000	Ft. Sam Houston	1 gal. Plastic jug rec'd 2/15/01
AP-032	JP-8	AJ	Kovatch Unit97L-069, Tank Sump	Grand Forks AFB	125 mL jar
AP-033	JP-8	AJ	Recovery tank 660	Grand Forks AFB	125 mL jar
AP-034	JP-8	AJ	Recovery tank 660	Grand Forks AFB	125 mL jar
AP-105	JP-8	Fuel	8.11001E+12	Lajes Field	1 gal can, rec'd 3/29/01
AP-108	JP-8	AJ	Oshkosh R-11 91L-355, 62F	Lajes Field	125 mL, rec'd 4/10/01
AP-109	JP-8	Fuel	Oshkosh R-11 91L-355, cu-213, FSII-.12	Lajes Field	1 gal can, rec'd 4/10/01
AP-110	JP-8	AJ	Oshkosh R-11 91L-356,65F	Lajes Field	500 mL, rec'd 4/10/01
AP-111	JP-8	Fuel	Truck 356, cu-238, FSII-.13	Lajes Field	1 gal can, rec'd 4/10/01
AP-001	N/A	AJ (Apple Jelly)	R12, R11, & hydrant separators	Maine ANG	1 gal. Can rec'd 2/13/01
AP-002	N/A	AJ	Reclaim Tank: fuel comes from 2 storage tanks & 2 receipt separators	Maine ANG	1 gal. Can rec'd 2/13/01
AP-058	N/A	AJ	Product reclaim tank - hand pump	Maine ANG	125 mL, fuel temp 37°F, rec'd 3/9/01
AP-059	N/A	AJ	Product reclaim tank - hand pump	Maine ANG	125 mL, fuel temp 37°F, rec'd 3/9/01
AP-062	N/A	AJ	981076 hydrant servicing vehicle, 2-27-01	Maine ANG	14Dr. Vial, rec'd 3/12/01
AP-063	N/A	Fuel	981076 hydrant servicing vehicle, 2-27-01, 22°F	Maine ANG	14Dr. Vial, rec'd 3/12/01
AP-064	N/A	Fuel	981076 hydrant servicing vehicle, 2-27-01, 22°F	Maine ANG	14Dr. Vial, rec'd 3/12/01
AP-005	JP-8	Fuel	Tank 4, Bulk storage	Maxwell AFB	l gal. can rec'd 2/21/01
AP-006	JP-8	AJ	Consolidated refueling units	Maxwell AFB	500 mL rec'd 2/21/01
AP-007	JP-8	AJ	Jet Fuel Boswer 002 bulk storage	Maxwell AFB	125 mL rec'd 2/21/01
AP-008	JP-8	AJ	Bulk storage, Tank 4	Maxwell AFB	125 mL rec'd 2/21/01
AP-009	JP-8	AJ	Bulk storage, Tank 4	Maxwell AFB	125 mL rec'd 2/21/01

Sample ID	Sample Matrix (Jet-A/JP-8/JP-5/other)	Type of Sample (Fuel/Apple Jelly/DIM E/other)	Sample Location (where sample was taken from in the system)	Base Name	Additional Information
AP-037	N/A	AJ	Tank 2 product recovery, sample #1	McConnell AFB	1 L jar
AP-038	N/A	AJ	Tank 2 water bottoms, sample #2	McConnell AFB	1 L jar
AP-039	N/A	AJ	Storage issue separator, sample #3	McConnell AFB	500 mL jar
AP-040	N/A	AJ	Tank 1 water bottom, sample #4	McConnell AFB	1 L jar
AP-041	N/A	AJ	Bowser #2, sample #5	McConnell AFB	1 L jar
AP-042	N/A	AJ	Receipt separator #2, sample #6	McConnell AFB	1 L jar
AP-043	N/A	AJ	Tank water bottom, sample #7	McConnell AFB	1 L jar
AP-044	N/A	AJ	Kovatch R-11, 97L039, sample #8	McConnell AFB	1 L jar
AP-045	N/A	AJ	Refueling unit, sample #9	McConnell AFB	1 L jar
AP-103	N/A	AJ	Sample #10, 48°F, Storage Browser, Tanks #1 & 2	McConnell AFB	1L, rec'd 3/29/01
AP-065	N/A	AJ	Refueling unit filter separator sump, 2-26-01, 38°F, FSII +.25	McGuire AFB	500 mL, rec'd 3/12/01
AP-066	N/A	AJ	Refueling unit filter separator sump, 2-23-01,10:00pm 38°F, FSII +.25	McGuire AFB	125 mL, rec'd 3/12/01
AP-067	N/A	AJ	Kovatch Refueling unit filter separator sump, 2-23-01,9:15am, 36°F, FSII +.25	McGuire AFB	125 mL, rec'd 3/12/01
AP-068	N/A	AJ	Aircraft 196 sump, 3-1-01, 8:00am, 40°F, FSII +.25	McGuire AFB	125 mL, rec'd 3/12/01
AP-106	JP-8	Fuel	Type III Receipt Separator Sump, 3-1-01, 8:00 am, 42°F, FSII 0.12	McGuire AFB	1 gal can, rec'd 3/12/01
AP-107	JP-8	Fuel	Aircraft 196 sump, 3-1-01, 8:00am, 40°F, FSII +.25	McGuire AFB	1 gal can, rec'd 3/12/01
AP-084	N/A	AJ	Sample #1, 12-5-00, Kovatch R-11 96L174	Misawa AB	125 mL, rec'd 3/23/01
AP-085	N/A	Fuel	Sample #1, 12-5-00, Kovatch R-11 96L174	Misawa AB	500 mL, rec'd 3/23/01
AP-086	N/A	AJ	Sample #2, 12-8-00, Kovatch R-11 96L209	Misawa AB	125 mL, rec'd 3/23/01
AP-087	N/A	Fuel	Sample #2, 12-8-00, Kovatch R-11 96L209	Misawa AB	200 mL bottle, rec'd 3/23/01
AP-088	N/A	AJ	Sample #3, 1-11-01, Kovatch R-	Misawa AB	125 mL, rec'd 3/23/01
AP-119	JP-8	Fuel	Unit 185, 3-27-01	Misawa AB	1 gal can, rec'd 4/12/01
AP-120	JP-8	AJ	Filter Separator Unit 185, 3-27-01	Misawa AB	2 test tubes, rec'd 4/12/01
AP-121	JP-8	AJ	Filter Separator Defuel Unit 188, 3-28-01	Misawa AB	1 test tube, rec'd 4/12/01
AP-057	N/A	AJ	Receiving separator vessel: scraped off side of vessel	New York ANG	125 mL, AJ temp 68°F, rec'd 3/9/01
AP-010	JP-8	AJ	Reclaim tank bottom	NFARS	500 mL jar
AP-011	JP-8	AJ	Issue separator #3	NFARS	500 mL jar
AP-012	JP-8	AJ	Product recovery tank "C" 2515	NFARS	500 mL jar
AP-013	JP-8	Fuel	Tank B 2514, issue tank for the day	NFARS	1 gal. can

Sample ID	Sample Matrix (Jet-A/JP-8/JP-5/other)	Type of Sample (Fuel/Apple Jelly/DIME/other)	Sample Location (where sample was taken from in the system)	Base Name	Additional Information
AP-046	JP-8	Fuel	N/A, 2/20/01	Shaw AFB	1 gal. can, FSII (refractometer) 0.15% , flash point 114°F
AP-047	JP-8	Fuel	Fillstand 3, 2/22/01	Shaw AFB	1 gal. can
AP-048	JP-8	AJ	Fillstans #3, filter separator sump, 2/20/01	Shaw AFB	500 mL jar
AP-049	JP-8	AJ	Tank 28, product recovery tank, 2/20/01, 65°F	Shaw AFB	125 mL jar
AP-050	JP-8	AJ	Tank 28, product recovery tank, 2/20/01, 65°F	Shaw AFB	125 mL jar
AP-051	JP-8	AJ	Tank 28, product recovery tank, 2/20/01, 65°F	Shaw AFB	125 mL jar
AP-052	JP-8	AJ	Fillstand #3, sump, 2/21/01, 61°F	Shaw AFB	125 mL jar
AP-053	JP-8	AJ	Fillstand #3, sump, 2/21/01, 61°F	Shaw AFB	125 mL jar
AP-054	JP-8	AJ	Fillstand #3, sump, 2/21/01, 61°F	Shaw AFB	125 mL jar
AP-069	N/A	AJ	Product recovery tank 28, 64°F, 3-8-01	Shaw AFB	125 mL, rec'd 3/14/01
AP-089	JP-8	Fuel	Sample 100389, 3-23-01, FSII 0.14	Shaw AFB	1 gal can, rec'd 3/26/01
AP-090	JP-8	AJ	Pol yard, 91L-386 filter separator sump, 3-23-01,	Shaw AFB	125 mL, rec'd 3/26/01
AP-102	N/A	AJ	Kovatch R-11 91L-386 Filter Separator sump, pol yard, 3-23-01, 71.2°F	Shaw AFB	125 mL, rec'd 3/27/01
AP-070	N/A	AJ	Oshkosh R-11 91L-102 filter separator sump, 12-7-00	Travis AFB	500 mL, rec'd 3/14/01
AP-113	N/A	AJ	#001, 3-6-01, 96L-190	Yokota	inside filter separator, rec'd 4/10/01
AP-114	N/A	AJ	#002, 2-15-01, 98L-84	Yokota	inside filter separator, rec'd 4/10/01
AP-115	N/A	AJ	#004, Combined refueling units 91L0095, 96L0063, and 96L0190, 2-13-01, 47°F	Yokota	500 mL, rec'd 4/10/01
AP-116	N/A	Filter Media Element	#003	Yokota	filter element, rec'd 4/10/01
AP-104	N/A	Filter Media Element	N/A		filter media, rec'd 3/29/01

APPENDIX E

Site Visit Reports

E-1: Barksdale AFB, LA
E-2: TEPPCO Bossier City, LA
E-3: DFSP Ludlow
E-4: Pease ANGB
E-5: Otis ANGB
E-6: Westover AFB
E-7: Bradley ANGB
E-8: Quonset Holland ANGB
E-9: NAS Brunswick
E-10: DFSP New Haven
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E-13: DFSP Carteret
E-14: DFSP Jacksonville
E-15: McGuire AFB
E-16: DFSP Port Mahon
E-17: Dover AFB
E-19: DFSP Grand Forks
E-20: Grand Forks AFB
E-21: BP/AMOCO Mandan Refinery
E-22: Minot AFB
E-23: McConnell AFB
E-24: CONOCO Pipeline Company Terminal
E-25: Edwards AFB
E-26: Kinder Morgan Holding Tank Facility
E-27: Beale AFB
E-28: Fairchild AFB
E-29: US Oil & Refining Company
E-30: McChord AFB
E-31: Hill AFB
E-32: NAS Corpus Christi

Appendix E-1

Barksdale AFB, LA

2BW/LGSF
1049 Davis Avenue, Suite 101
Barksdale AFB, LA 71110-2284

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AJ Investigation Team: Larry Dipoma (C4e), E. Mac Fishburn (C4e), Dwight Duncan (C4e), Calvin Martin (Martin & Associates), Andy Waynick (SwRI), Ruben Alvarez (SwRI), Bud Rodee (DFR-Americas), and Dan Lee (DESC-QSR).

AJ Incidents
AJ-like contamination has been found in R-11 refuelers equipped with water absorption cartridges manufactured by Facet. However, no AJ has been found in the HSV-12 refuelers equipped with standard filter-separator elements. Water absorption elements manufactured by Facet were first installed in the Barksdale refuelers during January and February 2000. The Facet water absorption elements have experienced premature failures. Seventeen sets of elements have been changed since November 2000. The changes occurred simultaneously with a significant drop in ambient temperature accompanied by rain and high humidity. Refueling Maintenance personnel report that in a "majority" of the changes, a sticky, dark caramel colored substance is found on the bottom of the filter vessel. High viscosity AJ-like material has generally not been observed in water drained from the vessels but accumulates in the bottom of the vessel and is held within the vessel by the circular weld that attaches the sump to the horizontal vessel wall.

The change to the water absorption elements was made to accommodate the Air Force use of JP-8+100. The "+100" additive used to enhance the thermal stability of JP-8 by approximately 100° F includes detergents, dispersants, and antioxidants. The surface-active nature of the detergents and dispersants disarm standard filter-coalescer elements that have consequently been replaced by water absorption elements. Though Barksdale does not issue JP-8+100, the water absorption elements are used because of the potential of defueling transient aircraft or home station aircraft serviced in-flight or at other locations with fuel containing the +100 additive.

On January 29, 2001, Refueling Maintenance personnel installed a set of Velcon manufactured water absorption elements in one R-11 (97L00142) refueler for a comparison against the Facet elements. The Facet water absorption filters originally installed in this vehicle during February 2000 were changed on November 14 and again on November 28 because of high differential pressures. Photos of the F/S vessel are shown below.

Again, because of high differential pressure, new elements, this time Velcon elements, were installed on January 29th, after only 144 hours of operation since the November 28th change. Though in service for a short period of time, the differential pressure of the Velcon elements climbed quickly to 16 PSI. We asked the refueling maintenance personnel to open this vessel. Small flakes of the AJ-like material were observed on the bottom of the vessels, as well as several inches up the access port of the horizontal vessel. The material was very sticky. When pinched between two fingers, the material would stretch out in multiple fine strands as the figures were separated. The strands would break apart at approximately one-inch of separation in the figures. The color of these small flakes or AJ "freckles" was very similar to those in the above photographs. There was not a sufficient amount of this material to collect as a meaningful sample.

Product Receipts and Issues

The receiving line from the Bossier Terminal is a four-inch line that enters a ten-inch manifold with two 1200 GPM F/Ss. The pressure drop across the F/S was observed to be 2 psi. The receiving rate is from 275 to 300 bbls/hr (or 192 to 210 gpm) and their daily demand rate averages 275 bbls/hr. We took a receipt sample upstream from the Air Force-owned receiving filters at bulk storage and found the fuel to be cloudy. The fuel down stream of the F/S was clear and bright, and given the critical fuel resupply situation with the shutdown of the LaGloria refinery, the QSR and Barksdale personnel opted to continue the receipt. Base personnel complained about the reliability of the FSII injector at the TEPCO Bossier terminal and stated that at one time they received a batch of fuel that was nearly pure FSII. Because of a recent problem with the hydrocracker at the LaGloria refinery, Barksdale is receiving an increased number of tank truck deliveries to supplement the pipeline shipments from LaGloria via TEPPCO.

Fuel is shipped from the LaGloria refinery via TEPPCO's multiproduct pipeline, which is approximately 100 miles long, and contains approximately 32,000 gallons of line fill. During July 2000, pipeline drag reducer (PDR) additive was used in this pipeline for other product shipments. We asked the QSR to obtain additional information about the use of PDR. The Shreveport terminal breaks JP-8 from the LaGloria Refinery into multiproduct tanks that are also used for breakout of kerosene and DF-2. The tanks are drained and stripped of other product before the JP-8 is received. The Bossier City Terminal that supplies Barksdale AFB receives JP-8 from the Shreveport Terminal breakout tanks. No additives are injected at the Shreveport terminal; however, Corrosion Inhibitor and Antioxidants are injected at the refinery. The team did not visit the Shreveport Terminal. Barksdale AFB issue approximately 57 million gallons per year.

Bulk Storage

Barksdale has two 40,000-bbl tanks and two 30,000-bbl tanks that were constructed during the 1950s. Additionally, they have two 10,000-bbl tanks and two 5,000-bbl tanks constructed during 1998. The four tanks, originally constructed in the 1950s, were modified during the mid-1980s with cone bottoms that slope to the center of the tanks and geodesic domes to aid in control of water contamination of the fuel.

One of the 40,000-bbl tanks, Tank #4, has previously experienced a rim fire, is out-of-round, and leaks badly during periods of heavy rain. As much as 400 to 500 gallons of water have been drained from Tank 4 following heavy rainstorms. Fuels Flight personnel report that the other geodesic domes are not as effective in preventing the introduction of rain water into the fuel as is desired. Barksdale AFB has an inventory capacity of 6.3 million gallons and an average inventory level of 2.9 million gallons. Barksdale personnel are currently working to obtain an increase in their authorized inventory level. While it appears that an increase in inventory levels may be needed, we recommend that Tank #4 be removed from service until it is repaired.

We examined one of the product recovery systems (Tank #3). The water drain line is a ¾ inch line that travels approximately 38 feet from the center of the cone bottom to the tank wall and is wrapped around the tank wall for approximately 12 feet to the drain collection point. This water drain is inadequate because of the small size of the ¾ inch drainpipe and the length of the pipe. A project to replace the product recovery system has been funded and is Currently in design. We strongly recommend that the new design has a drainpipe with a minimum diameter of 1½ inches—a 2-inch line would be even better. The tank discharge line is directly over the sump as part of a "self cleaning" design of the tank. Without an effective water drain system, the discharge line could send a slug of FSII/water mixture and sediment to the filter coalescer that could damage or disarm the elements. In addition to the installation of a water drain line, we recommend that the discharge line be relocated or shortened to help preclude damage to the F/Ss. The fuel in the fuel recovery drain basin had an unusual, dark material that was swirling at the top of the surface. A sample of this material was taken from the top surface and compared with fuel from the bottom surface to determine if it might be un-dissolved FSII. Results from the tests of both samples indicated an identical FSII content. Samples were also provided to SwRI.

Barksdale AFB has a very aggressive water draining policy. Tanks are drained daily and F/Ss are drained twice daily while the truck fill stand F/S is drained prior to each truck fill.

The Barksdale Fuels Manager reported that they down grade approximately 5,000 gallons of JP-10 to JP-8 twice each year. During the first down grade while using an R-11 equipped with the water absorption cartridges (during June 2000), there was a failure to follow operating procedures, and the operator attempted to pump the JP-10 through the filter equipped with water absorption elements. Due to the heavy viscosity of the JP-10, the flow ceased after transferring 50 to 60 gallons. Normal operating procedures are to connect a hose on the refueler sump and gravity draining the JP-10 into the bulk system. The contaminated elements were replaced after the attempted transfer, before returning the R-11 to service.

Assigned Refueling Equipment

Assigned refueling equipment includes: nine R-11s (seven Kovatch and two Oshkosh); and four Tristate R-12s and six Page AVJET R-4s. We drained water from the sumps of an HSV-12 hydrant servicer and materials with three distinct phases: a creamy colored bottom (which we assume to be water and FSII), a cloudy layer of fuel, and a thin top layer of an oily looking amber material. We retained two samples of these materials for shipment to SwRI. We drained water from the sumps of three other HSV-12s, one R-11 refueling truck, and one R-4 hydrant hose truck, and we found the fuel to be clear and bright.

Hydrant System

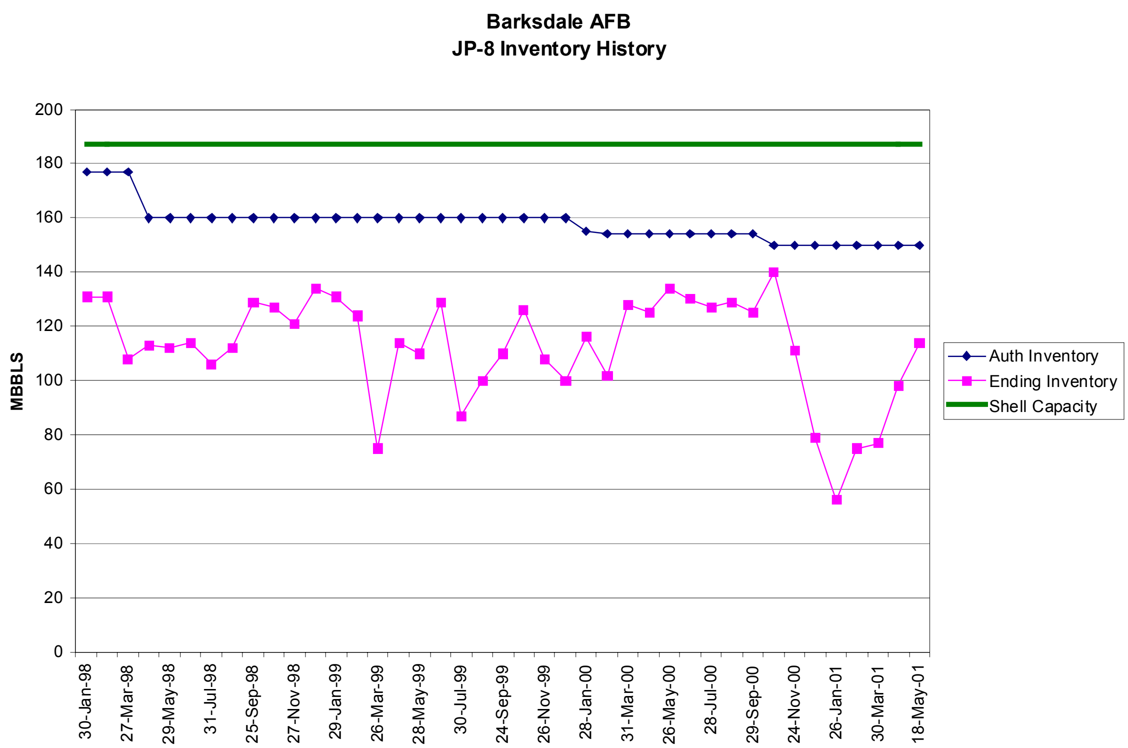
Barksdale has two Type III hydrant systems.

Products Stored

JP-8 and JP-10

Product Quality Data

Since August 2000, the quantities of FSII in the shipments have been consistently between 0.15% and 0.17%. Conductivity readings range from 250 to 300 CUs but average closer to the low end of 250 CUs.



Appendix E-2

TEPPCO Bossier City Terminal

TEPPCO
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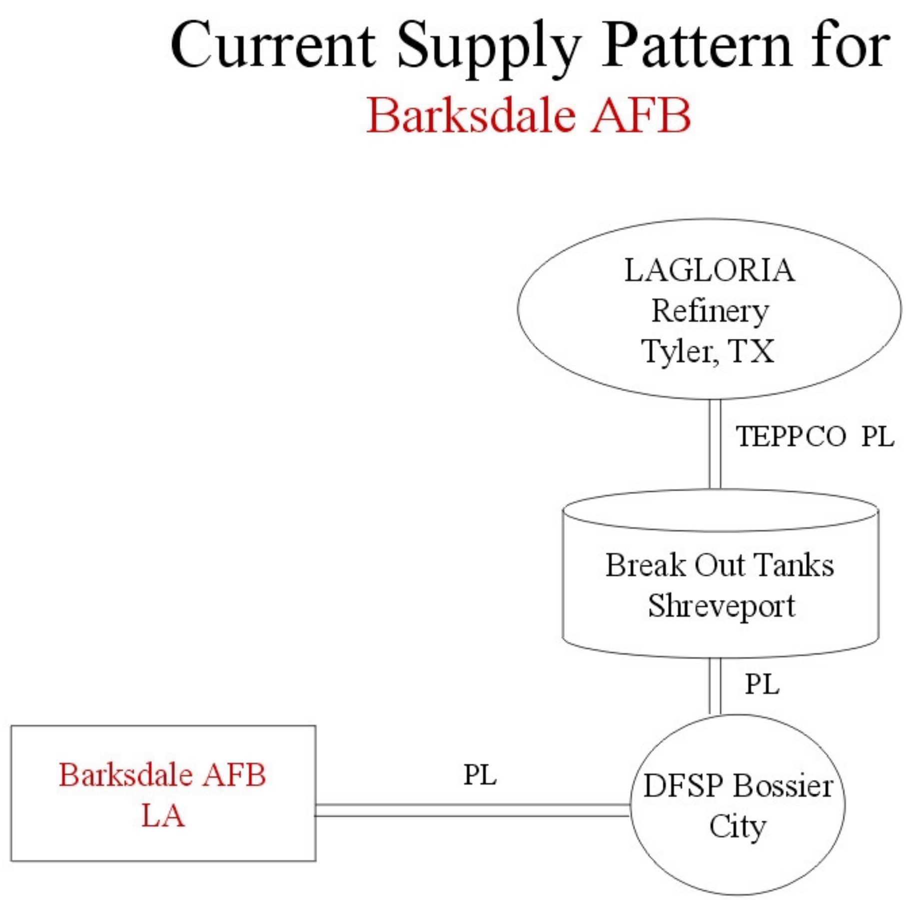
TEPPCO Bossier City Terminal receives JP-8 into two tanks, a 35,000 BBLS tank and a 40,000-bbl tank. Each batch is settled for a minimum of 24 hours before shipment to Barksdale AFB. The QSR and TEPPCO personnel take samples jointly. These tanks appear to have been originally designed as breakout tanks with a common receiving and suction line. The "as built drawings" show the "suction" line entering the bottom of the tank and sitting in a well approximately 16 inches deep. This line is capped with a diffuser and appears to rise above the floor of the tank by approximately one inch. This line, identified as the suction line in the drawings, is currently used as the receipt line, and a new suction line has been installed in the tank at about 18 inches above the tank floor. There is no bottom water & and sediment (BS&W) drain on the tank. Because of the design of the tank, any BS&W in the well around the receiving line would be swirled into solution with the incoming product.

Two additives are injected at the Bossier City Terminal: SDA and FSII. The SDA injection point is two feet upstream from the pump, and the FSII injection point is four feet down stream from the pump. Government supplied FSII is stored in a bulk tank which is structured to provide pressure relief to or from the atmosphere of a vacuum in excess of four ounces or pressure in excess of 2 ounces. The tank is not equipped with a desiccant to preclude absorbing moisture from the atmosphere and the FSII in the tank is not sampled for water content. We asked that the QSR draw a sample to be tested for water. Test results showed the water content to be within the specification limits. Approximately three feet down stream of the point of FSII injection, the fuel enters a "Coriolas" meter manufactured by Smith Meter Company. The Coriolas has a seven-foot long venturi (approximately 2 inch diameter) that increases the pressure on the upstream side and dramatically reduces the discharge pressure into the four-inch transfer line to Barksdale. The pump pressure was noted to be 150 psi and the pressure downstream of the venture was 50 psi. The four-inch line stretches 3.98 miles to Barksdale AFB where the receiving pressure is approximately 4 psi. It is highly unlikely that this arrangement would result in adequate blending of the FSII into the fuel.



Appendix E-3

DFSP Ludlow

Terminal Manager: Steve Schirch, Phone: 413-289-3642
Buckeye Regional Manager: David Fancher, Phone: 860-289-3331, Fax: 860-289-3642

AJ Investigation Team: Larry Dipoma (C4e), Dwight Duncan (C4e), and Bud Rodee (DFR-Americas).

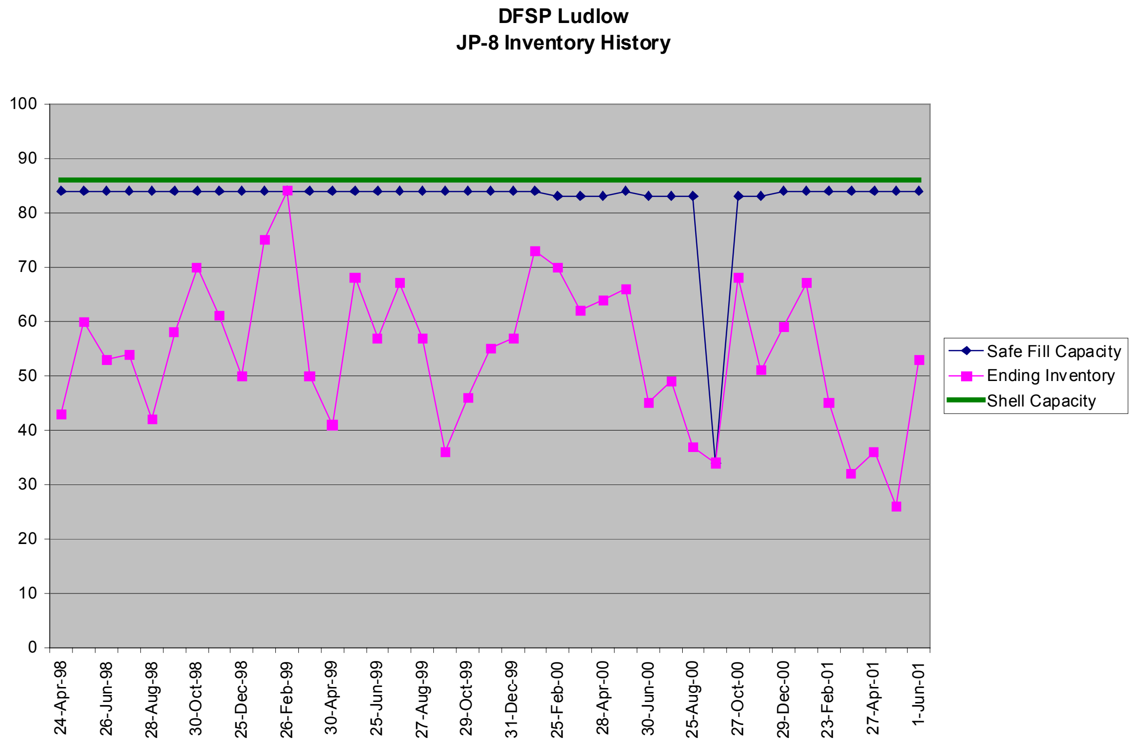
DFSP Ludlow receives pipeline shipments from DFSP New Haven. The product is moved through a multi-product pipeline that also transports #2 fuel oil, gasoline, kerosene, and Jet A fuels. Pipeline time from New Haven is approximately 12 to 13 hours and moves at a rate of 2,000 bbls per hour. DFSP Ludlow stores only JP-8. The JP-8 is not filtered on receipt. They have two dedicated storage tanks with a 55,000-bbl capacity, though the safe fill level is restricted to 41,000 BBLS because of the small capacity of the tanks dikes. The steel tanks are above ground, have floating-roofs with no covers over the floating-roofs. The tanks have flat bottoms and a fixed discharge (suction line) that is approximately one foot above the tank bottom. The bottom of Tank #2 is epoxy coating and Tank #1 is scheduled for cleaning, epoxy coating and installation of a cone roof. The terminal manager reported that they maintain a one-inch water bottom in both tanks. Approximately 5,000 gallons of water is removed from the two tanks 3 to 5 times a year. The most water drained from the two tanks at any one time totaled 5,300 gallons. The draining procedure involves draining until the "black gunky stuff ends, and the product becomes milky." Water bottoms are dark amber. The all-level samples prior to receipt on the day of the visit (February 22, 2001) was clear and bright; however, the post receipt sample was cloudy. The terminal manager reported he periodically notices a clear white jell in receipts received from August through December.

Mr. David Fancher was asked if they used pipeline drag reducer additive in any of the products moved through the Buckeye pipeline, and he said they did. When asked what time of the year PDR is used, he replied that it is used in the winter months normally starting in December to meet the increased demand for heating oils. He said the PDR is injected at New Haven but not within two hours before or two after a JP-8 or other aviation fuel shipment. When asked about the controls to insure against the accidental injection of PDR, he reported that there had been one such incident, but Buckeye identified the error and cut the contaminated JP-8 product into a diesel tank.

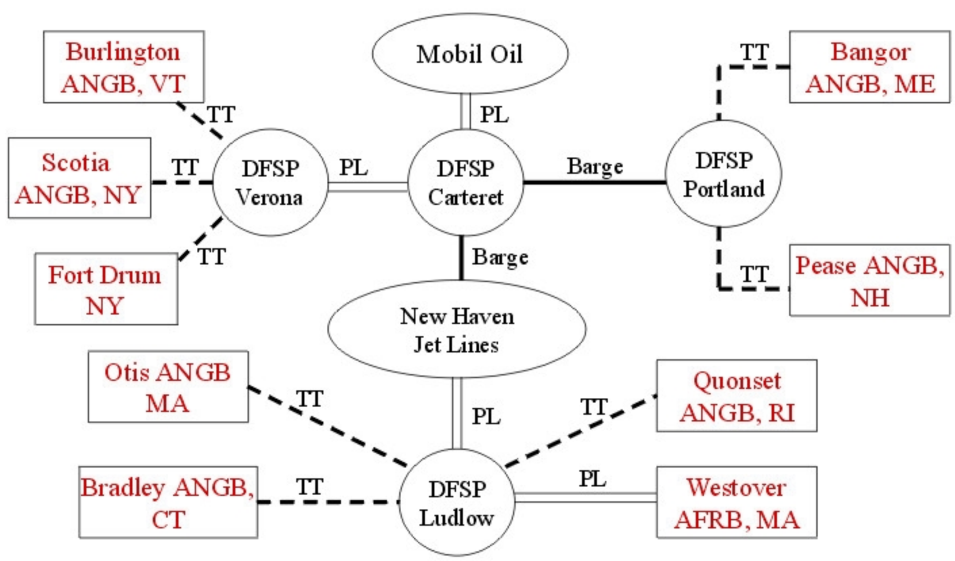
Though SDA and FSII are injected as DFSP Carteret, DFSP Ludlow must re-inject at DFSP Ludlow because of exposure to water. Stadis 450 is added as necessary to increase the conductivity level as the product is pumped into the tanks. SDA is blended with JP-8 in a ratio of 1 to 9 and is stored in a 50-gallon tank. They attempt to achieve 200 CU reading. FSII is injected in the issue line up stream from the pump by using a Hammons turbine injector. They attempt to achieve an FSII level of 0.12%. The FSII is stored in a steel tank that is not equipped with a drier. They were in the process of refilling the FSII tank, which was last filled during April of 2000. Drums of FSII are stored outside, on end rather than horizontal. The tops of the drums were covered with water because it had been raining. Two five-gallon cans of metal deactivator were stored in a metal sample storage locker. When asked, the terminal manager reported that they had never used any metal deactivator.

A Bowser F/S vessel is installed in the issue line; however, this vessel has been modified for use in micronic filters only. Velcon 2 micron filter (F0629PLF1) elements are used (12 element per bank of filters) on the issue line for trucks and the pipeline. The sump on this vessel is only drained two or three times per year. The vessel has been modified to allow draining by vacuum truck and there is no way we could obtain a sample from the sump without a vacuum truck. The truck fill rate is 900-gpm for a single truck and 1,000 gpm for two trucks. They pump JP-8 to Westover ANGB at a rate of 15,000 bbl/hr. JP-8 is also shipped to Otis, Bradley, Barnes, Quonset, Pease, GE and Pratt & Whitney, and several Army Guard units by tank truck. Tank trucks are not dedicated, though the terminal manager said he does not load trucks that carried gasoline as a previous product.

Team members climbed both bulk tanks. Snow and ice had accumulated on the top of both floating-roofs. Removal of the snow and ice is hampered by the safe fill capacity, which is restricted to 75% of the tank capacity because of limited dike capacity. The floating-roof on one tank appeared to list at approximately 5 degrees because of the uneven distribution of the snow and ice accumulation. This is an unsafe condition. Rain-water entry into the tank is facilitated by the limited fill capacity and the tilt of the roof, which interferes with the floating-roof seal. Because of the tilting position of the roof, we did not climb down onto the roof to examine the seal. The terminal manage/operator (only person assigned to the terminal) was on this roof attempting to shovel the snow/ice to the center of the roof to balance the weight. When descending the second tank, an open-ended 55-gallon drum of florescent "lime green" antifreeze was observed near the floating-roof drain. (If the floating-roof drain is leaking, this may have been the source of the "lime green" material drained from the receiving F/S sumps at Pease AFB. Also, if rock salt or some other form of sodium is used to melt the snow and ice on the floating-roof, that may explain the high sodium content in AJ samples from Pease ANGB reported by the Air Force Research Laboratory.) We later learned from the QAR at DFSP Carteret that the Department of Transportation had mandated pressure testing of the Colonial Pipeline with water containing a green dye. Since that time it has not be unusual for JP-5 and JP-8 coming through the pipeline to have a lime green tint. DFSP Carteret and supplies DFSP New Haven Jet Lines which, in turn, DFSP Ludlow.


DFSP Ludlow
JP-8 Inventory History
100
90
80
70
60
50
40
30
20
10
0
24-Apr-98
26-Jun-98
28-Aug-98
30-Oct-98
25-Dec-98
26-Feb-99
30-Apr-99
25-Jun-99
27-Aug-99
29-Oct-99
31-Dec-99
25-Feb-00
28-Apr-00
30-Jun-00
25-Aug-00
27-Oct-00
29-Dec-00
23-Feb-01
27-Apr-01
1-Jun-01
Safe Fill Capacity
Ending Inventory
Shell Capacity

Supply Pattern for NE Bases with Apple Jelly Problems



Appendix E-4

Pease ANGB, NH

157 LS/LGSF
302 New Market Street
Pease ANGB, NH 03803-0157

Fuels Officer: Major Elizabeth Terrien, Phone: 603-430-3155, Fax: 603-852-3157, Elizabeth.Terrien@NHPEAS.ANG.AF.MIL
Fuels Superintendent: MSgt Jason Griffith, Phone: 603-430-3155, Fax: 603-852-3157, Jason.Griffith@NHPEAS.ANG.AF.MIL
QC&I Supervisor: SSgt Steve Richardson, Phone: 603-430-3155, Fax: 603-852-3157 Steve.Richardson@NHPEAS.ANG.AF.MIL
LFM Supervisor: TSgt Bill Russell, Phone: 603-430-3381
RFM Supervisor: MSgt Baley
QSR: Louie Barbosa

AJ Investigation Team: Larry Dipoma (C4e), Dwight Duncan (C4e), and Bud Rodee (DFR-Americas).

AJ Incidents
Pease ANG reported that they first experienced AJ-like contamination during a period when they were receiving all of their fuel from DFSP Ludlow. They maintain they never have a problem when receiving tank trucks from DFSP Portland but frequently receive cloudy fuel from DFSP Ludlow. Once recent receipt from Ludlow also failed on flash point. Dark contaminants are drained from the receipt vessels during late October and early November when the tank temperatures drop to 40°F. The materials become lighter as the winter progresses. Receipt filters are changed at approximately 11-month intervals, and they frequently drain an AJ-like substance from the receipt filters. Issue filters are changed every three years, and they report they have never drained AJ-like materials from the pump house issue filter vessels. Current pressure differentials on the five issue F/Ss range from 4 psi to 9. Three vessels are due element changes during Jan 2002, and the other two are due during February 2002. All F/S sumps are drained into a bucket at the beginning of each day. The "dark gunky" materials are collected into drums for disposal as hazardous waste. Two one-quart samples were obtained from a 55-gallon drum, which had accumulations from late July to early February. At one point, approximately one pint of "root beer" colored material was drained from an R-12 filter sump, and on another occasion, "buckets full of lime green fuel" were drained from one of the receipt filter vessels. We later learned from the QAR at DFSP Carteret that the Department of Transportation had mandated pressure testing of the Colonial Pipeline with water containing a green dye. Since that time it has not be unusual for JP-5 and JP-8 coming through the pipeline to have a lime green tint. DFSP Carteret supplies New Haven Jet Lines, which in turn supplies DFSP Ludlow.

Product Receipts and Issues
Pease AFB receives fuel from Ludlow DFSP or Portland DFSP via tank trucks that are not dedicated to JP-8. The fuel is filtered through three horizontal 300-GPM-receipt filter vessels manufactured by ME Industries (Model # CFCS-0-3N388B-1636T2M). There are three coalescer elements and one separator element. Differential pressure at the time of our visit ranged from 5 to 7 psi on two of the receipt vessels and from 4 to 6 psi on the third vessel. The filter change due date for all three vessels is March 2003. The vessels are epoxy-coated steel. All vessels are within a heated pump house. The receipt temperature during January ranges from a high of 33° F to a low of 28° F, with an average 30° F. During August, the temperatures range from a high of 85° F to a low of 65° F, with an average of 65 to 70° F.

Bulk Storage
The JP-8 is stored in two fixed-roof tanks with floating pans. One has a 12,500-bbl capacity, and the other has a 10,500-bbl capacity. The tanks are the self-cleaning design with the bottom sloped to the center with the suction line over the sump. The water drain line is a three-inch line that empties into a 4,000-gallon product recovery tank. Reclaimed product is pumped through the F/S back into the bulk tank.

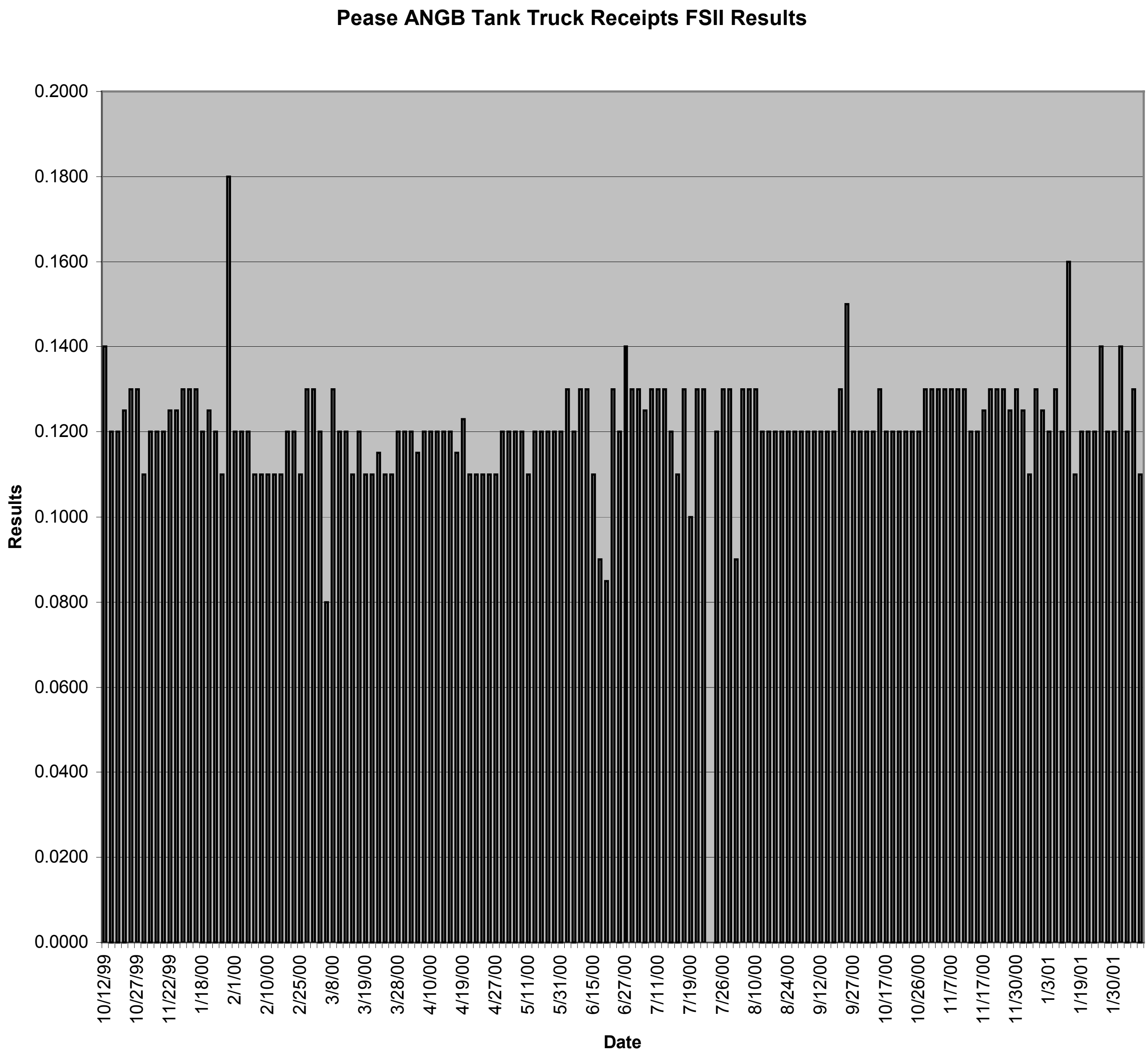
Assigned Refueling Equipment
Pease has three R-11 refuelers, one Oshkosh and two Kovatch. They report that the differential pressure runs higher on the Oshkosh. They also have three HSV-12 hydrant servicing vehicles and report that the DPs on the R-12s generally run lower than the truck DPs.

Hydrant System
Pease ANGB has a Type III Hydrant System with horizontal F/S vessels rated at 600 GPM manufactured by Facet with Quantek API elements.

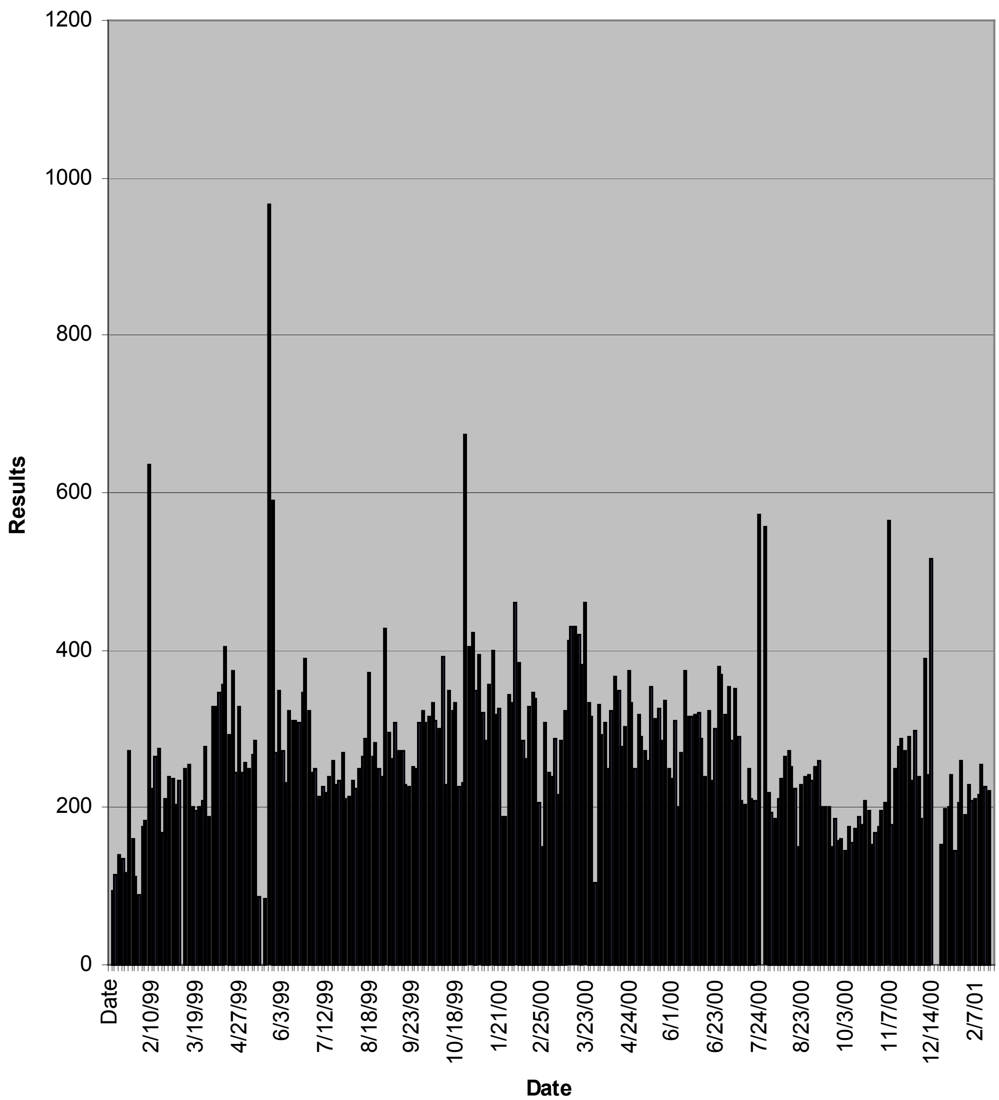
Products Stored
JP-8.

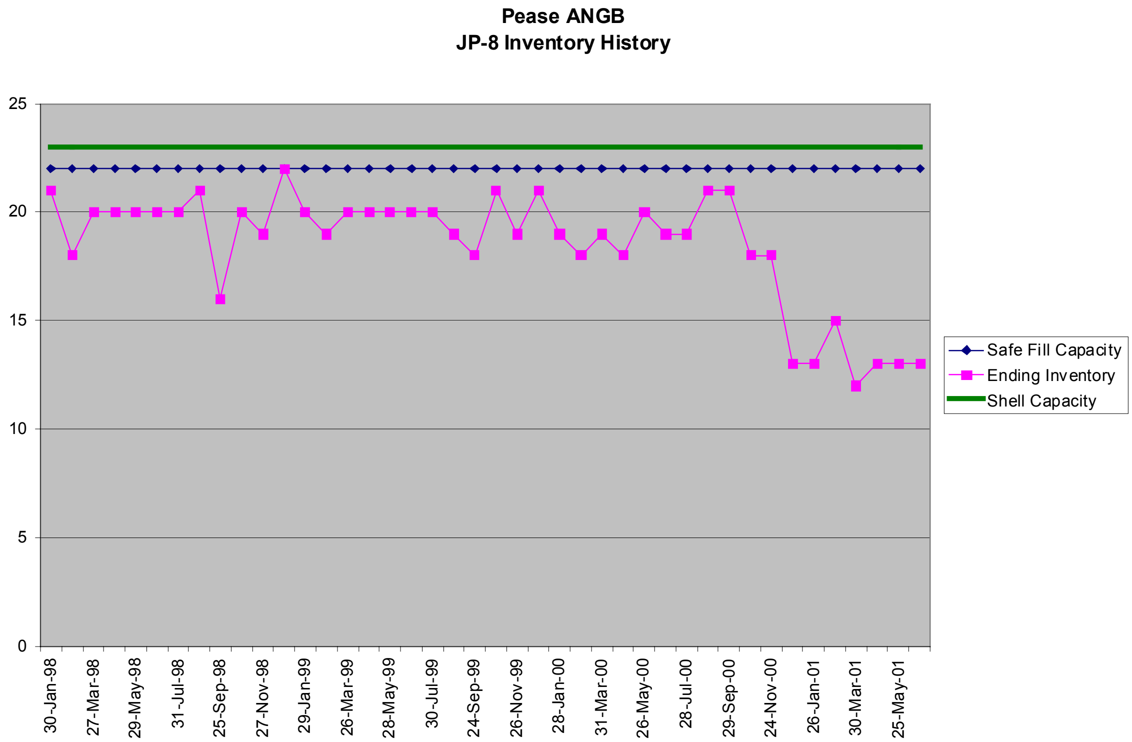
Product Quality Data
FSII and Conductivity levels are shown in the charts on the following pages.

Aircraft Maintenance Questionnaire
We met with CMSgt Kendal Brock, LGLM, (Phone: 430-603-2426) to determine if any AJ-like substances had been found in fuel cells, tank probes or engine filters. Chief Brock reported that he was unaware of any such finding and felt sure he would have been made aware had any been found. He stated he would check with personnel for the various maintenance shops and get back to us if anyone had AJ findings.


Pease ANGB Tank Truck Receipts FSII Results
Results
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
10/12/99
10/27/99
11/22/99
1/18/00
2/1/00
2/10/00
2/25/00
3/8/00
3/19/00
3/28/00
4/10/00
4/19/00
4/27/00
5/11/00
5/31/00
6/15/00
6/27/00
7/11/00
7/19/00
7/26/00
8/10/00
8/24/00
9/12/00
9/27/00
10/17/00
10/26/00
11/7/00
11/17/00
11/30/00
1/3/01
1/19/01
1/30/01
Date

Pease ANGB Conductivity of Tank Truck Receipts




Pease ANGB
JP-8 Inventory History
25
20
15
10
5
0
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
26-Jan-01
30-Mar-01
25-May-01
Safe Fill Capacity
Ending Inventory
Shell Capacity

Appendix E-5

Otis ANGB, MA

102 FW/LGSF
158 Reily Street
Otis ANGB, MA 02542-5028

Fuels Officer: MSgt Mike Veloza, Phone: 508-968-4982, Fax: 968-4980, Michael.Veloza@MAOTIS.ANG.AF.MIL
Fuels Superintendent: Dennis Storsveen, Phone: 508-968-4982, Fax: 508-968-4980, Dennis.Storsveen@MAOTIS.ANG.AF.MIL
Quality Control Supervisor: Daniel Lanowe, Phone: 508-968-4982, Fax: 508-4980, Daniel.Lanowe@MAOTIS.ANG.AF.MIL

AJ Investigation Team: E. Mac Fishburn (C4e), Cal Martin (Martin and Associates), Bill Tyler (QSR), and Jim Young (SFTH).

AJ Incidents
Otis ANGB experiences AJ routinely from October through April primarily in the receipt F/S sump. Fuels personnel have been successful containing AJ to their receipt and pump house issue vessels since March of 1999. During March of 1999, they had to change all of the elements in their refuelers and the receipt and issue vessels after being overwhelmed by AJ. They were receiving AJ until a few weeks ago when they discontinued receipts due to major tank construction. SwRI forwarded sampling containers to Otis ANGB to be available should AJ be encountered again.

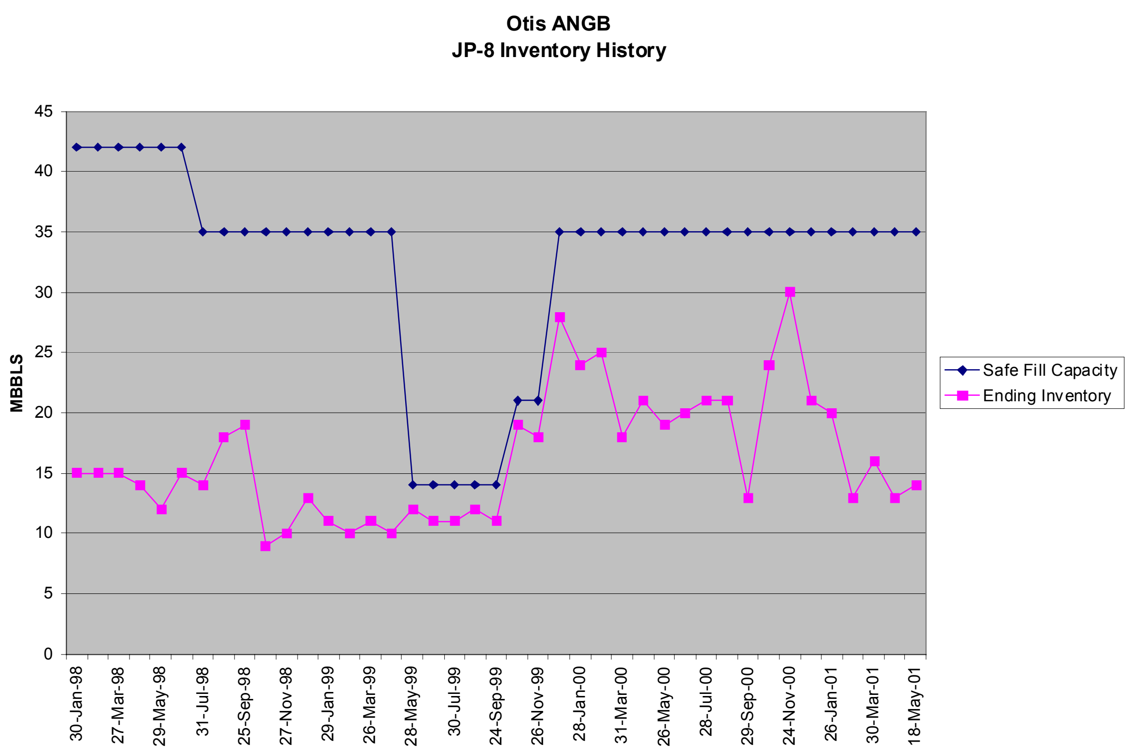
Product Receipts and Issues
Product is delivered to Otis ANGB from Ludlow DFSP by tank trucks by JP Noonan Transportation, Inc., West Bridgewater MA. The Buckeye Pipeline Company operates the Ludlow DFSP. The average product shipment temperature on 20 Feb 01 was 29 degrees F. Otis ANGB has two 600-gpm horizontal receipt filter separators and two 600-gpm horizontal issue filter separators installed in the pump house. The heated pump house, which houses the receipt and issue F/S, was taken out of service due to major tank construction. An R-14 ATHRS unit was placed in service outside in the climatic elements to provide fuel receipt and issue filtration. No further incidences of AJ have been experienced since placing the R-14 in service. MSgt Mike Veloza suggested that the disappearance of AJ might be due to the lack of heat on the R-14 F/S. Under normal operating conditions, a Hammond Injector Model 800 injects JP-8+100 into a 4-inch pipeline downstream from the pump house. During the tank construction project injections have been suspended. Otis ANGB has Facet M-100 elements on hand that they plan on installing in their receipt and issue F/Ss upon completion of the current construction project. The Facet M-100 elements are API 1581, 4th Edition elements that may be more effective than any elements used previously.

Bulk Storage
Bulk Storage consists of two forty year old steel ASTs. Tank #15 is a 19,000-bbl floating-roof tank with a geodesic dome that leaked badly until it was recently repaired. The serious water problem they were experiencing with this tank seems to have been resolved. Tank #16 has a fixed-roof and a capacity of 1,300 bbls. However, the product recovery systems on both operating tanks are inadequate due to poor design. A major construction project will replace the existing system.

Assigned Refueling Equipment
There are five Oshkosh and two Kovatch R-11s equipped with Facet absorption elements. The water absorption elements in the refuelers are holding up very well since the fleet-wide change following the contamination incident in March 1999.

Products Stored
JP-8 and JP-8+100

Product Quality Data
FSII reading on receipts average 0.09%. Fuel conductivity ranges of 110-140 CUs. JP-8+100 injections have been suspended due to construction.



Appendix E-6

Westover ARB, MA

439 AW/LGSF
100 Logistics Drive, Suite 1
Westover ARB, MA 01022-2143

Fuels Officer: Wilfred Mathieu, Phone: 413-557-2994, Fax: 413-557-3162, Wilfred.Mathieu@westover.af.mil
Fuels Superintendent: Chuck Berry, Phone: 413-557-2924, Fax: 413-557-3162, Chuck.Berry@westover.af.mil
Primary POC: James Maloney, Phone: 413-557-3884, Fax: 413-557-3162, James.Maloney@westover.af.mil
LFM: Roger Martin, Phone: 413-557-2445
RFM: Carl Hall
QSR: Bill Tyler, 315-337-3128

AJ Investigation Team: Larry Dipoma (C4e), Dwight Duncan (C4e), Andy Waynick (SwRI), and Bud Rodee (DFR-Americas)

AJ Incidents

The first observance of AJ was at the receipt filter, prior to the construction of the two 20,000-bbl bulk receipt tanks. This occurred between late fall and early December. Following the completion of the two bulk receipt tanks, Westover discontinued the use of receipt filters and has not experienced further AJ occurrences. This might indicate that the electrostatic charging of the product moving through a pipeline and then a receipt filter may play a role in AJ formation. It may also indicate that settling in a receiving tank (settling time generally exceeds 24 hours) prior to coalescence, eliminates the FSII/Water bottoms that are the principle constituents of AJ. Westover personnel reported finding AJ in the receipt filters prior to Desert Storm and afterwards, but not during the period of heavy product movement in support of Desert Storm activities. AJ samples were taken shipped to Searsport laboratory for identification testing; however, no results were provided to the base. Since Desert Storm they report finding AJ on four occasions.

Product Receipts and Issues
JP-8 receipts are by pipeline from DFSP Ludlow. The pipeline from Ludlow to Westover is an eight-inch line and static line fill of 29,600 gallons. Product is received unfiltered into designated bulk receipt tanks where the fuel settles, generally for 24 hours or more, before it is transferred to the hydrant systems. Product receipts range in temperature from 32 to 35 degrees F in January with an average of 34 degrees F, and a range from 60 to 66 degrees F in August with an average of 64 degrees F. The JP-8 is filtered as it is transferred to the operating hydrant tanks. Westover issues 550,000 gallons and defuels an average 40,000 gallons per month. Reclaimed JP-8 is placed back into the tank it was obtained from through a filter/separator.

Bulk Storage
Westover has two 20-bbl, epoxy-coated receipt tanks with fixed-roofs, floating pan, and slope to center sump, with a self-cleaning discharge (suction line) over the sumps. Fuel is filtered as it is transferred to the hydrant operating tanks through two 600-gpm vertical Velcon F/S with Velcon elements.

Assigned Refueling Equipment
Westover has three R-11s, 1-Oshkosah and 2-Kovatch, four HSV-12s, and two 2 MH2C (Type II) hose carts. The refueling truck fleet is Currently using standard coalescer elements, though they have water absorption cartridges for installation during the next filter change.

Hydrant System
Westover has a Type II and Type III fueling systems. Fuel is filtered as it is transferred into the hydrant system by a vertical 600-gpm Dollinger F/S with Velcon elements.

Products Stored
JP-8.

Product Quality Data
FSII levels at time of receipt average 0.11% and conductivity averages 250 CUs.


Westover AFB
JP-8 Inventory History
60
50
40
30
20
10
0
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
26-Jan-01
30-Mar-01
25-May-01
Safe Fill Capacity
Ending Inventory

Appendix E-7

Bradley ANGB, CT

103 FW/LGSF
Bradley ANGB
East Granby, CT

Fuels Officer: MSgt Brian E. Roy, Phone: 860-292-2395, Fax: 860-292-8556, Brian.Roy@CTBRAD.ANG.AF.MIL
Fuels Superintendent: MSgt Mark Benedetto, Phone: 860-292-2544, Fax: 860-292-8556, Mark.Benedetto@CTBRAD.ANG.AF.MIL
QC&I Supervisor: MSgt Morris York, Phone: 860-292-2544, Fax: 860-292-8556 Morris.York@CTBRAD.ANG.AF.MIL

AJ Investigation Team: E. Mac Fishburn (C4e), Cal Martin (Martin & Associates), Bill Tyler (QSR), and Jim Young (SFTH).

AJ Incidents

Bradley ANGB experienced AJ last winter in their pump house receipt and issue F/S vessels. This pump house is equipped with a heater normally operated with the thermostat set around 50ºF. Heat is required in the pump house to prevent a water main and an emergency eyewash station from freezing. This fall the heater failed and was not repaired until mid-December. When the heater was out of service, a portable Herman Nelson H1 heater was used in the pump house for minimal heat. With the heater out of service, there has been no reappearance of the AJ. There is some speculation that the minimum heat provided might have played a role in the disappearance of AJ.

Product Receipts and Issues

Product is shipped from the Ludlow DFSP in dedicated tank trucks with a transient time of 45 minutes. Product receipt temperatures ranges from 20 to 30ºF with an average of 25ºF during the winter. The system-receiving header is higher than a normal tank truck discharge manifold. The discharge manifold being higher than the tank truck manifold is simply a poor design problem and creates a challenge for the base fuels personnel. For instance, when pumping off a tank truck pump, cavitations occur at the end of the discharge. Operating personnel must continue to let the pump run without sufficient fuel in order to attempt to remove fuel from the header hoses. The hoses must be disconnected, removed and stored after each receipt. Often fuel is left in the hose, resulting in a spill in the contained area. The fuel drains into an oil water separator to preclude environmental problems. A project work order has been submitted to abate this problem but priority funding is unlikely. There are two 300-gpm vertical Quantek vessels with Velcon coalescers for receipts and two 600-gpm vertical Quantek vessels with Velcon coalescers for issues. JP-8+100 has not been used at Bradley ANGB.

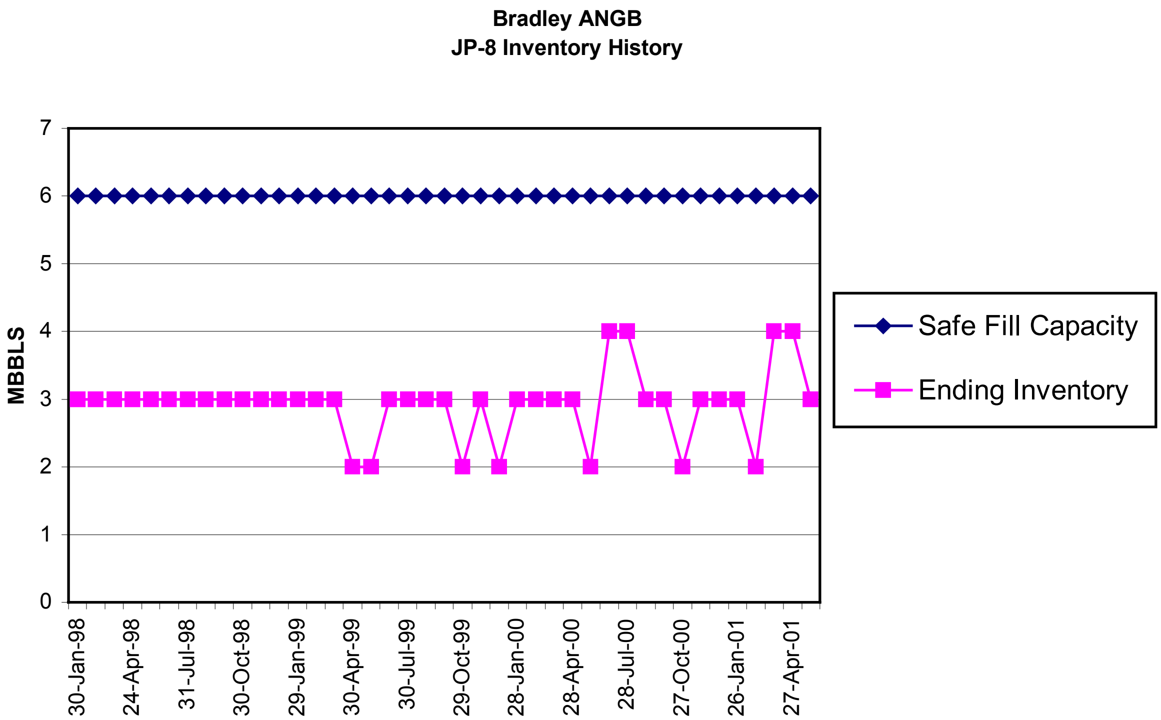
Bulk Storage
Bradley ANGB has two steel, fixed-roof, ASTs that were constructed in 1993. This relative new system has some design features that are helpful in fuel handling. The product recovery system consists of a 2,000-gal underground collection tank that is connected to both bulk storage tanks and is used to receive water and cloudy fuel from the tank sumps via a three-inch drain line. Here the drained product and fuel is allowed to settle out and separate. After separation, the fuel is pumped back through the receipt F/S to the operating tanks. The product recovery tank is gauged for water using a plumb bob, tape and water finding paste. Once a gauge of four inches of water is present, the water is pumped from the below ground tank using a 600-gal bowser. The bowser is equipped with a pneumatic diaphragm pump, which provides the required vertical lift to remove the water from below ground. The operating personnel report they are not experiencing a problem removing water from the tanks.

Assigned Refueling Equipment
The base has four Oshkosh R-11s. Facet absorption media elements were installed during the fall of 2000.

Product Stored
JP-8.

Product Quality Data
FSII averaged 0.10% for receipts and fuel conductivity ranged from 120-130 CUs.

Aircraft Maintenance Questionnaire
A series of questions pertaining to the aircraft fuel systems and engines were coordinated with TSgt Gary Piascik, Fuel Cell Repair and Chief John P. Saccente, Propulsion Element Chief. Neither has encountered AJ in their systems. Chief Saccente said there have been no reports of engine by-pass which would likely result if a screen became blocked or restricted. The Chief is the ANG point of contact on any A-10 aircraft engine problems. He said he would make an inquiry and forward any significant comments to us via e-mail.


Bradley ANGB
JP-8 Inventory History
MBBLS
7
6
5
4
3
2
1
0
30-Jan-98
24-Apr-98
31-Jul-98
30-Oct-98
29-Jan-99
30-Apr-99
30-Jul-99
29-Oct-99
28-Jan-00
28-Apr-00
28-Jul-00
27-Oct-00
26-Jan-01
27-Apr-01
Safe Fill Capacity
Ending Inventory

Appendix E-8

Quonset Holland ANGB

143 AW/LGSF
Quonset State Airport
14 Flightline Drive
North Kingston, RI 02852-7549

Fuels Officer: Captain Richard Taito, Phone: 401-886-1315, Fax: 401-886-1450, Richard.Taito@RIQUON.ANG.AF.MIL
Superintendent: SMSgt Dennis Nye, Phone: 401-886-1320, Fax: 401-886-1450, Dennis.Nye@RIQUON.ANG.AF.MIL
QC&I Supervisor: TSgt Bruce Nichols, Phone: 401-886-1335, Fax: 401-886-1450,
LFM: Edward Bergheimer, Phone: 401-886-1226
RFM: CMSgt Madeiros, Phone: 401-886-1272

AJ Investigation Team: E. Mac Fishburn (C4e), Bill Tyler (QSR), and Jim Young (SFTH).

AJ Incidents
Foreign matter is periodically found in the receipt and issue F/S sumps. The Fuels Superintendent feels that the material periodically drained from issue and receipt filter separators is normal BS&W. Fuels personnel will continue to monitor the situation and will forward samples upon the next occurrence using the SWRI-sample containers on hand.

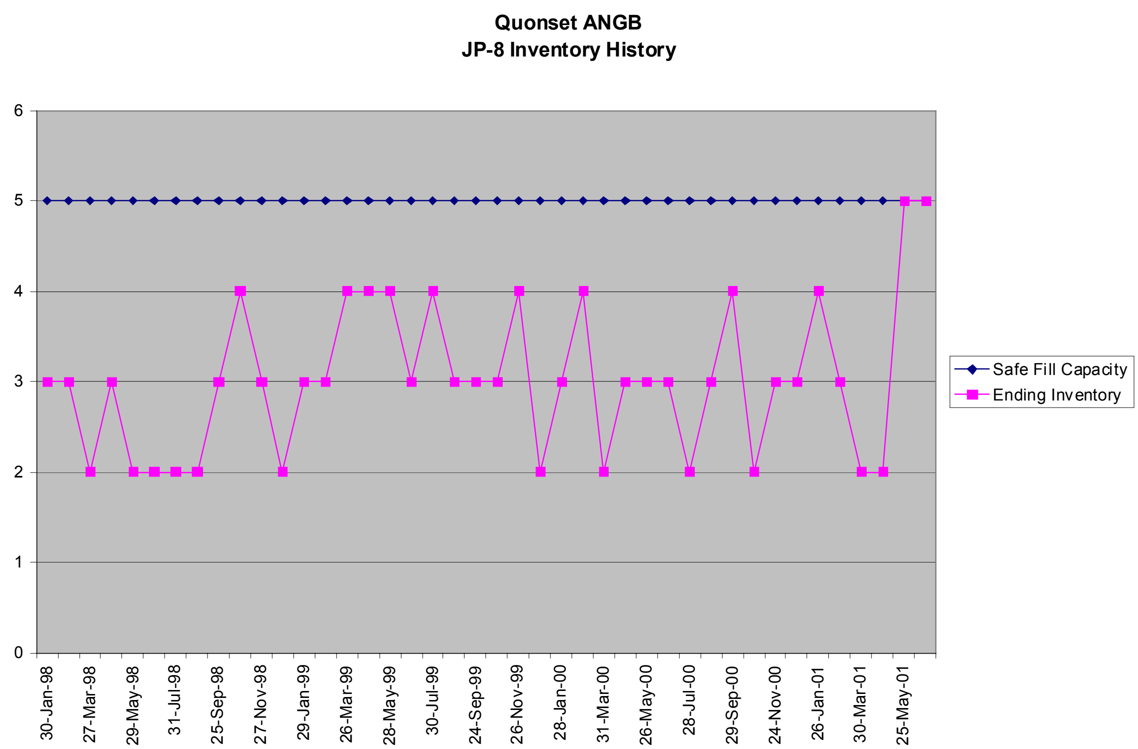
Product Receipts and Issues
Contract carrier tank trucks that are not dedicated solely to jet fuel deliver product to Quonset Holland ANGB. However, the quality of the product received is satisfactory. This product is hauled from the Ludlow DFSP with an average driving time of 2.25 hours. There are two vertical F/S vessels with coalescers for fuel receipts and a vertical vessel with coalescers for issues. A Hammonds Model 800 injects JP-8+100 into a 3-inch pipeline downstream of the issue filters. The unit has temporarily suspended JP-8+100 injection pending a final decision from the ANG Bureau regarding C-130 units.

Bulk Storage
There are two 2,500 BBL above ground steel tanks with fixed-roofs and floating pans. The tanks are 100% epoxy coated. The two product recovery systems are inadequate due to poor design. Operating personnel have had to resort to draining water into buckets and carrying it to a product container for settling, and recovering product after water separation.

Assigned Refueling Equipment
Three Oshkosh R11s with Facet absorption media elements.

Products Stored
JP-8.

Product Quality Data
FSII levels averaged .115% at time of receipt with a fuel conductivity range from 184 CUs to 244 CUs and an average of 209 CUs.



Appendix E-9

NAS BRUNSWICK, ME

FUELS OFFICER Message Address: NAS BRUNSWICK ME//19F//
NAVAL AIR STATION BRUNSWICK
CODE 19F DSN COMMERCIAL
1251 ORION ST Facsimile (24 Hour) 476-2234 (207) 921-2234
BRUNSWICK, ME 04011-5000 Alternate Facsimile 476-1371 (207) 921-1371

Fuels Officer/COTR MR Denny Barrett 476-2234 (207) 921-2234
barrett@nasb.navy.mil

COTR MR Victor Gustafson 476-2234 (207) 921-2234
DOSS AVIATION (0600 – 2200) MR VIC LEEMAN 476-2582 (207) 921-2582

NAS Brunswick receives JP-8 from DFSP Ludlow via tank truck delivery. The fuel is received through two 600-gpm receipt F/S vessels manufactured by M.E. Industries. The vessel model number is VFCS-C-6N38SB-3630T2N. Each of these vessels contains six coalescer elements, P/N CC-N38SB, and three separator screens, PN CS639T2N. After the fuel passes through one of the receipt F/S vessels, it passes through an M.E. Industries "Fuel Quality Monitor," model nr. M2030V600 containing water absorption cartridges. The receipt F/S vessels drain automatically to a product recovery tank, so the operators do not see what is drained from the receipt filter sumps.

The fuel storage tanks have fixed-roofs and cone bottoms that slope to center sumps. They have two issue F/S vessels that are identical to the receipt vessels described above with the exception that the sumps are do drained automatically. The issue F/S sumps are directly connected to a product recovery system via a ¾ inch pipe. The only visual observation of materials drained from the sump is through a site glass installed in the sump drain line. After the fuel passes through the receipt F/S vessel is goes through a "Fuel Quality Monitor" as described above.

NAS Brunswick personnel report that "two winters ago" (winter of 1998-1999) they did drain some drain material from their F/S sumps. At that time, the FSII content of the fuel was running from 0.18% to 0.22%. After the FSII content was reduced to approximately 0.12%, they no longer noticed any of the dark materials.

The NAS Brunswick fuel handling process differs from the process at Air Force/ANG bases supported by DFSP Ludlow in three ways. First, NAS Brunswick use a three-stage filtration process (coalescence, separation, and absorption) at each filtration step. The

Air Force uses either coalescence and separation (in fixed facilities and hydrant servicing equipment) or a single absorption phase on R-11 refueling trucks. Second, the receipt filters automatically drain to a product recovery system with no manual drain to allow the operator to examine materials drained from the sumps, while the other Air Force facilities have installed manual drains that permit close visual examination. Third, the NAS New Brunswick storage tanks have fixed-roofs, while most Air Force locations that experience significant amounts of AJ have floating-roof tanks retrofitted with geodesic domes.

Appendix E-10

DFSP New Haven, CT

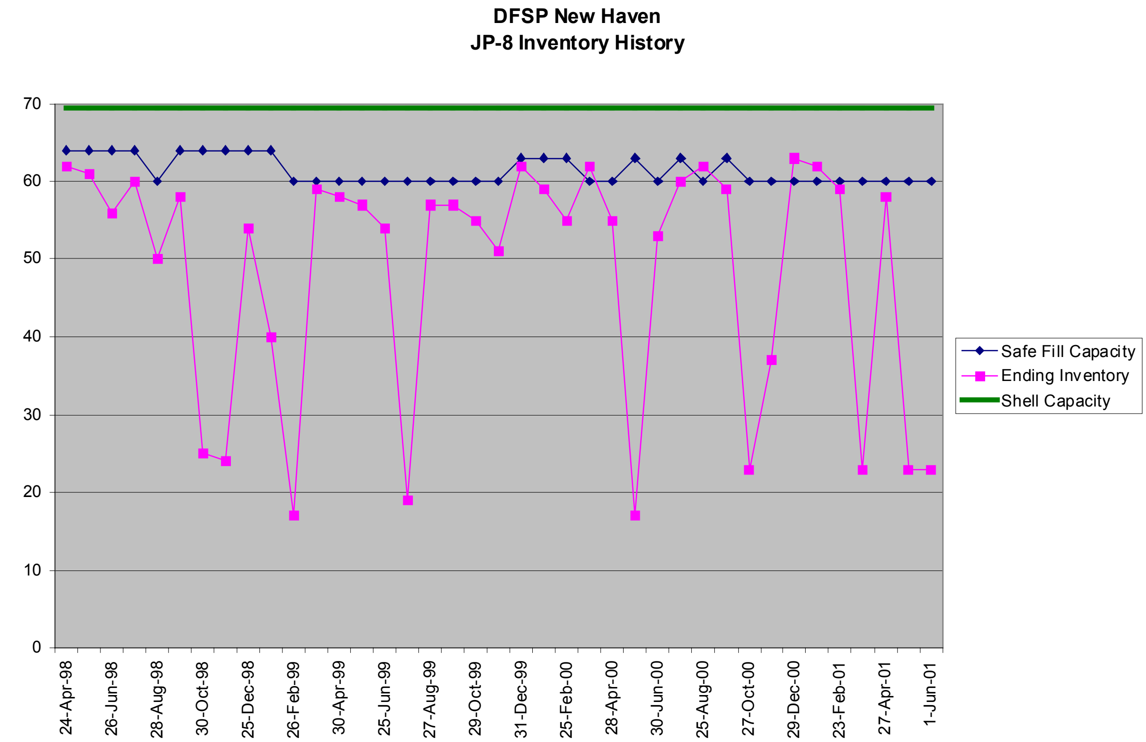
New Haven Jet Lines
Motiva Enterprises Inc.
481 E. Shore Parkway
New Haven, CT 06512-1813

Terminal Manager: Herm Rogers, Phone: 203-468-4000
Terminal Superintendent: Steven P. Knap, 203-468-4000 ext 103

Fully additized JP-8 is shipped from the Cartaret DFSP by dedicated jet fuel barge approximately each three weeks to once a month. Transient time via barge is approximately eight hours. The New Haven receipt tank is sampled following each receipt. An all-level is taken in addition to the barge retain sample for laboratory B-1 level testing. The fuel is not filtered at the barge off-load terminal nor is the fuel filtered during receipt or issue from the tank.

The fuel is transferred through a dedicated line from the tank to Buckeye's multi-product pipeline for shipment to the Ludlow DFSP. Buckeye multi-product pipeline from New Haven to Ludlow is approximately 90 miles and the average pumping rate is 3.3 miles per hour. The JP-8 is buffered in the multi-product pipeline with Jet A fuel. The JP-8 is sampled at the start and middle and one hour before finish of the transfer.

The one 60,000 BBL Motiva above ground steel tank with geodesic dome is located in the New Haven Buckeye terminal complex. The 60,000-bbl tank is equipped with two sumps and 1½ inch water drain valves. The discharge line is offset from the tank sumps by approximately forty feet. The single, common receiving and discharge line is equipped with a "piccolo tube" diffuser and extends 30 feet from the tank wall toward the center and descends from 25 to 21 inches from the bottom. All diffuser orifices are located on the top of the diffuser. (This arrangement minimizes turbulence in the tank and reduces the chance of BS&W contamination of the issued product.) The tank bottom and 18 to 24 inches of the tank wall is epoxy coated with Devoe 167 primer and Devoe 257 DevChem. In preparation to place the tank in service, the tank was cleaned in June 1998 and the coating was completed in August 1998.


DFSP New Haven
JP-8 Inventory History
70
60
50
40
30
20
10
0
24-Apr-98
26-Jun-98
28-Aug-98
30-Oct-98
25-Dec-98
26-Feb-99
30-Apr-99
25-Jun-99
27-Aug-99
29-Oct-99
31-Dec-99
25-Feb-00
28-Apr-00
30-Jun-00
25-Aug-00
27-Oct-00
29-Dec-00
23-Feb-01
27-Apr-01
1-Jun-01
Safe Fill Capacity
Ending Inventory
Shell Capacity

Appendix E-11

DFSP Portland, ME

DFSP Portland
Gulf Oil Terminal
175 Front Street
South Portland, Maine 04412

Terminal Manager: David J. Moody, Phone: 207-799-5561
QSR: Louie Barbosa

DFSP Portland receives JP-8 via spot charter barges where the fuel is transported in uncoated mild steel tanks. Most JP-8 has historically been received from the Sun Oil Marcus Hook Refinery, Pennsylvania, though some has come from DFSP Carteret (primarily refined at Mobil Oil Houston). Sun Oil did not re-bid on the most recent contract. JP-8 is received through a dedicated line from the pier into two above ground bulk tanks. One tank has a 51,000-bbl capacity and the other a 90,000-bbl capacity. The above ground, uncoated steel tanks have fixed-roofs with no floating pan. Within the past three years, mild steel secondary tank bottoms have been installed in the tanks. The new tank bottoms are 10” above the old bottom at the tank center and slope to 6” at the outer edge. Because of the gradual slope, the terminal manager considers the tanks to have “flat bottoms.” The fill and discharge lines are separate. One tank, Tank # 4 (55,000-bbl capacity), is equipped with floating suction that draws fuel 24 inches above the tank bottom at the lowest point. The other JP-8 tank, Tank #5, has a discharge suction line that extend approximately eight to ten feet into the tank and draws fuel at a point approximately 14” above the tank bottom. The entry into this suction line differs from the Air Force tank design in that the elbow curves toward the top of the tank rather than the bottom. The suction line is baffled at the end having the effect of widening the vortex created by suction. This design would minimize turbulence and the potential of drawing bottom sediment and water into the suction line. The water sump is some forty feet away from the discharge line. Water is removed from the tanks twice each year thru a 1½-inch drain line. While the tanks have two drain lines only one drain line is used per tank because tank “settling” has result in a slight pitch of the tank floor. On average the product turns over every 30 days. Significant cooling occurs during transfer of the product to the Portland DFSP. For example, this past August product was loaded at 95°F and had cooled on the Barge to 56°F just prior to discharge. The temperature of product in storage during August ranges from 60°F to 70°F, with the average being approximately 65°F. During January, the product temperature reach a low of 10 degrees, but averages approximately 29°F with a high temperature of 33°F.

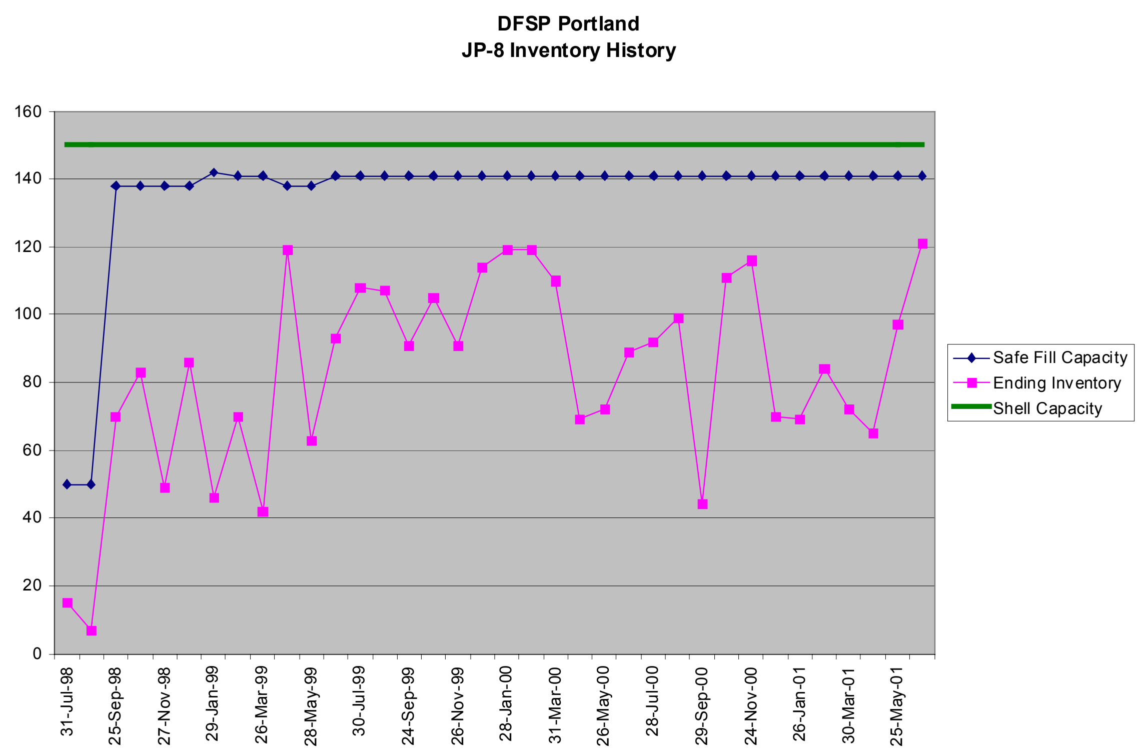
When issued, the product is pumped through two separate vessels, one for filtration and the other for coalescence. The maximum flow rate through the vessels is 1,100 GPM. FSII content of the product is fairly consistent at 0.13%, while the product conductivity ranges from 150 CUs in the winter to 350 CUs during the summer months. The Portland DFSP does have a 6,000-gallon stainless steel FSII tank equipped with a dryer vent.

Injection capability is provided via an injector manufactured by Gates City. The tank is empty and has not been used in recent years. They do have five drums of FSII on hand, which they have had stored in a warehouse for three-years.

Product is filtered through separate filter and coalescer vessels. Both are equipped with Velcon elements. The filter vessel contains 11 filter elements and the coalescer vessel contains 22 coalescer elements. There have been three filter changes since the beginning of the contract period (once in August 1999, again on October 28, 2000, and most recently on December 7, 2000). The changes occurred based on differential pressure.

The Portland DFSP ships solely by tank truck. A visual sample, and laboratory analysis for FSII, CU, and API gravity are taken each morning. Samples are retained for a 15-day period. The fill stand JP-8 pipe passes near a steam heat, Plexiglas enclosure, provided for operator and truck driver comfort. The JP-8 pipes were warmer to the touch in this area (on a cold day in March).

Tank trucks loaded at Portland go to Pease (50 minutes), Bangor (2.5 hours), Brunswick (45 minutes), and several Army National Guard units.



Appendix E-12

Bangor ANGB, ME

102nd Air Refueling Wing
107 Moran Street, Ste 530
Bangor, ME 04401-3099

Fuels Officer: Major John Leblanc, Phone: 207-990-7248, Fax: 207-990-7199, john.leblanc@mebngr.ang.af.mil
Fuels Superintendent: CMSGT Stephen Leavitt, Phone: 207-990-7248, Fax: 207-990-7199, Stephen.Leavitt@mebngr.ang.af.mil

AJ Investigation Team: Larry Dipoma (C4e), Dwight Duncan (C4e), Andy Waynick (SwRI), and Bud Rodee (DFR-Americas).

AJ Incidents
During pipeline receipts from DFSP Searsport, and especially toward the end of the pipeline use during late1997, "dark" contamination occurred frequently. At that time, it was believed that the dark materials were the result of pigging the pipeline to prepare it for closure. Materials with an "AJ-like" appearance were first found in the receipt filter during a filter change driving by a rapid rise in the filter differential pressure.

Since converting from pipeline receipts to tank truck receipts during 1997, Bangor ANG base found approximately one quart of AJ in one of the two hydrant system filter vessels in their Type Three hydrant system. These two F/S are located within an enclosed pump house along with all the other F/Ss. The temperature in the pump house is maintained at approximately 55 degrees during the winter (though operators occasionally turn up the thermostat). One unique feature about the vessel (designated as H-2) where AJ was found is that it sets directly beneath the overhead heater for the building.

A small amount (a few tablespoons) of AJ-like material that "flowed like mercury" was found in the filter vessel of one of the four assigned R-11 refueling trucks during change from coalescer elements to water absorption type elements. The R-11s were equipped with water absorbing elements during November 1999. The R-11 that has experience AJ was manufactured by Kovatch (Serial # 98L59) and has a horizontal API F/S vessel. The other three R-11s, manufactured by Oshkosh, and have vertical filter vessels built to use the old standard DoD NSN 4330-00-983-0998 filter coalescer elements. All of the R-11s were equipped with water absorption elements manufactured by Facet at the time of our site visit.

AJ was also found on several occasions in one (Serial #98L76) of the three assigned HSV-12 hydrant-servicing vehicles. On each occasion, a small amount (a few tablespoons) of AJ was found while draining the filter vessel the morning following a day of unusual heavy use. At that time the HSV-12 were parked in a heated barn over night. The HSV-12s are now parked outside and no AJ has been identified recently. Beta Systems manufactured the F/S on 98L76, during the 4^{th} quarter of 1997, Model # 182FS2001, and Serial # 182F-049. This vessel uses three coalescers and two separator elements. They have not observed any AJ-like material from either of the two older model HSV-12s that are equipped with Velcon vessel, Model # HV2856YTSR, that use seven coalescers (I-65688TB) and two separators (99-848V).

Product Receipt s and Issues
The Bangor ANGB receives JP-8 via tank trucks (not dedicated) that are filled at Portland DFSP. The trucks travel approximately 130 miles. Receipt temperature during January average 34 degrees and reached a low of 28 degrees. During August fuel temperatures are consistently 75 degrees. The product is filtered upon receipt via two vertical API standard filter-separators vessels, manufactured by M.E. Industries; the vessels are epoxy-coated steel. The F/Ss are drained following each receipt. The filter vessels are drained through a ¾" line equipped with a circular sight gauge. The Bangor ANG personnel have modified the sump drain to include a manual drain. No fuel receipt quality problems have been experienced since changing from pipeline to truck receipts during 1997. The pipeline receipts originated from Searsport DFSP and traveled 27 miles from the DFSP to the base. Bangor receives an average of six tank truck deliveries per day. They have the capability to offload three trucks simultaneously. A single truck can be offloaded within 35 minutes. The truck offloading system is equipped with two positive displacement pumps. The offload procedure results in pumping a significant amount of air as the tank trucks nears empty and while evacuating the discharge lines. The fuel is received through the receipt F/S into two above ground 10,000-bbl tanks. They store and issue approximately 800,000 gallons per month.

Bulk/Operating Storage
The two 10,000-bbl tanks ASTs were built in 1993/94 and placed into service during 1994. The tanks have fixed-roofs, floating pans, and are fully epoxy coated. The tanks are the "self-cleaning" design with the tank bottoms slopped to the center and the suction line directly over the tank sump. Bottom water is drawn out of the sump through a ¾ drain line (inside the tank) with a one-inch line outside the tank. The sump drain extends to within one inch of the bottom of the sumps. When draining the tank sumps, fuel is first drained into bucket for a visual examination. If there is no BS&W seen in the bucket, the fuel is pumped through the receipt F/S and back to the tank for approximately two minutes and monitored through a pipeline sight gauge. The filter vessel sump drain lines empty into a 2,000-gallon underground product recovery tank. Sight gauges on the hydrant and truck fill stand F/S sump lines are used to monitor the product, and manual drains have also been installed and are used daily. The product recovery system is equipped with a two-inch return line that moves JP-8 from the product recovery tank, through the receipt filters separators, back to the bulk tank. A 50-gpm pump powers the return line.

Assigned Refueling Equipment
There are four R-11s, one Oshkosh and three Kovatch, equipped with Facet water absorption elements. There are three HSV-12s assigned. The HSV-12s are equipped with coalescer elements, rather than water absorption cartridges.

(Serial # of the HSV-12s that have been free of AJ are 87L574 and 86L925.) We drained fuel from HSV-12 #98L76 filter housing and found the fuel drained to be slightly cloudy. We noted that the filter element change due date stenciled on the vessel was "Dec 2000" indicating that change was over due. The filter vessel on HSV-12 98L76 was manufactured by Beta Systems during the 4th quarter of 1997 and was assigned serial 182F-049. Velcon manufactured the filter vessel on HSV-12 86L925 (model # HV28566YTSR, serial # C-1366-35).

The refueling vehicle maintenance shop provided information on filter change dates. The last change date for HSV-12 98L76 was recorded as 5/17/2000. When asked about the stenciled " Dec 2000" change due date stenciled we were told that the elements were changed early and the failure to change the due date on the vessel must have been an oversight. The last change date on the other two HS-12s were as follows: 87L574, 12/1/99; and 86L925, 5/4/99. Other Filter Element change dates were:

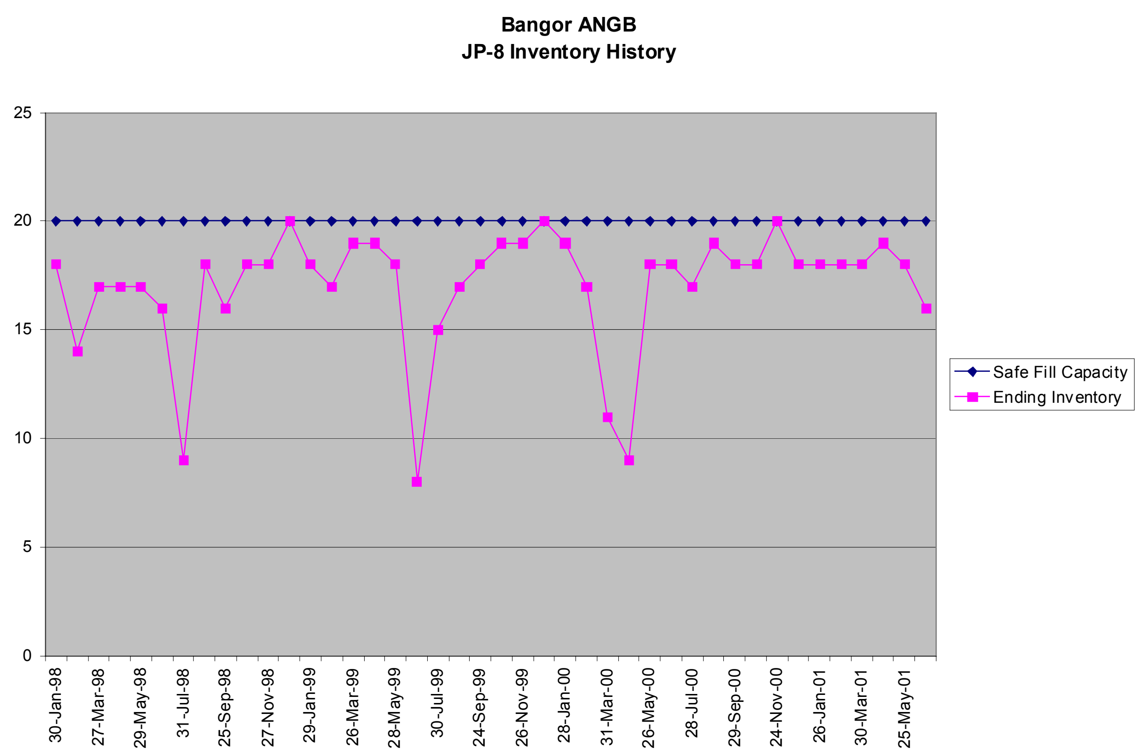
Equip Type	Serial #	Water Absorption Elements Installed	Last Filter Coalescer Element Change Date
R-11 (Oshkosh)	89L766	11/3/99	6/11/98
R-11 (Oshkosh)	91L230	11/6/99	6/13/97
R-11 (Oshkosh)	91L231	11/4/99	6/6/97
R-11 (Kovatch)	98L59	11/4/99 Replaced 5/17/2000	
HSV-12	86L925	N/A	5/4/99
HSV-12	87L925	N/A	12/1/99
HSV-12	98L76	N/A	2/2/99

Hydrant System
The Bangor ANGB Type III system was installed during 1994 at about the same time they converted from JP-4 to JP-8. All F/Ss are located within a heated pump house. There are two vertical, API, M.E. Industries receipt F/S vessels with Facet elements (six coalescers P/N 200 221 and three separators P/N 200 246) with a rated flow of 600 gpm. (Note: the LFM Supervisor reported that he "refuses" to use Velcon elements, as he believes they are unreliable.) There are four Facet (M.E. Industries) horizontal F/S

vessels with Facet elements (seven coalescers P/N 200 219 and two separators P/N 200 220) with a rated flow of 600 gpm. Two of these are used for hydrant issues and two support the refueling truck fill stand. The Type Three system is turned off at the end of the day and restarted the following duty day.

Products Stored
JP-8

Product Quality Data
FSII content is fairly consistent at 0.12%, with the low of 0.10% and a one-time high of 0.14% percent by volume. Conductivity ranges between 100-160 CUs during the winter months and 250-300 CUs during the summer months. While receiving by pipeline, the Bangor ANG cleaned the bulk tanks “every couple” of years; however, they have not cleaned the tanks since changing to tank truck receipts and expect the cleaning frequency to be once every eight years.



Appendix E-13

DFSP Verona, NY

R.D. # 2
Verona, NY 13478

Terminal Superintendent: Kenneth Peterson, Phone: 315-363-0650

AJ Investigation Team Member: E. Mac Fishburn (C4e).

DFSP Verona has experienced AJ problems during the November to December while temperatures ranged between 30 and 45 degrees F. AJ disappeared at 50ºF and below 30ºF. During the period AJ was observed, two to three cups were drained from the issue F/S each day. There are four F/S located at the track loading rack and additive is injected after the F/S. The injection units are the same as DFSP Carteret. The FSII concentration of the JP-8 received from DFSP Carteret averages from 0.9% to 0.10%. DFSP Verona normally injects FSII and SDA to deliver on-specification JP-8 to customers.

They have not experienced AJ in the past two months (December 2000 and January 2001); however the terminal manager reported observing a buttermilk substance not as heavy as AJ. He attributed this to FSII and water. The QSR explained that for the past two months, the supplying terminal, Carteret, has injected FSII and SDA after the F/S.

The storage tank used for issues during this visit to DFSP Verona has not experienced AJ. Receipts from DFSP Carteret have been cloudy but product drained from issue F/S at Verona does not meet the criteria of AJ. The F/S removes all of the cloud from the JP-8; however, when product arrives at Burlington, the customer finds AJ in the receipt F/S. Before Burlington installed receipt F/S they experienced no AJ. Travel time for the truck deliveries is five and one half-hours.

The JP-8 is stored in two 80,000-bbl tanks and has 35 to 40 days for settling prior to shipment to customers. The tanks are epoxy-coated geodesic domes with floating pans. The issue line is a 12-inch line from the storage tanks.

The occurrence of AJ in the F/S sump has no apparent correlation to whether the elements are new or nearing the required change date. Likewise there is no apparent correlation to AJ and the differential pressure across the filter vessel. Although AJ may have been drained from the F/S, there has been no AJ in tank trucks after draining them for inspection after the occurrence of AJ.

Appendix E-14

DFSP CARTERET

Kinder Morgan Liquid Terminals
78 Lafayette Street
Carteret, NJ 07008

Terminal Manager: Glenn Sandor, Phone: 732-541-5161
QSR: Joe Fish, Phone: 732-541-2371

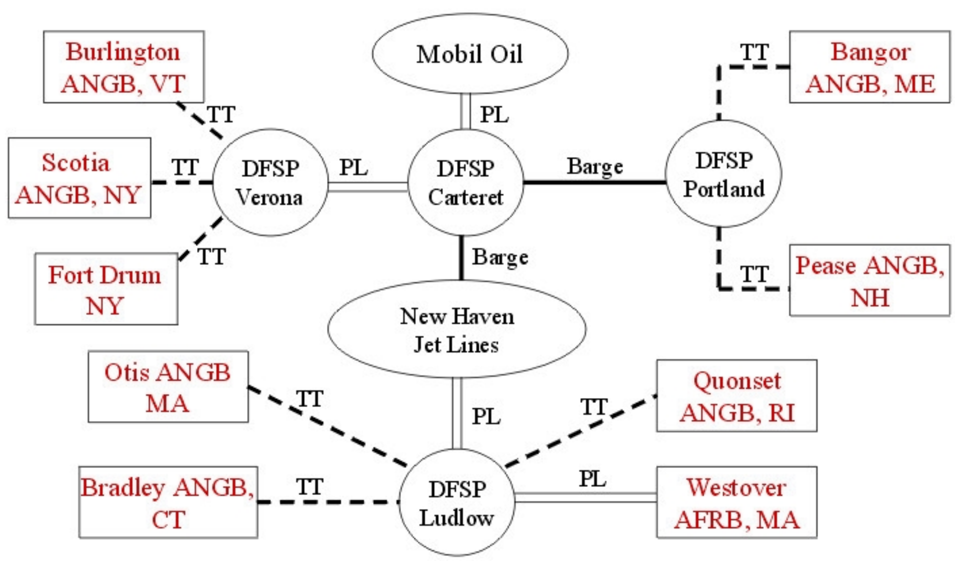
DFSP Carteret was activated as a new terminal with the closure of DFSP Stanton in 1999. Products handled by Carteret include JP-8, JP-5, and F-76. JP-8 is shipped to Cartenet neat via a multi-product pipeline operated by the Colonial Pipeline Company from breakout tanks in Linden, NJ. Four, fixed-roof, steel, ASTs constructed in the 1940s are dedicated to JP-8 storage. Since December 2000, unfiltered, neat JP-8 is received into Tank 100 (capacity 92,000 bbls) and additized in a tank-to-tank transfer to Tanks # 125 and 126 (capacities 23,000 bbls each). Unadditized JP-8 is filtered as it enters Tank # 44 (capacity 74,000 bbls) which is used primarily to fill barges and occasionally tank trucks. Receipt batches are limited to a maximum of 75,999 bbls. Three tanks are dedicated to storing JP-5, Tanks # 25-1 and 25-2 constructed in 1955 and 63, constructed in 1942. JP-5 is additized as it leaves the pipeline and enters Tank 63. Carteret also has tanker and barge capability and supplies fuel to DFSPs New Haven and Portland by barge and DFSP Verona by pipeline.

Tank # 100, the JP-8 primary receipt tank, has an epoxy-coated floor and epoxy coating 3 1/2 feet up the sides. It also has an eight-inch water dam around the suction line that has a duckbill six inches from the bottom. The discharge line and receipt line are separate and the suction line is fixed. The tank was last cleaned in May 1999, when the epoxy coating was applied. Tank # 44 is also coated similar to Tank # 100 and has a discharge line 18-inches from the bottom of the tank, positioned in the center, with a diffuser on the end and slots on the side. The tank sump is approximately 35 feet away from the discharge line. The 18-inch receipt line is also used to fill barges. An eight-inch line connects the tank to the tank truck loading rack. When Tank # 125 was last cleaned in March 1999, the coating was unacceptable and had to be sandblasted. The floor and walls are mild steel. The fixed discharge line is a duckbill approximately three feet from the side with a water dam six-inches from the floor. The tank sump is approximately four feet from the discharge line. Tank # 126 is similar to Tank #125.

FSII is stored in an 11,000-gallon tank with a nitrogen blanket. Since December 2000, both FSII and SDA is injected by the same Hammonds 2000D-40-1M injectors after it leaves Tank # 100 at a concentration of 0.11 to 0.13 for FSII and 200-250 CUs for SDA. The FSII concentration was traced from DFSP Carteret to New Haven with no significant loss of FSII evident.

There have been no reports of AJ since the terminal was activated, however the appearance of a lime green tint in fuel receipts, especially JP-5, has been frequent since the Department of Transportation mandated the use of green dyed water to pressure test the pipeline in December. Water is removed as needed when gauging indicates the need. BS&W is removed by using a vacuum truck. An immediate sample and all-level sample are taken and tested on all inbound and outbound shipments. A B-1 sample is taken on receipts after the fuel in the receipt tank has settled for a day.

Supply Pattern for NE Bases with Apple Jelly Problems



Appendix E-15

DFSP Jacksonville, NJ

Terminal Manager: Alex Dyson, Phone: 609-267-9100
Operations Manager: Gary Humphreys, Phone: 609-267-1116
Quality Surveillance Representative: George Tyras, Phone: 609-267-1116, Fax: 609-267-4394

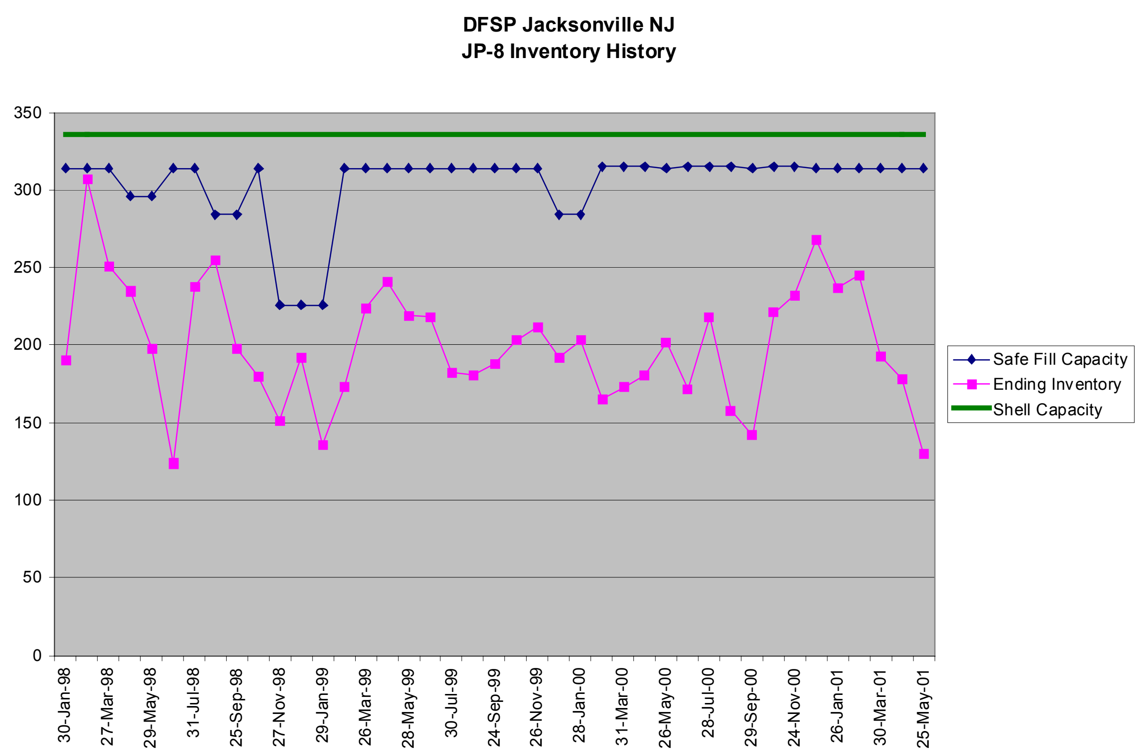
AJ Investigation Team: Dwight Duncan (C4e)

DFSP Jacksonville receives fuel (JP-8) primarily from the Sun Refinery, Marcus Hook, PA. On occasion, product may also be received from DFSP Yorktown and DFSP Baltimore. Product is primary received by dedicated barge, the Bay Trader, on contract to the government, although spot chartered barges may be used periodically. Travel time by barge is about 4.5 hours from Marcus Hook, 30 hours from Yorktown and about 8 hours from Baltimore. Product is fully additized when received at DFSP Jacksonville. The terminal has the capability of adjusting additive levels as barges are discharged should this be required. Product is received dry and there are no water problems. Tanks are drained as required based on water finding paste, but very infrequently.

The terminal has a total of 12 tanks but only 8 are in use for JP-8. All are above ground steel tanks equipped with fixed-roofs and internal floating pans. Four tanks have bottoms, which slope to the side and 4 bottoms slope to the center. Tanks are cleaned every 5 years. Product in tanks #1, #2, and #5 is rotated at least every 6 months, tanks #4, #9 and #10 every 1 to 1.5 months and in tanks #11, #12 (used to load barges) product is rotated weekly.

Product is shipped to McGuire AFB through a dedicated pipeline and loaded in tank trucks (non-dedicated) for shipment to various other locations. Product is filtered when shipped by pipeline and trucks. Shipping time to McGuire AFB varies from 8 to 12 hours depending on the batch size. Filter changes average about every 15 million gallons.

DFSP Jacksonville said they experienced a very small amount of AJ in the pipeline F/S to McGuire about 3 or 4 years ago.



Appendix E-16

McGuire AFB

305 AMW/LGSF
3101 Vandenberg Avenue
Building 1839
McGuire AFB, NJ 08641-5102

Fuels Officer: Lt Douglas Saab, Phone: 609-754-2458, Fax: 609-754-2246, douglas.saab@mcguire.af.mil
Fuels Manager: CMSgt John Adams, Phone: 609-754-4788, Fax: 609-754-2246, john.adams@mcguire.af.mil
QC&I Supervisor: Calvin Mason, Phone: 609-754-2661, Fax: 609-754-2661, Fax: 609-754-2246, calvin.mason@mcguire.af.mil
LFM Supervisor: Willie Duhart
RFM Supervisor: Wayne Lambert

AJ Investigation Team: Larry Dipoma (C4e) and Dwight Duncan (C4e)

AJ Incidents

McGuire AFB was selected as a site to visit because it had no history of Apple Jelly contamination. The plan was to contrast the facilities and handling process with locations that have experience AJ contamination to identify potential differences. However, just prior to our visit, McGuire AFB fuels personnel discovered a jelly-like substance in the sump of Kovatch R-11 # 97L0165. The substance drained from the sump had a foamy appearance, as though a lot of air was mixed with the product. It had a pinkish brown tint and had the appearance of a chocolate/strawberry milkshake. The appearance of the sample did not change significantly while sitting in the laboratory or even after it had been shipped to SwRI. The unique appearance of the sample is attributable to the unique circumstances that led to the discovery. This particular R-11 had been recently used to flush four 100 feet sections of hose while preparing a Forward Area Refuel Point (FARP) cart for deployment. The hoses, which had been in storage for three years at McGuire AFB, had been pressurized with water to 150 psi, drained and flushed by connecting the one end to the single point nozzle and the other to the bottom-loader of the R-11. Five hundred gallons of fuel were circulated through each of the hose section; then the content of the hoses was evacuated into the R-11. They allowed 97L0165 to sit over night to allow the water to settle and discovered the “Apple Jelly” contamination while draining the Sump the following morning. The R-11 was equipped with Facet water absorption elements, installed during July 2000. The hoses were not available for inspection because they had been deployed with the FARP cart. Very little information was available about the manufacture or materials in the hose. The ambient temperatures during the two-day period that encompassed the flushing of the hose and the discover of the “AJ” range from 23°F to 28°F with wind chill factors from 1°F to 16°F.

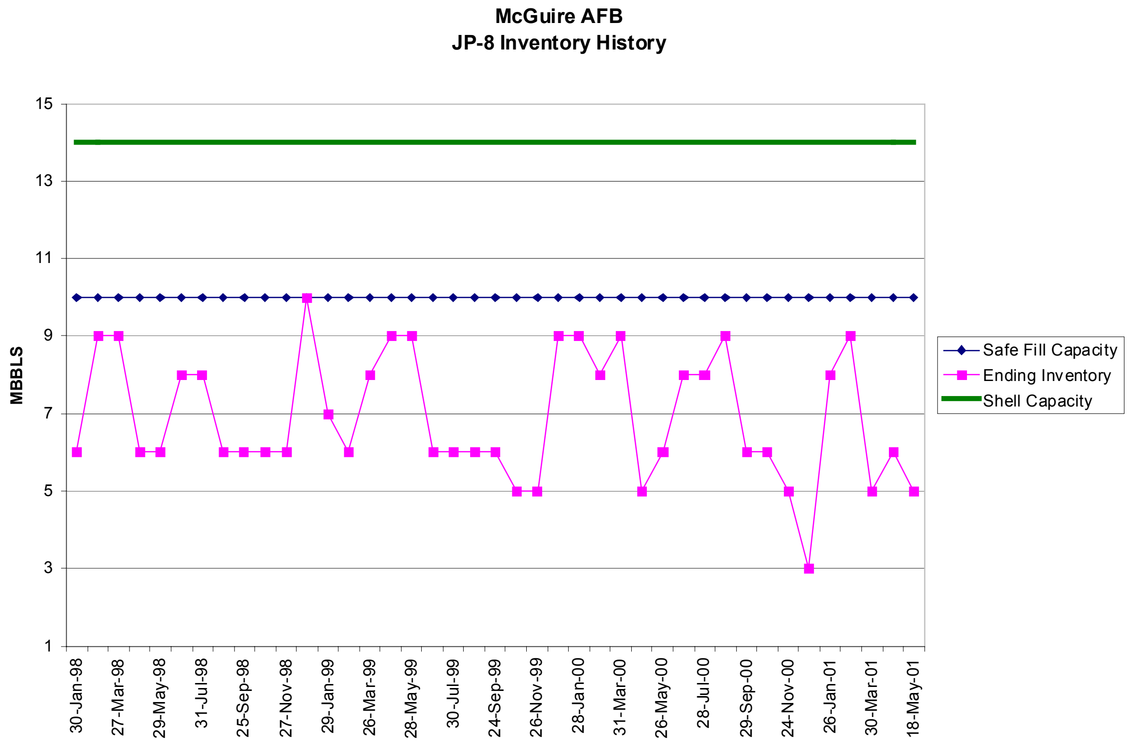
A second incident occurred on February 27, 2001, when a F/S shut down during a transfer between hydrant systems. Some dark materials were drained from the filter sump. The filter elements had been in service for 35 months and an apparent water slug shut down the F/S. AJ was not found during an internal inspection of the F/S. After examining the materials, the C4e team members concluded it was normal BS&W because it did not have a heavy viscous nature. Later in our investigation, once SwRI published its broad definition of AJ and after seeing numbers similar samples of material considered "AJ" in the field, we should have considered this material to be AJ within the SwRI definition.

Product Receipts and Issues
Fuel is received via a dedicated six-inch, eleven-mile pipeline from DFSP Jacksonville with a receipt capability of 648,000 gallons per day. A new tank truck off-loading facility will increase this capacity to 1.3 million gallons per day when it is completed. A pipeline modification, scheduled for completion in October 2001, will route both pipeline and tank truck receipts directly to the BRAC hydrant system bypassing bulk storage. C-Station, used primarily for storage and as a fillstand, has six 25,000-gallon tanks and two fillstands.

Bulk Storage
The primary storage is the two Type III Hydrant Systems, however three 450,000-gallon ASTs are out of service for maintenance and repair. Construction of a two million-gallon storage tank is scheduled for fiscal year 2002/2003.

Assigned Refueling Equipment
Twelve R-11s with water absorption elements installed in June-July 2000, six HSV-12s, and five MH2-C Hose Carts.

Hydrant System
McGuire AFB has one Type II and two Type III hydrant systems. The Type II system has six 50,000-gallon tanks, three laterals with five outlets on each with a flow rate of 600 gpm. The KC-10 hydrant system (BRAC) has two 1million-gallon tanks with five 600-gpm pumps and delivers up to 2,400 gpm. It also has two fillstands that can sustain six R-11s per hour. The C-141 Hydrant System (DLA) is located within Bulk Storage and has two 850,000 gallon tanks with four 600-GPM pumps that delivers 2,400 GPM to 16 spots. If one of the systems became inoperable, the system can be configured so that one hydrant system can service all spot with a reduced capacity.


McGuire AFB
JP-8 Inventory History
MBBLS
15
13
11
9
7
5
3
1
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
26-Jan-01
30-Mar-01
18-May-01
Safe Fill Capacity
Ending Inventory
Shell Capacity

Appendix E-17

DFSP Port Mahon

Port Mahon DFSP
PO Box 313
Dover, DE 19903

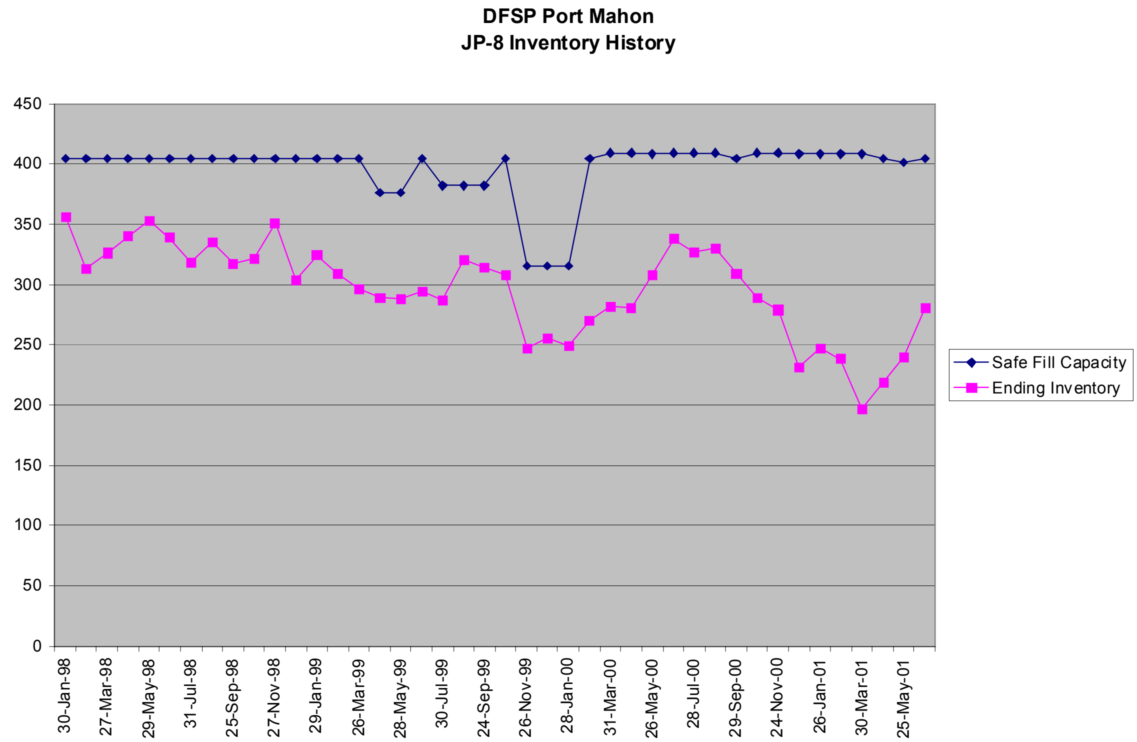
Terminal Manager: George Steady, Phone: 302-736-1774
QSR: Carl Knighting, 302-736-2639

Port Mahon experienced AJ during December 2000. On two occasions, they drained cloudy fuel from the F/S sump and got a dark material that was suspected to be AJ. This experience coincided with a drop in temperature and occurred at the same time that Dover AFB was experiencing AJ problems in their receipt F/S sumps.

The Delaware Storage and Pipeline operates the Port Mahon DFSP for the primary support of Dover AFB. Occasionally, tank trucks are loaded for destinations directed by DESC to relieve temporary shortages or resupply delays. There are eight fixed-roof storage tanks for JP-8: four 30,000 BBL tanks, three 96,000-bbl tanks and one 25,000-bbl tank. Tank #5 is a floating-roof tank but has been modified with a geodesic. The suction and discharge into Tank #5 is typical of the other tanks. The single 8 inch suction line goes 30" into the tank, turned down 90 degrees, and comes to within 3 ½" off the floor. The tanks are cleaned on a three-year cycle, and Tank #5 was last cleaned in 1999. This 96,000-bbl tank was constructed in Aug 1964.

Product is received at Port Mahon by barge from Sun Oil, Marcus Hook, PA (75%) and Baltimore DFSP Terminal (25%). The US Coast Guard limits barge size to 13,000 bbls because of the shallow bay. Eight to ten barges per month are received at Port Mahon. Product received normally has all the needed additives for JP-8. Additional SDA can be injected at Port Mahon if needed.

There are two 1200-gpm vertical F/S vessels installed on the outbound lines. The vessels are Model # VFCS-C-12N38-5636TN2. Both vessels are API 1581, Group II. Class B. **It was noted during the walk around that the F/S vessel drains were blocked with pipe plugs below the drain valves and the vessel air eliminator lines were capped.** The Terminal Manager stated that they were blocked to avoid a spill and the associated environmental impact. This type of an arrangement inhibits checking the F/S sumps for water. If water is allowed to build-up in a F/S sump, the water will be transferred down stream when the vessel is over-whelmed.


DFSP Port Mahon
JP-8 Inventory History
450
400
350
300
250
200
150
100
50
0
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
26-Jan-01
30-Mar-01
25-May-01
Safe Fill Capacity
Ending Inventory

Appendix E-18

Dover, AFB DE

436 AW/LGSF
639 Everux Street
Dover AFB, DE 19902-5639

Fuels Officer: Lt Jeffrey Magee, Phone: 302-677-6730, Fax: 302-677-6736, Jeffrey.magee@dover.af.mil
Fuels Manager: CMSgt Robert F. Vella, Fuels Manager, Phone: 302- 677-6301, Fax: 302-677-6736, Robert.Vella@dover.af.mil
Carl Knighting, QSR, (302) 736-2639

AJ Investigation Team: E. Mac Fishburn (C4e) and Calvin Martin (Martin & Associates)

AJ Incidents
Dover AFB experienced AJ only during a ten-day period in December 2000. During this time, AJ was frequently drained from the sumps of receipt F/Ss #1 & #2, which are installed in a heated pump house. When the problem occurred, the ambient temperature had dropped from 40 to 20ºF. It was also noted that slugs of water were coming through the F/S, and they were experiencing high AEL water readings. Pete Shields, Bulk Storage Supervisor, reported that the F/S pressures decreased during the temperature drop from a high of 11 to a low 5 psi differential pressure. After the temperature went back up, the differential pressure also went back up. Kevin Hughes, LFM Foreman, was prepared to change the elements, and he verified this condition. They removed the F/S tops and inspected the vessels internally. Finding nothing wrong, they reinstalled the tops and placed the vessels back into service.

Product Receipts and Issues
Product at Dover is received from the Port Mahon DFSP, which is approximately five miles away. Fuel is transferred from Port Mahon to Dover through two 6-inch dedicated pipelines. The pipelines run approximately five miles from Port Mahon to Dover AFB. The normal transfer rate is 35,000 gph and during an upsurge, a boost pump is utilized that will increase the flow to 51,500 gph. The fuel is filtered at Port Mahon outbound to Dover. Line displacement time to Dover from Port Mahon is three hours. Pipeline receipts from Port Mahon are not filtered upon receipt and transfer from the bulk tanks. Dover AFB issues an average of 300,000 gallons of fuel per day.

Bulk Storage
Dover AFB has three above ground steel tanks used to store JP-8. Two of the bulk storage tanks are equipped with floating-roofs with geodesic covers. The third tank is an above ground steel tank with fixed-roof and floating pan. This 55,000-bbl was tank built in1971. It is equipped with a product recovery system with hand pump and ¾ inch line for water removal.

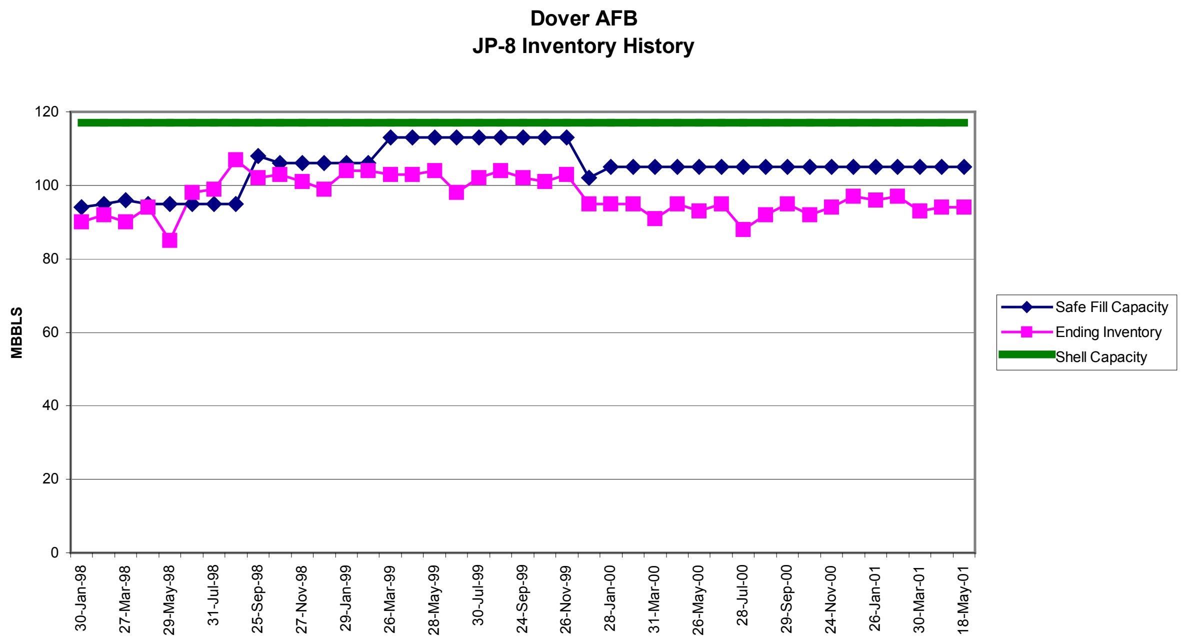
Assigned Refueling Equipment
Dover AFB has three Beta, two Tri-State and one Page AVJET Hydrant servicers. The frequency of F/S element changes on this equipment averages three years and the changes are based upon the maximum use life. No AJ has been encountered in these hydrant servicers. They have nine R-11 refuelers that are equipped with absorption media elements. The Facet elements were installed in July 2000, and no problems have been encountered. Fuels Management at Dover has implemented an aggressive water-draining program. Operators drain the sumps of the refuelers and hydrant servicers at checkpoint and at the second shift change daily. Personnel report that they are not seeing anything abnormal.

Hydrant System
There are two-Type III constant pressure hydrant systems installed at Dover. Each of the Type III hydrant systems has an independent pump house, buildings #758 and #759. In each pump house, there are seven F/Ss. Two are used for filtration of receipts into the system operating tanks, and five are issue F/Ss that filter fuel from the two 10,000-bbl operating tanks. These F/Ss are horizontal, 600-gpm capacity, Facet Model #CFCS-D-7K39SB-1-2S636FM qualified to API 1581, Group II, Class B, and 3rd edition elements.

The first filtration occurs during transfers to the two Type III constant pressure hydrant systems. Each hydrant system has two receipt and re-circulation F/Ss and five issue F/Ss. Each hydrant system is equipped with two above ground steel fixed-roof 10,000-bbl operating tanks. The suction discharge lines in all four tanks are positioned within the tanks directly above the sumps. Again, the product recovery systems are equipped with ¾ inch lines. The four hydrant operating tanks are 100 percent epoxy coated and are equipped with three-inch diameter stripper lines. During surge operations, as much as 600,000 gallons of fuel per day may be issued, primarily by hydrant systems.

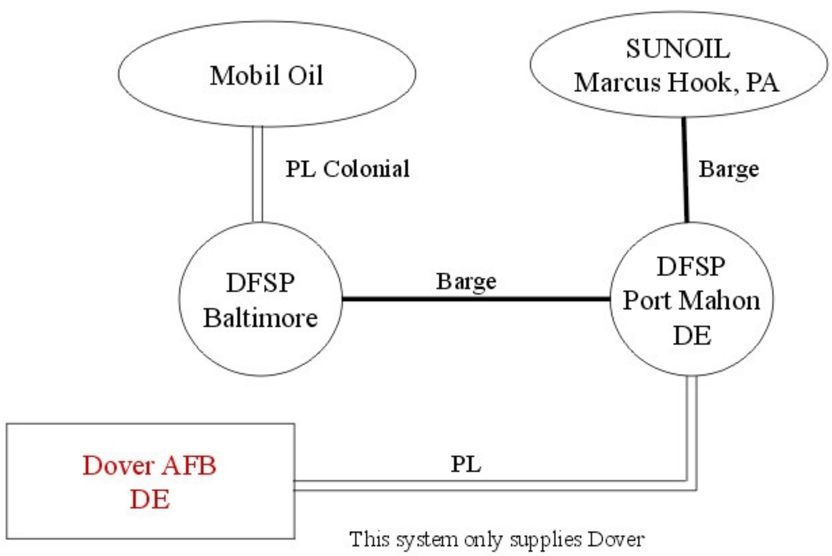
Products Stored
JP-8

Product Quality Data
The FSII content of the fuel received and issued at Dover is normally 0.13% to 0.14 % on receipt and is normally 0.12% to 0.13% upon issue. (Perhaps the FSII level could be reduced without creating a problem.)



Dover AFB
JP-8 Inventory History
MBBLS
0
20
40
60
80
100
120
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
26-Jan-01
30-Mar-01
18-May-01
Safe Fill Capacity
Ending Inventory
Shell Capacity

Current Supply Pattern for
Dover AFB



Appendix E-19

DFSP Grand Forks, ND

4128-A 27th Avenue
North Grand Forks, ND 58203
Terminal Manager: David Kovar, Phone: 701-795-1383, Fax: 701-795-5679
gfdoss@rrv.net
QSR: Bill Pulley, Phone: 710-772-9421, Fax: 701-795-5679
wpulley@desc.dla.mil

AJ Investigation Team: Dwight Duncan (C4e) and Bud Rodee (DFR-Americas)

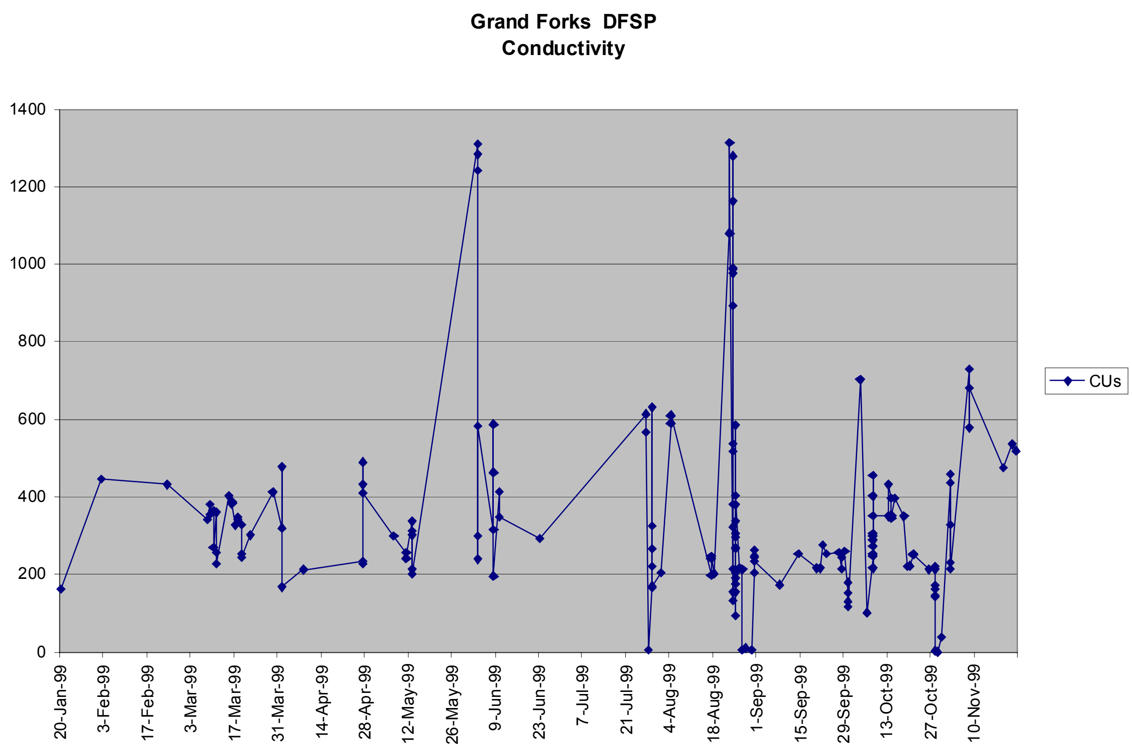
DFSC Grand Forks receives JP-8 from Conoco's Ponca City, OK Refinery via a multi-product (jet fuel, diesel fuel, and gasoline) pipeline operated by Williams Pipeline. Pipeline Drag Reducer (PDR) is used in some of the pipeline product movements, but not JP-8. Because of the line fill in this pipeline, it takes approximately three weeks for a shipment to reach DFSP Grand Forks. DFSP Grand Forks receives a "heart cut" of the pipeline shipment, based on API gravity readings. The transmix at the front and end of the batch is not separated as transmix but is reportedly blended with "other" products. Grand Forks DFSP has two 1959 vintage 55,000-bbl steel tanks, and two 80,000-bbl tanks, also built in 1959. The floor of the tanks are epoxy coated and the coating extends three-feet up the tank walls. The tanks have floating-roofs with geodesic dome covers. The roof drains have been removed. The tanks slope to the center and are equipped with 2" BS&W drain lines. The tanks are drained weekly and after each receipt. Tank receipt and discharge lines are separate. The discharge (suction) lines are fairly close to the BS&W sumps. The distances range from 17" to 43".

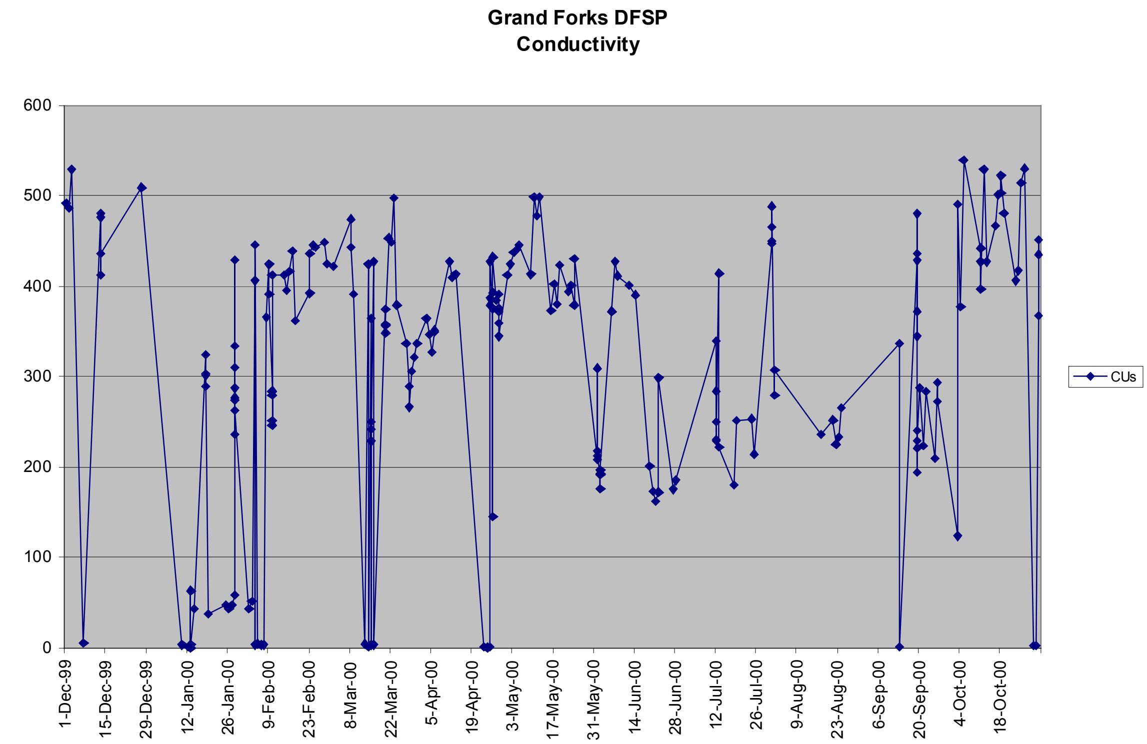
During January, product receipt temperatures range from 33° to 35°F, while the temperature of JP-8 in storage ranges from -2° to +20°F. During August, receipt temperatures range from 65° to 69°F, while storage temperatures range from 65° to 70°F. **The JP-8 is not filtered during receipt at DFSP Grand Forks or during transfer to Grand Forks AFB.**

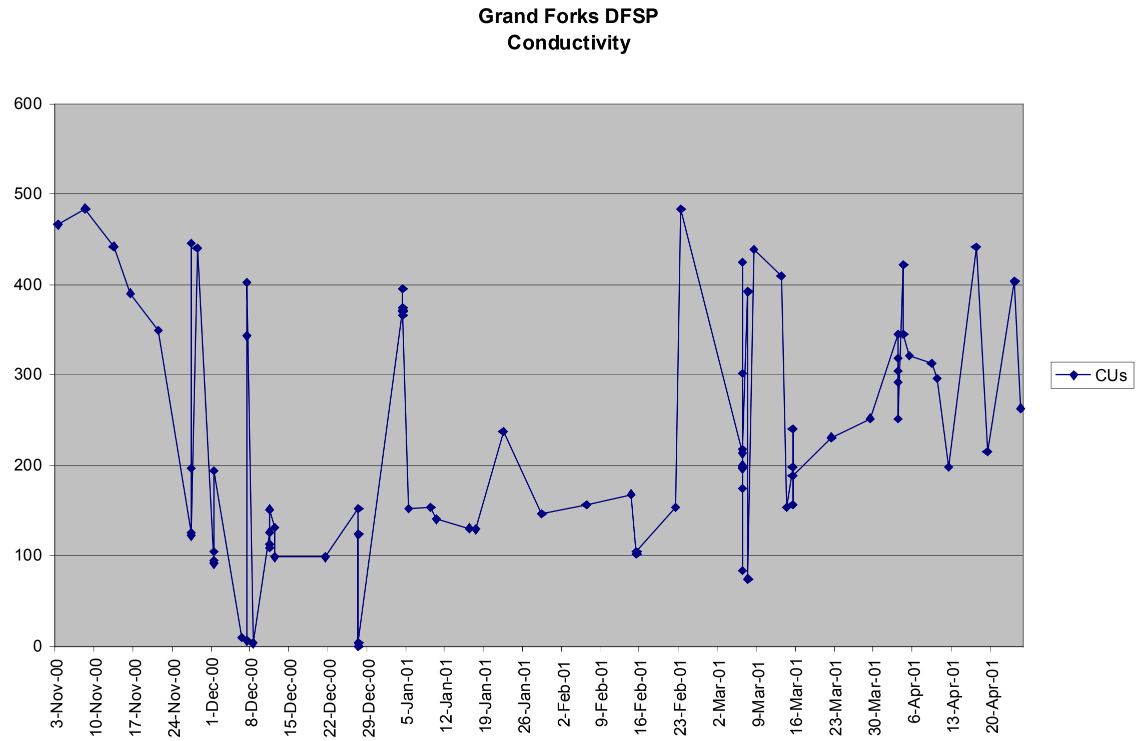
SDA and FSII additives are injected using Hammond injectors (six model 6T-4L for the truck fill stand and a model 1400 for the pipeline). The same injection unit injects both additives. A 6" pipeline, which operates at 500 gpm, supplies the fill stands. The transfer pipeline to Grand Forks AFB is an 8" line with an average pumping rate of 650 gpm and a 210- average operating pressure (300 max). STADIS 450 is received in 55 gal drums and is blended with JP-8 at a ratio of 20 parts JP-8 to 1 part of STADIS 450 in a 27.5 gal tank. The JP-8 retain samples (fully additized) are used to dilute the STADIS 450. FSII is received by bulk from Ashland Distribution Co. and is stored in a 6,353 gal tank. The tank is equipped with a desiccant dryer, and the FSII turns over every six months. The DFSP personnel work hard to maintain a 0.11% FSII injection ratio and keep meticulous records. FSII test results show a range from 0.099% to 0.12%. They report that the Hammonds injectors are not completely reliable and require constant monitoring. There does not appear to be a water problem with any of the DFSP Grand Forks tanks.

Tank truck deliveries are also made from DFSP Grand Forks to military activities in Minnesota (6 to 8 hours transit time), North Dakota (up to 4 hours transit time), Wisconsin (8 hours) and South Dakota (up to 15 hours driving time, which requires an over night stop). Trucks are not dedicated but each truck is inspected and the manifolds drained prior to loading.

The only significant changes reported by the DFSP was that several hundred feet of pipeline were replaced in the line coming from the pipeline breakout tanks and also in the line going to Grand Forks AFB. This repair requirement was identified by smart pig analysis.




Grand Forks DFSP
Conductivity
600
500
400
300
200
100
0
1-Dec-99
15-Dec-99
29-Dec-99
12-Jan-00
26-Jan-00
9-Feb-00
23-Feb-00
8-Mar-00
22-Mar-00
5-Apr-00
19-Apr-00
3-May-00
17-May-00
31-May-00
14-Jun-00
28-Jun-00
12-Jul-00
26-Jul-00
9-Aug-00
23-Aug-00
6-Sep-00
20-Sep-00
4-Oct-00
18-Oct-00
CUs


Grand Forks DFSP
Conductivity
600
500
400
300
200
100
0
3-Nov-00
10-Nov-00
17-Nov-00
24-Nov-00
1-Dec-00
8-Dec-00
15-Dec-00
22-Dec-00
29-Dec-00
5-Jan-01
12-Jan-01
19-Jan-01
26-Jan-01
2-Feb-01
9-Feb-01
16-Feb-01
23-Feb-01
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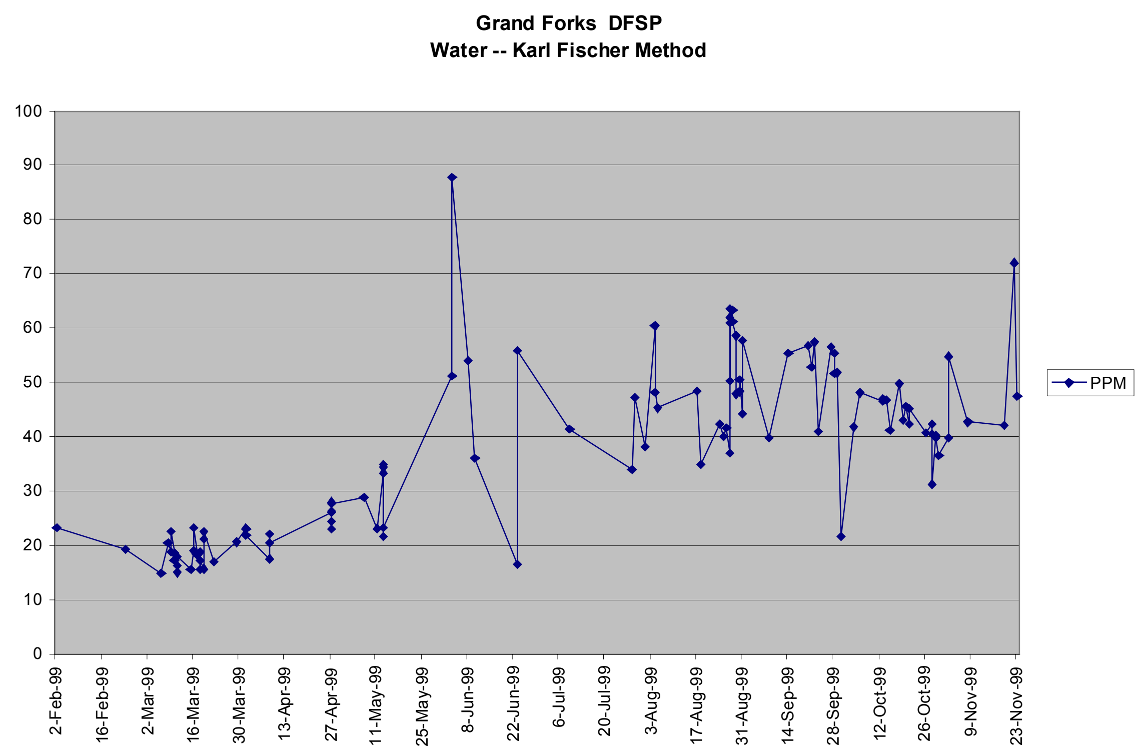
6-Apr-01
13-Apr-01
20-Apr-01
CUs


Grand Forks DFSP
Water -- Karl Fischer Method
100
90
80
70
60
50
40
30
20
10
0
2-Feb-99
16-Feb-99
2-Mar-99
16-Mar-99
30-Mar-99
13-Apr-99
27-Apr-99
11-May-99
25-May-99
8-Jun-99
22-Jun-99
6-Jul-99
20-Jul-99
3-Aug-99
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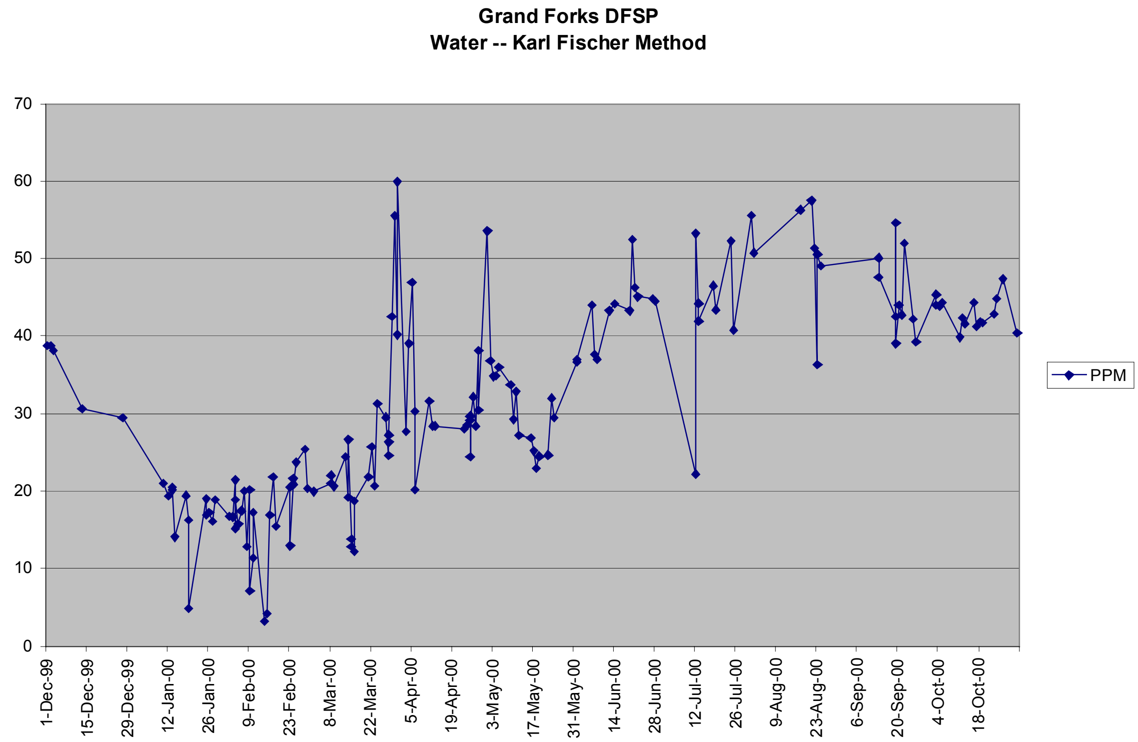
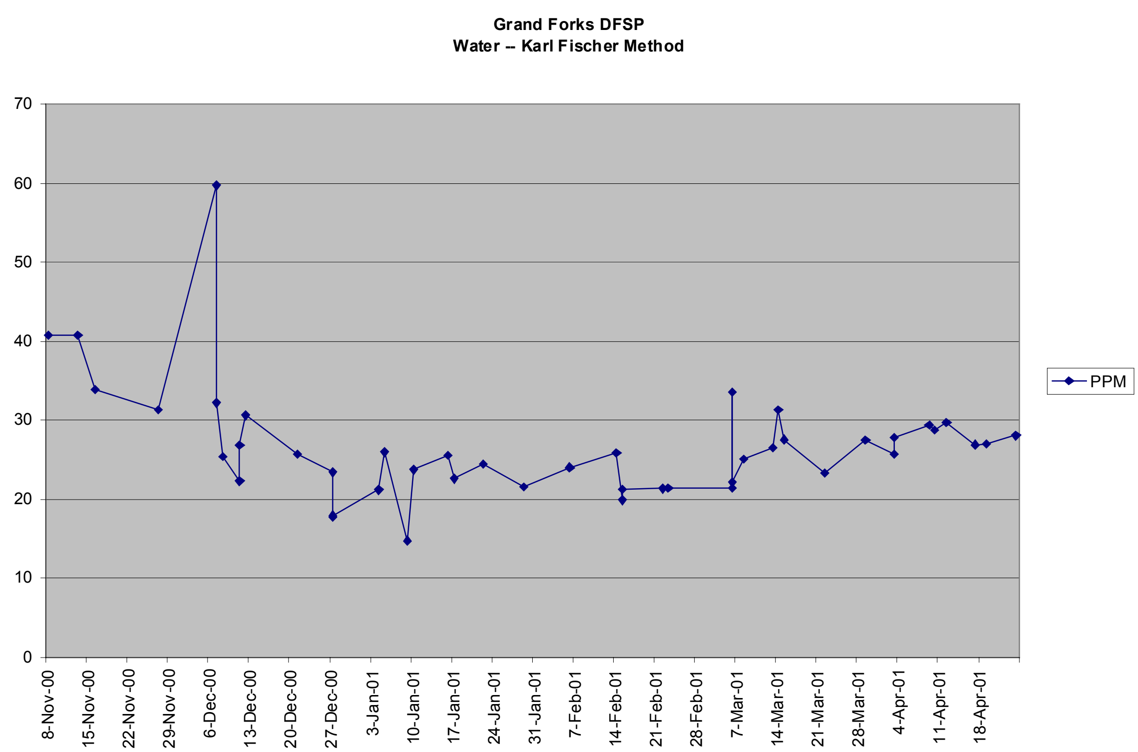
9-Nov-99
23-Nov-99
PPM


Grand Forks DFSP
Water -- Karl Fischer Method
70
60
50
40
30
20
10
0
1-Dec-99
15-Dec-99
29-Dec-99
12-Jan-00
26-Jan-00
9-Feb-00
23-Feb-00
8-Mar-00
22-Mar-00
5-Apr-00
19-Apr-00
3-May-00
17-May-00
31-May-00
14-Jun-00
28-Jun-00
12-Jul-00
26-Jul-00
9-Aug-00
23-Aug-00
6-Sep-00
20-Sep-00
4-Oct-00
18-Oct-00
PPM


Grand Forks DFSP
Water -- Karl Fischer Method
70
60
50
40
30
20
10
0
8-Nov-00
15-Nov-00
22-Nov-00
29-Nov-00
6-Dec-00
13-Dec-00
20-Dec-00
27-Dec-00
3-Jan-01
10-Jan-01
17-Jan-01
24-Jan-01
31-Jan-01
7-Feb-01
14-Feb-01
21-Feb-01
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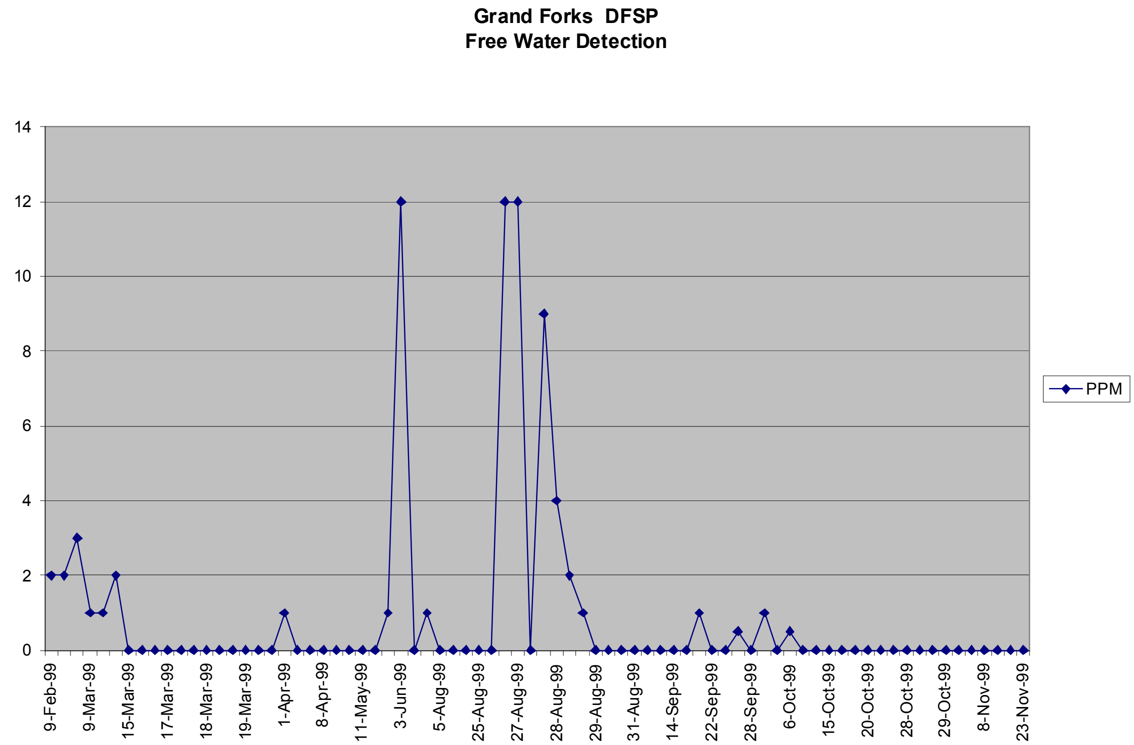
18-Apr-01
PPM



Grand Forks DFSP
Free Water Detection
14
12
10
8
6
4
2
0
PPM
9-Feb-99
9-Mar-99
15-Mar-99
17-Mar-99
18-Mar-99
19-Mar-99
1-Apr-99
8-Apr-99
11-May-99
3-Jun-99
5-Aug-99
25-Aug-99
27-Aug-99
28-Aug-99
29-Aug-99
31-Aug-99
14-Sep-99
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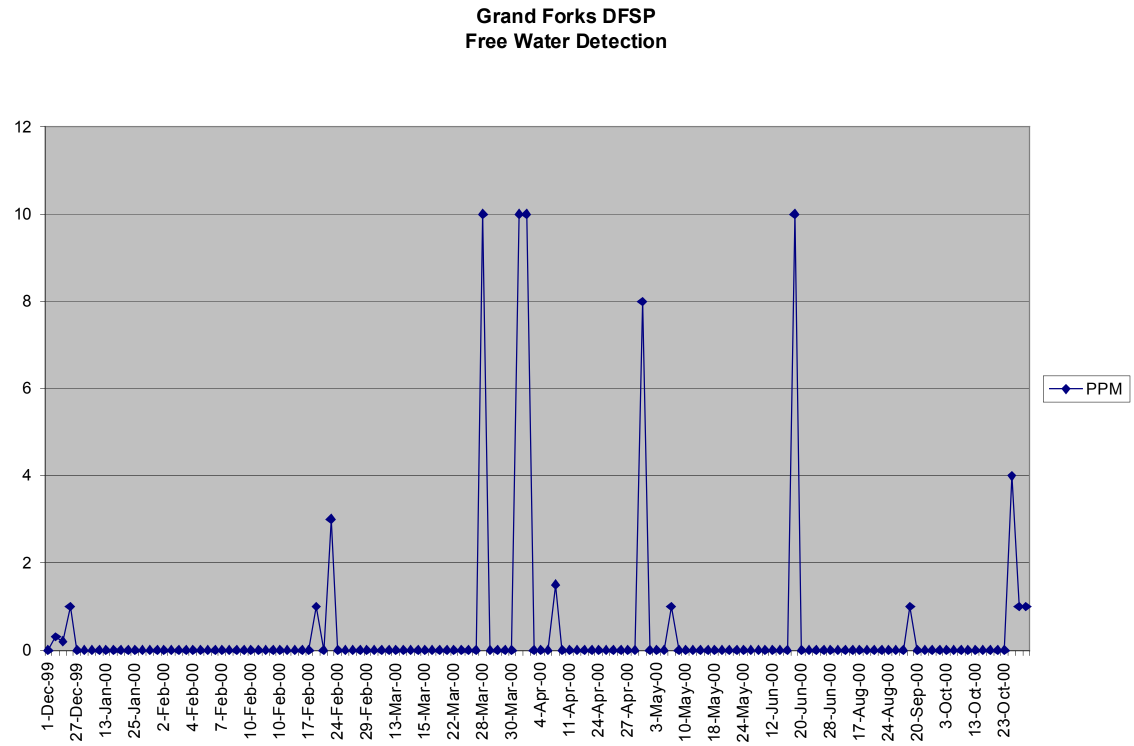
8-Nov-99
23-Nov-99


Grand Forks DFSP
Free Water Detection
12
10
8
6
4
2
0
PPM
1-Dec-99
27-Dec-99
13-Jan-00
25-Jan-00
2-Feb-00
4-Feb-00
7-Feb-00
10-Feb-00
10-Feb-00
17-Feb-00
24-Feb-00
29-Feb-00
13-Mar-00
15-Mar-00
22-Mar-00
28-Mar-00
30-Mar-00
4-Apr-00
11-Apr-00
24-Apr-00
27-Apr-00
3-May-00
10-May-00
18-May-00
24-May-00
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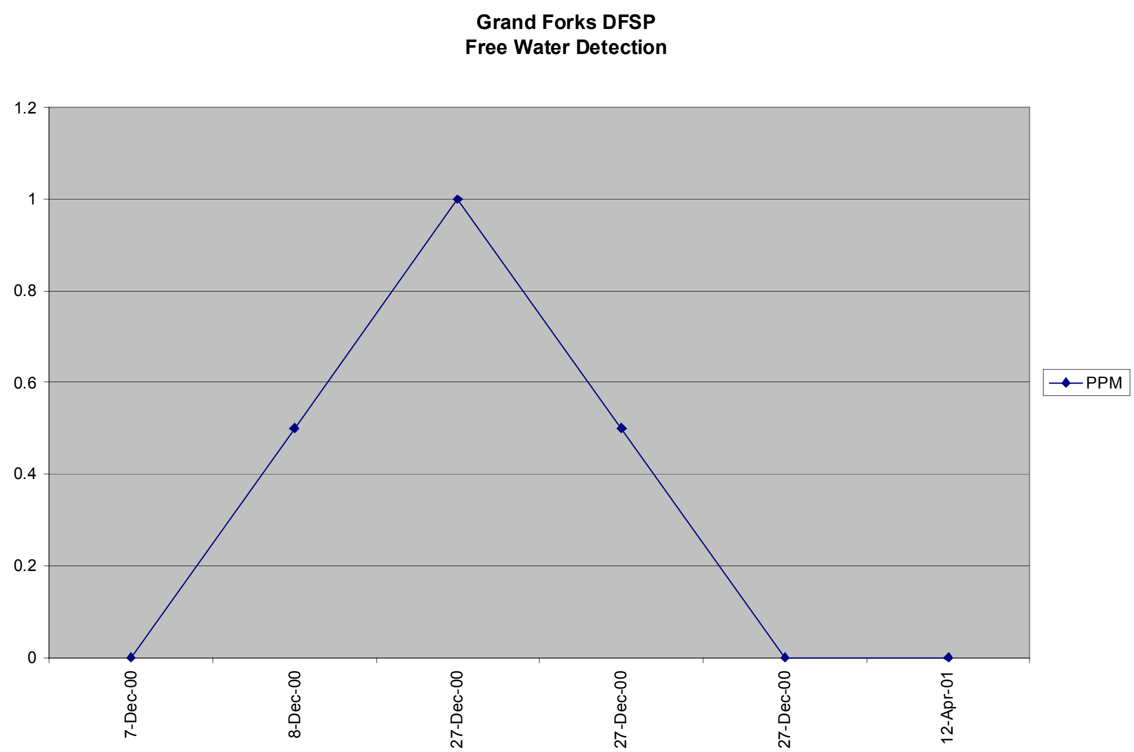
23-Oct-00


Grand Forks DFSP
Free Water Detection
1.2
1
0.8
0.6
0.4
0.2
0
PPM
7-Dec-00
8-Dec-00
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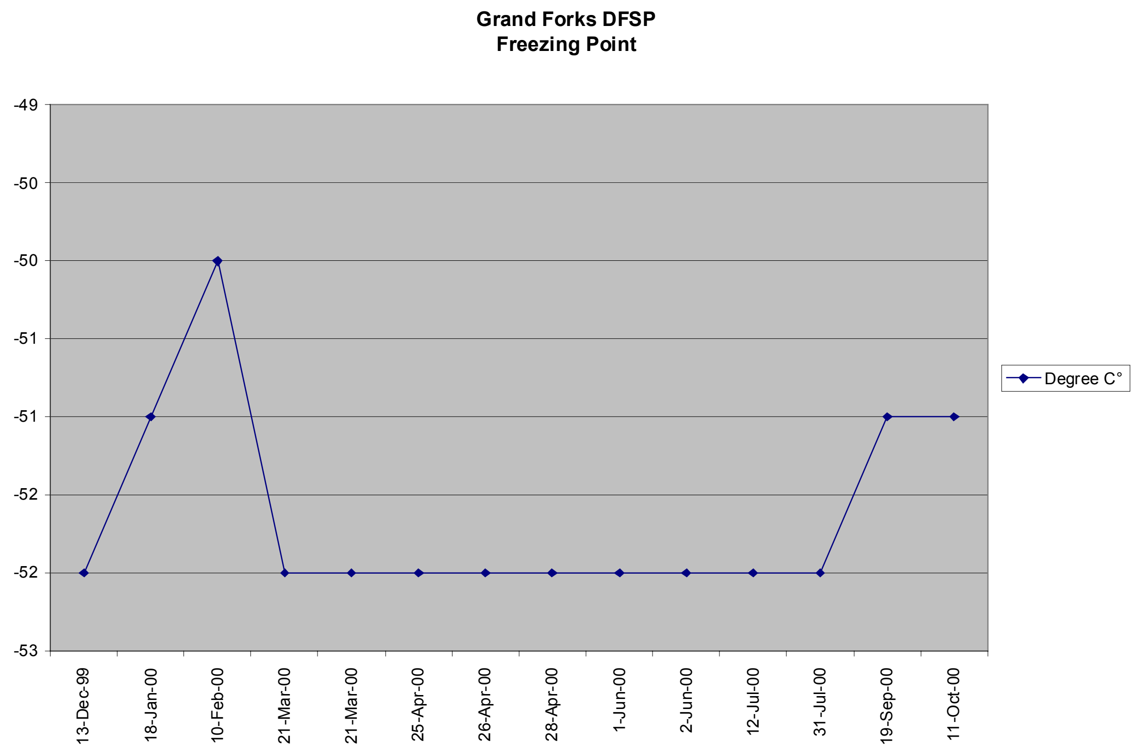
27-Dec-00
12-Apr-01

.


Grand Forks DFSP
Freezing Point
-49
-50
-50
-51
-51
-52
-52
-53
Degree C°
13-Dec-99
18-Jan-00
10-Feb-00
21-Mar-00
21-Mar-00
25-Apr-00
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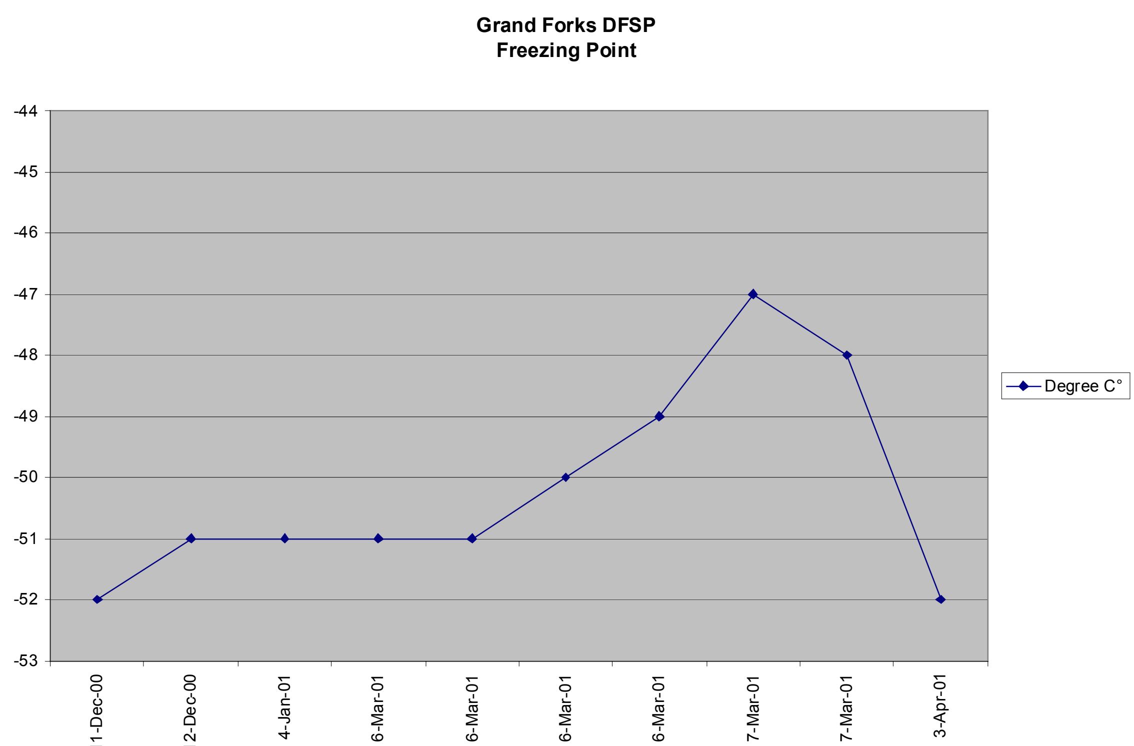
19-Sep-00
11-Oct-00


Grand Forks DFSP
Freezing Point
-44
-45
-46
-47
-48
-49
-50
-51
-52
-53
Degree C°
11-Dec-00
12-Dec-00
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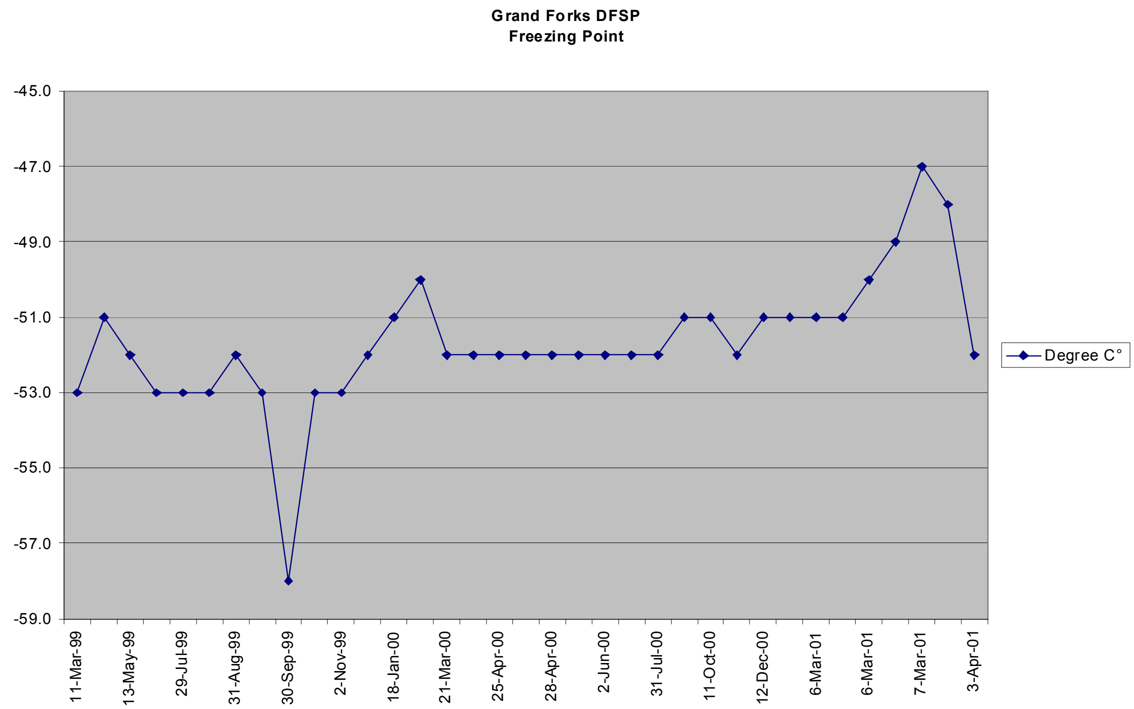
7-Mar-01
7-Mar-01
3-Apr-01



Grand Forks DFSP
Freezing Point
-45.0
-47.0
-49.0
-51.0
-53.0
-55.0
-57.0
-59.0
11-Mar-99
13-May-99
29-Jul-99
31-Aug-99
30-Sep-99
2-Nov-99
18-Jan-00
21-Mar-00
25-Apr-00
28-Apr-00
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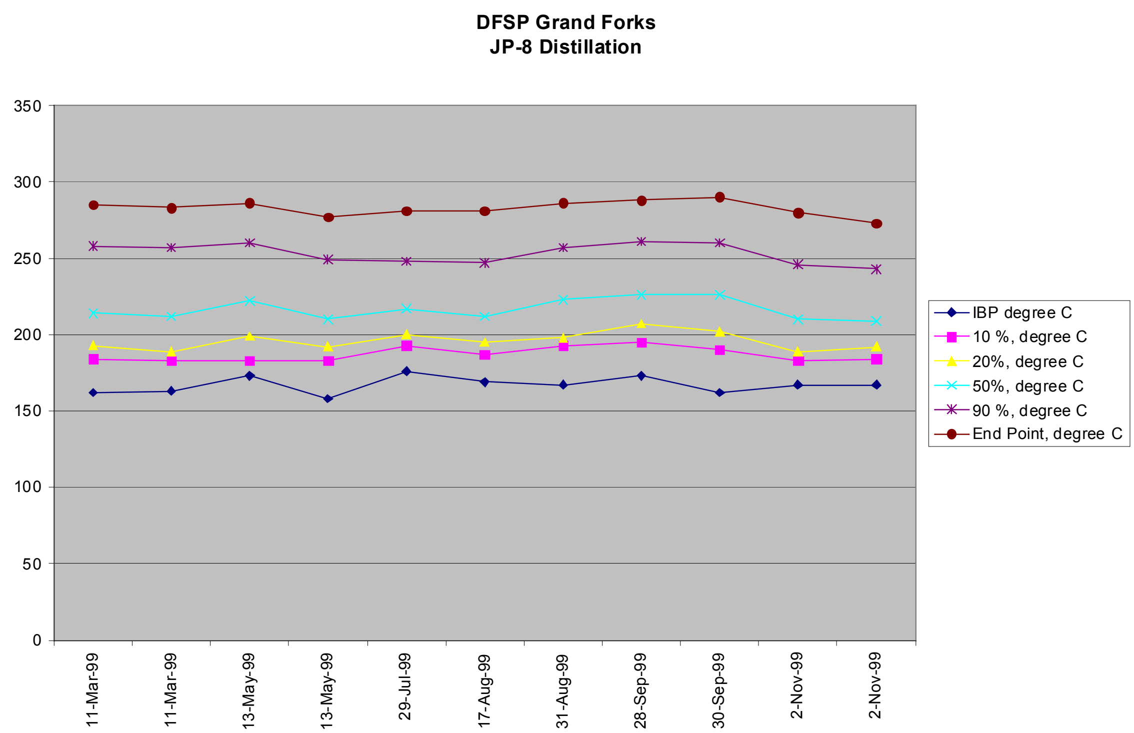
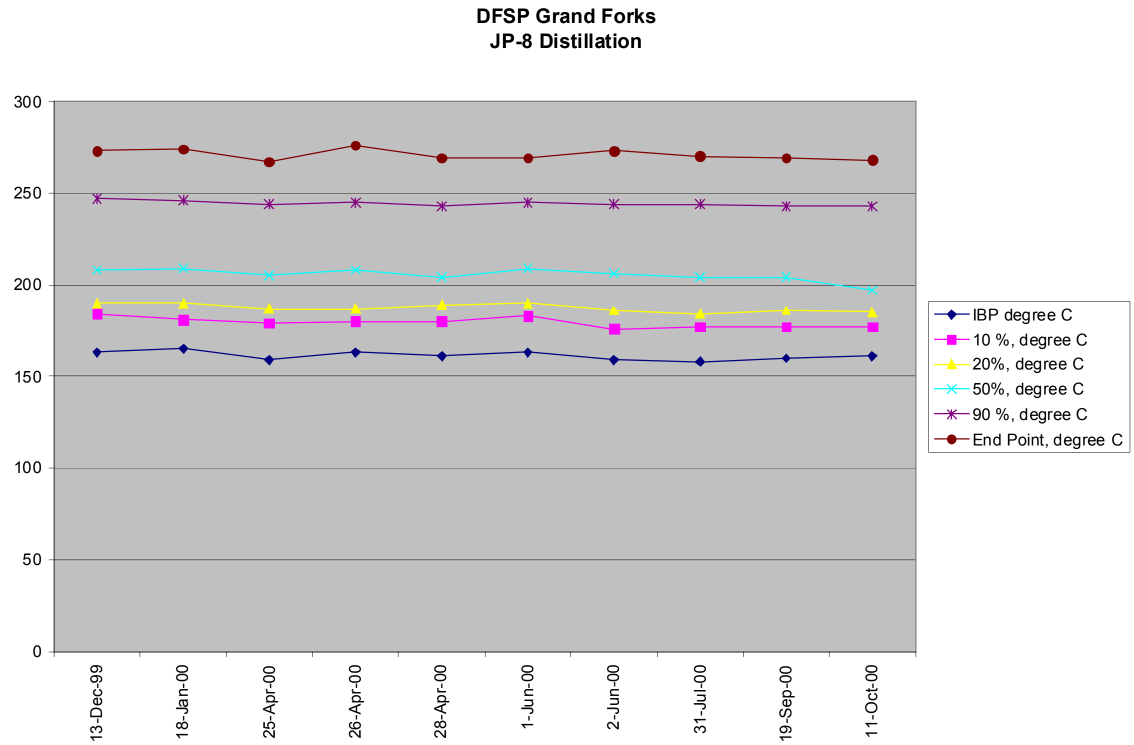
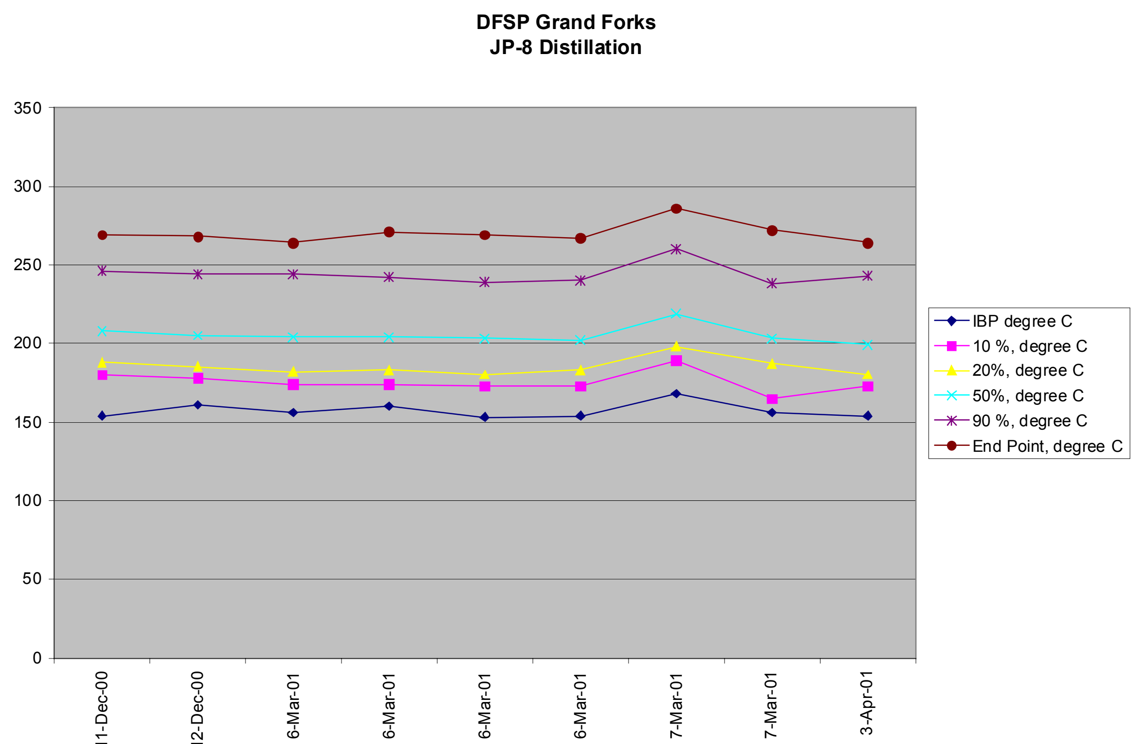
3-Apr-01
Degree C°

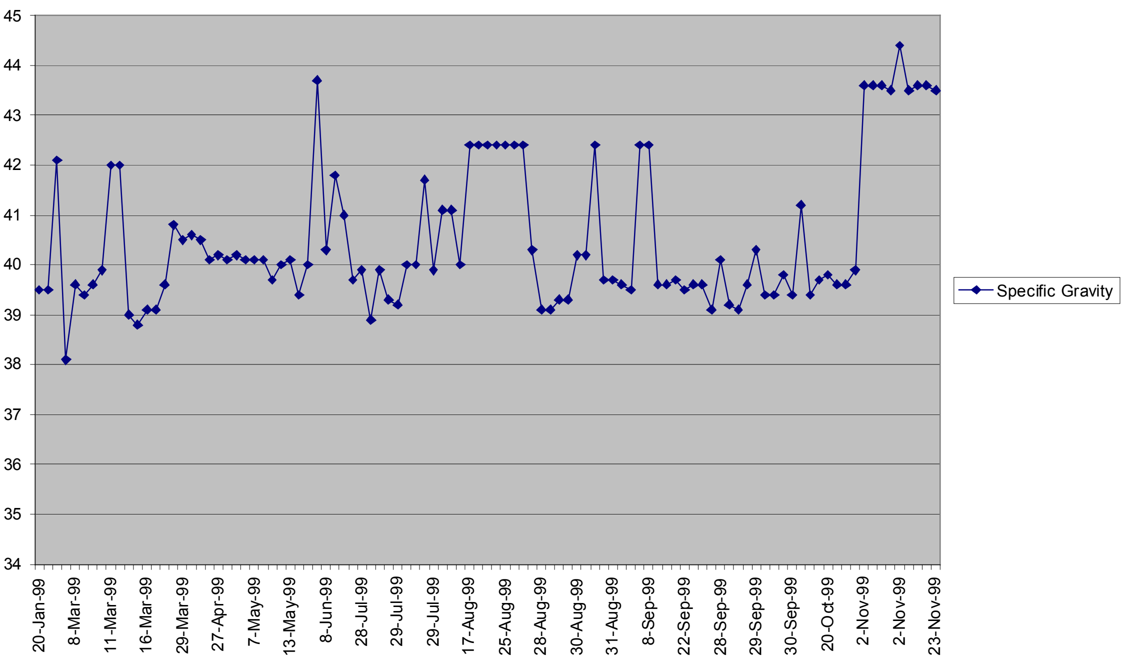


DFSP Grand Forks
JP-8 Distillation
350
300
250
200
150
100
50
0
11-Mar-99
11-Mar-99
13-May-99
13-May-99
29-Jul-99
17-Aug-99
31-Aug-99
28-Sep-99
30-Sep-99
2-Nov-99
2-Nov-99
IBP degree C
10 %, degree C
20%, degree C
50%, degree C
90 %, degree C
End Point, degree C

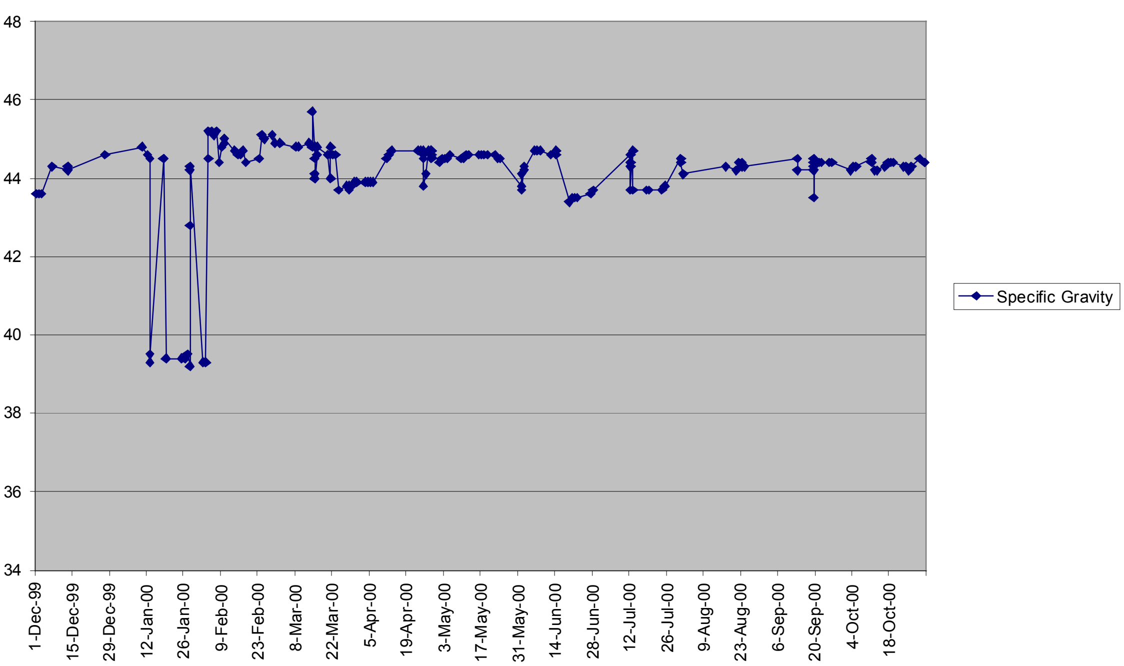

DFSP Grand Forks
JP-8 Distillation
300
250
200
150
100
50
0
13-Dec-99
18-Jan-00
25-Apr-00
26-Apr-00
28-Apr-00
1-Jun-00
2-Jun-00
31-Jul-00
19-Sep-00
11-Oct-00
IBP degree C
10 %, degree C
20%, degree C
50%, degree C
90 %, degree C
End Point, degree C

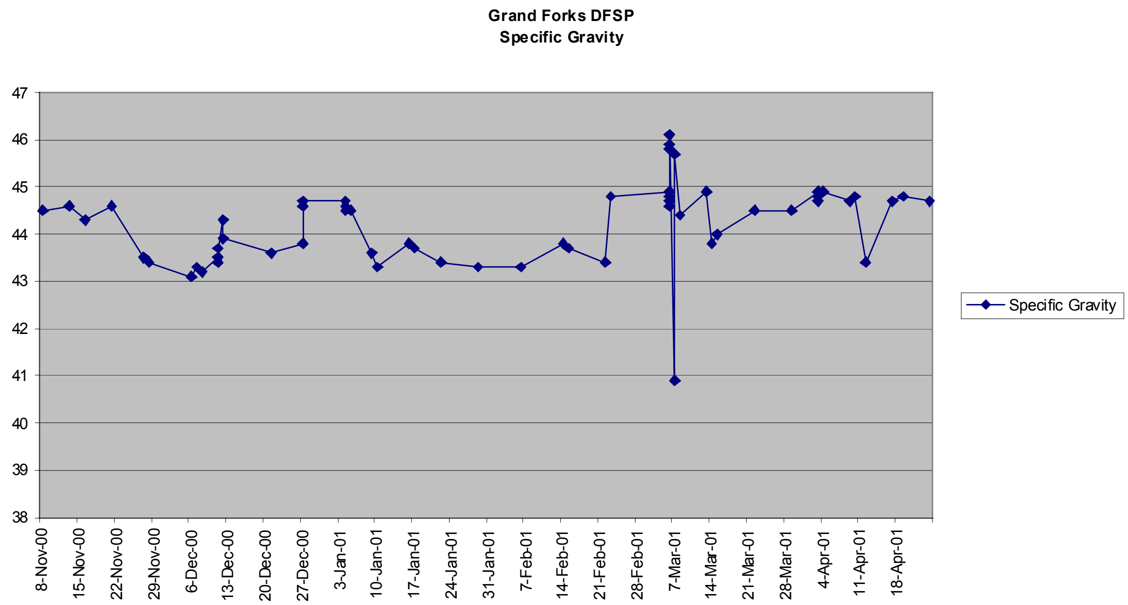

DFSP Grand Forks
JP-8 Distillation
350
300
250
200
150
100
50
0
11-Dec-00
12-Dec-00
6-Mar-01
6-Mar-01
6-Mar-01
6-Mar-01
7-Mar-01
7-Mar-01
3-Apr-01
IBP degree C
10 %, degree C
20%, degree C
50%, degree C
90 %, degree C
End Point, degree C

Grand Forks DFSP
Specific Gravity



Grand Forks DFSP
Specific Gravity




Grand Forks DFSP
Specific Gravity
47
46
45
44
43
42
41
40
39
38
8-Nov-00
15-Nov-00
22-Nov-00
29-Nov-00
6-Dec-00
13-Dec-00
20-Dec-00
27-Dec-00
3-Jan-01
10-Jan-01
17-Jan-01
24-Jan-01
31-Jan-01
7-Feb-01
14-Feb-01
21-Feb-01
28-Feb-01
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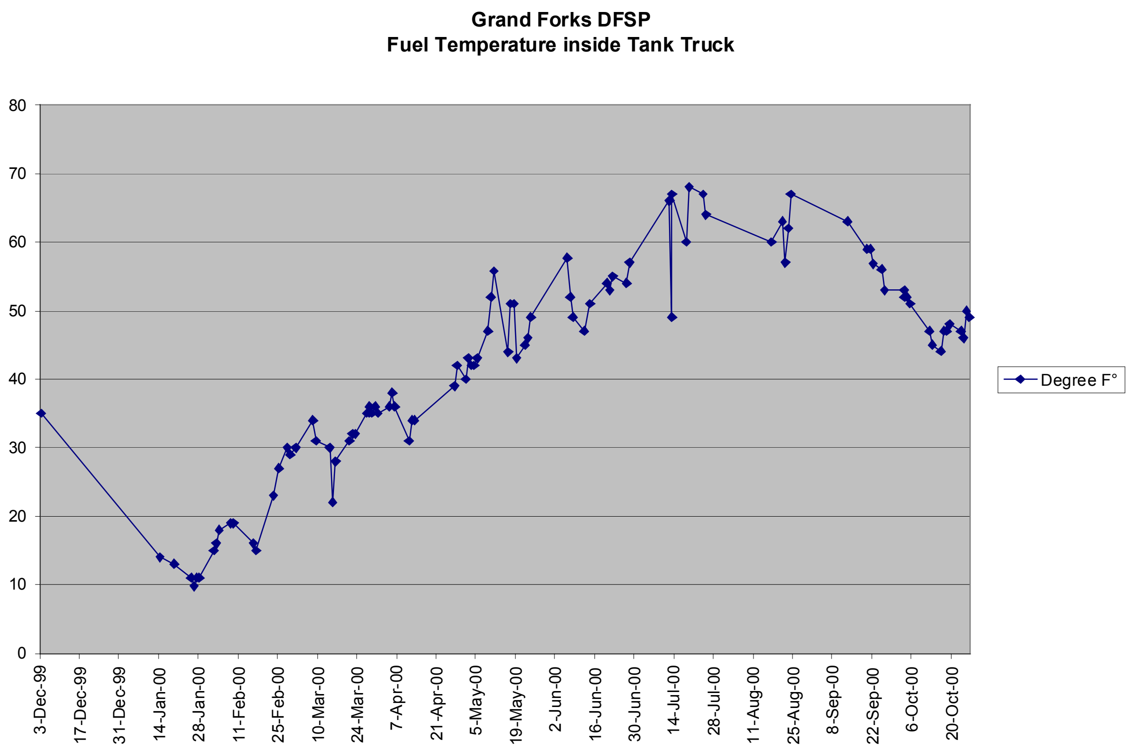
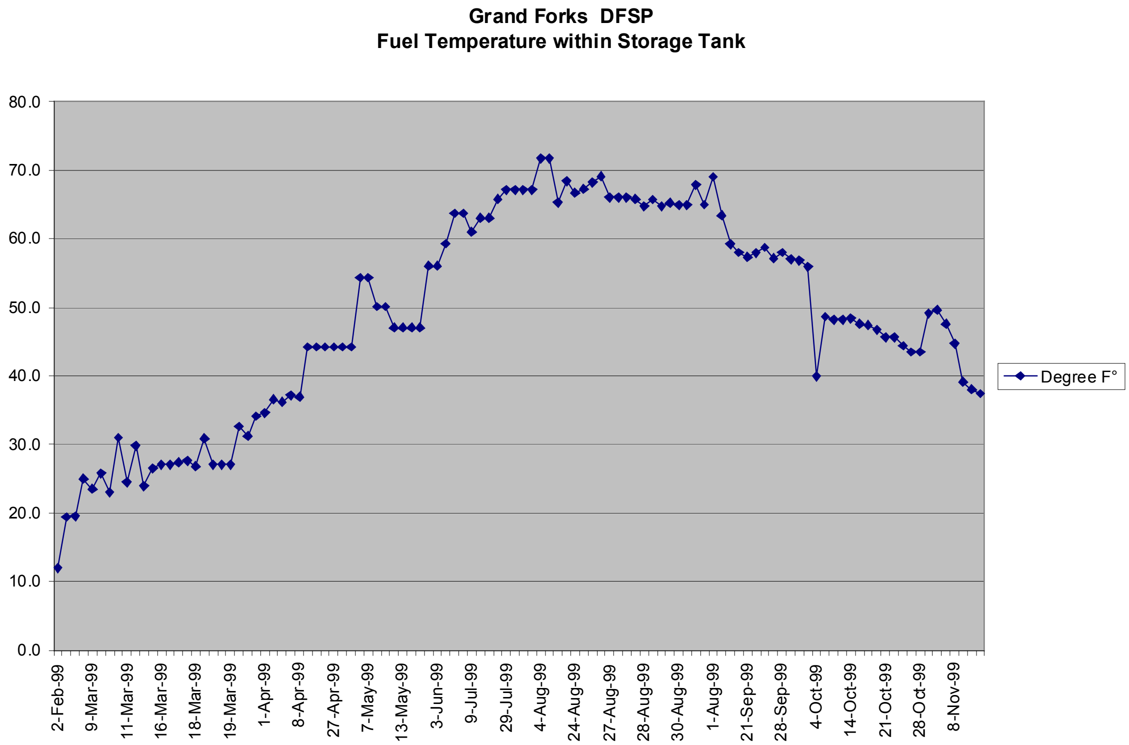
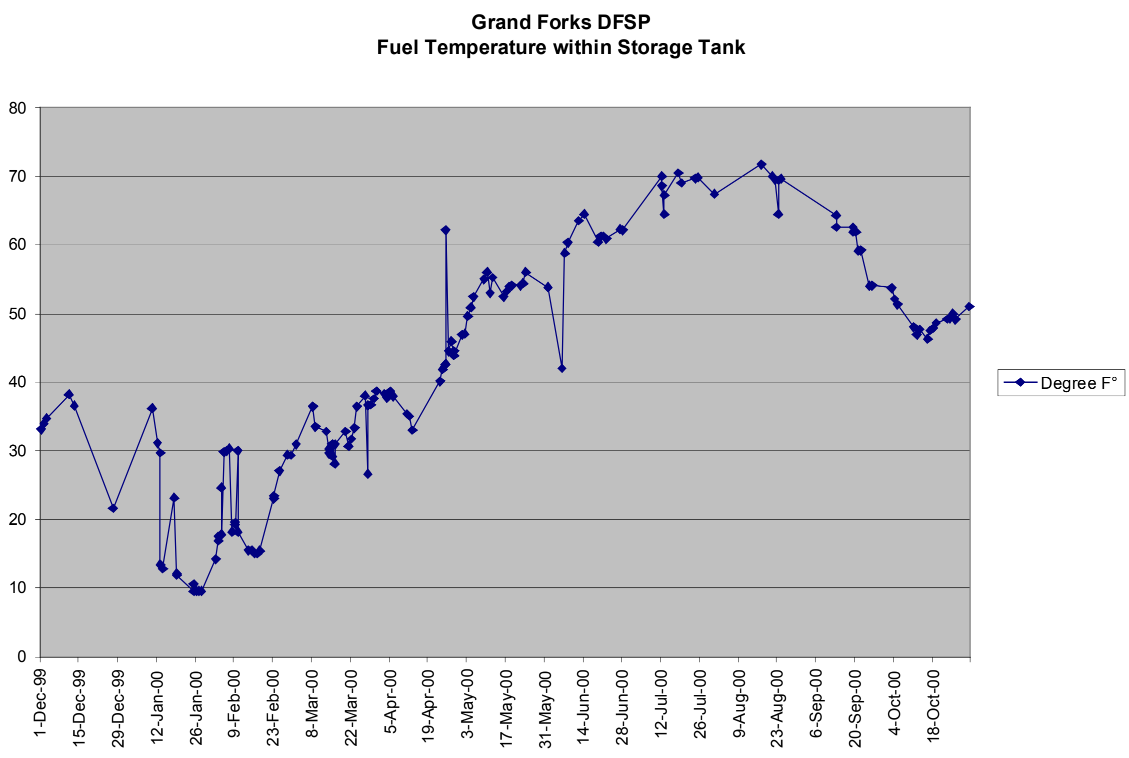
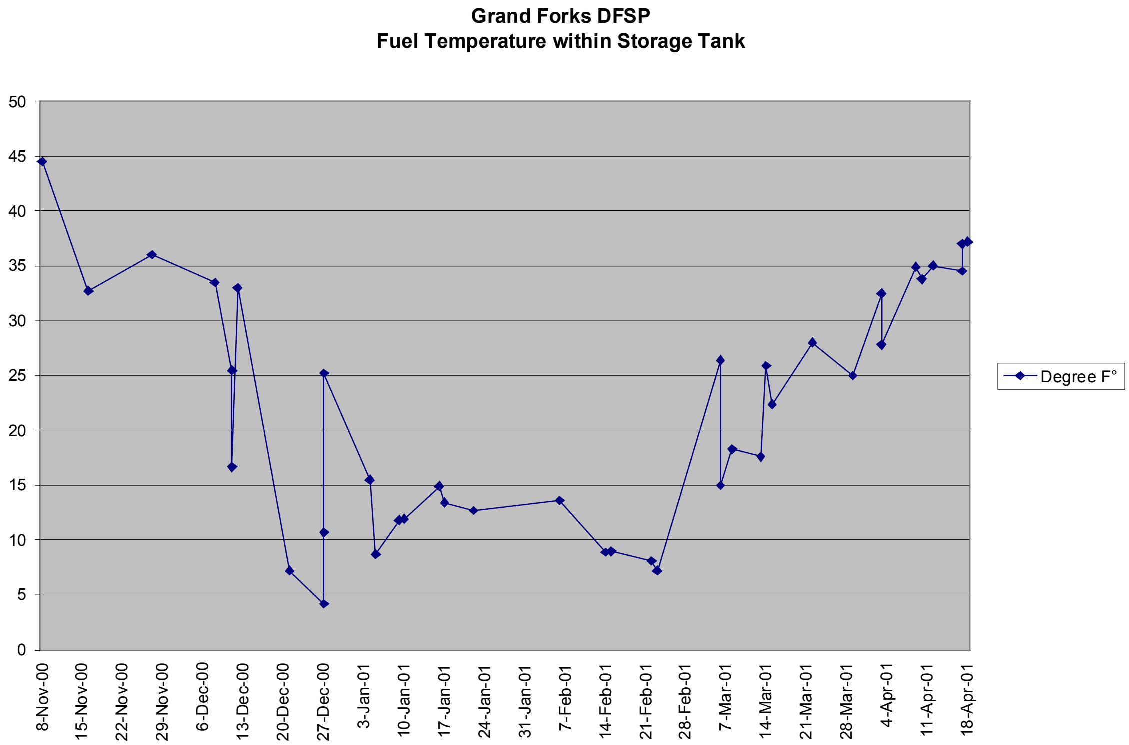
4-Apr-01
11-Apr-01
18-Apr-01
Specific Gravity


Grand Forks DFSP
Fuel Temperature inside Tank Truck
80
70
60
50
40
30
20
10
0
3-Dec-99
17-Dec-99
31-Dec-99
14-Jan-00
28-Jan-00
11-Feb-00
25-Feb-00
10-Mar-00
24-Mar-00
7-Apr-00
21-Apr-00
5-May-00
19-May-00
2-Jun-00
16-Jun-00
30-Jun-00
14-Jul-00
28-Jul-00
11-Aug-00
25-Aug-00
8-Sep-00
22-Sep-00
6-Oct-00
20-Oct-00
Degree F°

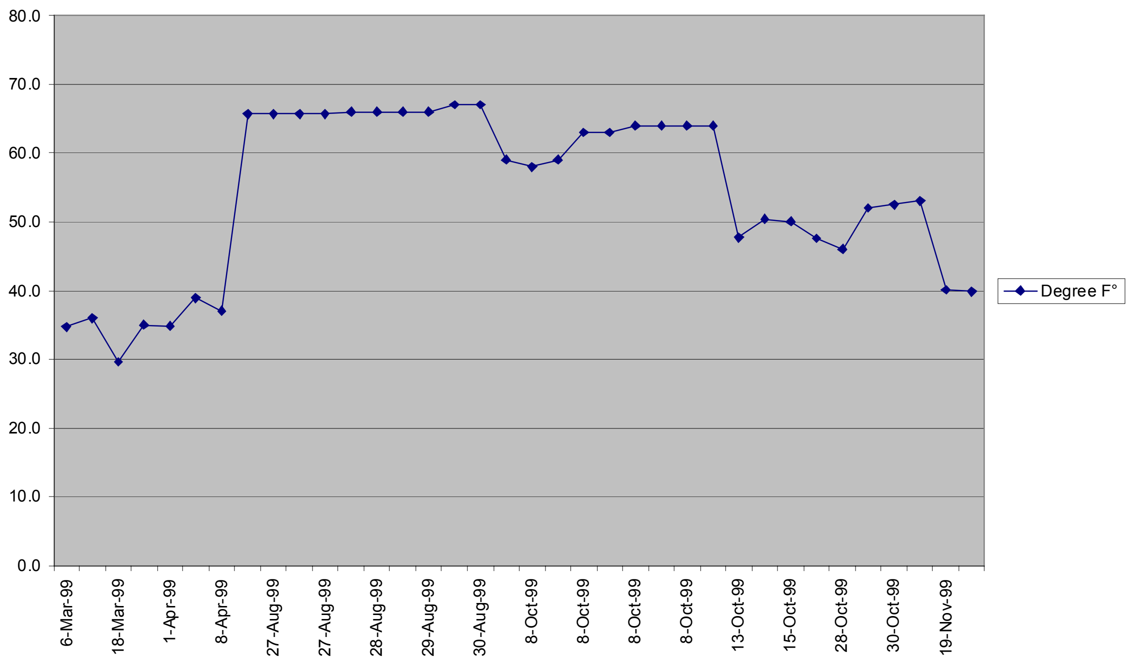

Grand Forks DFSP
Fuel Temperature within Storage Tank
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2-Feb-99
9-Mar-99
11-Mar-99
16-Mar-99
18-Mar-99
19-Mar-99
1-Apr-99
8-Apr-99
27-Apr-99
7-May-99
13-May-99
3-Jun-99
9-Jul-99
29-Jul-99
4-Aug-99
24-Aug-99
27-Aug-99
28-Aug-99
30-Aug-99
1-Aug-99
21-Sep-99
28-Sep-99
4-Oct-99
14-Oct-99
21-Oct-99
28-Oct-99
8-Nov-99
Degree F°


Grand Forks DFSP
Fuel Temperature within Storage Tank
80
70
60
50
40
30
20
10
0
1-Dec-99
15-Dec-99
29-Dec-99
12-Jan-00
26-Jan-00
9-Feb-00
23-Feb-00
8-Mar-00
22-Mar-00
5-Apr-00
19-Apr-00
3-May-00
17-May-00
31-May-00
14-Jun-00
28-Jun-00
12-Jul-00
26-Jul-00
9-Aug-00
23-Aug-00
6-Sep-00
20-Sep-00
4-Oct-00
18-Oct-00
Degree F°

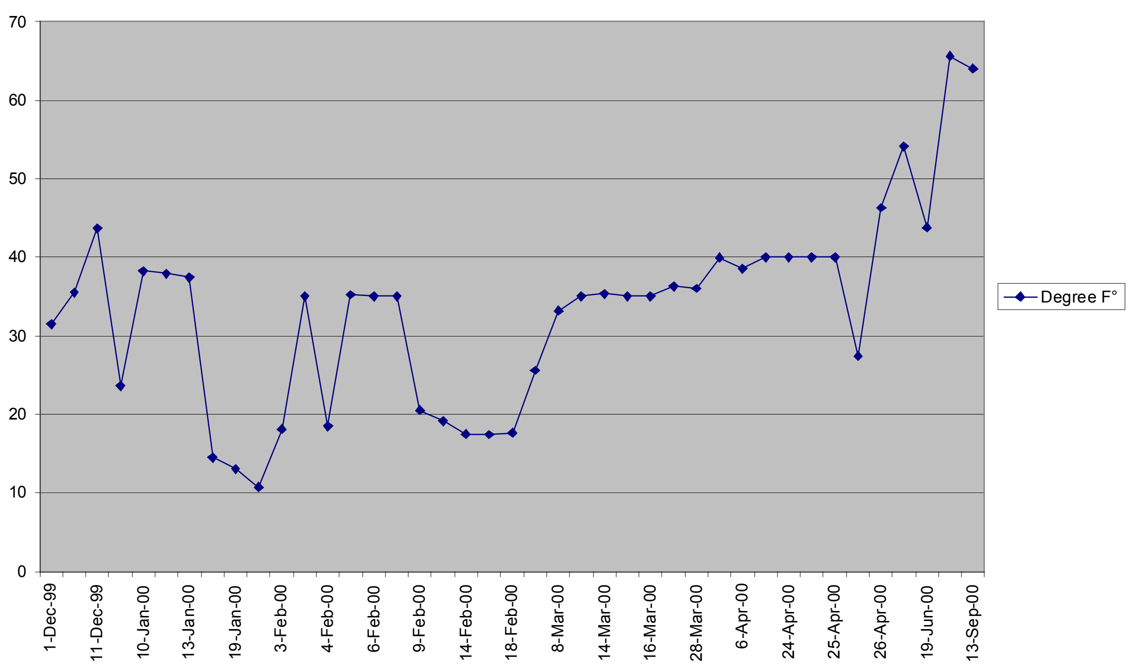


Grand Forks DFSP
Fuel Temperature within Storage Tank
50
45
40
35
30
25
20
15
10
5
0
8-Nov-00
15-Nov-00
22-Nov-00
29-Nov-00
6-Dec-00
13-Dec-00
20-Dec-00
27-Dec-00
3-Jan-01
10-Jan-01
17-Jan-01
24-Jan-01
31-Jan-01
7-Feb-01
14-Feb-01
21-Feb-01
28-Feb-01
7-Mar-01
14-Mar-01
21-Mar-01
28-Mar-01
4-Apr-01
11-Apr-01
18-Apr-01
Degree F°

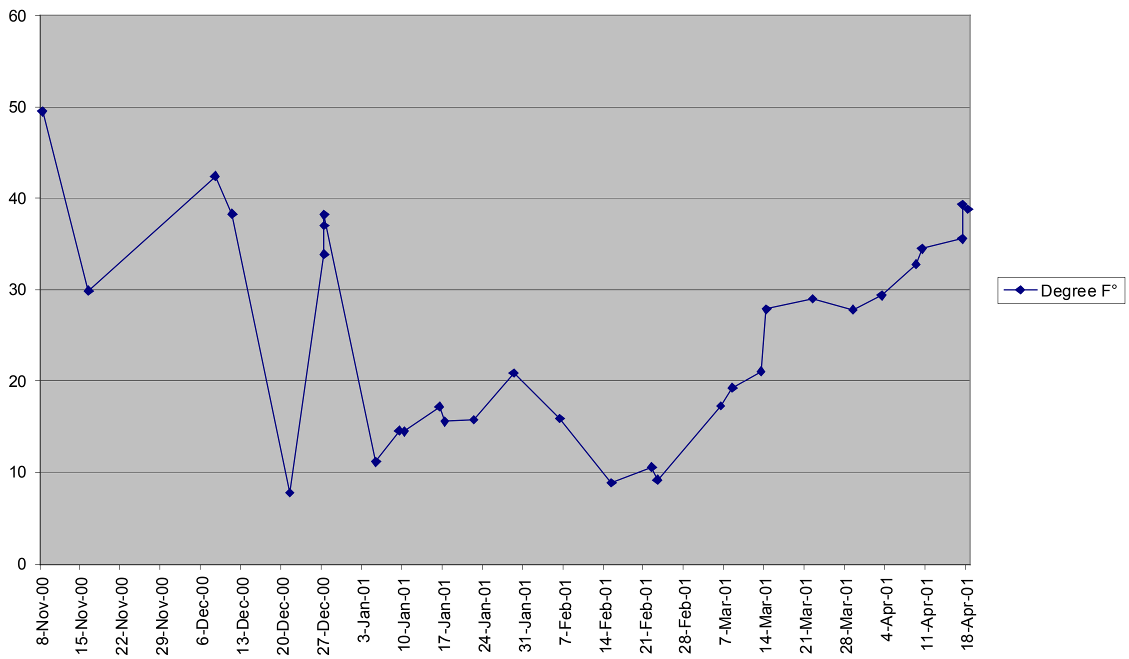
Grand Forks DFSP
Fuel Temperature inside Pipeline



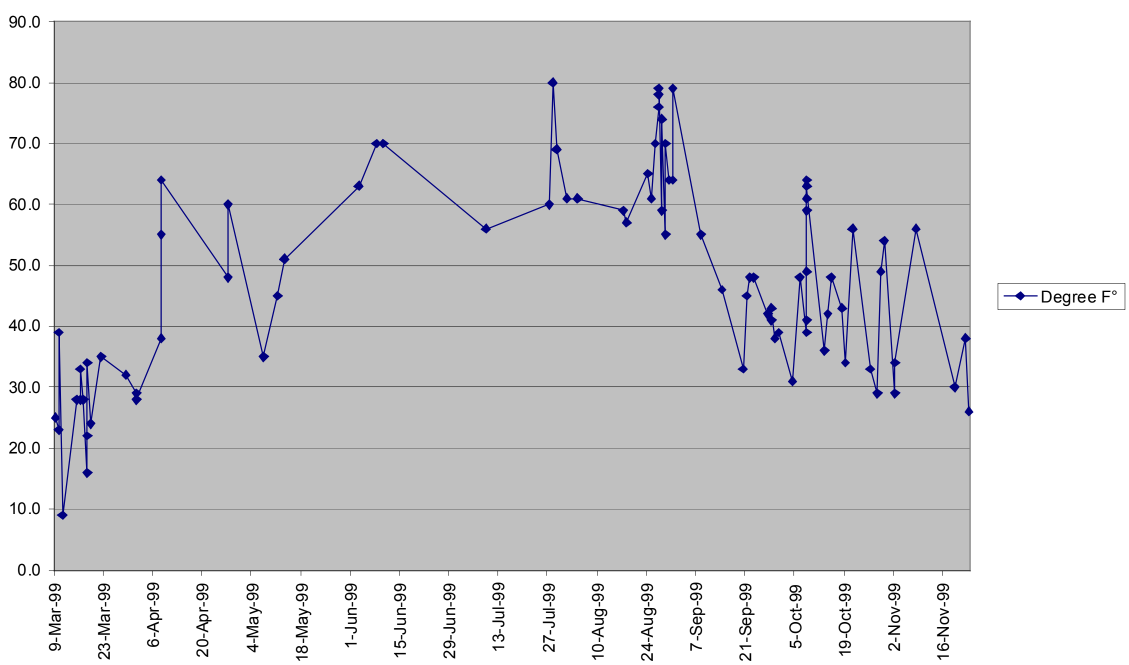
Grand Forks DFSP
Fuel Temperature inside Pipelines

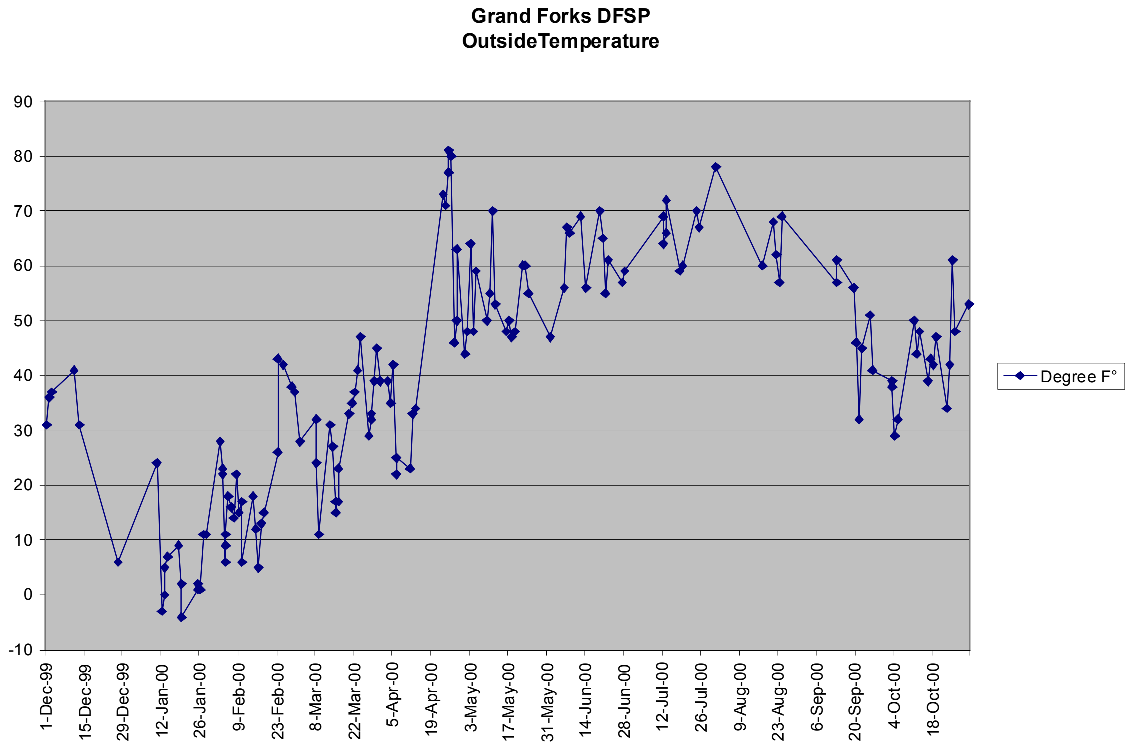


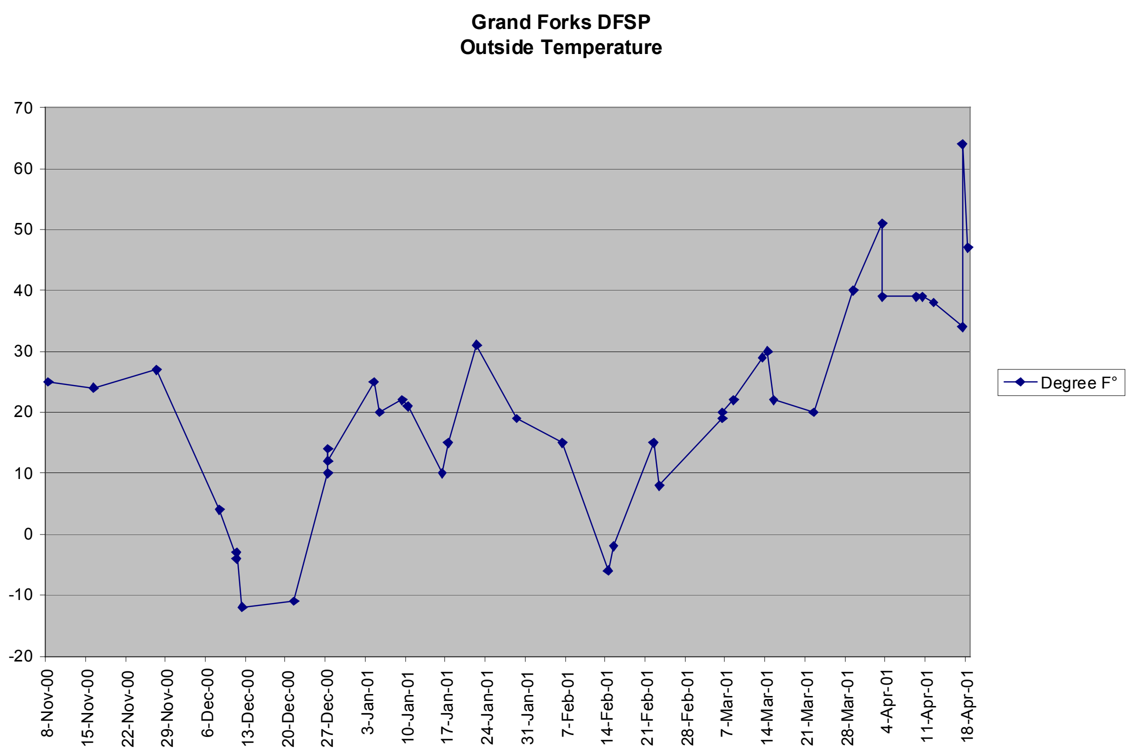
Grand Forks DFSP
Fuel Temperature inside Pipeline

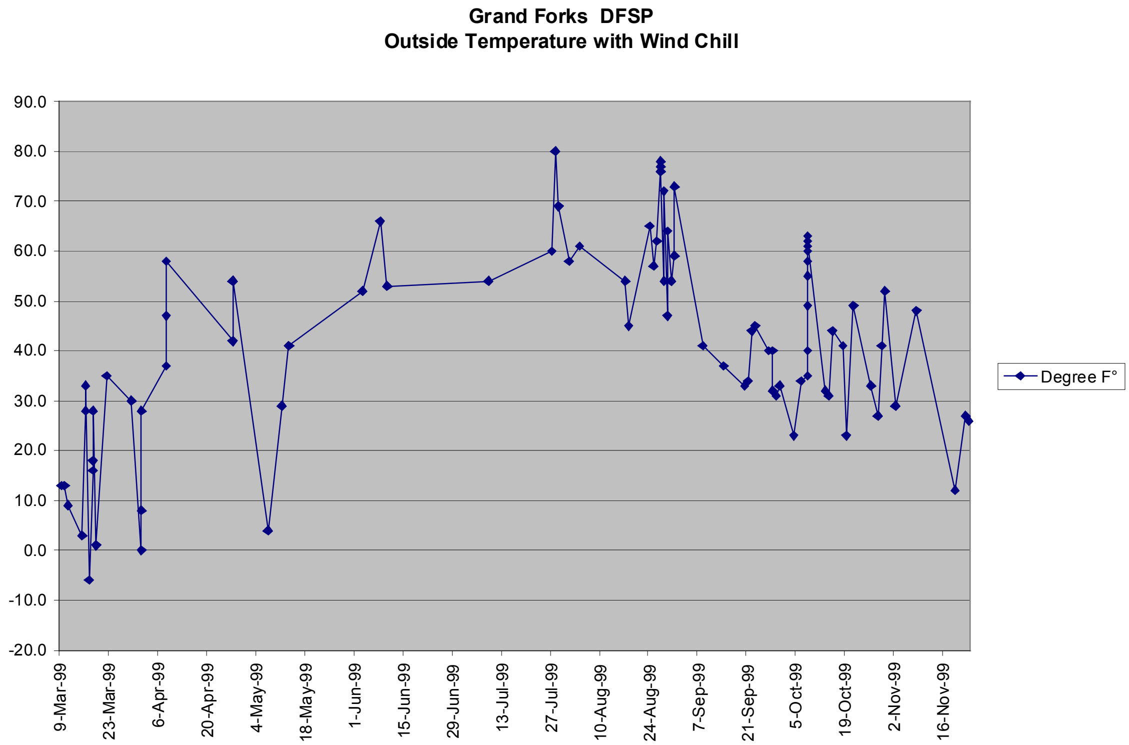


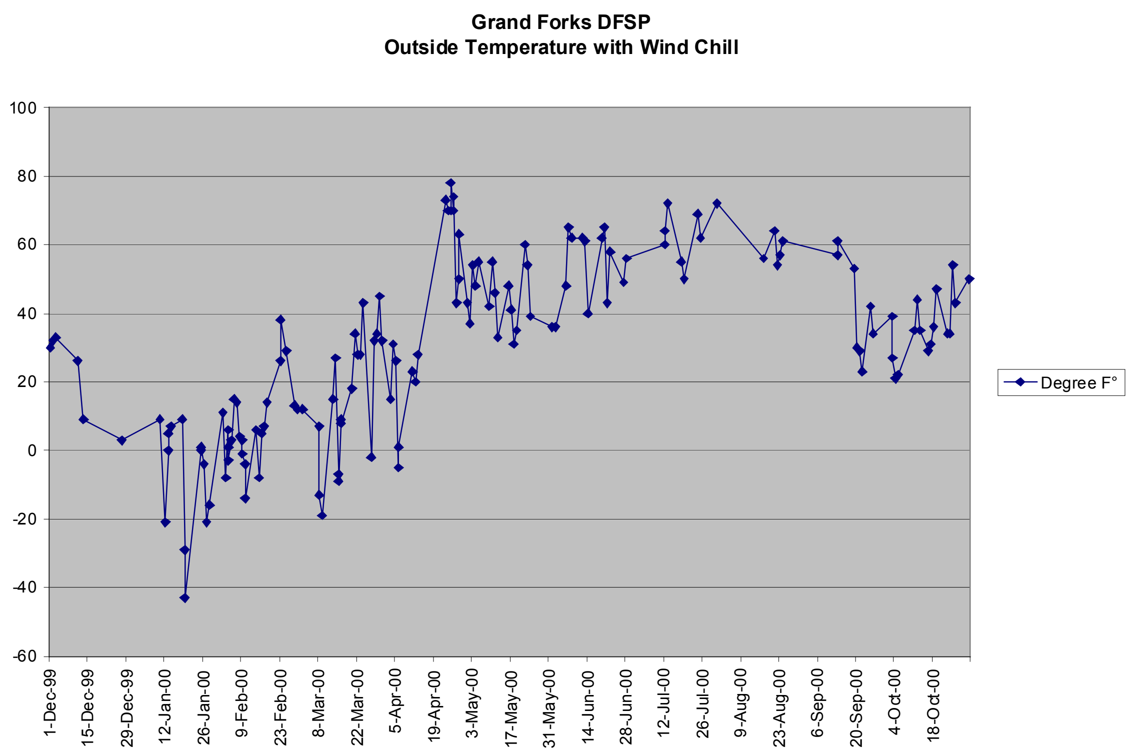
Grand Forks DFSP
Outside Temperature

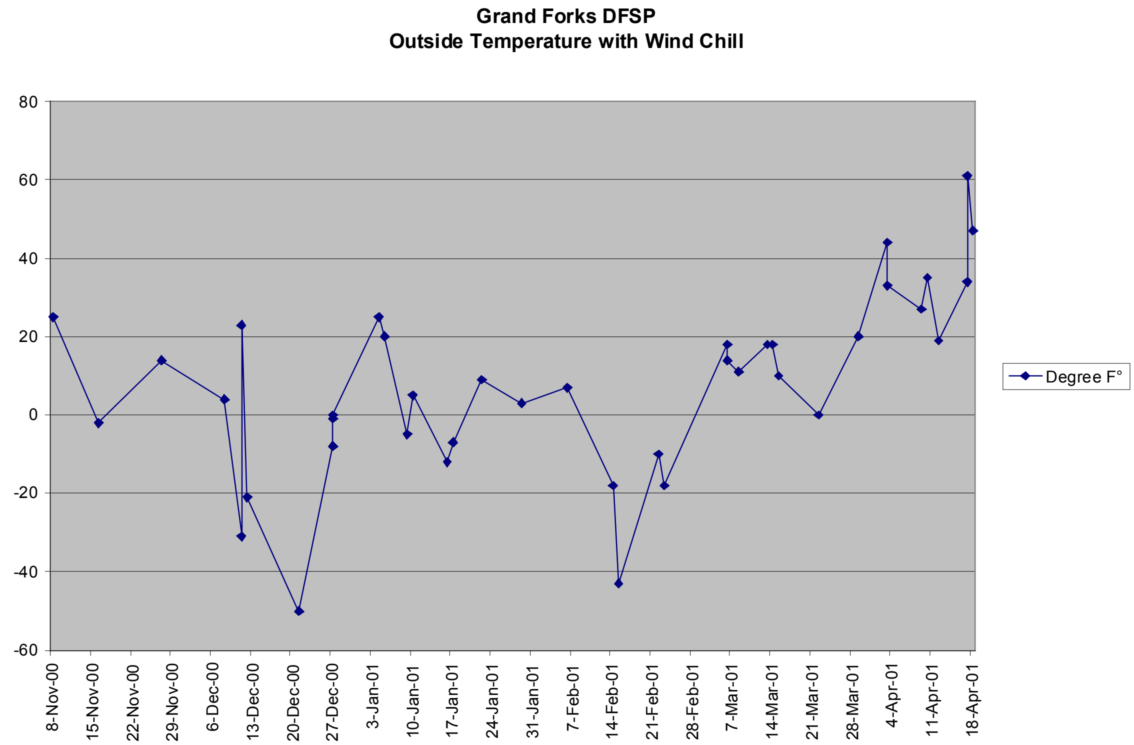



Grand Forks DFSP
OutsideTemperature
90
80
70
60
50
40
30
20
10
0
-10
1-Dec-99
15-Dec-99
29-Dec-99
12-Jan-00
26-Jan-00
9-Feb-00
23-Feb-00
8-Mar-00
22-Mar-00
5-Apr-00
19-Apr-00
3-May-00
17-May-00
31-May-00
14-Jun-00
28-Jun-00
12-Jul-00
26-Jul-00
9-Aug-00
23-Aug-00
6-Sep-00
20-Sep-00
4-Oct-00
18-Oct-00
Degree F°


Grand Forks DFSP
Outside Temperature
70
60
50
40
30
20
10
0
-10
-20
8-Nov-00
15-Nov-00
22-Nov-00
29-Nov-00
6-Dec-00
13-Dec-00
20-Dec-00
27-Dec-00
3-Jan-01
10-Jan-01
17-Jan-01
24-Jan-01
31-Jan-01
7-Feb-01
14-Feb-01
21-Feb-01
28-Feb-01
7-Mar-01
14-Mar-01
21-Mar-01
28-Mar-01
4-Apr-01
11-Apr-01
18-Apr-01
Degree F°


Grand Forks DFSP
Outside Temperature with Wind Chill
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
9-Mar-99
23-Mar-99
6-Apr-99
20-Apr-99
4-May-99
18-May-99
1-Jun-99
15-Jun-99
29-Jun-99
13-Jul-99
27-Jul-99
10-Aug-99
24-Aug-99
7-Sep-99
21-Sep-99
5-Oct-99
19-Oct-99
2-Nov-99
16-Nov-99
Degree F°


Grand Forks DFSP
Outside Temperature with Wind Chill
100
80
60
40
20
0
-20
-40
-60
1-Dec-99
15-Dec-99
29-Dec-99
12-Jan-00
26-Jan-00
9-Feb-00
23-Feb-00
8-Mar-00
22-Mar-00
5-Apr-00
19-Apr-00
3-May-00
17-May-00
31-May-00
14-Jun-00
28-Jun-00
12-Jul-00
26-Jul-00
9-Aug-00
23-Aug-00
6-Sep-00
20-Sep-00
4-Oct-00
18-Oct-00
Degree F°


Grand Forks DFSP
Outside Temperature with Wind Chill
80
60
40
20
0
-20
-40
-60
8-Nov-00
15-Nov-00
22-Nov-00
29-Nov-00
6-Dec-00
13-Dec-00
20-Dec-00
27-Dec-00
3-Jan-01
10-Jan-01
17-Jan-01
24-Jan-01
31-Jan-01
7-Feb-01
14-Feb-01
21-Feb-01
28-Feb-01
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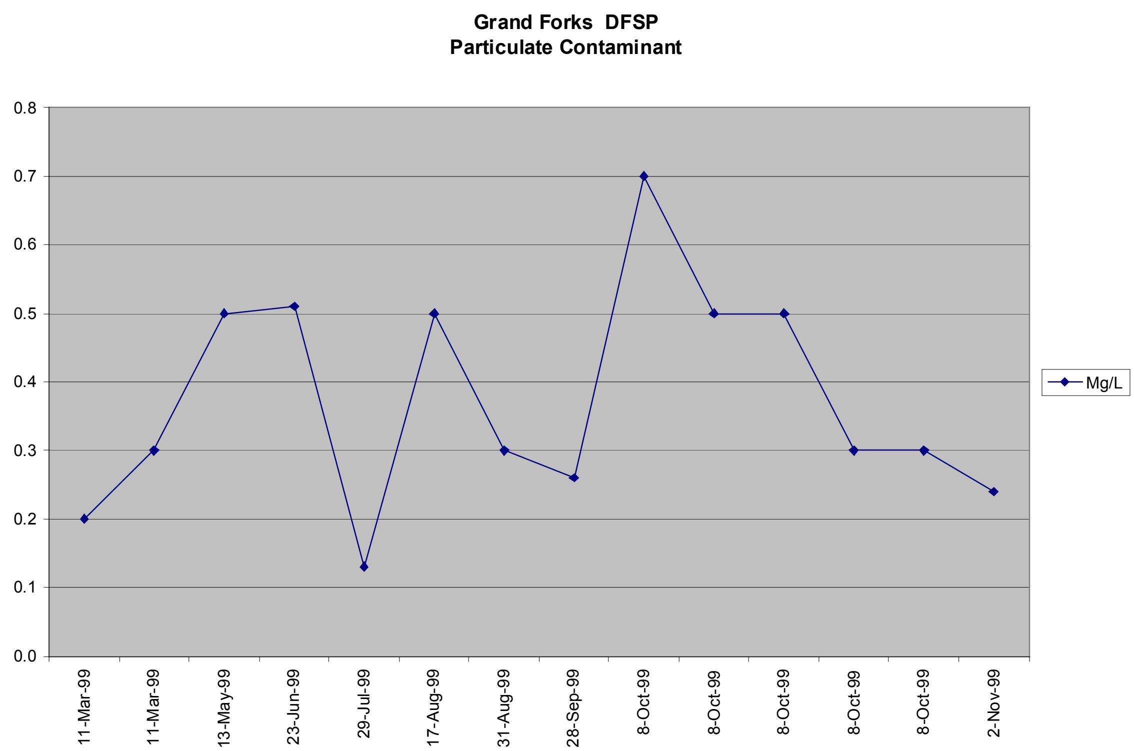
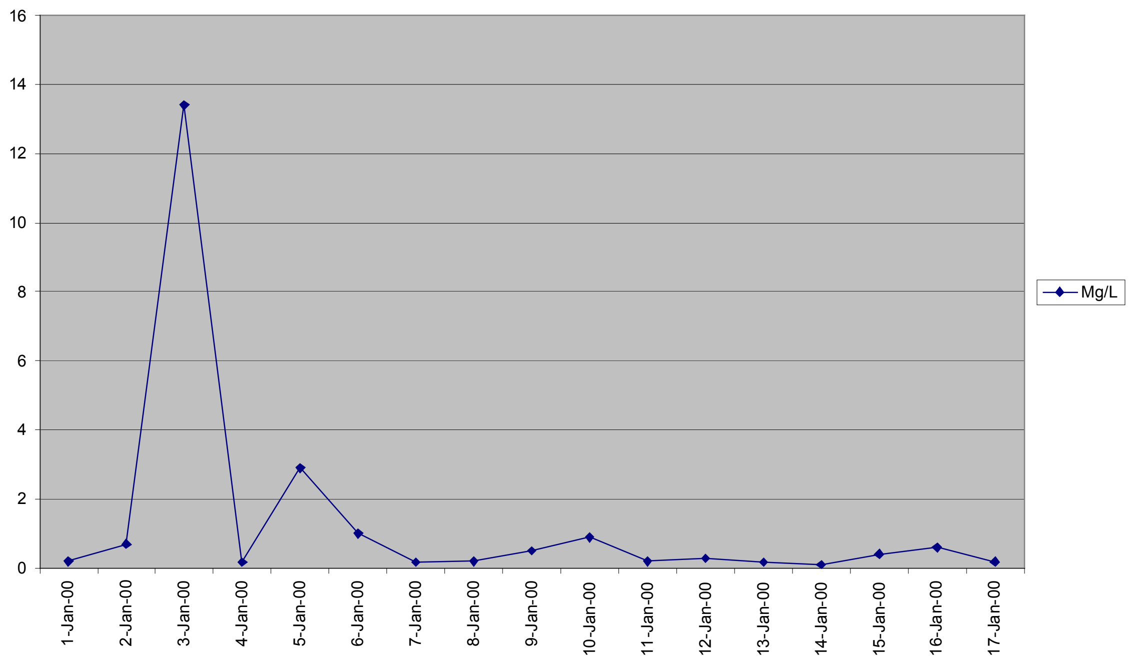
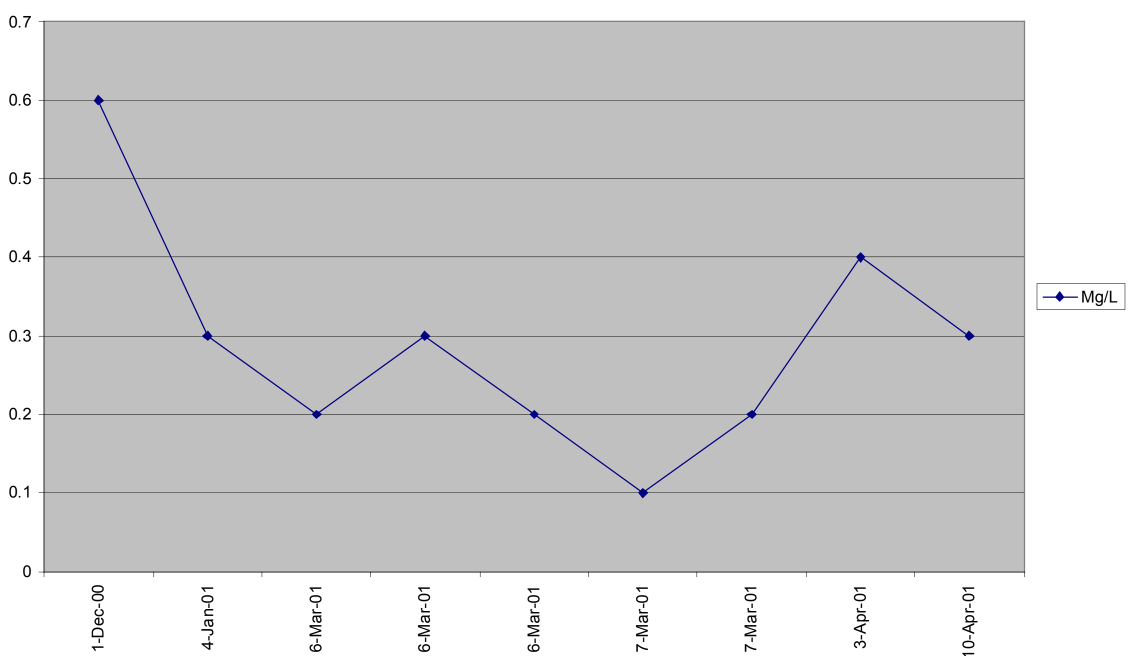
4-Apr-01
11-Apr-01
18-Apr-01
Degree F°


Grand Forks DFSP
Particulate Contaminant
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11-Mar-99
11-Mar-99
13-May-99
23-Jun-99
29-Jul-99
17-Aug-99
31-Aug-99
28-Sep-99
8-Oct-99
8-Oct-99
8-Oct-99
8-Oct-99
8-Oct-99
2-Nov-99
Mg/L

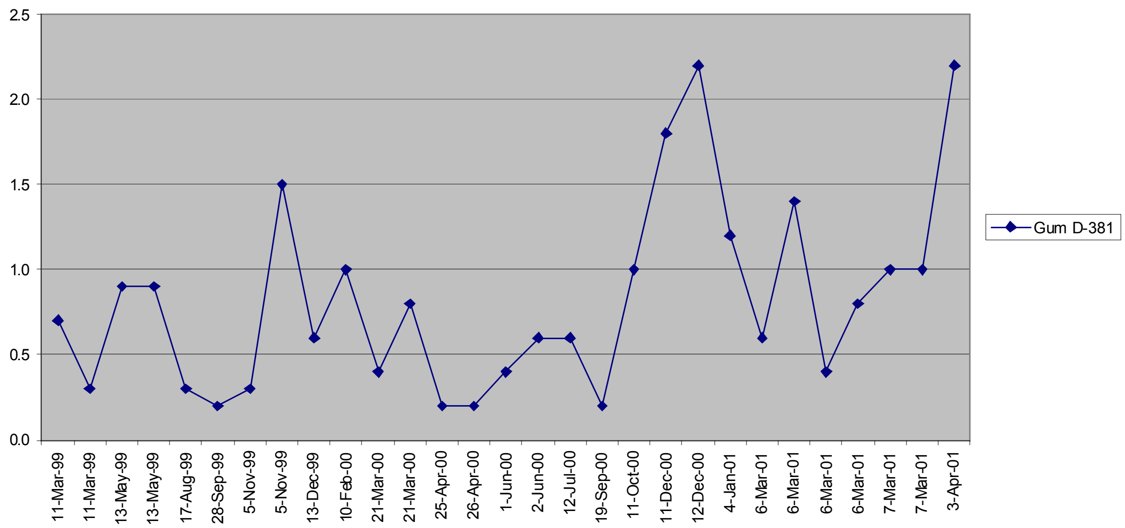
Grand Forks DFSP
Particulate Contaminant



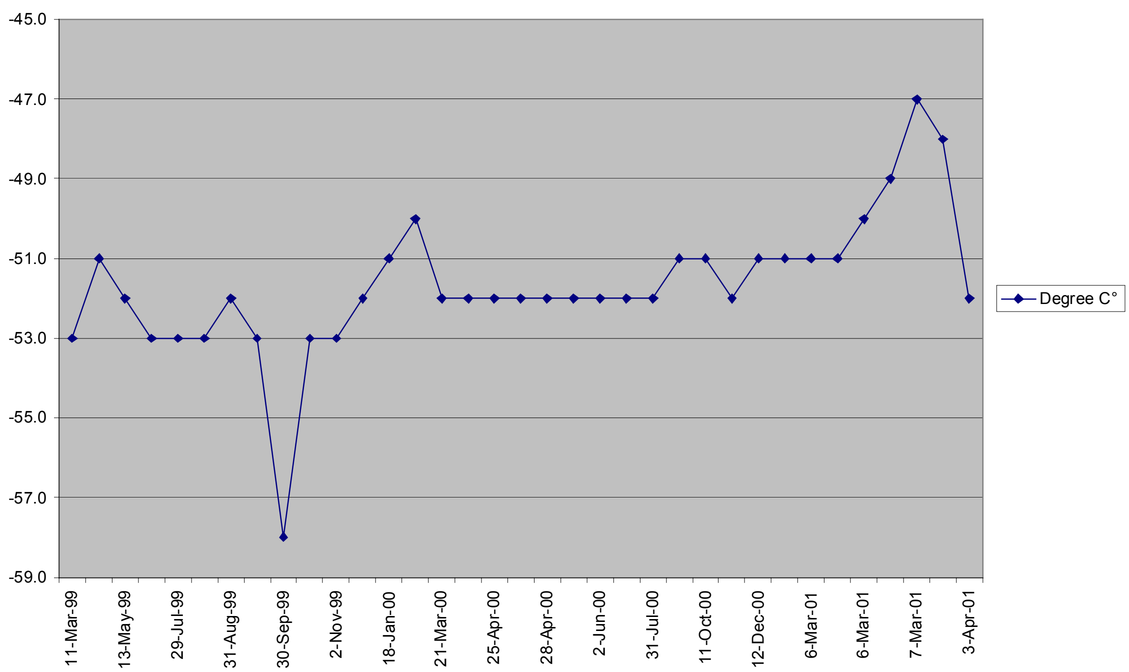
Grand Forks DFSP
Particulate Contaminant



Grand Forks DFSP
Gum in Fuels



Grand Forks DFSP
Freezing Point



Appendix E-20

Grand Forks AFB, ND

319 ARW/LGSF
636 1st Avenue
Grand Forks AFB, ND 58205

Fuels Officer: Robert Lyon, Phone: 701-747-3713, Fax 701-747-3746, Robert.lyon@grandforks.af.mil
Fuels Superintendent: CMSgt Danny Holwerda, Phone: 701-747-3711, Fax 701-747-3746, danny.holwerda@grandforks.af.mil
QC&I Supervisor, Wayne Kendle, wayne.kendle@grandforks.af.mil
LFM Supervisor: Winston Johnson, 701-747-5169
RFM Supervisor: John Brunswick, 701-747-3380

AJ Investigation Team: Dwight Duncan (C4e) and Bud Rodee (DFR-Americas).

AJ Incidents
Grand Forks AFB has been plagued with AJ for the past three years. It was worse three years ago but they continue to struggle with periodic occurrences. The very first was in receipt F/S 1 and 2 at Bulk Storage. These two F/S also yielded the largest amount of AJ, ranging from 2 quarts to 15 gallons. The second largest amounts are found in F/S 1 though 8 within the Type III Hydrant System, with amount ranging from 1 quart to 2 gallons. The third largest amount comes from tank sumps and range from 2 quart to 2 gallons. The smallest amount comes from R-11 refueling units with 2 milliliters usually found in the F/S sump. The first occurrence this past fall was on October 16, 2001. AJ is occasionally found in the transfer F/S and is frequently found in the R-11 parked in the four heated stalls over night. Base personnel noted this phenomenon and conducted an experiment during December 2000 and January 2001 that involved moving the trucks inside the heat storage for several days, then outside, then back inside. AJ was drained from the sumps while inside, but no AJ was drained from trucks kept outside overnight. They also conducted a similar experiment with the transfer pump house by turning the heat off for a period and time, and then back on. When the heat was on, AJ was produced. When the heat was off, no AJ was drained from the sumps. Base personnel reported that they take advantage of this phenomenon to reduce the differential pressure on vessels approaching the 25- differential pressure change criteria of the elements. They report that the Air Force has provided a waiver to extend the use of water absorption elements from the 22-psi differential pressure change requirement to 25-psi. On vehicles approaching the 25-psi limit, they frequently park those R-11s inside to allow the water absorption media to drain. This lowers the differential pressure and extends the "life" of the elements. It also results in the accumulation of AJ in the filter sumps.

Product Receipts and Issues
JP-8 is shipped via pipeline to Grand Forks AFB from the DFSP at Grand Forks. Product is filtered as it is received through a Facet CDCS-D-7K39SB-1-2S636FM element

located in Facility 511. As fuel is issued, it passes through a transfer/issue station located in Facility 50l and is filtered by Bowser 1838 elements.

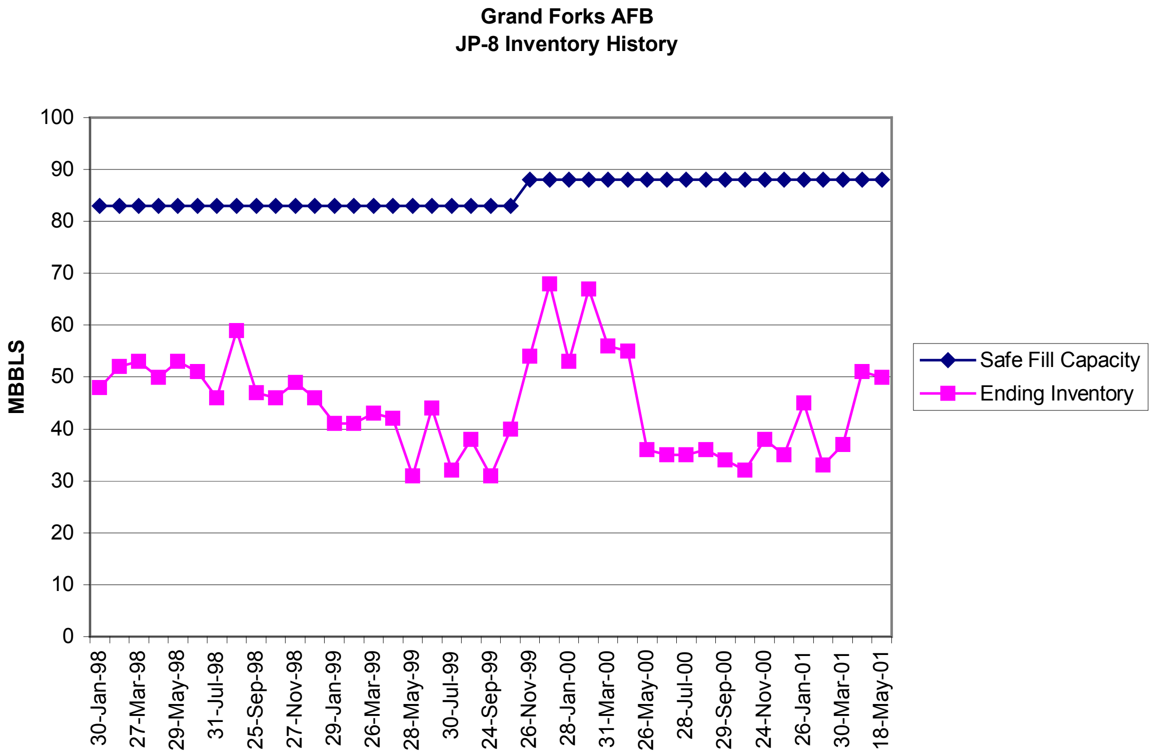
Bulk Storage
Grand Forks AFB receives JP-8 into two steel, epoxy-coated ASTs. One tank has a 30,000-bbl capacity and the other is a 25,000-bbl tank. Both were constructed in 1958. The tanks have floating-roofs and geodesic dome covers. The geodesic domes do not have a complete seal against the tanks and during periods of heavy rain and high winds, water enters the tank by blowing up under the skirts on the geodesic domes. They have an active project to extend the skirts of the geodesic domes to preclude water entry into the tanks. The tanks slope to the center, and the discharge (suction) lines are located approximately 15" from the bottom of the BS&W sumps. Product in these tanks is turned over every two to three days. During January, product storage temperatures ranged from 11ºF to 22°F. The base reports that inventory levels had dropped by 45% over last two-three years. On average, only 50% of the existing capacity is currently in use.

Assigned Refueling Equipment
The base has seven Oshkosh R-11 refuelers, and one Kovatch R-11. All are equipped with water absorbent elements manufactured by Facet or Velcon. Grand Forks AFB also has four HSV-12s with Facet CA56-35B-51 elements. Because the HSV-12s tend to leak when taken from a warm environment to a cold environment, the HSV-12s are primarily (except for maintenance) parked outside rather than in the heated facility. No AJ has been found in the HSV-12s.

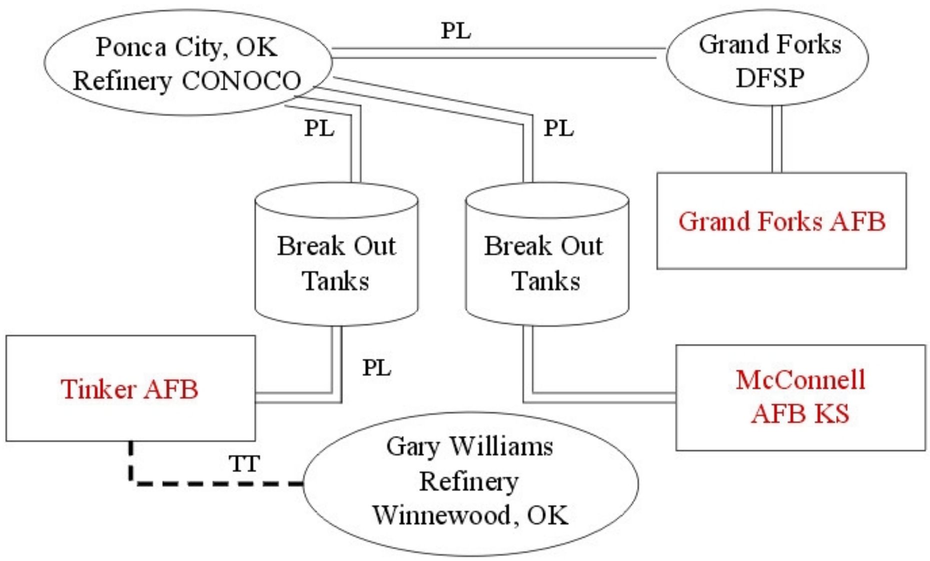
Hydrant System
Grand Forks has a Type II and a Type III System.

Product Stored
JP-8

Product Quality Data
Receipt AEL samples show that product averages 3 ppm, which confirms the effective water management at DFSP Grand Forks. FSII levels run between .10 and .11. Base personnel report that the occurrence of AJ was greater three years ago and at that time FSII level averaged 0.14%. Conductivity readings range between 200 CUs and 300 CUs; temperature variation is reported as the key factor.


Grand Forks AFB
JP-8 Inventory History
MBBLS
100
90
80
70
60
50
40
30
20
10
0
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
26-Jan-01
30-Mar-01
18-May-01
Safe Fill Capacity
Ending Inventory

Current Supply Patterns for
Grand Forks, Tinker, and McConnell AFBs



Appendix 21

BP/AMOCO Mandan Refinery

Mandan Avenue, PO Box 5000
Mandan, N.D. 58554

Laboratory Supervisor: Ronald Just, Phone: 701- 667-2497, Fax: 701-667-2576,

AJ Investigation Team: Dwight Duncan (C4e) and Bud Rodee (DFR-Americas).

The Mandan BP/AMOCO Refinery refines various grades of petroleum product, diesel fuels, heating fuels, gasoline, commercial jet A and JP-8. The crude oil is North Dakota sweet crude, Williston Basin. This crude is sometimes green in color and has API gravity between 41 and 42. They have on occasion purchased from Canada but have not done so in the last few years. The refinery capacity is 60 thousand barrels per day. The JP-8 is straight run distilled from one tower with no cracking or blending, however the JP-8 does pass through a salt dryer. There is a change from summer to winter grade diesels and #2 oil, but there is no change to the JP-8 process.

The refinery has three dedicated storage tanks. Tanks #757 and #717, constructed in 1954, are 43 MBBL steel, ASTs with floating-roofs and are used for truck rack loading. Tank #726 is a 96,000-bbl steel AST tank with a floating-roof and is used primarily for pipeline shipments. The roof is equipped with a flex-line roof drain. The sump wells are 18-inches deep and tanks are drained prior to issue or when rain or water intrusion is suspected. The receipt line extends straight 18 inches into the tanks with no loops or turns. It is off set from the suction line by 20 feet. The tanks floors are epoxy-coated extending three feet up the sides. A three-inch diameter sight glass is used to visually observe the removal of water from the tank sumps. The Laboratory Supervisor reported that all water removed is clear with no discoloration. Storage tanks are drained after quality acceptance and before issue to customers. No water gauging is performed and quantity determination is by meter. The JP-8 contract requires storage tanks to be cleaned every 5 years.

Tank #726 is connected directly to the multi-product pipeline that feeds the BP/AMOCO terminal located in Morehead, MN. The refinery makes 20,000-bbl batches for pipeline shipment once per month because of the small capacity of the Morehead terminal. Side sample taps are affixed to all storage tanks, however since tank #726 is never full all samples are obtained from a goose neck located 12-inches from the 3 inch water drain line. JP-8 is filtered from the refinery through a clay filter and two paper filters prior to entering storage tanks. All JP-8 shipped by pipeline contains one additive, CI. The Morehead terminal injects FSII and SDA.

The refinery ships to Minot AFB twice per week by tank truck. FSII and SDA are injected at the tank truck loading rack. The FSII injector is manufactured by GATE-PAC, model, EI 2007-1. Setting is at 0.10% to 0.15% as per specification requirement.

FSII storage tank is 10,000 gallons equipped with a dryer. FSII is received by tank tuck from EquaStar, located in Bay Port, TX. The SDA injector is a GATE-PAC, Model, EI 0755-1, and the FSII tank has 500-gallon capacity. The tank trucks load at 600-gpm, not allowing for much turbidity. The JP-8 passes through a F/S vessel as tank trucks load.

Appendix E-22

Minot AFB, ND

5 SUPS/LGSF
130 Bomber Blvd.
Minot AFB, ND 58705

Fuels Officer: Captain Lisa Reyna, Phone: 701-723-6503, Fax: 701-723-3246, Lisa.reyna@minot.af.mil
Fuels Superintendent: MSgt Richard Dailey, Phone: 701-723-6503, Fax: 701-723-3246, richard.dailey@minot.af.mil
QC&I Supervisor, TSgt Timothy Michutak, Phone: 701-723-6503, Fax: 701-723-3246, timothy.michutak@minot.mil
LFM Supervisor: Erwin Wright, Phone: 701-723-6503, Fax: 701-723-3246, erwin.wright@minot.af.mil.
RFM: SSgt David Jenckes, Phone 701-723-6503, Fax 701-723-3246, David.jenckes@minot.af.mil.
QSR: Bill Pulley, Phone: 710-772-9421, Fax: 701-795-5679 wpulley@desc.dla.mil

AJ Investigation Team: Dwight Duncan (C4e) and Bud Rodee (DFR-Americas).

AJ Incidents

Minot AFB has experienced AJ on 16 separate occasions from December 1 through March 14. AJ was found seven times each in issue F/S #2 and issue F/S #3, once in tank #4 product recovery, and once in a hose cart.

Minot Base Fuel Personnel are aware of the FSII, water and temperature combination causing a possible problem with AJ. A policy letter implemented a rigorous plan for removing water from all units and storage tanks. All systems and storage tanks are drained at the beginning of each shift. AJ occurrences have lessened since the adoption of the new procedures; however, small amounts are found almost daily.

Product Receipts and Issues

Minot receives JP-8 from Mandan by tank truck, and the average travel time from the loading point to receipt is 3 hours. All JP-8 is filtered upon receipt through a Facet, SS636FF vessel. During January, product receipt temperatures range from 28° to 13°F, while the temperatures of JP-8 at the time of issue ranges from 34° to 11°F. During August, receipt temperatures range from 81 ° to 65 °F, while storage temperature ranges from 76° to 67°F. JP-8 received at Minot AFB contains all additives upon receipt. The base has two types of receipt F/Ss: Facet, SS636FF/CC-K388B1, and Faudi separators, F.7-965 8806796 that are being tested at Minot for the sake of comparison. Personnel reported no significant difference between the Faudi filter and the NSN 4330-00-983-0998 ordered from stock. Issue/hydrant F/S vessels use Velcon NSN 4330-00-983-0998coalescers.

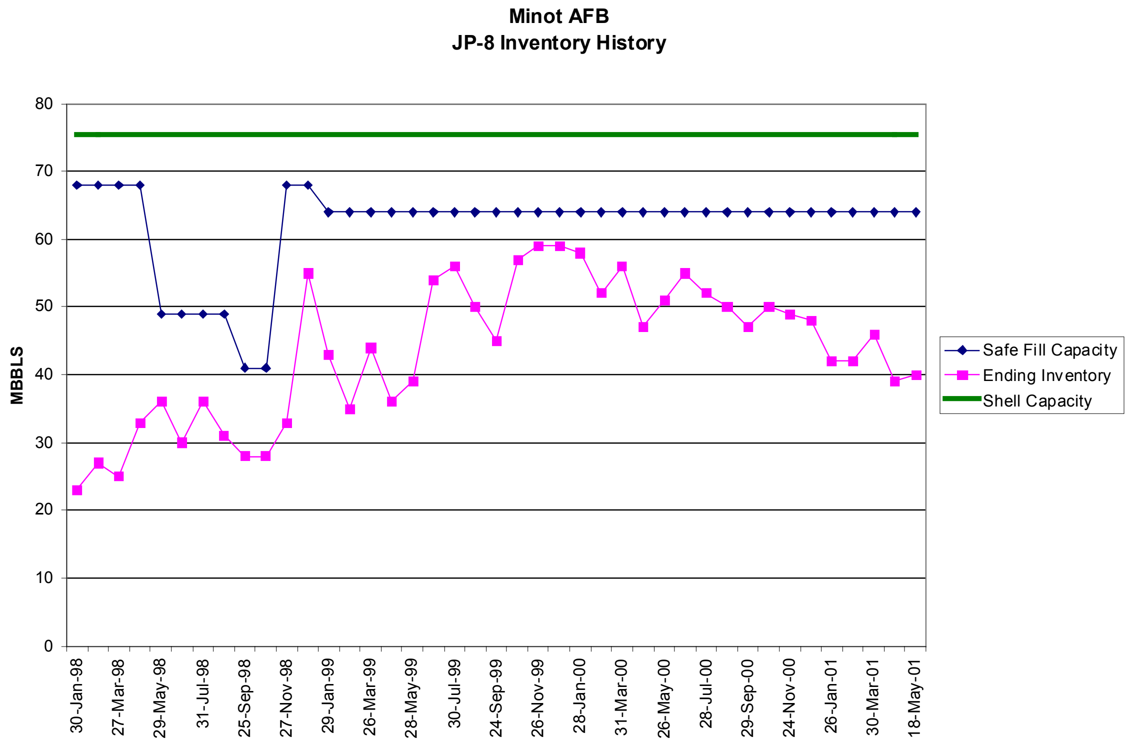
Bulk Storage
All above ground bulk storage tanks are 100% epoxy coated, modified floating-roof tank with geodesic dome covers. Tank bottoms slope to the center where a ¾ inch line to the sump well is located to remove BS&W. The issue (suction) line is 12 inches from the bottom and is located in the same area as the sump drain. During warm weather, the bulk tanks are drained for water daily through the product recovery system. After settling the product is pumped back to the tank with a hand pump. During cold weather, the hand pumps freeze and tanks are drained manually into a jerry can, which are emptied into bowsers.

Assigned Refueling Equipment
Minot AFB has seven R-11s and MH2C Hose carts for hydrant fueling.

Hydrant System
Minot has a Type II and a Type III hydrant system.

Products Stored
JP-8 and JP-4.

Product Quality Data
When JP-8 was received in August from DFSP Grand Forks, the FSII levels were between 0.11% and 0.14%, averaging 0.12%. From March 5 through March 21, JP-8 received from AMOCO Mandan, ND, FSII levels were from 0.12% to 0.16%, and averaged 0.14%. On March 21, the day of our visit the FSII concentration was 0.16%. SDA additive concentration levels in August averaged 263 CUs; however, throughout January of 2001, the SDA averaged 445 CUs.



Minot AFB
JP-8 Inventory History
MBBLS
80
70
60
50
40
30
20
10
0
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
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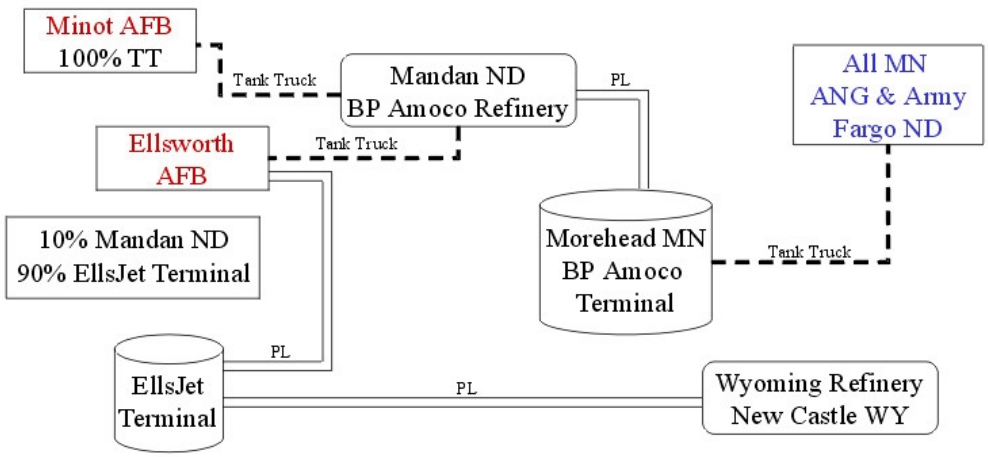
30-Mar-01
18-May-01
Safe Fill Capacity
Ending Inventory
Shell Capacity

Current Supply Pattern for
Minot, Ellsworth, Fargo AFBs



Appendix E-23

McConnell AFB, KS

62 ARW/LGSF
57706 Independence Street
Building 990
McConnell AFB, KS 67221-3729

Fuels Officer: Lt Giovanni Ortiz, Phone: 316-759-4112, Fax: 316-759-5904, Giovanni.Ortiz@mcconnell.af.mil
Fuels Superintendent: CMSgt Christopher Page, Phone: 316-759-4112, Fax: 316-759-5904, Christopher.page@mcconnell.af.mil
Q&I Supervisor, MSgt Hornback
LFM Supervisor: Mr. Lennie Morris
RFM Supervisor: SSgt Boyd
QSR: Dick Hoffman, DESC St. Louis

AJ Investigation Team: Dwight Duncan (C4e) and Bud Rodee (DFR-Americas)

AJ Incidents
McConnell AFB has experienced Apply Jelly in a clear white form. The substance appears to be thick and gummy. A sample was sent to Southwest Research.

Four KC135s have found Apply Jelly in 2 main tanks after reports of fuel gauge problems. Two of the incidents were within a week of each other. All four aircraft had refueled at another location prior to reporting the problem to aircraft maintenance. The AJ found in the aircraft fuel cells was not as thick as the material drained from the fuel F/S mentioned above. During pre-flight inspection, KC-135 sumps are drained and crews report never having observed AJ. Aircraft fuel cells contain ribs with water outlets located at the bottom of the ribs, and the Apply Jelly seems to have difficulty draining through the outlets. Fuel cells must be entered and wiped out by hand. The KC-135 is equipped with three fuel pumps. The main fuel pump pressure is 35 psi. This pump feeds the low-pressure pump, which increases the pressure to 125 psi. The low pressure pump feeds the high-pressure pump that increases the pressure to 450 psi at idle, and +1000 psi at full speed. The KC-135 is equipped with a filter bypass system that allows fuel to the engines if the fuel filters would become clogged. However, if the main cargo pump becomes clogged, fuel could not reach the engine. This may be unlikely because of the size of the intake and outlet of the main cargo pump.

The Air National Guard uses the same JP-8 from the same system as McConnell AFB and has not experienced any AJ. The ANG has the Oshkosh R-11 refuelers. Boeing engineers have reported a problem with AJ in their refuelers to the McConnell AFB Fuels Flight. Boeing loads their truck at the same location as the ANG at the McConnell AFB.

McConnell has established a more aggressive policy to remove water from the fuel system as a means to reduce the occurrences of the AJ.

Product Receipts and Issues
JP-8 is received by dedicated pipeline from the CONOCO terminal approximately 1½ mile from the base. Tank trucks are received twice per year to exercise the truck receiving system. Pipeline receipts are normally scheduled for Wednesdays and are normally 614,000 gallons. After start-up, it takes about ten minutes to displace receipt lines. JP-8 is not filtered upon receipt, though the fuel is filtered as it leaves the CONOCO terminal. Tanks and F/S sumps are drained for water at each shift change, and tanks are drained each day while temperatures are below 55 degrees F.

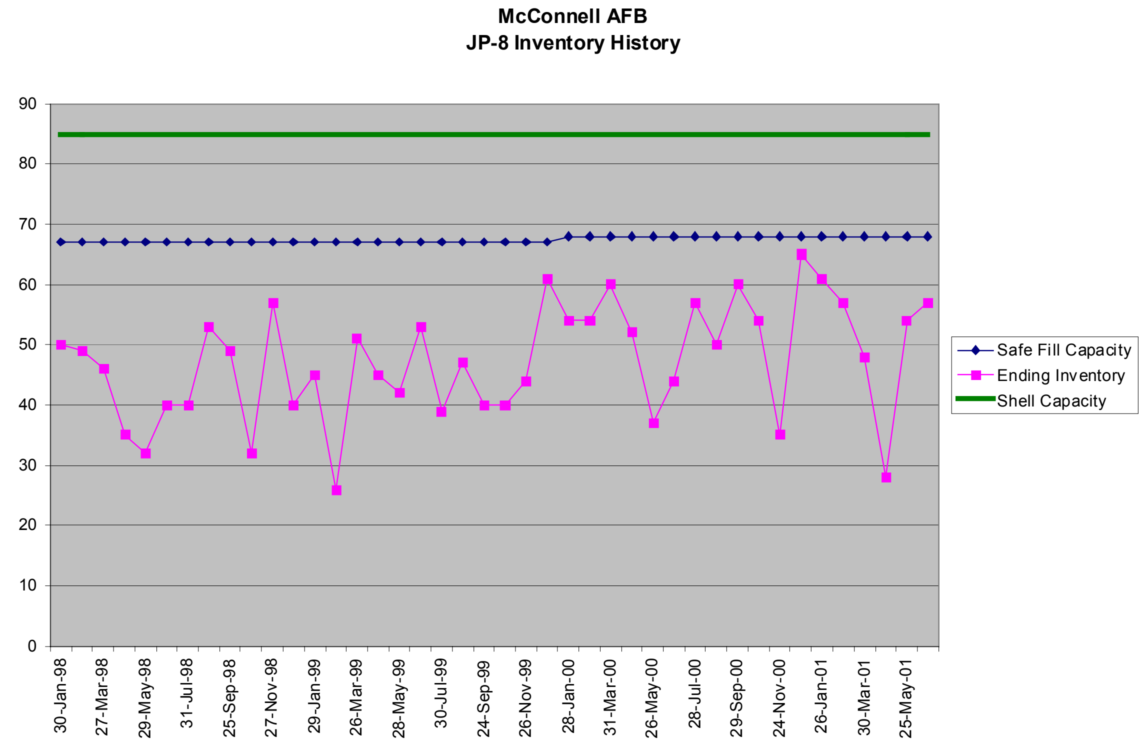
Bulk Storage
All tanks are 100% epoxy coated. Tanks are above ground steel with geodesic domes and floating-roofs. Two 35,000-bbl tanks were constructed in 1950, and two 10,000-bbl tanks in 1998. Tanks are sloped to a center sump that has ¾-inch water drain line. With one exception, suction lines extend to the center on a slight angle parallel with the tank floor, approximately 18-inches from bottom. There are no elbows on the suction line and they are directly over the sump. Tank #1, a 35,000-bbl tank, is the exception in that the suction line has an elbow that is angled away from the sump.

Assigned Refueling Equipment
McConnell has ten R-11 Kovach refuelers and four Beta HSV-12s.

Hydrant System
Type II and a Type III hydrant fueling systems.

Products Stored
JP-8.

Product Quality Data
The FSII receipts range from 0.105% to 0.125%. Fuel conductivity averages 260 CUs, as measured by McConnell AFB. Fuels Management has requested that the FSII maximum level be reduced to 0.11%.


McConnell AFB
JP-8 Inventory History
90
80
70
60
50
40
30
20
10
0
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
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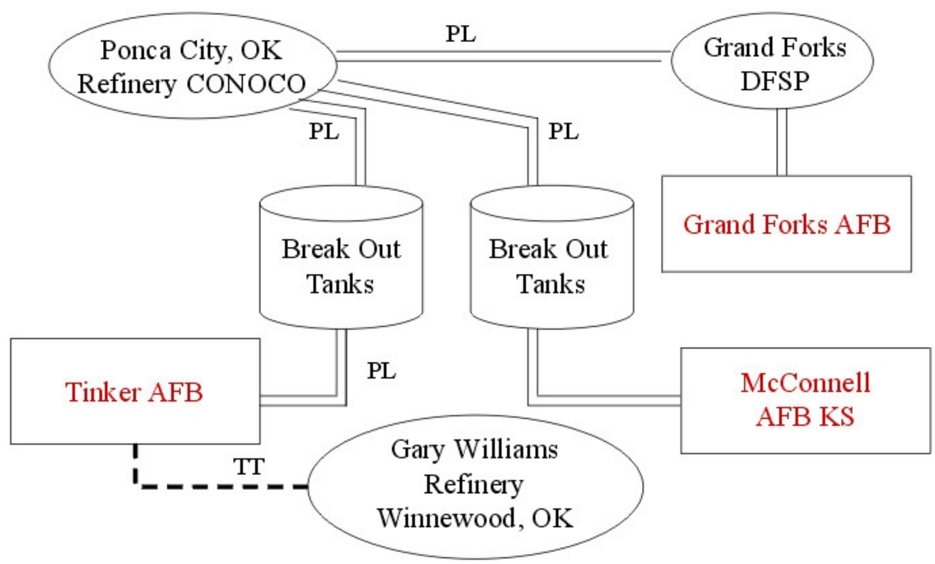
30-Mar-01
25-May-01
Safe Fill Capacity
Ending Inventory
Shell Capacity

Current Supply Patterns for Grand Forks, Tinker, and McConnell AFBs



Appendix E-24

CONOCO Pipeline Company

8001 Oak Knoll
Wichita, KS 67207

Terminal Manager: Scott Salisbury, Phone: 316-681-2081, Fax: 316-681-1697,
QSR: Dick Hoffman, DESC-St Louis

AJ Investigation Team: Dwight Duncan (C4e) and Bud Rodee (DFR-Americas)

CONOCO receives JP-8 by multi-product pipeline from Ponca City, OK. JP-8 is sampled upon receipt and tanks are equipped with side taps for representative sampling. The contractor obtains all samples. All transmix is diverted into one of the CONOCO tanks to be blended with commercial product. JP-8 is stored in three dedicated, above ground, steel tanks. Storage tanks are epoxy coated, bottom and 1 1/2 feet up the sides. Tank bottoms slop to the edge and are equipped with water sump drains. Tank #1259 has a common receipt and issue line. It is a flat bottom tank equipped with four sump drains, one at the center and three around the edge. Tank #202 receipt line extends 5 feet into the tank and the suction line is 10 inches from the bottom with a ninety-degree elbow; the line is equipped with a vortex de-fuser. Tank #1258 suction line extends 12-inches into the tank and is set on a pedestal 10-inches off the bottom. Sump wells are from 18 inches to 3-feet deep. Water draw-off lines are 2-inchs in diameter. Storage tanks are cleaned at 5-year intervals in accordance with contract requirements. The terminal has three FSII tanks, one 4,000-gallon and two-2000 gallon tanks. The SDA tank has a 15 gallons capacity. The filter is equipped with 6-Velcon elements, FO-644 PLF. There are 7-Velcon coalescing elements, I-644 85 TB and three screens, SO 636 PV.

Water is removed after each receipt and all water is drained through the oil-water separator. Their procedure is to drain the sumps until “the brown color turns clear.”

FSII and SDA are injected into a 6-inch receipt line during receipt, after the product passes through a 0.5-micron filter. After injection, the product travels through nine 90-degree elbows before entering the tank. Receipt pressure is 25 psi. The injector is a GATE-PAC manufactured by Milton Roy. The FSII injector enters the JP-8 receipt line and is flush with the inside surface of the JP-8 receipt line. SDA is blended 9 to 1 and is also injected into the receipt line as described above. The FSII concentration has been lowered to 0.11% at the request of McConnell AFB Fuels Management. The FSII receipts range from 0.105% to 0.125%. Fuel conductivity averages 260 CUs, as measured by McConnell AFB.

Fully additized prior to shipment and normally settled for 4 days, JP-8 is shipped to McConnell AFB by dedicated pipeline. Pipeline shipments are filtered through the same .5-micron filter and coalescing elements as fuel receipts. Approximately 16 ounces of AJ-like materials are found in the separator unit each time the elements are changed.

Element changes are based on differential pressures. Pipeline shipments to McConnell normally take 26 hours to complete.

Appendix E-25

Edwards AFB, CA

95 ABW/LGSF
114 S Wolfe Avenue
United Paradyne Corporation
Edwards AFB, CA 93524

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LFM Supervisor: Claudie Carr, Phone: 661-277-3850, Claudie.Carr@edwards.af.mil
RFM Supervisor: TSgt James Holland, Phone: 661-277-3645, James.Holland@edwards.af.mil

AJ Investigation Team: E. Mac Fishburn (C4e) and Calvin Martin (Martin & Associates).

AJ Incidents
Edwards AFB first experienced AJ on January 31, 2001. When sampling R-11 refueler 96L-144 using a single filter monitor, the Quality Control Specialist observed orange specks on the filter membrane. When observed under the microscope, the specks appeared to be AJ. *Note that this event is the first reported detection of AJ being identified in a quality test performed downstream of the final filtration before fuel enters the aircraft*. Subsequent use of the refueler resulted in collecting samples of AJ from the F/S sump. Upon the differential pressure reaching the maximum, the refueler was put in maintenance for element change. Visual examination of two samples of the material from this refueler appeared to be AJ to both team members. In one sample the material adhered to the bottom of the container, while the other sample was in a fluid state. The base has also observed a limited amount of AJ from Oshkosh R-11 refueler 91L-69. This refueler is being monitored and the differential pressure has not increased. The base sent samples to SwRI along with a sample from one of the filter elements removed from Kovach refueler 96L-144. The two R-11 refuelers, 96L-144 and 91L-69, and the F/S between bulk storage and the hydrant systems are the only locations where AJ has been found. One of the refuelers has a horizontal F/S and the other has a vertical F/S.

On March 13th, prior to our arrival, the differential pressure on refueler 96L-144 was recorded as 4 psi @ 400 gpm during re-circulation through the F/S. During recirculation of 20,071 gallons of fuel on 19 March, while on our visit, the differential pressure was recorded as 1 psi @ 400 gpm. After this re-circulation, about ¼ inch of AJ in a quart jar was collected from the F/S sump drain. The starting fuel temperature was 74ºF, and upon completion of the transfer, the temperature of the fuel was 81ºF. The differential pressure decrease is somewhat puzzling. One possible explanation is that the circulating fuel is washing AJ out of the elements and into the sump. The same refueler was used on March

20th to transfer another 15,107 gallons through the F/S. The starting fuel temperature was 57ºF, and the fuel temperature upon completing the transfer was 67ºF. The differential pressure upon completion of the transfer was 2 psi @ 400 gpm which was an increase from the pressure on the March 19th. Mr. Carr, the Liquid Fuels Maintenance Foreman, invited us to look at the elements removed from the transfer F/S between bulk storage and the hydrant systems. We examined a number of these elements and selected one that had an orange discoloration along the bottom portion of the element. This element was cut open and a sample of the orange material was removed for microscopic examination. Under the microscope, the material appeared to be AJ. This material was shipped to SwRI for further analysis.

Product Receipts and Issues
All products, except JP-8, are received by tank truck. JP-8 is received by pipeline from DFSP San Pedro by way of the Kinder Morgan Pipeline (KMP) to Carson (better known as Watson Station) breakout point. Product leaves Watson Station breakout point via KMP to Colton. Here it splits and goes to March AFB or Luke AFB or to CAL/NEV breakout tanks which are across the street at Colton. Product then leaves Colton in the CAL/NEV line for Las Vegas. As product travels to its primary destination, Las Vegas, small batches (5000 – 6000 bbls) are heart cut at Adelanto into tanks for subsequent shipment to Edwards AFB. The 6-inch pipeline from Adelanto to Edwards provides a receiving rate of 21,000-gph at Edwards. The average receipt quantity at Edwards is 100,000-120,000 gallons and requires 5 – 8 hours. Pipeline displacement time from Adelanto to Edwards is 23.5 hours; therefore, it takes an average of 3 or 4 receipts to completely displace the line.

Adelanto has two 20,000-bbl floating-roof tanks and one 25,000-bbl tank both with geodesic domes. This location is completely automated. FSII and SDA are injected into the small batches (5,000 – 6000 bbls) of product for later shipment to Edwards after completion of B-1 testing.

Fuels issues vary considerably at Edwards depending on the aircraft testing in progress. At times defuels exceed issues. The average daily issues are normally about 75,000 gallons. Defuels primarily involve home station aircraft.

Bulk Storage
Edwards has two above ground JP-8 bulk tanks. Tank #19 has a capacity of 20,000-bbl and tank #28 is a 10,000-bbl tank. **Both tanks are equipped with floating-roofs without covers. Seals on both tanks are in bad condition, and tank #19 is out of round. After a recent heavy rain, 2,000 gallons of water were removed from the two tanks and associated fill stand F/S sumps**. Tank #19 has floating suction and it was reported that tank #28 also has floating suction. A drawing of tank #19 verified floating suction; a drawing of tank #28 was not available. **On tanks #19 and #28, the ineffective product recovery systems have been abandoned and removed.** The tanks were retrofitted with 1 ½ inch valves and hoses that adapt to their 600-gallon bowser for a more effective system of removing water and emulsion from the tanks. Fuel is not filtered upon receipt, and the first filtration occurs as the product is transferred to hydrant

operating storage. The transfer F/S uses American Bowser vessels with the old style DoD NSN 4330-983-0998 elements manufactured by Velcon, which are also used in the Type I and III hydrant system FS's. The bulk storage area has the capability to load refuelers but is rarely used due to travel distance.

The three 8,000-bbl JP-7 tanks have suction lines directly above the center sump and are equipped with inadequate product recovery systems. It was noted that these tanks have sections of fiberglass-reinforced pipe and one flange has a small seep.

Assigned Refueling Equipment
Edwards AFB has eighteen R-11 refuelers (one Kovatch, seventeen Oshkosh) and five hydrant servicing vehicles (HSV–12s). Water absorption elements replaced the coalescer elements in the refueling trucks beginning in September 1999. Two trucks are dedicated for use of JP-8+100, though the quantity used is small. The +100 additive is injected at the truck fill stand.

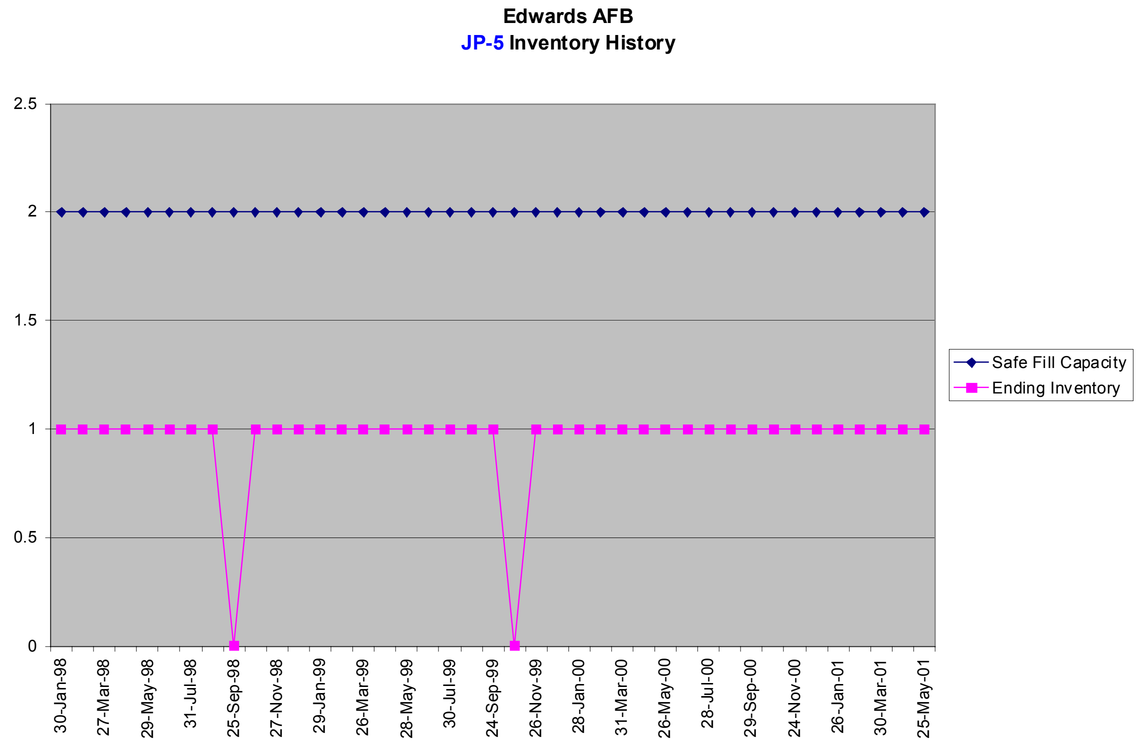
Hydrant Systems
Hydrant System 1 (facility 1724) has four 50,000-gallon horizontal cylinder tanks sloped to the sump end. Three are used for JP-8 and one for JP-4. This facility is used primarily to fill 95% of the refuelers at Edwards. There are 3 Bowser, 2 Gil, and 1 American Pipe and Steel F/S vessels with the old DoD style elements manufactured by Velcon.

The Type III system has minimum use. It has two 12,000-bbl fixed-roof operating tanks. Product recovery systems equipped with hand pumps, 3/4 inch lines and small (approximately 30-gallons) product recovery tanks. This system has minimum utilization because helicopters occupy the hydrant outlets, precluding access to the outlets by large aircraft. There are 2 Gil V-600 and 3 Gil V-1200 F/S vessels with the old style elements manufactured by Velcon.

Products Stored
Edwards AFB stores JP-4, JP-5, JP-8, and JP-7.

Product Quality Data
FSII levels averaged 0.11% in storage and at time of issue with a fuel conductivity history range of 70-110 CUs. When tested for fuel moisture content, one refueler had 5-ppm water with AJ.

Aircraft Maintenance Questionnaire
The Aircraft Maintenance "Apply Jelly" questionnaire was hand carried to the aircraft maintenance focal point by Mr. William Hatch, United Paradyne. Maintenance management advised that the form will be further distributed to all aircraft weapons key maintenance and Quality Assurance personnel for their information and input.


Edwards AFB
JP-5 Inventory History
2.5
2
1.5
1
0.5
0
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27-Mar-98
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31-Jul-98
25-Sep-98
27-Nov-98
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28-May-99
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24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
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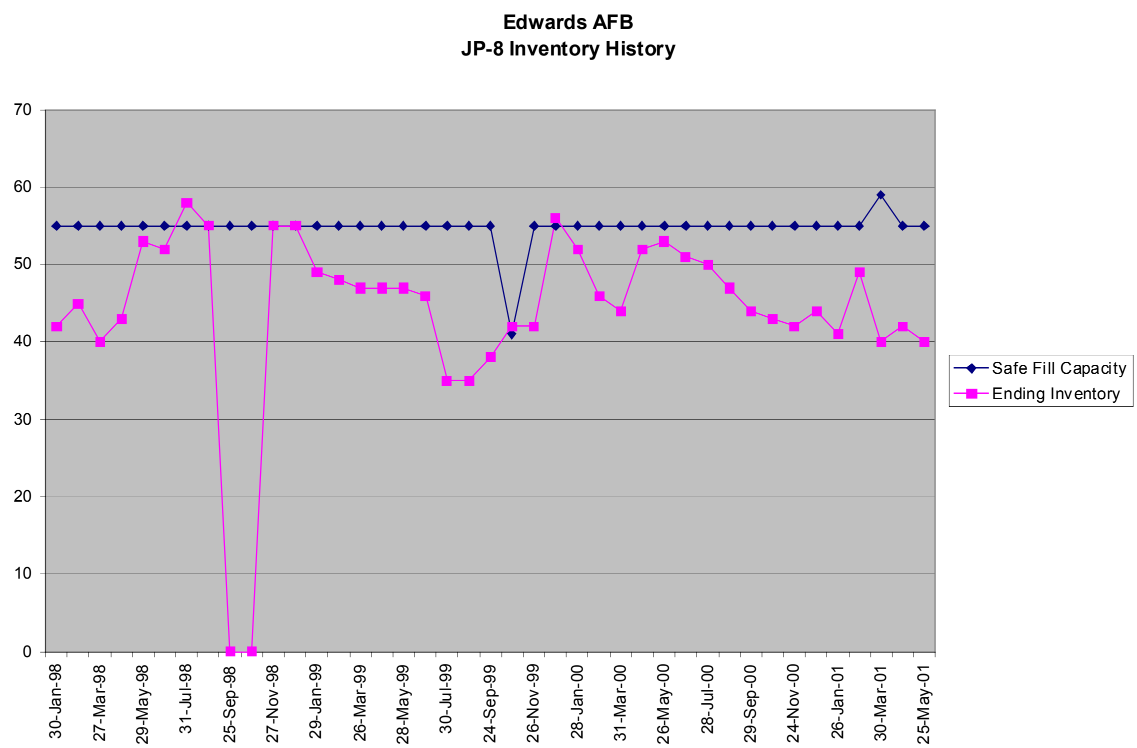
30-Mar-01
25-May-01
Safe Fill Capacity
Ending Inventory


Edwards AFB
JP-8 Inventory History
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60
50
40
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20
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0
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26-May-00
28-Jul-00
29-Sep-00
24-Nov-00
26-Jan-01
30-Mar-01
25-May-01
Safe Fill Capacity
Ending Inventory

Appendix E-27

Beale AFB, CA

9 SUPS/LGSF
19501 Edison Avenue
Beale AFB, CA 95903

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Fuels Superintendent: MSgt Christopher Watson, Phone: 530-634-8396, Christopher.Watson@beale.af.mil
Fuels Analysis Supervisor: SSgt Mark Hoover, Phone: 530-634-4620, mark.hoover@beale.af.mil
QSR: Jim Anderson, Phone: 650-603-8785, janderson@desc.dla.mil

AJ Investigation Team: E. Mac Fishburn (C4e) and Calvin Martin (Martin & Associates)

AJ Incidents

During November 2000, a gel-like substance was drained from the F/S sump of Kovatch R-11 97L-358 on two occasions. On December 1, 2000, checkpoint personnel noticed globs of AJ coming from the F/S sump on R-11 refueler 98L-005. This was followed by periodically obtaining 50 ml trace quantities of AJ. Absorption media elements were installed in the refuelers during August 2000.

On December 13, 2000, traces of AJ contaminant were found in the F/S sump on MH-2C # 81W0104. Since there were no replacement elements available, the housing was cleaned and the hosecart was returned to service. On December 13, 2000, two other hosecarts (81W0109 and 81W0111) were opened and examined and no evidence of AJ was found.

On January 2, 2001, hosecart 81W0104 was re-inspected (filters removed) and 700 ml of AJ was found inside the vessel near the sump. The 700 ml sample from the hosecart along with an AJ found in the sump of R-11 97L171, were forwarded to the Mukilteo Laboratory for analysis. Test results were received on January 17th for R-11 97L038 and hosecart 81W0104. The Mukilteo Laboratory reported that the samples contained FSII and water. No other constituents were identified. Interestingly, FSII made up 75.7% of the R-11 sample and only 38% of the hosecart sample. The R-11 sample was described as the "truest form of AJ" that they have seen at the Mulilteo Lab.

Product Receipts and Issues

JP-8 for Beale is refined at ARCO, Ferndale, WA and tendered into DFSP Selby at Crocket, CA. From there it enters the Kinder/Morgan Pipeline, passing through their Concord, CA terminal and on to their Rocklin, CA terminal. From Concord, it enters KMP's Chico, CA pipeline onto Erle Junction where it is cut over to Beale AFB. It then goes into KMP's 30,000 barrel tank located next to Beale tank farm. Once the product passes quality testing, tank lockouts are removed and Beale is then able to draw from the tank as needed. Additives (FSII and SDA) are injected into the line where it comes out of the ground, prior to passing through a horizontal filter and on into the KMP tank. The fuel also passes through a metering device just after leaving the filter chamber then on to the tank inlet that ends in a mixing nozzle. The tank has a floating-roof. The FSII additive tank and injector pump are about 50 feet from the injection point.

Beale normally receives about 100,000 gallons of JP-8 twice a week. Issues are 25,000 to 30,000 gallons per day.

Inventory minimum levels were increased in December 2000, therefore, smaller and more frequent receipts are required. Settling times between receipts are less. Due to a history of water in the receipts, a Haypack dehydrator was installed January 5, 2001, but the system is not operational. The contractor has not yet released it to the US Air Force. This system makes no provisions for the proper containment and collection of water discharged from the vessel. Normally, when a dehydrator is installed, the separated water discharges into an oil/water separator. We were told that the state of California EPA would not approve an oil/water separator.

When discussing this issue with the LFM Supervisor, MSgt Grygierczyk, he explained the dehydrator would shut down when receiving excessive water. When shutdown occurs, operating personnel will have to drain the vessel into barrels for disposal as hazardous waste. The LFM Supervisor is developing start up tests and procedures, and working directly with Kinder Morgan Pipeline personnel to determine if the system functions as designed. On the initial attempt to pump through this system, the Kinder Morgan automated system shut the pumps off due to inadequate flow through the vessel. The flow was reduced from 735 gpm to 235 gpm when the dehydrator was placed on line. MSgt Grygierczyx is confident that the flow control valve on the dehydrator will allow him to adjust the system to a flow that will not decrease the incoming flow rate through the 4 inch line, which is 735 gpm.

Bulk Storage JP-8 Fill Stand

The JP-8 fillstand at bulk storage has one Facet F/S model number VFCD-D-6N39SB-3S630FD. Elements required are six CA43-3SB coalescers and three SS330FD separators.

There is also a Facet dehydrator vessel, rated at 940-gpm was manufactured in CY2000 and installed in January 2001. The required element is a 1-WZ-1500

Bulk Storage

There are two operational 15,000-bbl tanks (#10 and #11) both of which have geodesic domes and floating pans. **Due to design of the geodesic domes, blowing rain penetrates the vents on the skirts of the domes**. The vents are louvered, approximately four feet wide and surround the periphery of the tank. Both tanks have cone down bottoms with center sumps and the discharge suction lines are positioned directly above the sumps. The tanks are equipped with product recovery systems which discharge directly through about 1½ inch lines into 30-gallon product recovery tanks. Collected water and fuel are drained into a 600-gallon bowser for separation and proper disposal. Tank water drains are inspected daily and drained as needed.

A third tank, #14, has been inoperative since 1996 and is programmed for extensive repair including a new bottom. This is a 10,000-barrel tank. Upon completion of this project, the availability of this tank should reduce the frequency of receipts and will accommodate greater settling time.

Assigned Refueling Equipment
Beale AFB has five R-11 refuelers, in JP-8 service, as well as eight MH2C Hose-Carts, which have NSN 4330-00-983-0998 filter elements.

Hydrant Facilities
Hydrant Facility 1017 is a renovated Type II hydrant system with eight 50,000-gallon epoxy coated underground tanks. This system has eight 300-gpm F/S vessels and two 600 gpm receipt separators. This system provides 8 multiple outlet laterals that primarily support hydrant servicing of AFRES KC-135s. This hydrant system is also used primarily used to fill trucks.

Hydrant Facility 1019 is a Type II hydrant system and was shut down on February 24, 2001, and it is scheduled for dismantling and environmental clean up by contract.

Filter Separators
Hydrant Facility #1017 has 8 issue F/S's that are API 1581 Group II Class B vertical 300 GPM Facet F/Ss, model numbers VCS-343-133. Theses vessels use three CA43-3SP coalescers elements and one SS633FD separator. There are also two 600-gpm receipt F/S vessels, model number VFCS-D-6N39SB-3S630FD. Each receipt F/S uses six CA43-3SB coalescers elements and three SS630FD separators.

Products Stored
Products stored at Beale AFB are JP-8 and JPTS.

Product Quality Data
Data on FSII and CU with associated temperatures was downloaded from the FAS system. This data was collected and retained as part of this survey.

Kinder Morgan Holding Tank Facility
As discussed in the paragraph on receipts and issues above, product is received into a 30,000-bbl holding tank. The tank is a flat bottom **floating-roof tank without cover**. This tank has floating suction attached to the floating-roof. Product is received from the Rocklin breakout tank that is used for aviation and diesel fuels. The KMP pipeline from Rocklin to Erle Junction is 8 inches and from Erle Junction to Beale is 6 inches. Transit time is 9 hours with product moving at about 5 mph providing a receiving rate of 1,350 bbls per hour into the KMP holding tank BE1. Product is filtered upon receipt through a

Warner Lewis Model HP-1000 horizontal vessel rated at 1000 GPM. This is a micronic filter primarily used for particulates and does nothing for water removal.

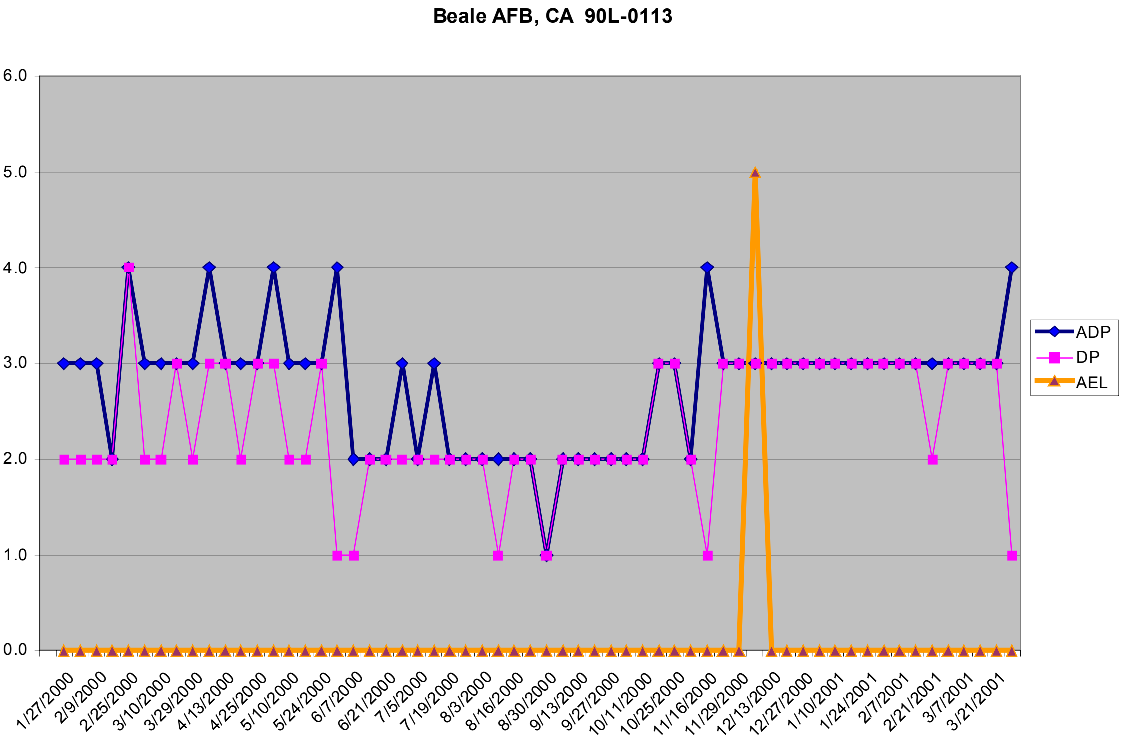
SDA is aspirated in the concentrated form into the line and tank-heal at the beginning of each receipt, proportional to the expected quantity of the receipt. FSII is proportionally injected into the line using a Milroyal model MRI-69-113S17 injector. This injector is equipped with a Rockwell Meter which measures the quantity of FSII injected and is then compared with the before and after stick readings on the 6000 gallon FSII tank. The FSII tank (BE-A1) has a pressure vacuum relief and breathes to the atmosphere. The FSII tank is replenished on average twice each year through DESC contract delivery by tank truck.

There is a 6,000-gallon wastewater tank that is plumbed into the tank water draw off line. Wastewater is drained prior to each receipt and after heavy rains. The water drain line is equipped with a visa-flo gauge and draw off valve for water/fuel interface monitoring. The tank is emptied about twice each year.

JPTS Tanks
There are three above ground steel JPTS tanks in the bulk storage area. These tanks have fixed dome roofs and there are no vents that allow rain to penetrate the tanks. These tanks are equipped with product recovery systems that facilitate removal of any water present in the tanks from condensation etc. Delivery of JPTS is by 20,000-gallon railcars. Prior to off loading the railcars, they are inspected for water and any water found is drained. Beale AFB personnel report they have not experience any problems AJ in JPTS.

Cargo Tank Cleanup Procedure
The Refueling Maintenance Foreman explained that one refueler that came in for replacement of the F/S elements had a lot of AJ inside of the cargo tank. He realized that if the tank was not cleaned, the AJ would go into the new elements after they were installed. He found that the normal method of cleaning the cargo tank with hot water and steam worked excellently. We should recommend that all cargo tanks be inspected and cleaned if needed when replacing the F/S elements.

Aircraft Maintenance "AJ " Questionnaire
A meeting was held with aircraft and refueling equipment maintainers. Mr. R. Nocher of the 9LSS/LSO, T-38A aircraft stated that they had seen no evidence of AJ in the aircraft. Other aircraft maintenance personnel were invited but did not attend.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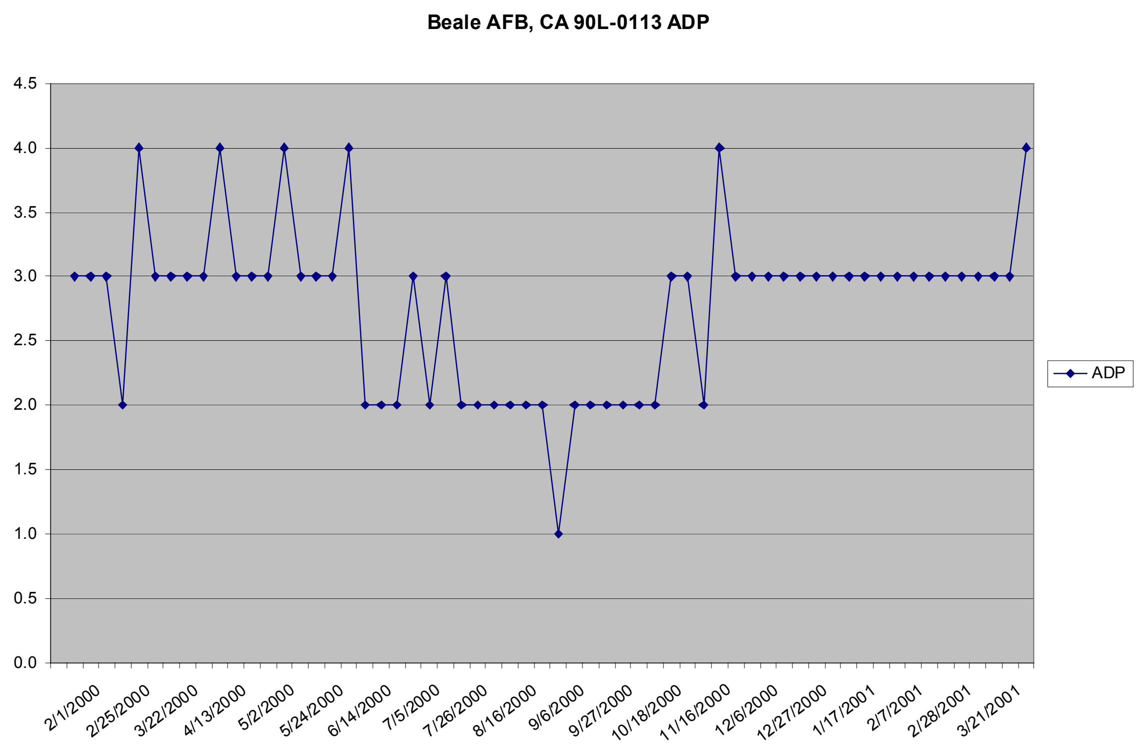
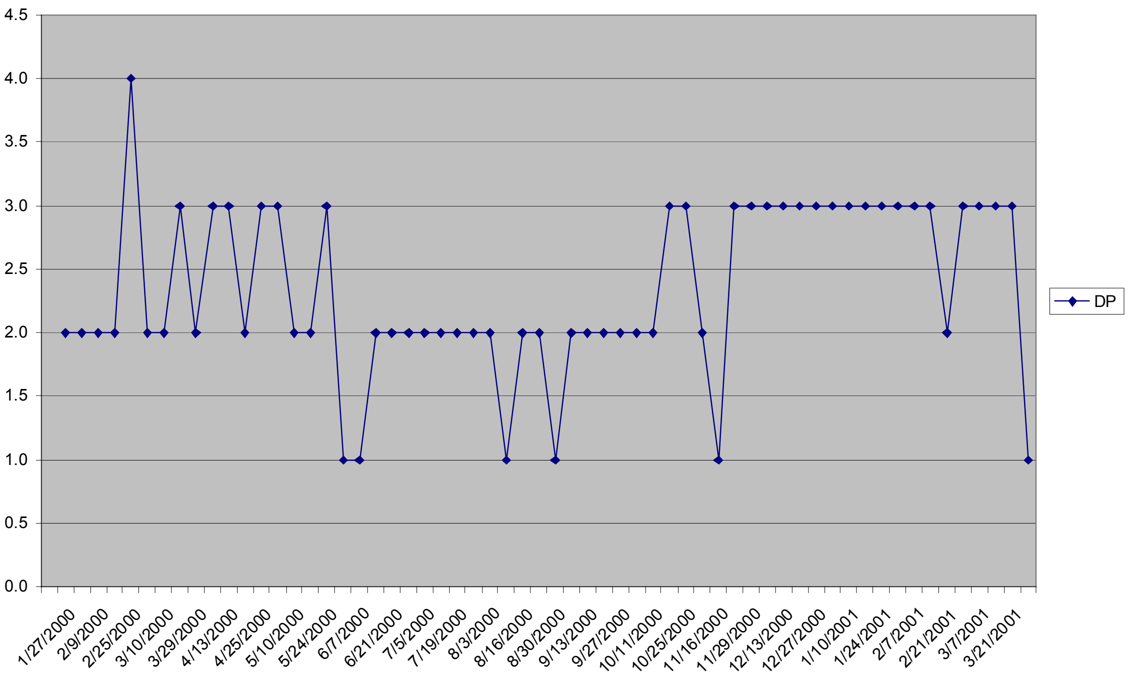
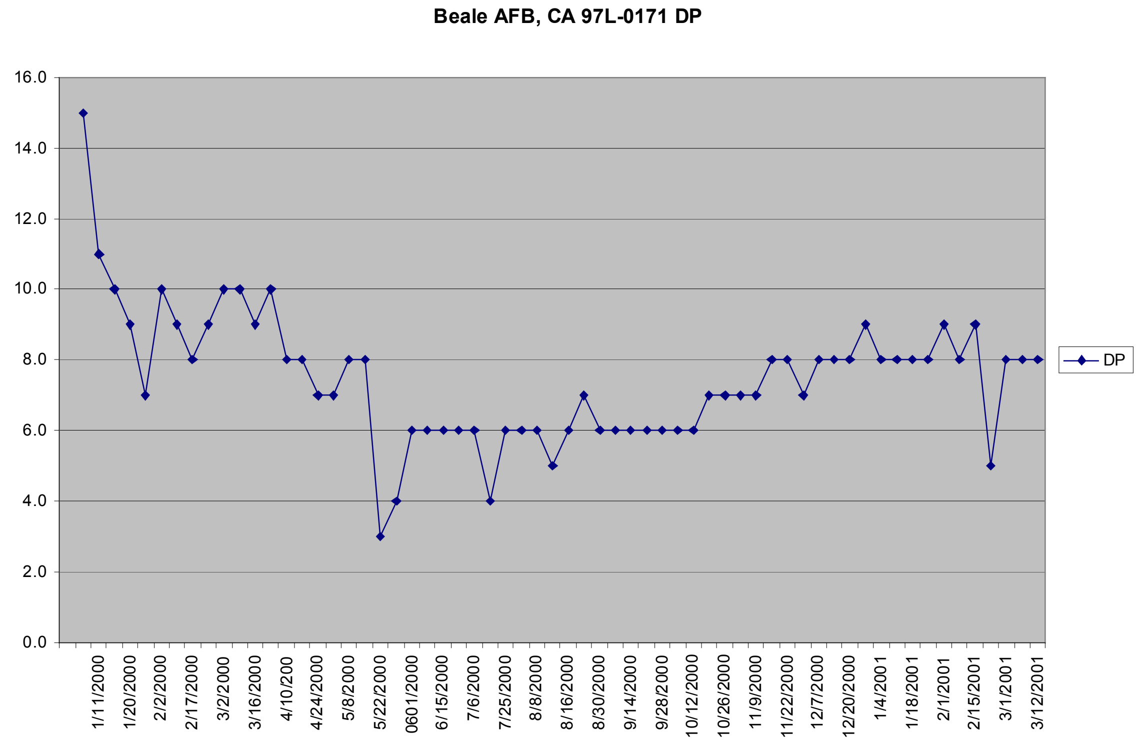
4.0
3.0
2.0
1.0
0.0
1/27/2000
2/9/2000
2/25/2000
3/10/2000
3/29/2000
4/13/2000
4/25/2000
5/10/2000
5/24/2000
6/7/2000
6/21/2000
7/5/2000
7/19/2000
8/3/2000
8/16/2000
8/30/2000
9/13/2000
9/27/2000
10/11/2000
10/25/2000
11/16/2000
11/29/2000
12/13/2000
12/27/2000
1/10/2001
1/24/2001
2/7/2001
2/21/2001
3/7/2001
3/21/2001
ADP
DP
AEL


Beale AFB, CA 90L-0113 ADP
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2/1/2000
2/25/2000
3/22/2000
4/13/2000
5/2/2000
5/24/2000
6/14/2000
7/5/2000
7/26/2000
8/16/2000
9/6/2000
9/27/2000
10/18/2000
11/16/2000
12/6/2000
12/27/2000
1/17/2001
2/7/2001
2/28/2001
3/21/2001
ADP

Beale AFB, CA 90L-0113 DP

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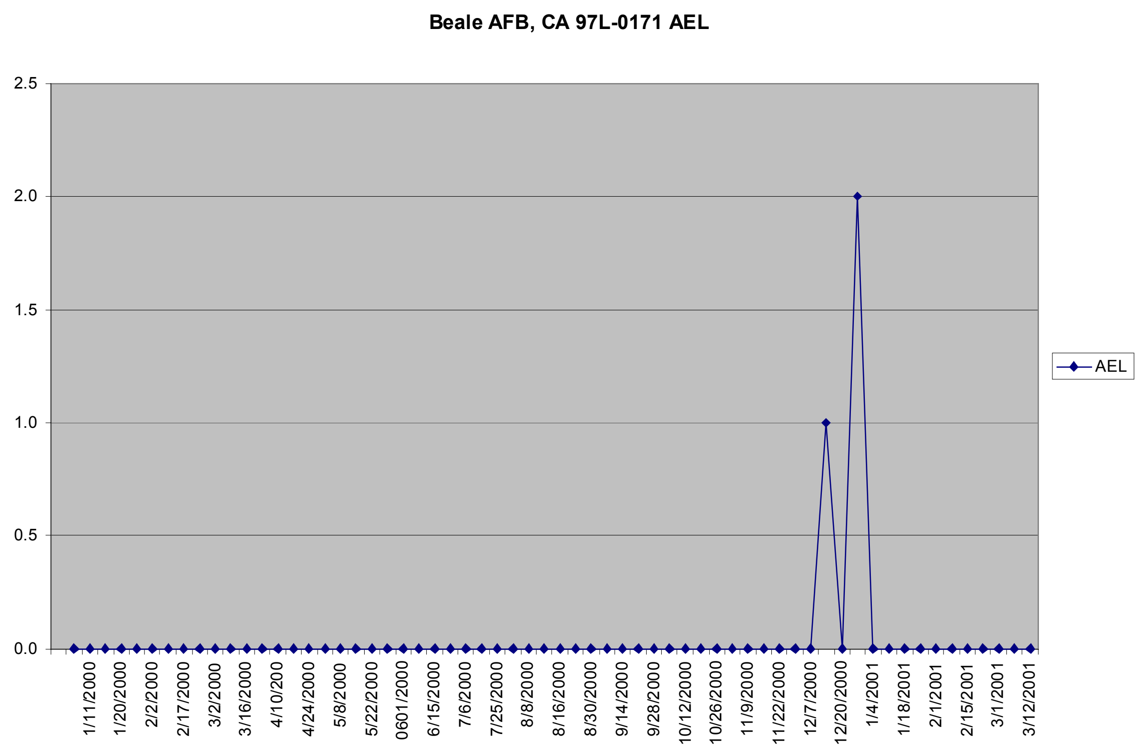
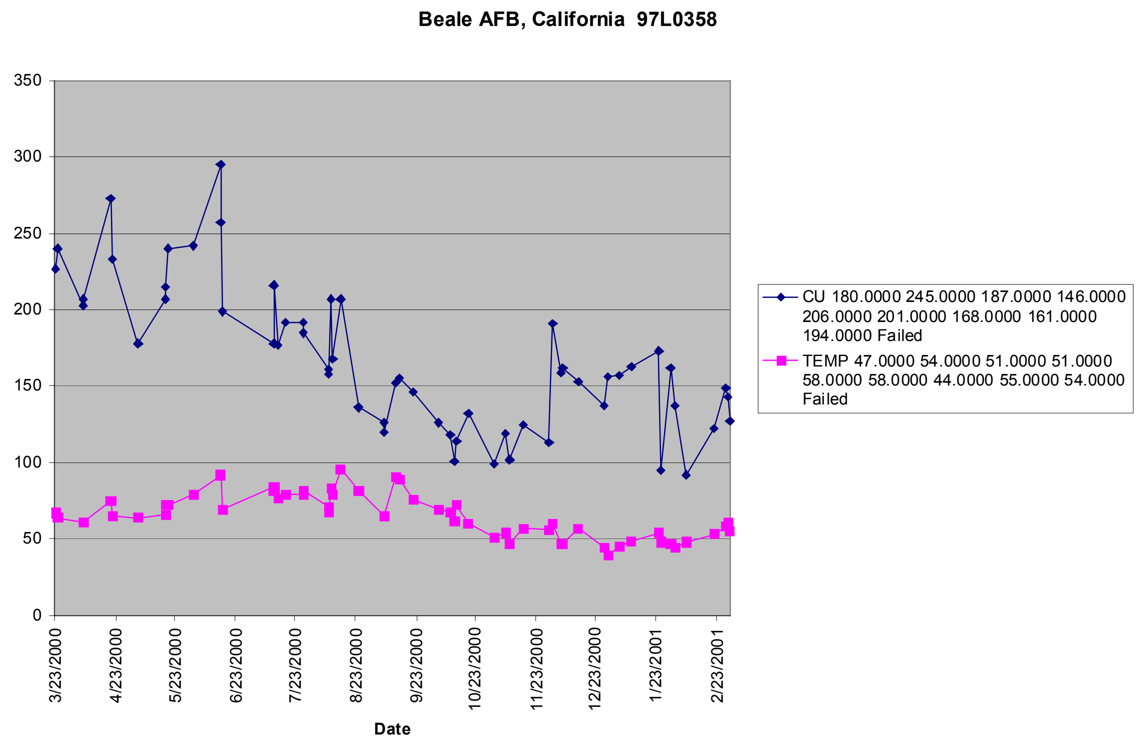
DP


Beale AFB, CA 97L-0171 AEL
AEL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350
300
250
200
150
100
50
0
3/23/2000
4/23/2000
5/23/2000
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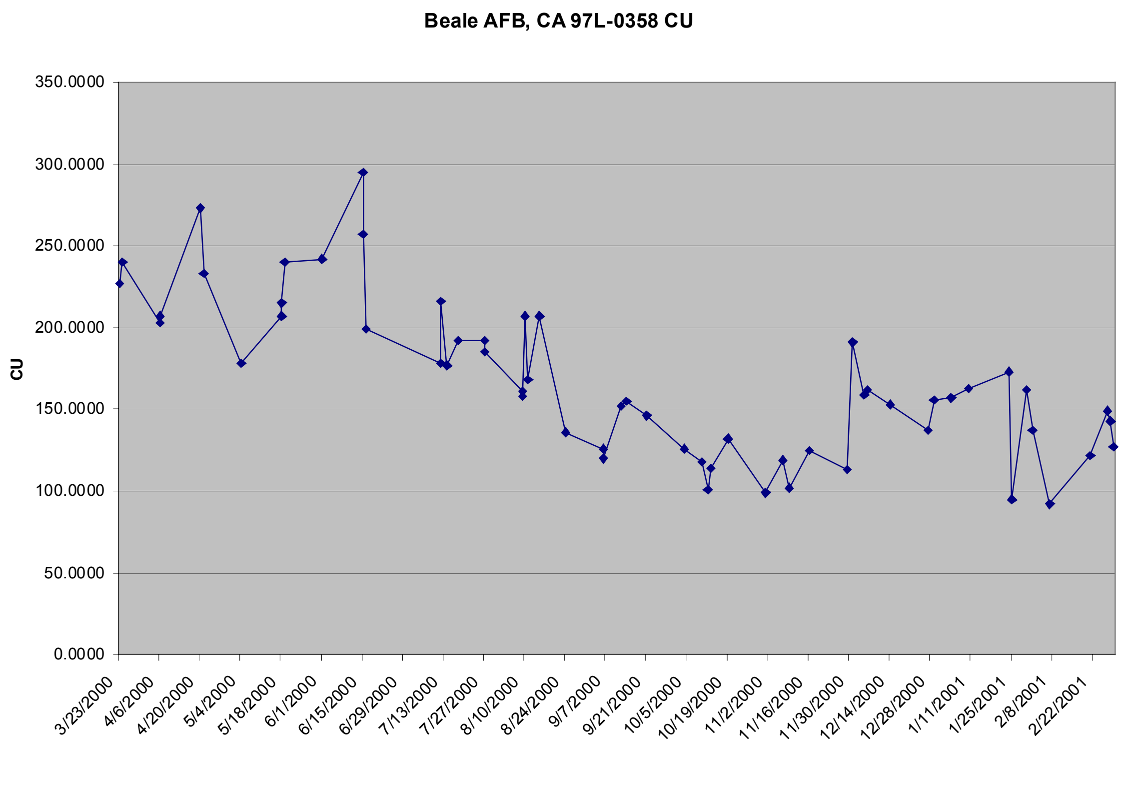
7/23/2000
8/23/2000
9/23/2000
10/23/2000
11/23/2000
12/23/2000
1/23/2001
2/23/2001
Date
CU 180.0000 245.0000 187.0000 146.0000 206.0000 201.0000 168.0000 161.0000 194.0000 Failed
TEMP 47.0000 54.0000 51.0000 51.0000 58.0000 58.0000 44.0000 55.0000 54.0000 Failed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200.0000
150.0000
100.0000
50.0000
0.0000
CU
3/23/2000
4/6/2000
4/20/2000
5/4/2000
5/18/2000
6/1/2000
6/15/2000
6/29/2000
7/13/2000
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8/10/2000
8/24/2000
9/7/2000
9/21/2000
10/5/2000
10/19/2000
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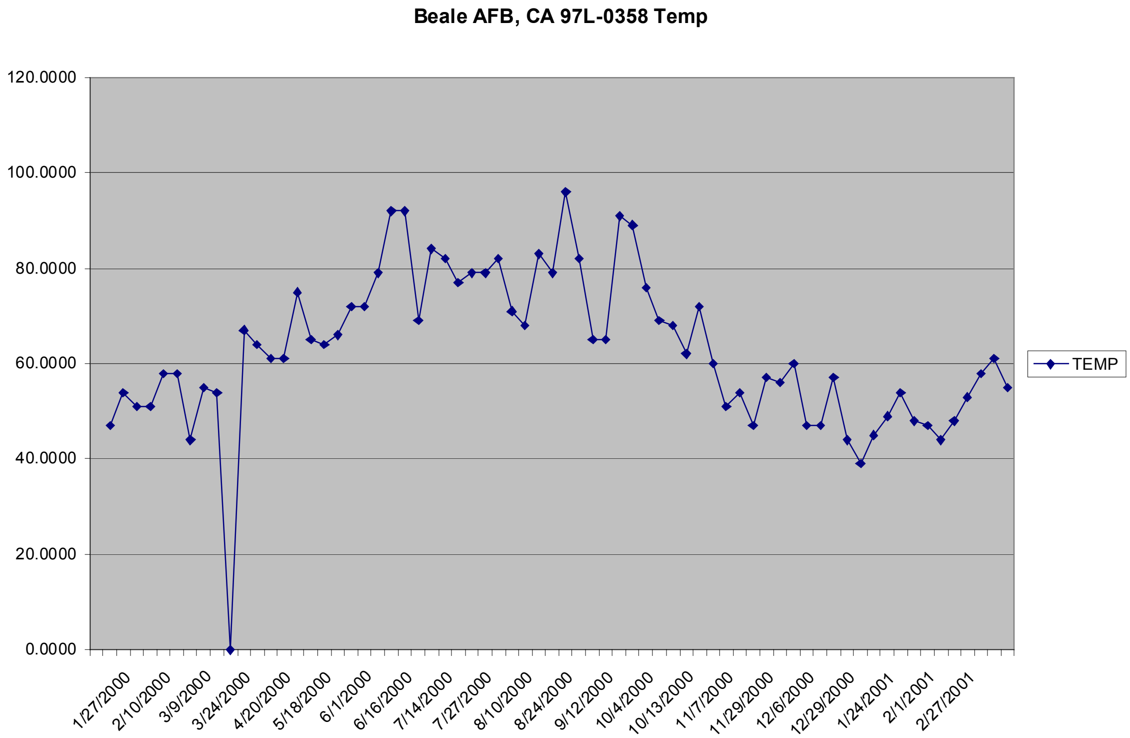
2/8/2001
2/22/2001



Beale AFB, CA 97L-0358 Temp
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100.0000
80.0000
60.0000
40.0000
20.0000
0.0000
TEMP
1/27/2000
2/10/2000
3/9/2000
3/24/2000
4/20/2000
5/18/2000
6/1/2000
6/16/2000
7/14/2000
7/27/2000
8/10/2000
8/24/2000
9/12/2000
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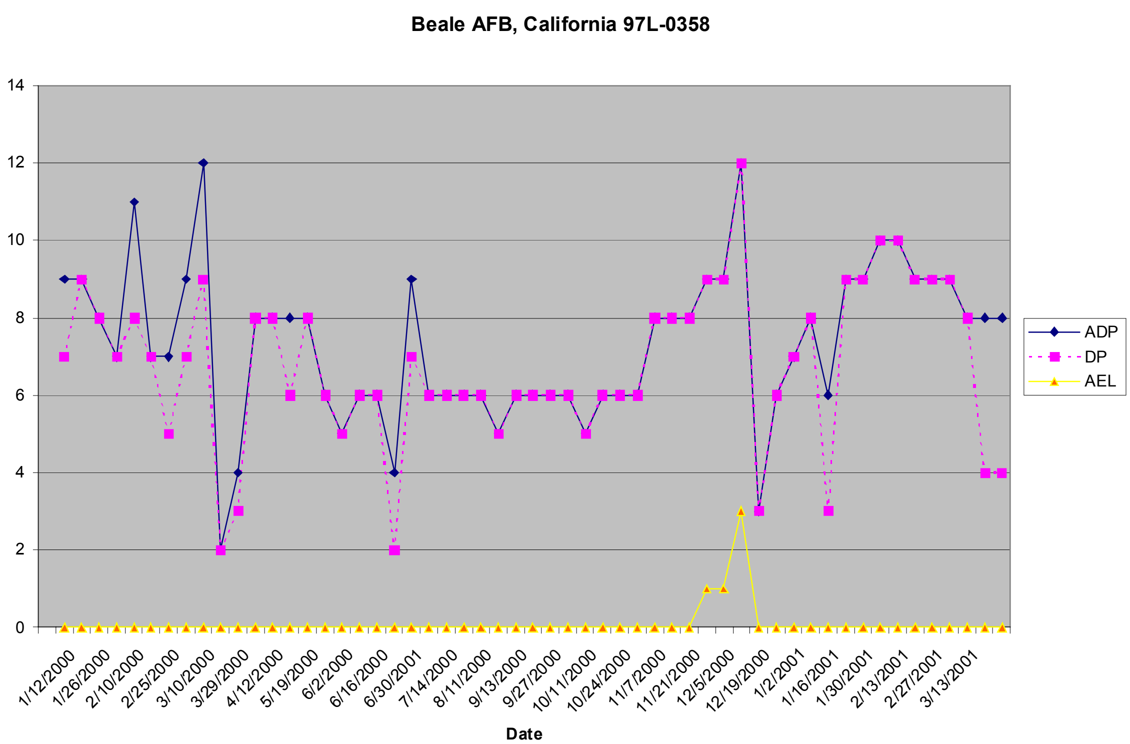
2/1/2001
2/27/2001



Beale AFB, California 97L-0358
14
12
10
8
6
4
2
0
ADP
DP
AEL
1/12/2000
1/26/2000
2/10/2000
2/25/2000
3/10/2000
3/29/2000
4/12/2000
5/19/2000
6/2/2000
6/16/2000
6/30/2001
7/14/2000
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11/21/2000
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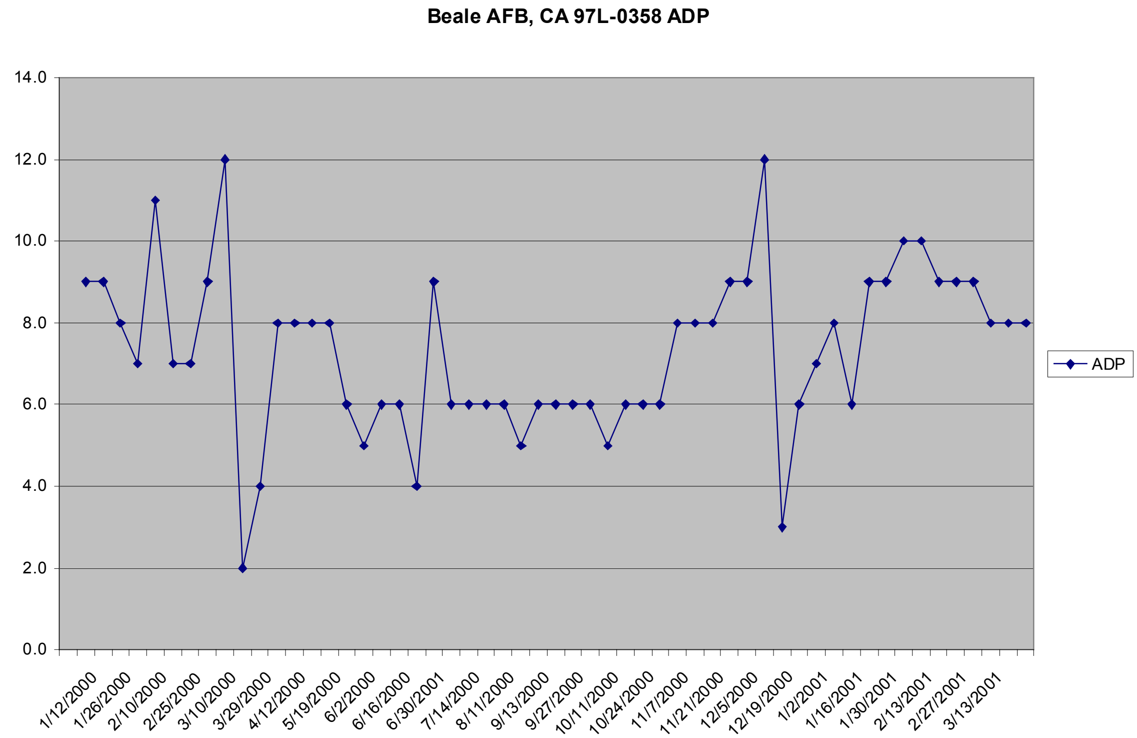
2/13/2001
2/27/2001
3/13/2001
Date



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6.0
4.0
2.0
0.0
ADP
1/12/2000
1/26/2000
2/10/2000
2/25/2000
3/10/2000
3/29/2000
4/12/2000
5/19/2000
6/2/2000
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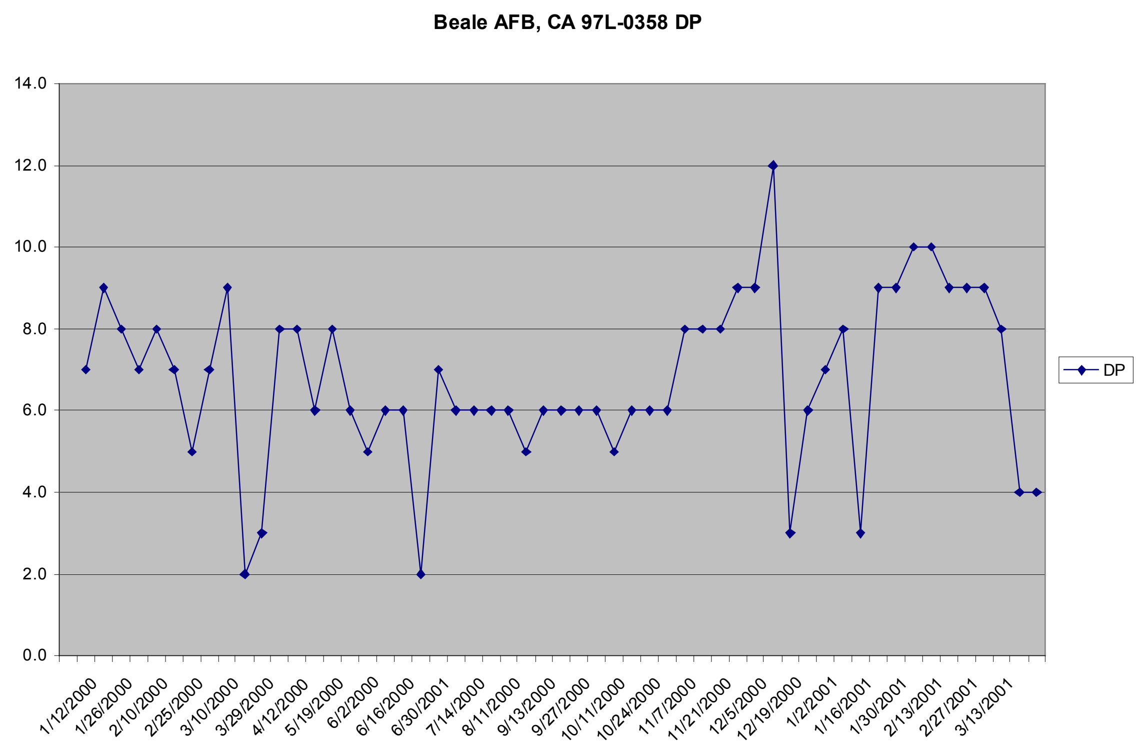
2/27/2001
3/13/2001



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1/12/2000
1/26/2000
2/10/2000
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4/12/2000
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6/2/2000
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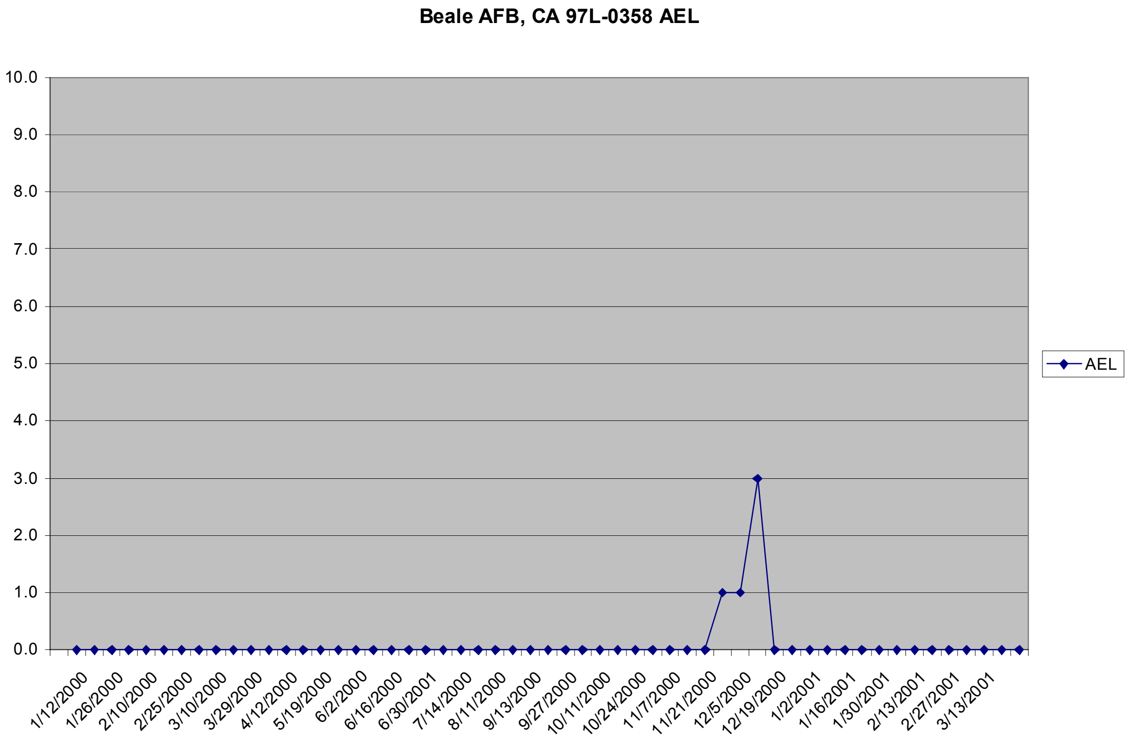
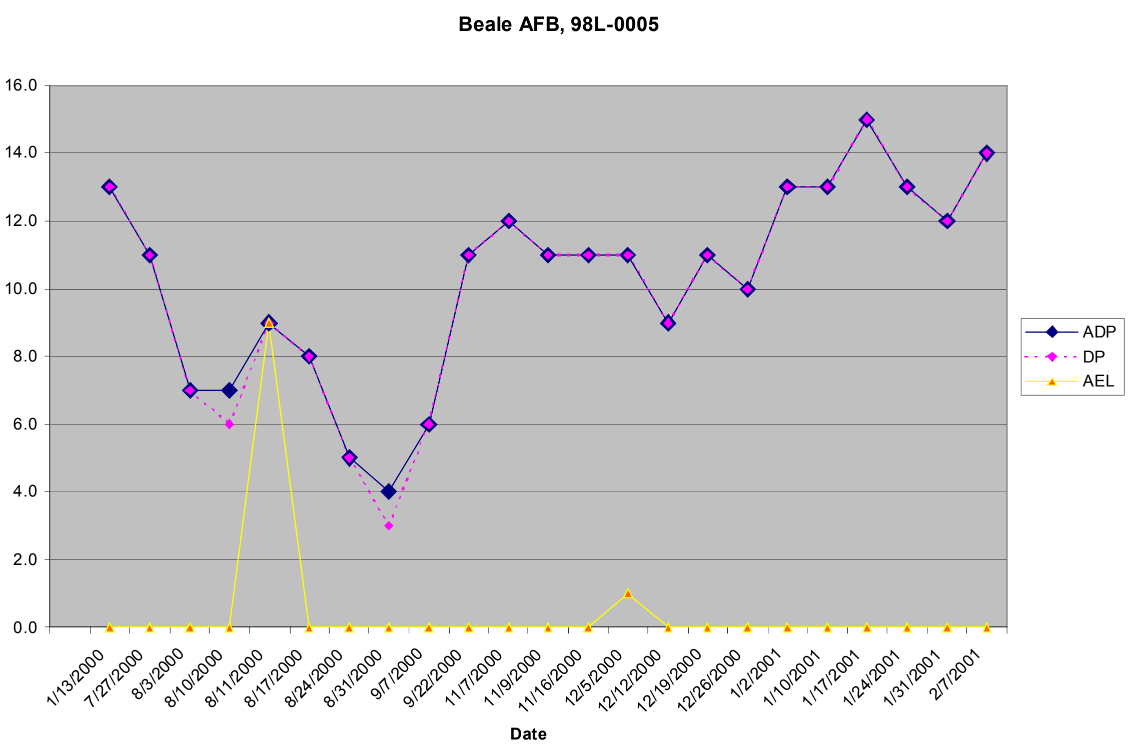
3/13/2001


Beale AFB, CA 97L-0358 AEL
AEL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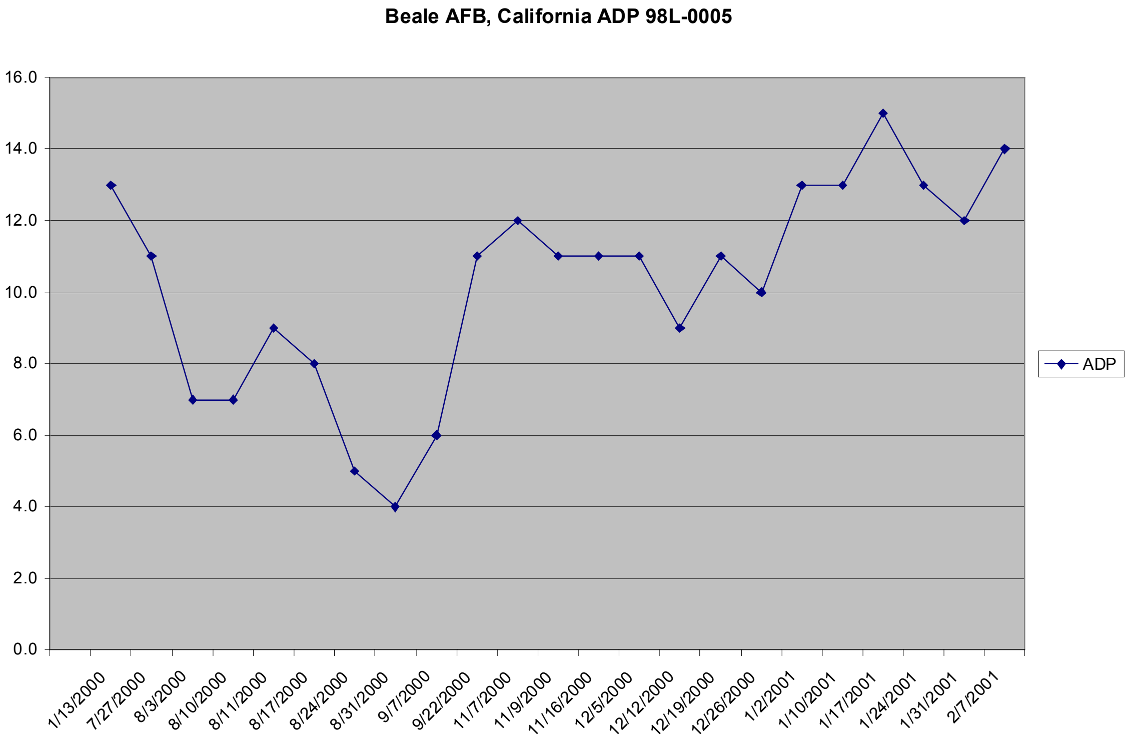
ADP
DP
AEL
Date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7/27/2000
8/3/2000
8/10/2000
8/11/2000
8/17/2000
8/24/2000
8/31/2000
9/7/2000
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12/12/2000
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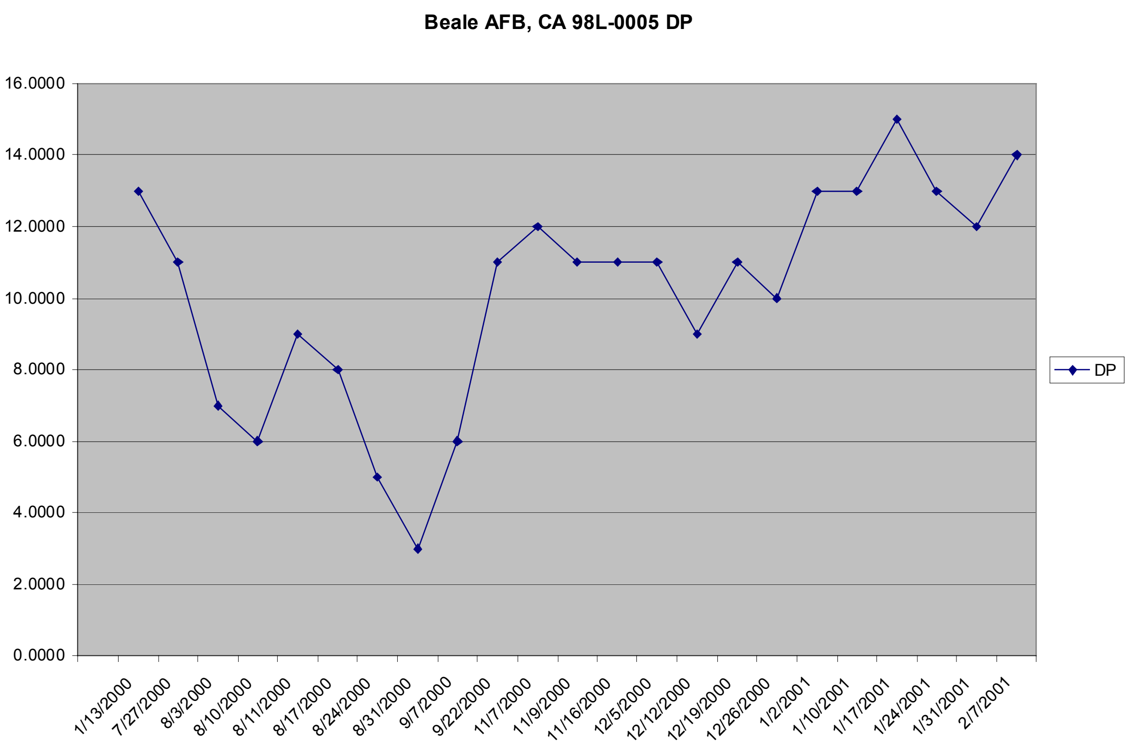
1/24/2001
1/31/2001
2/7/2001
ADP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8.0000
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1/13/2000
7/27/2000
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8/11/2000
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8/31/2000
9/7/2000
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12/5/2000
12/12/2000
12/19/2000
12/26/2000
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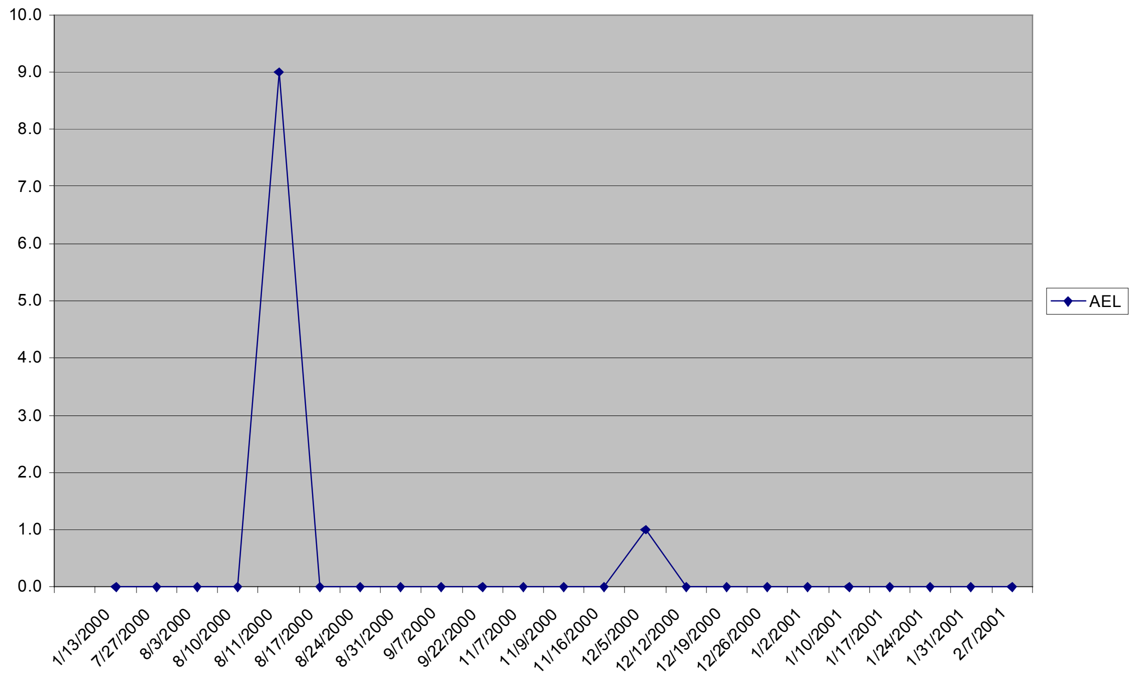
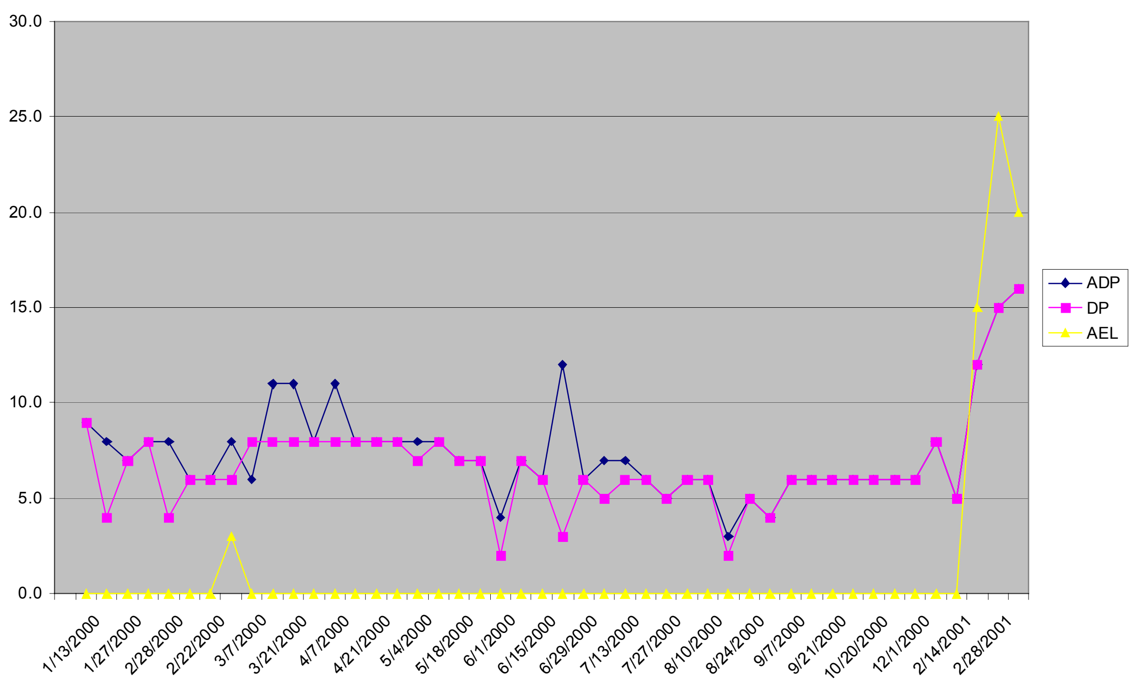
1/24/2001
1/31/2001
2/7/2001
DP

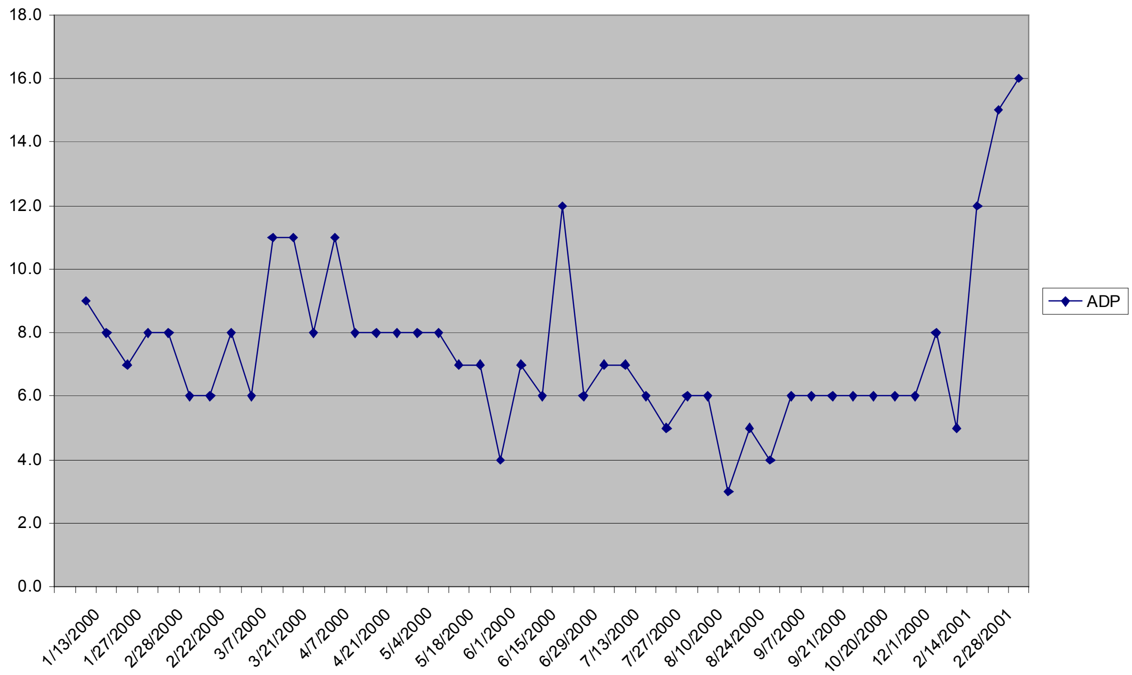
Beale AFB, CA 98L-0005 AEL



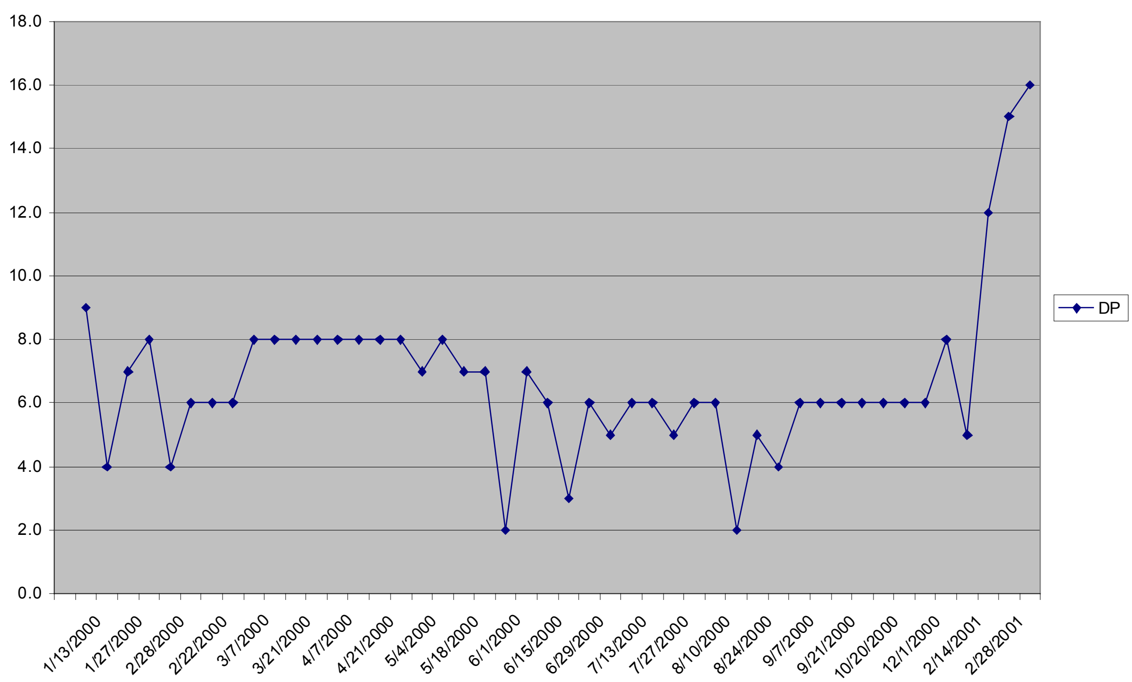
Beale AFB, California 98L-0024

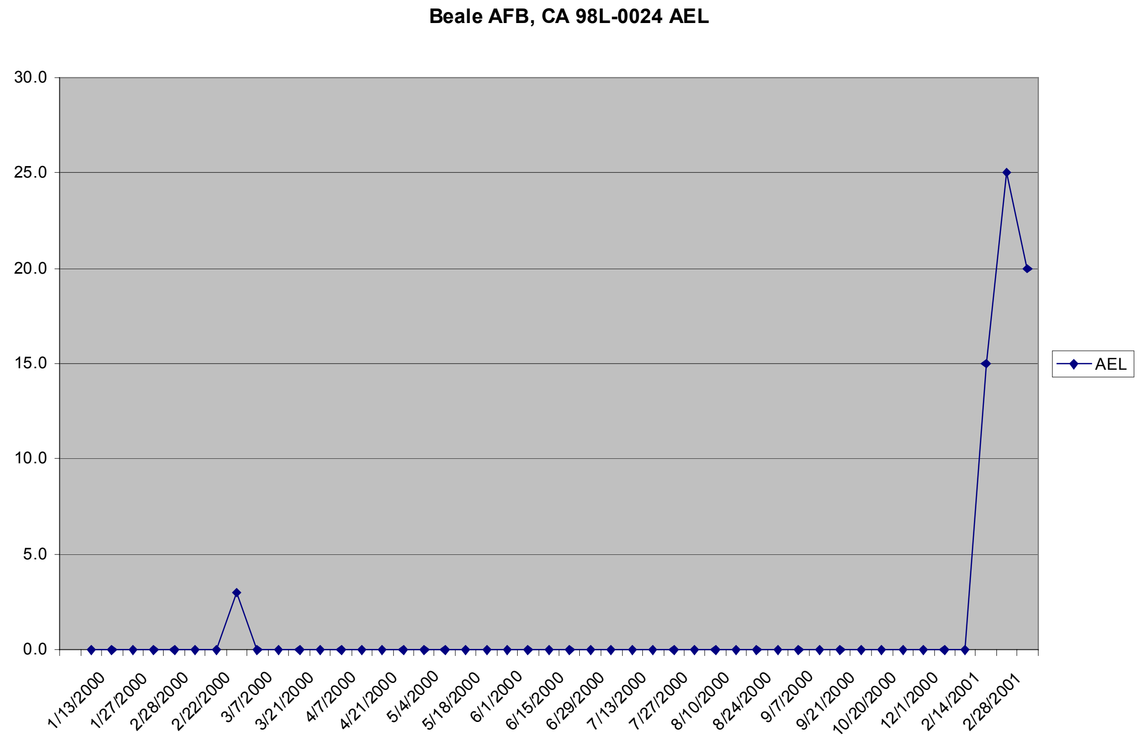


Beale AFB, CA 98L-0024 Refueler ADP



Beale AFB, CA 98L-0024 Refueler DP

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5.0
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1/13/2000
1/27/2000
2/28/2000
2/22/2000
3/7/2000
3/21/2000
4/7/2000
4/21/2000
5/4/2000
5/18/2000
6/1/2000
6/15/2000
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7/27/2000
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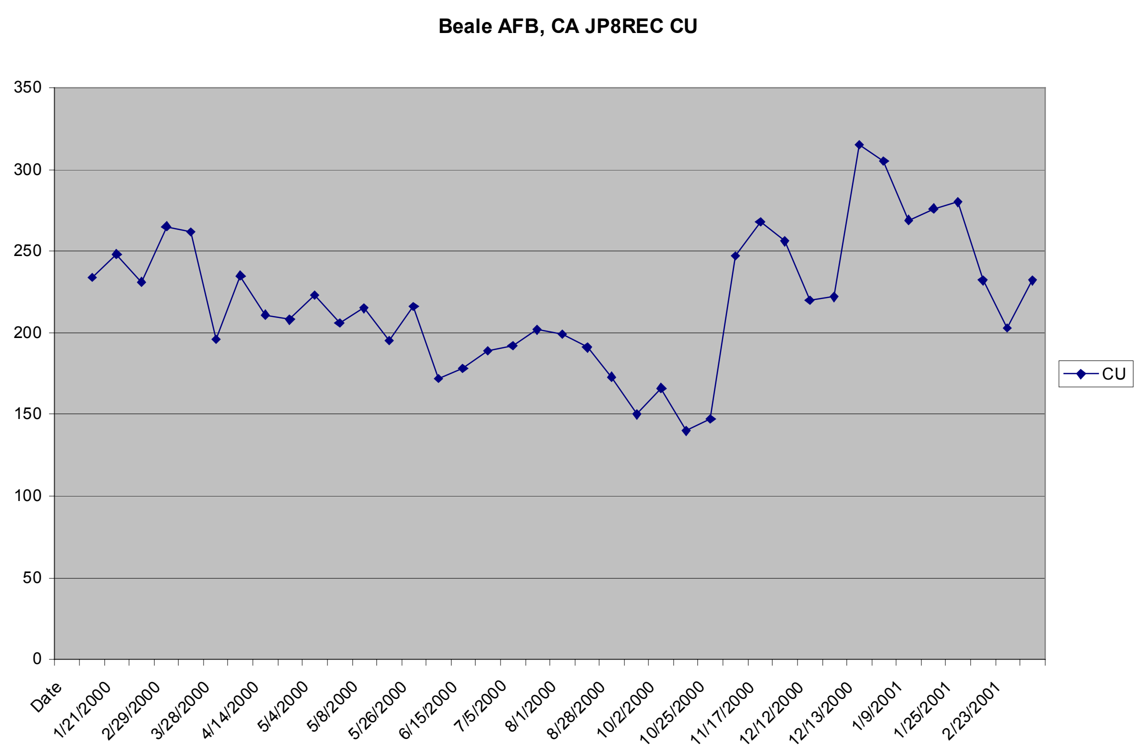
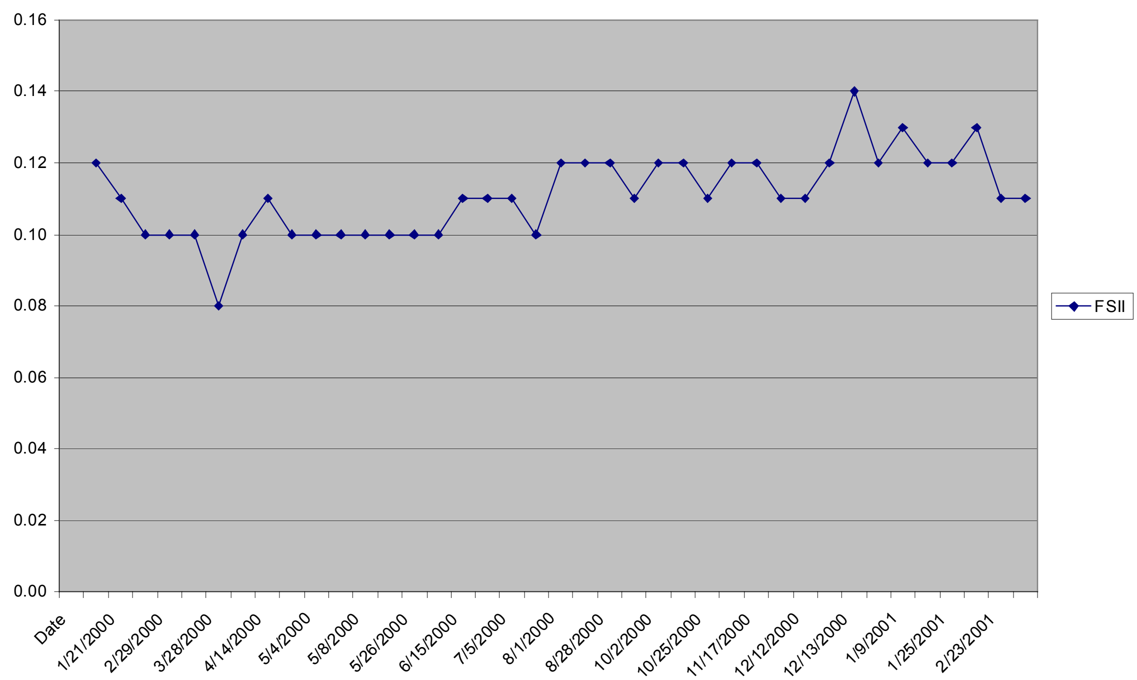
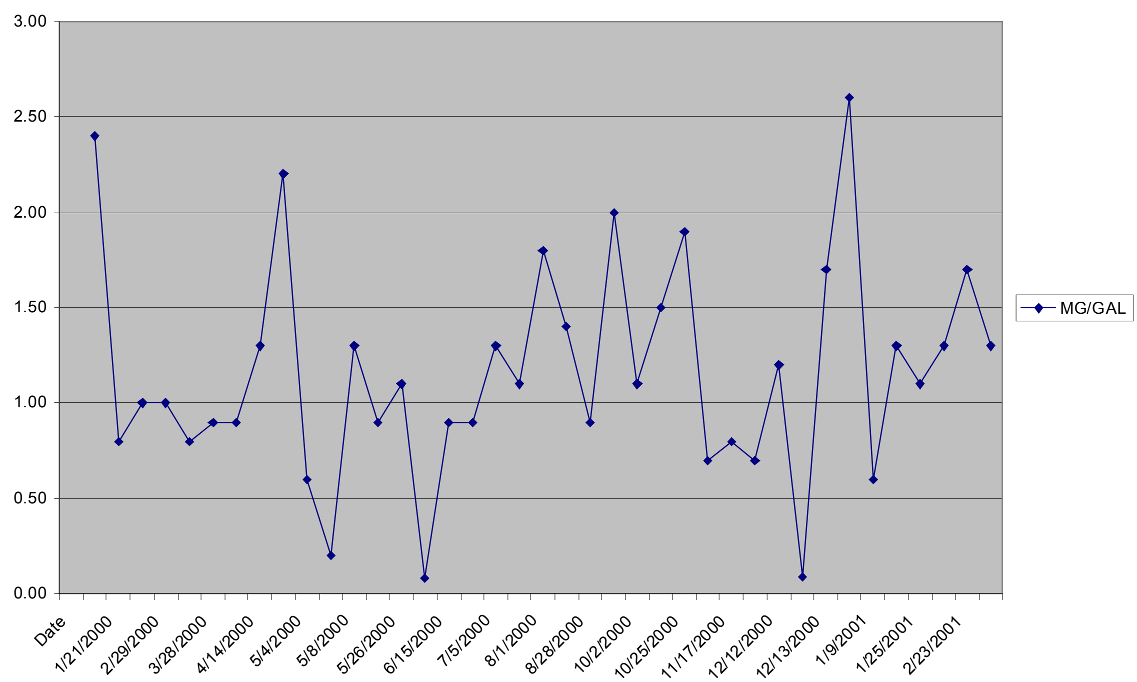
9/21/2000
10/20/2000
12/1/2000
2/14/2001
2/28/2001
AEL

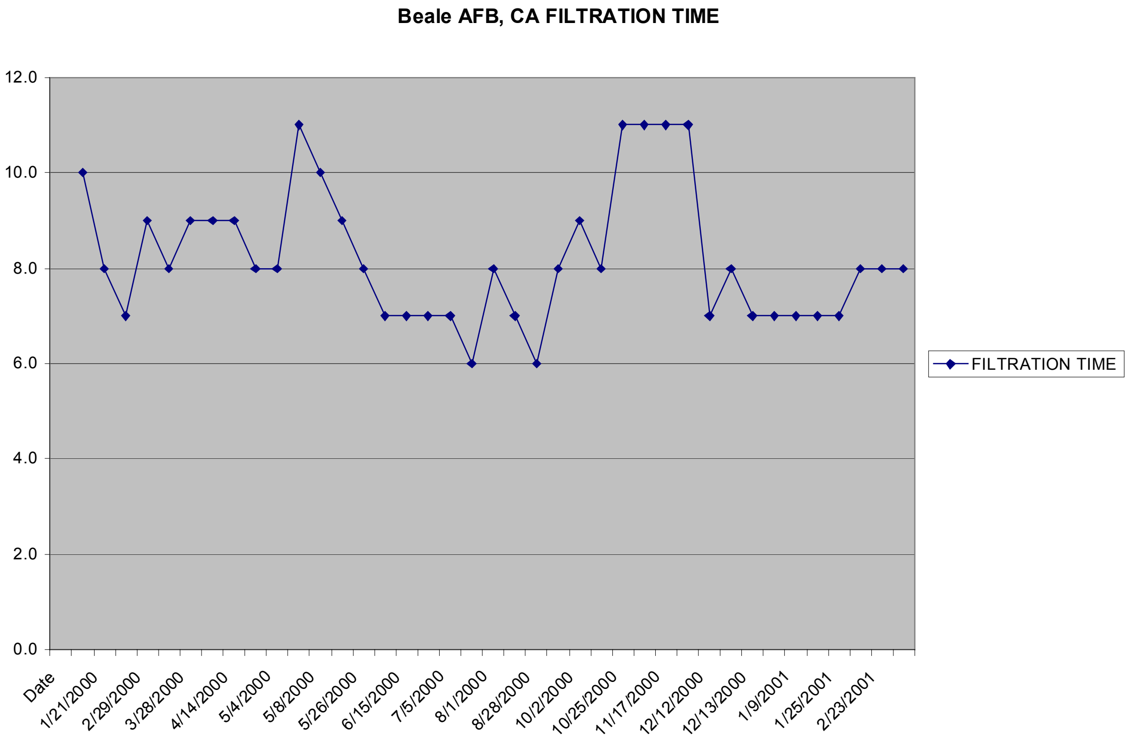

Beale AFB, CA JP8REC CU
350
300
250
200
150
100
50
0
Date
1/21/2000
2/29/2000
3/28/2000
4/14/2000
5/4/2000
5/8/2000
5/26/2000
6/15/2000
7/5/2000
8/1/2000
8/28/2000
10/2/2000
10/25/2000
11/17/2000
12/12/2000
12/13/2000
1/9/2001
1/25/2001
2/23/2001
CU

Beale AFB, CA JP8REC FSII



Beale AFB, CA JP8REC MG/GAL

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10.0
8.0
6.0
4.0
2.0
0.0
Date
1/21/2000
2/29/2000
3/28/2000
4/14/2000
5/4/2000
5/8/2000
5/26/2000
6/15/2000
7/5/2000
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8/28/2000
10/2/2000
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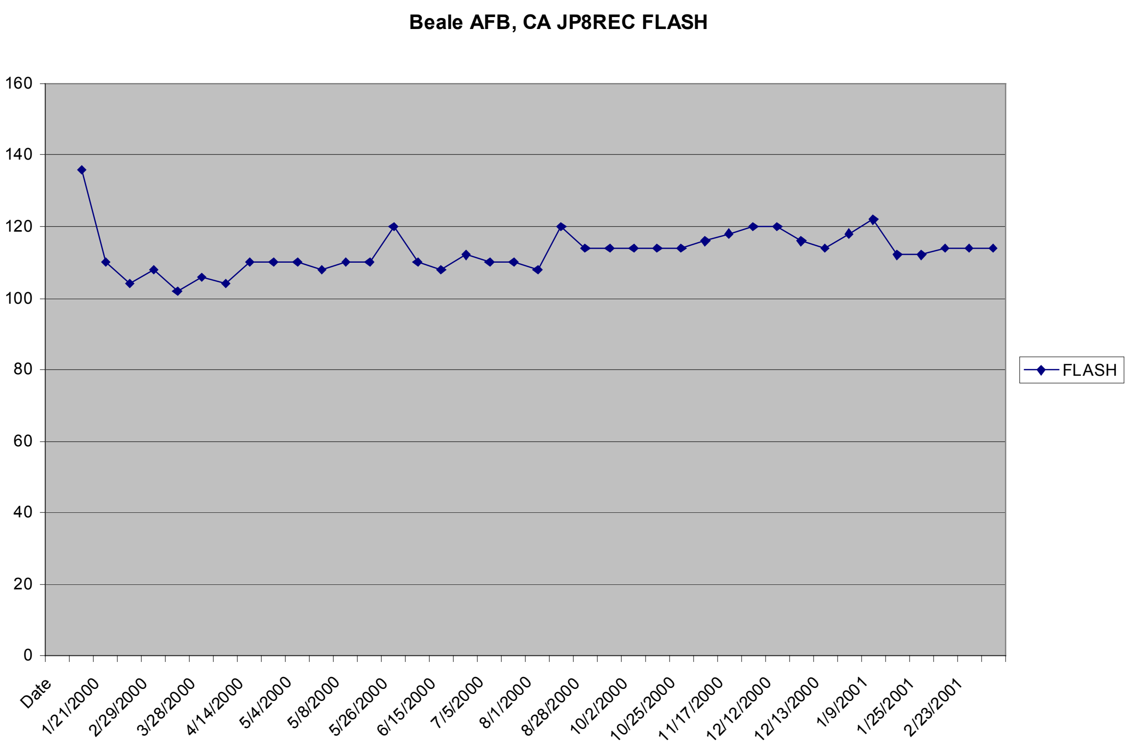
12/13/2000
1/9/2001
1/25/2001
2/23/2001
FILTRATION TIME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160
140
120
100
80
60
40
20
0
Date
1/21/2000
2/29/2000
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4/14/2000
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5/8/2000
5/26/2000
6/15/2000
7/5/2000
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8/28/2000
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11/17/2000
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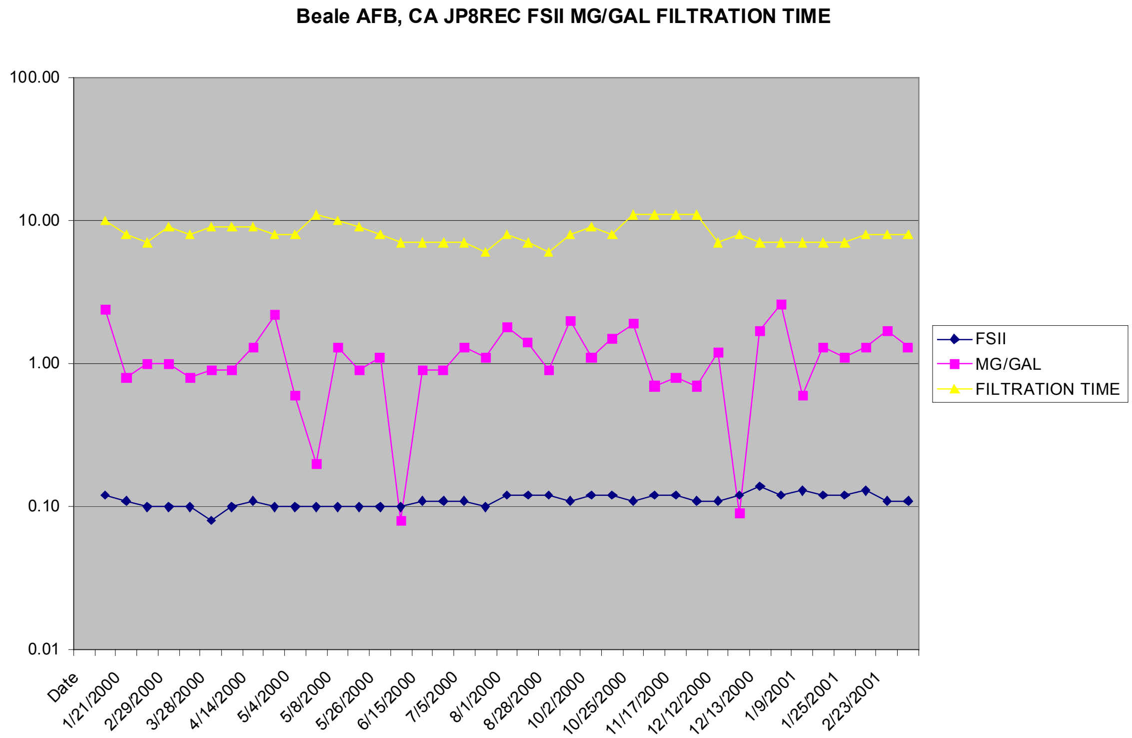
12/13/2000
1/9/2001
1/25/2001
2/23/2001
FLASH



Beale AFB, CA JP8REC FSII MG/GAL FILTRATION TIME
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0.10
0.01
Date
1/21/2000
2/29/2000
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5/8/2000
5/26/2000
6/15/2000
7/5/2000
8/1/2000
8/28/2000
10/2/2000
10/25/2000
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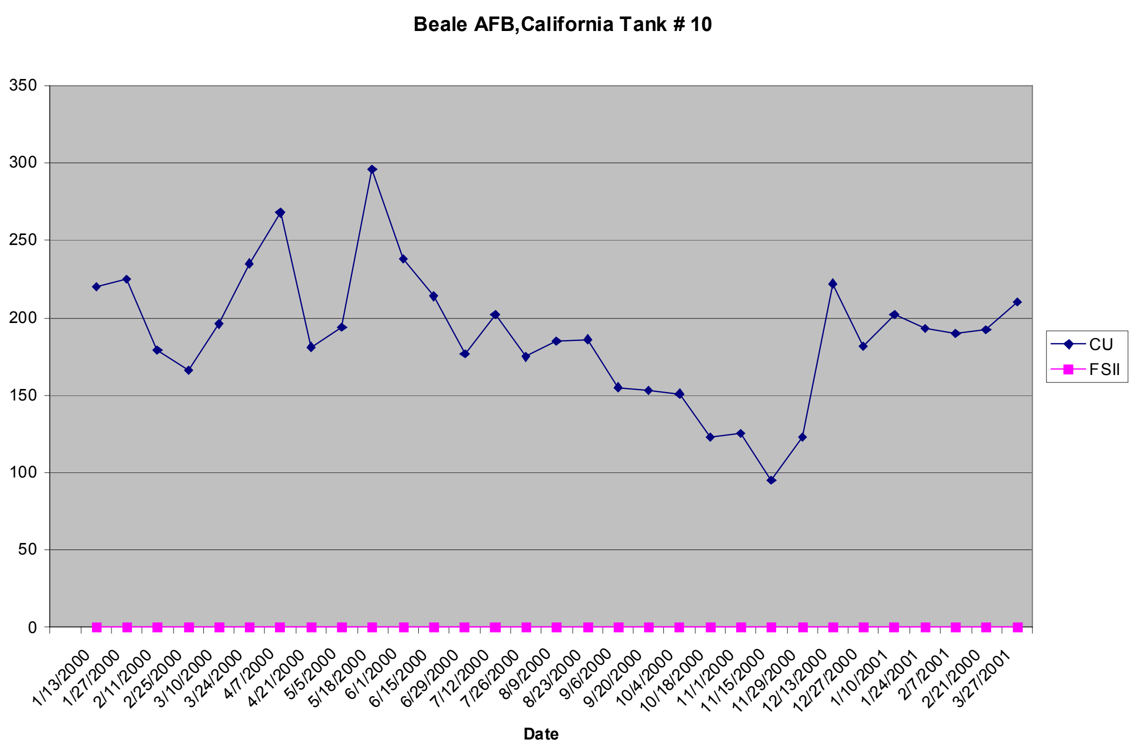
12/13/2000
1/9/2001
1/25/2001
2/23/2001
FSII
MG/GAL
FILTRATION TIME



Beale AFB,California Tank # 10
350
300
250
200
150
100
50
0
1/13/2000
1/27/2000
2/11/2000
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3/10/2000
3/24/2000
4/7/2000
4/21/2000
5/5/2000
5/18/2000
6/1/2000
6/15/2000
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10/4/2000
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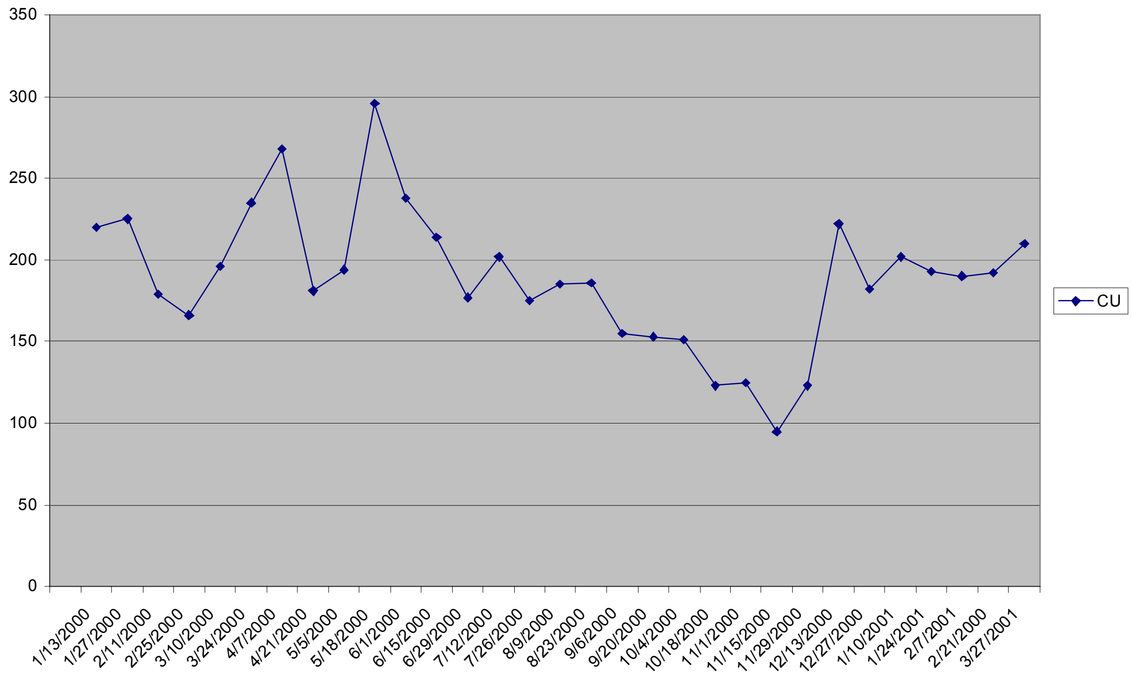
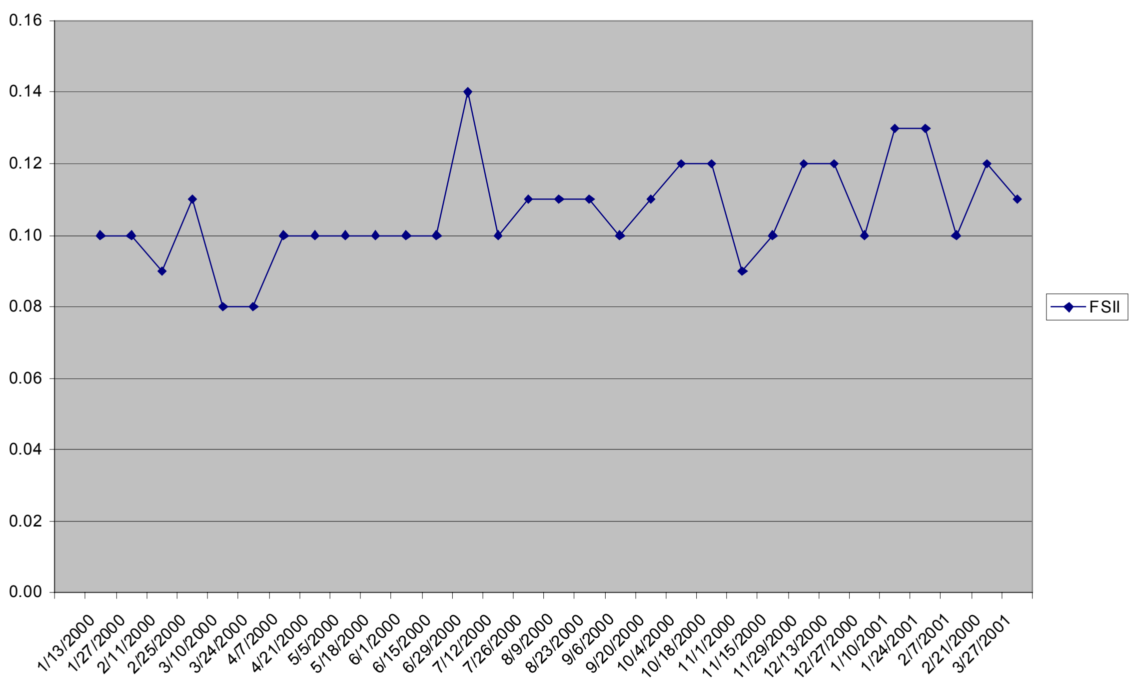
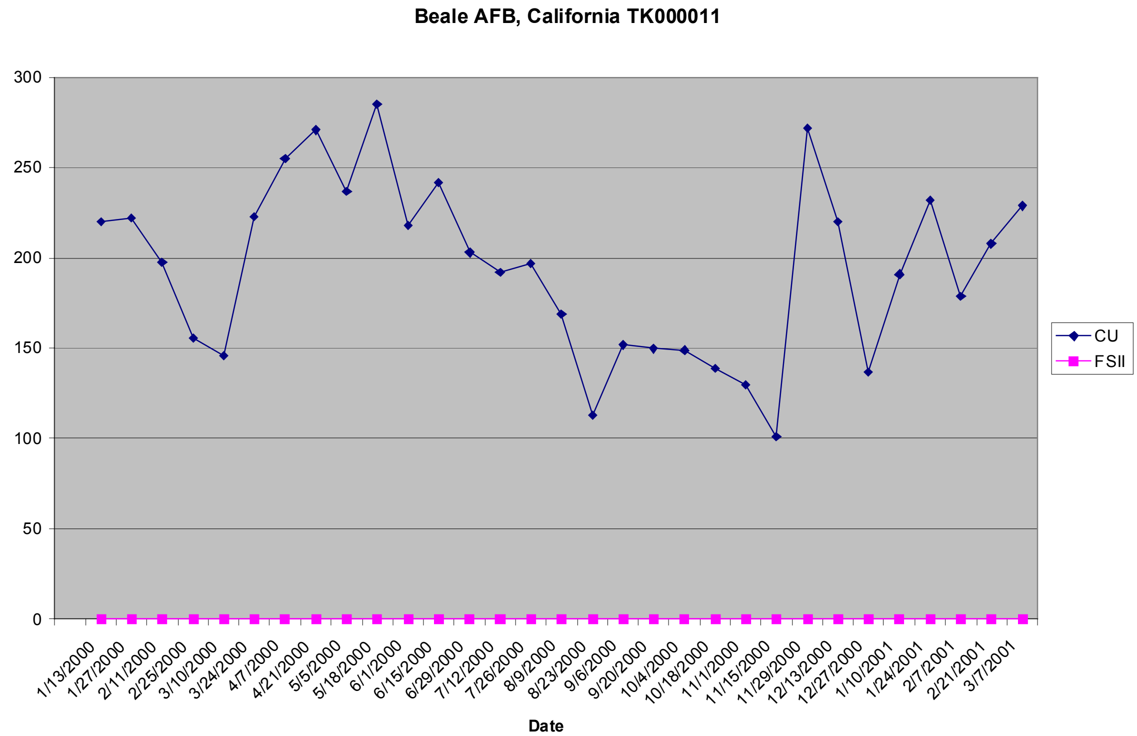
11/15/2000
11/29/2000
12/13/2000
12/27/2000
1/10/2001
1/24/2001
2/7/2001
2/21/2000
3/27/2001
Date
CU
FSII

Beale AFB, CA Tank #10 CU



Beale AFB, CA Tank # 10 FSII

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250
200
150
100
50
0
CU
FSII
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1/27/2000
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4/7/2000
4/21/2000
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5/18/2000
6/1/2000
6/15/2000
6/29/2000
7/12/2000
7/26/2000
8/9/2000
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11/15/2000
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2/7/2001
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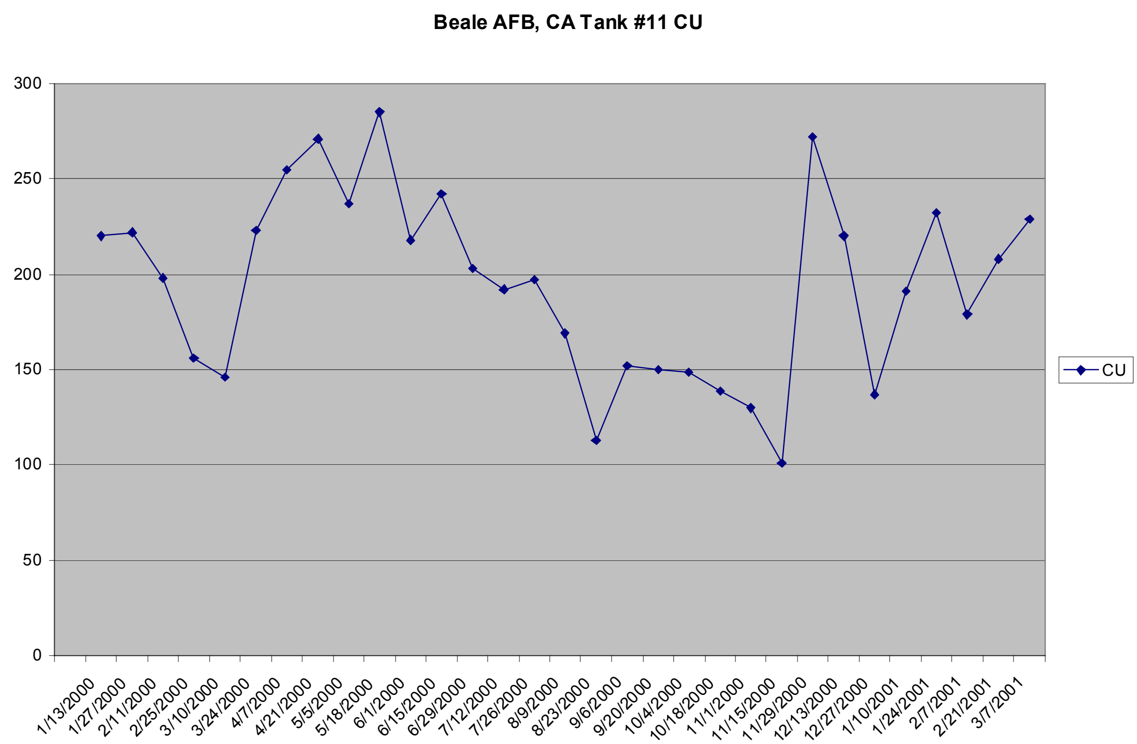
3/7/2001
Date


Beale AFB, CA Tank #11 CU
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150
100
50
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CU
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6/1/2000
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10/4/2000
10/18/2000
11/1/2000
11/15/2000
11/29/2000
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1/24/2001
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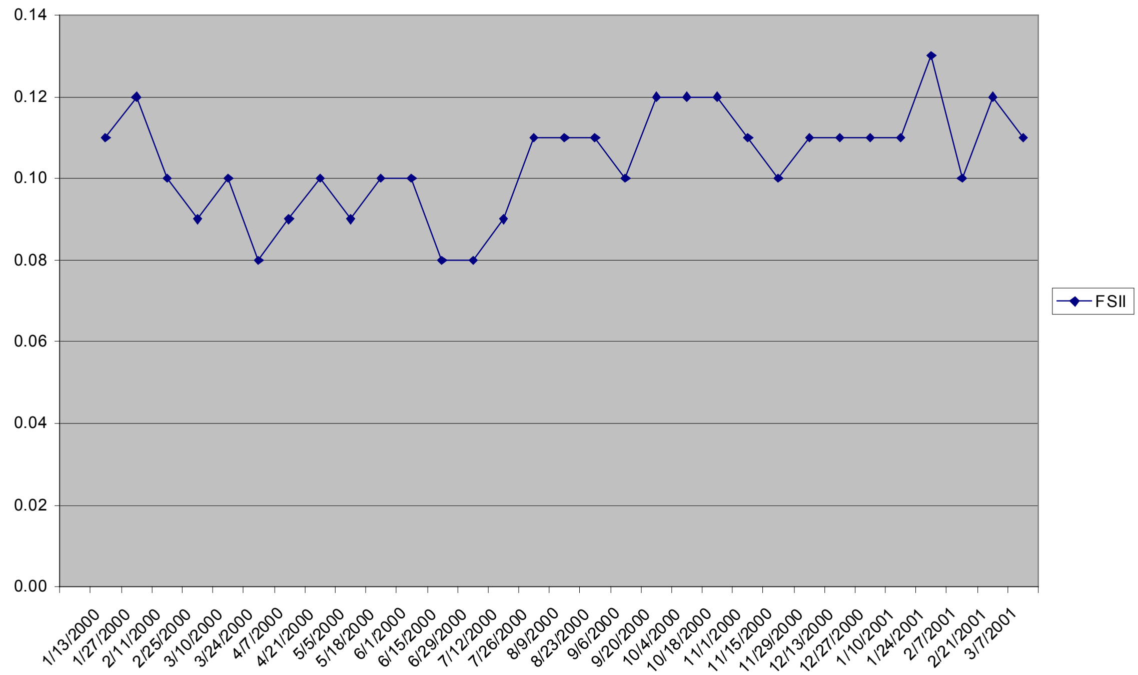
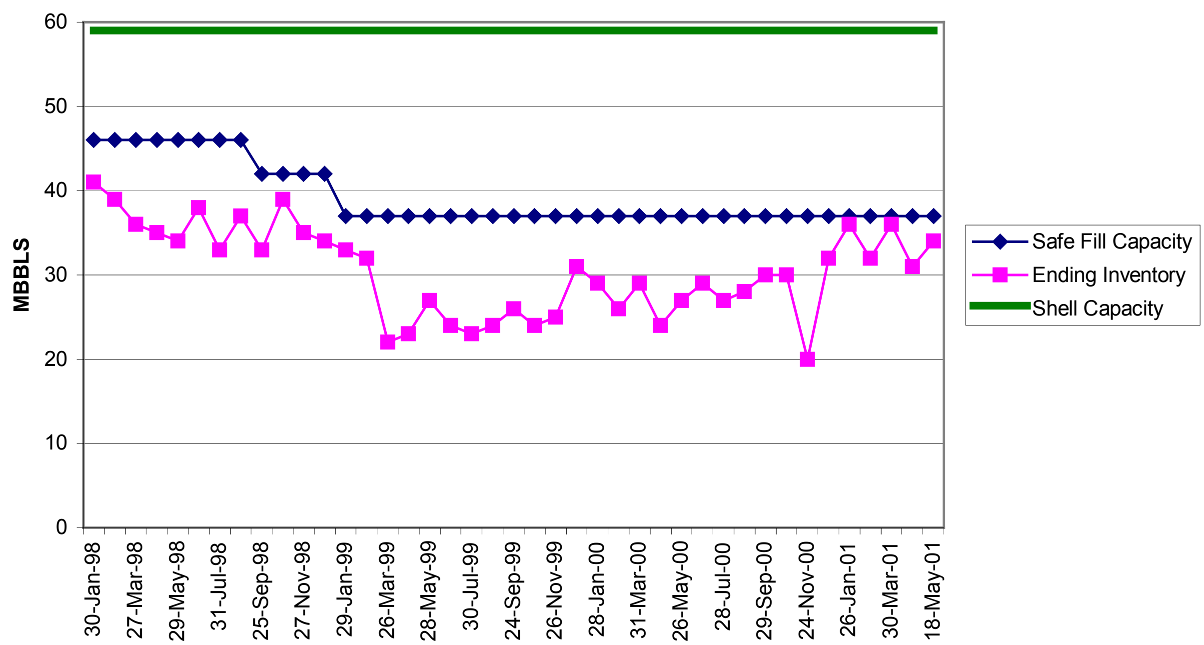
2/21/2001
3/7/2001

Beale AFB, CA Tank#11 FSII



Beale AFB
JP-8 Inventory History



Appendix E-28

Fairchild AFB, WA

92 SUPS/LGSF
610 Depot Avenue
Fairchild AFB, WA 99011

Fuels Officer: 2Lt Anthony Mostek, Phone: 509-247-4258, Fax: 509-247-2882, anthony.mostek@fairchild.af.mil
Fuels Superintendent: CMSgt Lloyd Tyre, Phone: 509-247-4258, Fax: 509-247-2882, lloyd.tyre@fairchild.af.mil
QC&I Supervisor: Thomas Wade, Phone: 509-247-4250, Fax: 509-247-2882, thomas.wade@fairchild.af.mil
LFM Supervisor: Charles Whitted, Phone: 509-247-2715, Fax: 509-247-8980, charles.whitted@fairchild.af.mil
RFM Supervisor: Charles Gooch, Phone: 509-247-5843, Fax: 509-247-3500, charles.gooch@fairchild.af.mil

AJ Investigation Team: Larry Dipoma (C4e) and E. Mac Fishburn (C4e).

AJ Incidents
Fairchild AFB first encountered AJ on December 13, 2000, after differential pressures on the filter-separators of four Kovatch R-11 refuelers rapidly increased. In addition, AJ was drained from the cargo tank sump (upstream of the F/S) from one truck. The R-11 refuelers were equipped with Facet water absorption media elements during June 2000. The AJ was traced back to bulk tank #4, where they drained two or three quarters of AJ each day for several days. Following a transfer between Tank #4 and Tank #1 (20,000-bbl), AJ was also identified in Tank #1. Tanks #1 and #4 both have center-down cone bottoms with the suction lines located immediately above the bottom, sediment, and water sumps. Storage operators report that following heavy rainstorms, it is not unusual to drain 30 gallons of water from tank #4. Little water is found following product receipts. An active tank and vehicle sump-draining program has significantly reduced the amount of AJ drained from bulk tanks and vehicles, though AJ continues to be found periodically.

Product Receipts and Issues
JP-8 receipts range from 10,000 to 20,000 bbls. The JP-8 is moved by barge from DFSP Portland OR where it is loaded on barges that travel up the Columbia River for approximately 35 hours prior to arrival at DFSP Pasco. It takes about 12 hours to off load a barge into Chevron's 30,000-bbl tank at Pasco, WA. After the tank has settled approximately a day and a half, the tank is sampled. Following certification, the product is scheduled into the Chevron pipeline for delivery (approximately 150 miles and 60 hours later) to the Chevron Detection/Injection point. At this point the fuels passes through two 1,200-gpm Velcon vertical F/S vessels (model W 3644285) used

simultaneously, in parallel. Each F/S is equipped with eleven coalescers (I-64485TB and five-separator elements S-636PV}. According to the Chevron station manager, David Otto, the elements in these vessels are changed when the differential reaches 7 to 10 psi. FSII and SDA are injected approximately 25 feet downstream of the F/S. There is no breakout tankage at the Chevron Detection/Injection station, and the fuel moves directly into bulk storage at Fairchild AFB. The JP-8 moves though the Chevron Detection/Injection station at a rate that ranges from 16,800 to 31,500 gph through a six-inch pipeline. The above ground FSII storage tank is not equipped with moisture control (such as a desiccant or nitrogen blanket) but has a standard vacuum pressure vent and breathes to the atmosphere. The Government owned deliveries of FSII (6,000 tank trucks) are sampled at the loading point, but FSII in the Chevron tank is not sampled. FSII and SDA are injected with Gates City Injectors. The points of injection are approximately 10 inches apart. The Chevron facility is an automated station, though it is manned during receipts. It is an attractive station, constructed in 1996, and appears to be well maintained and managed. A continuous, automated sample is extracted from each receipt. The Chevron station manager, Dave Otto, reports that Pipeline Drag Reducer is not used for any product moved through the Chevron line.

Bulk Storage

The bulk storage at Fairchild AFB consists of two fixed-roof 20,000-bbl tanks. One is equipped with a vapor recovery dome. In addition, there is a 5,000-bbl tank, and a 30,000 bbl floating-roof tank with a geodesic dome designated as Tank #4. The geodesic dome on Tank #4 is ineffective in keeping water from entering the tank. The floating-roof in Tank# 4 leaks due to an ineffective tank seal that permits water to enter the fuel. FSII from the tank water bottoms was identified as damaging the epoxy around the tank perimeter. A project to make significant repairs to the three largest bulk storage tanks is at 35% design and badly need to resolve the AJ problem at Fairchild. This project will replace the floating pans in two tanks and the floating-roof in Tank #4. The 5,000-bbl tank will be removed. The product recovery system is ineffective and should be reviewed for possible inclusion in this project. We also recommend that the positioning of the product suction lines in these tanks be reviewed to insure that bottom sediment and water is not easily picked up and forced into the F/S. Our investigation indicates that water does not readily settle from JP-8. While we realized that this would be the situation because of the higher density of JP-8 (as compared to JP-4) we now are concerned that the problem of water retention within JP-8 is far more serious than we previously believed. Alternative methods of water removals, such as the use of a centrifuge (typically used by the Navy in the handling of JP-5 on board ships) or smart use of "haypack" dehydrators, should be explored.

Assigned Refueling Equipment

Fairchild has 10 assigned R-11 refuelers, 6 Kovatch and 4 Oshkosh. Water absorption (JP-8+100) elements were installed in these refuelers during the period from June through December 2000. There are five hydrant servicers, 3 R-12Cs and 2 R-12s. The R-12C does not have defueling capability.

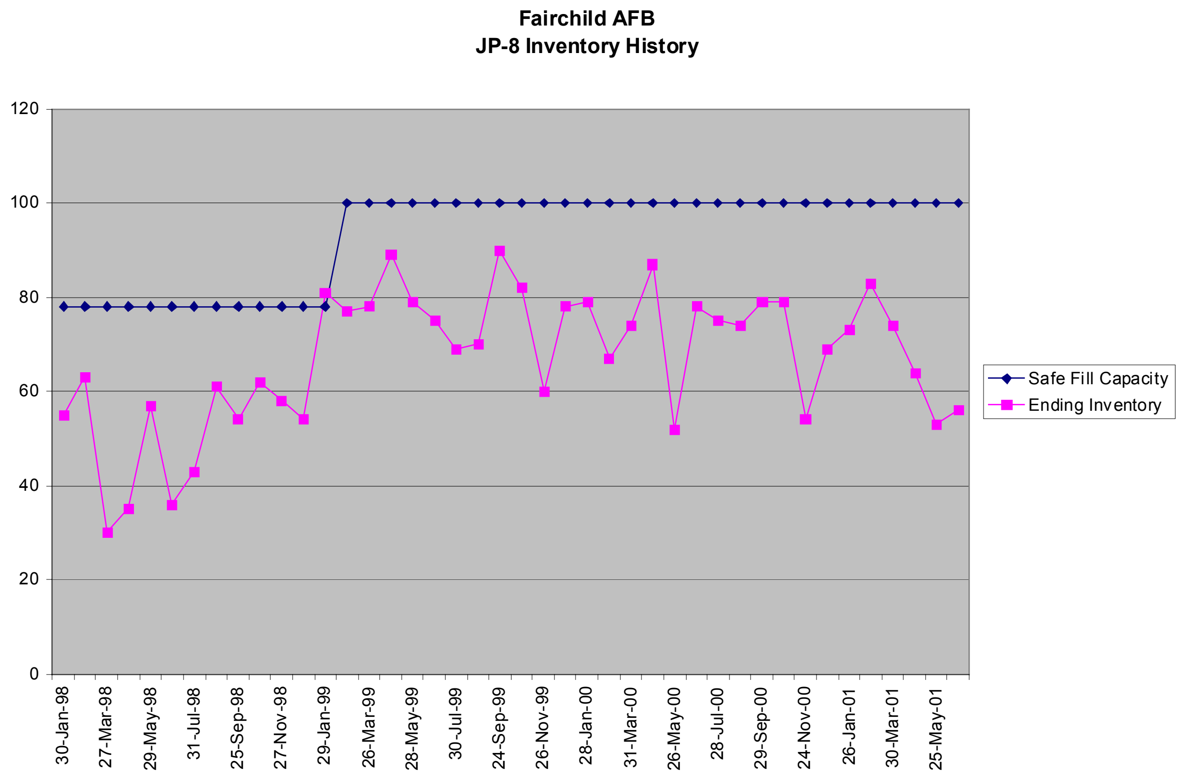
Hydrant Facilities
Hydrant System A is a Type II system with 10 each Bowser 842 vertical F/S vessels used to issue to a truck fill stand and KC-135 aircraft. This system is being replaced with a Type III system that is currently under construction. We drew a sample from the sump of the F/S with widest differential pressure spread over the last 30 days (3-12 psi) and found the sample to be clear and bright with no indication of free-water or AJ.

Hydrant System B is a Type III system with seven horizontal API Group II, Class B, 600 GPM vessels. The F/S vessels were manufactured by Facet (CFCS-D-7K395B-1-2 636FM) and use seven CA38-35B coalescer elements and two SS636FF separator elements. Two F/S vessels are used to filter transfers from bulk storage and five are used for hydrant issues. These F/S are flow rated at 600-gpm and are all the same model and manufacturer. The hydrant systems are normally used to refill JP-8 refuelers in lieu of traveling to the bulk storage area.

Products Stored
JP-8.

Product Quality Data
Data on FSII and SDA test results with associated temperatures were downloaded from the FAS system. This data was collected and retained as part of this survey. In general terms, the fuel is received clear and bright. FSII readings on receipt range from .09 to .15 and conductivity ranges from 219 to 560 CUs. Additionally, we measured the conductivity of an AJ sample that was stored in the fuels laboratory. Fuel from the sample was separated from the AJ and tested separately. The fuel had a conductivity level of 3,000+ while the AJ reading exceeded 4,000 CUs.

Aircraft Maintenance Questionnaire
The Aircraft Maintenance Questionnaire was distributed to the fuel cell repair and aircraft maintenance personnel, and they attended a meeting for a general discussion of the AJ problem. They reported that AJ had not been encountered on the assigned KC-135s. One crew chief invited us to accompany him to his KC-135 where he briefed us on the engine fuel system, and he touched on the fact that the engine was a GE 110 engine. He explained that this engine is also used with an augmenter section on the F-16.


Fairchild AFB
JP-8 Inventory History
120
100
80
60
40
20
0
30-Jan-98
27-Mar-98
29-May-98
31-Jul-98
25-Sep-98
27-Nov-98
29-Jan-99
26-Mar-99
28-May-99
30-Jul-99
24-Sep-99
26-Nov-99
28-Jan-00
31-Mar-00
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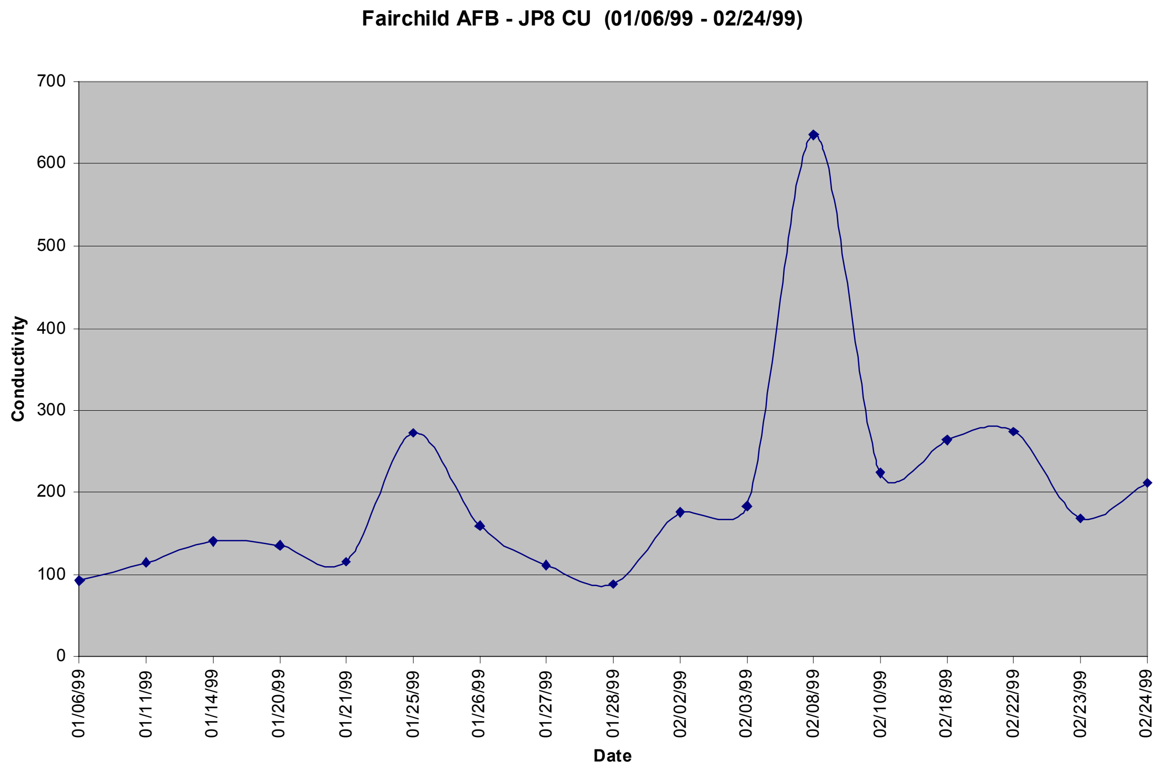
Safe Fill Capacity
Ending Inventory


Fairchild AFB - JP8 CU (01/06/99 - 02/24/99)
Conductivity
0
100
200
300
400
500
600
700
01/06/99
01/11/99
01/14/99
01/20/99
01/21/99
01/25/99
01/26/99
01/27/99
01/28/99
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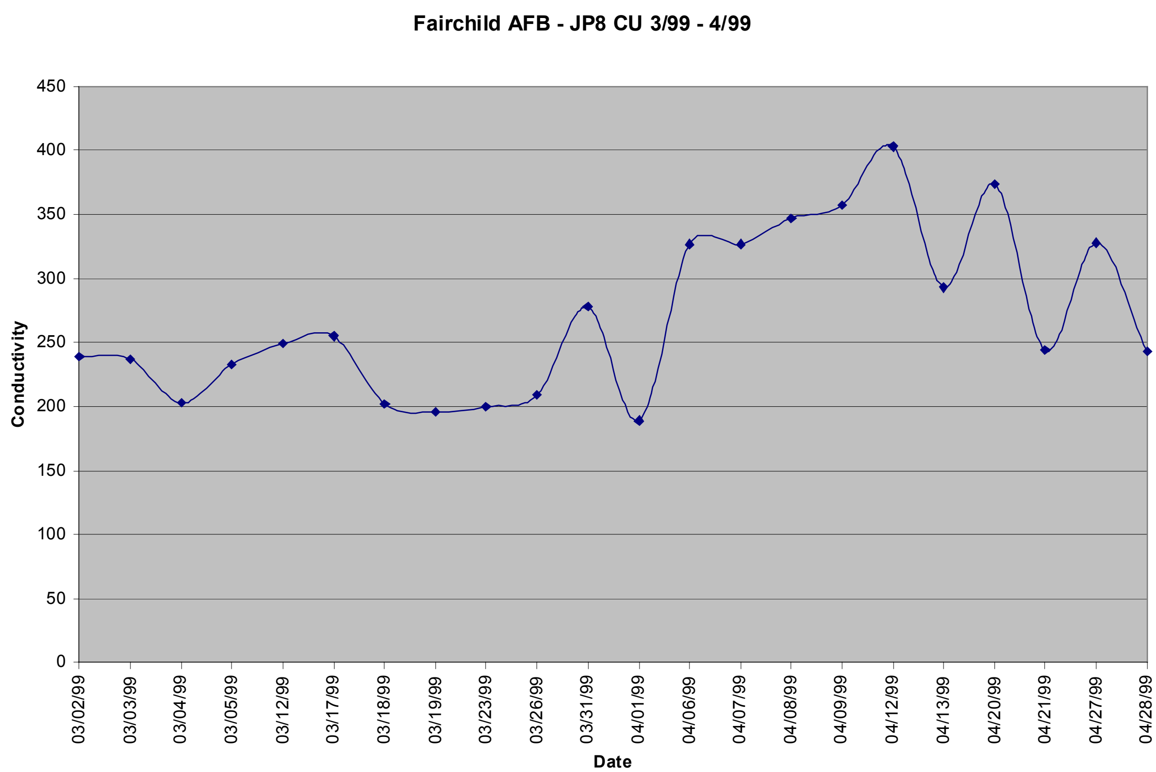
02/23/99
02/24/99
Date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Conductivity
0
50
100
150
200
250
300
350
400
450
03/02/99
03/03/99
03/04/99
03/05/99
03/12/99
03/17/99
03/18/99
03/19/99
03/23/99
03/26/99
03/31/99
04/01/99
04/06/99
04/07/99
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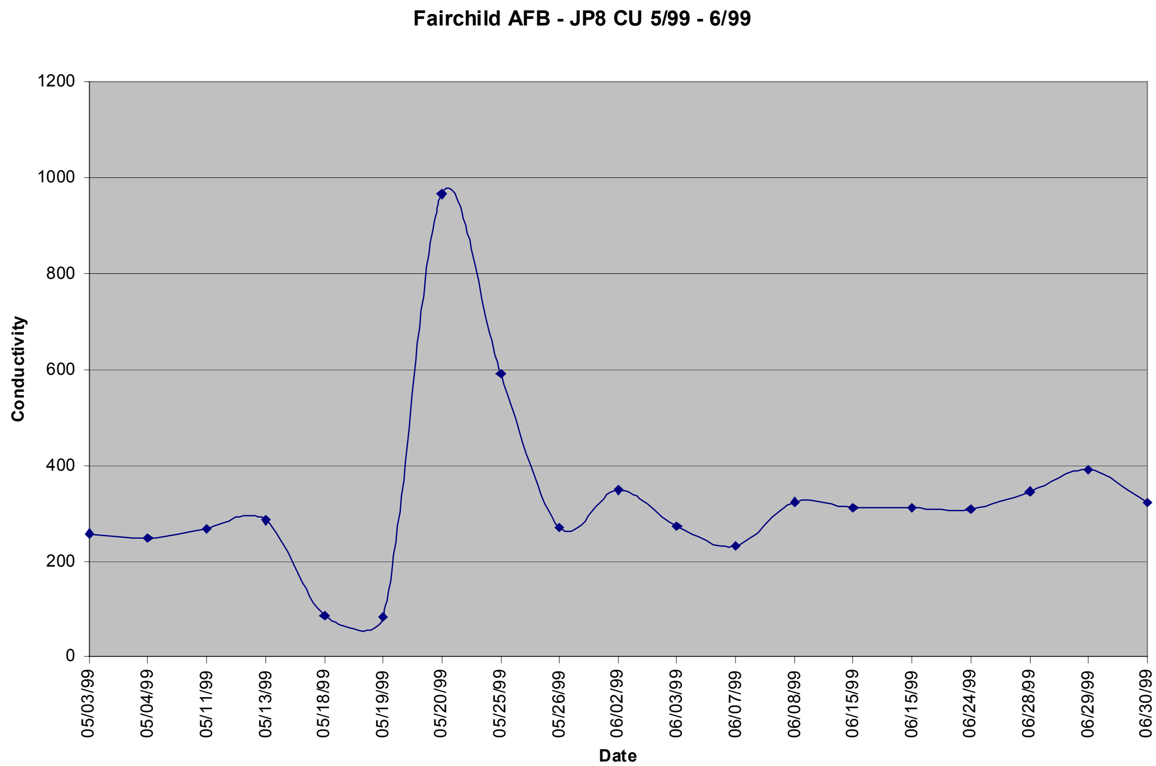
04/27/99
04/28/99
Date



Fairchild AFB - JP8 CU 5/99 - 6/99
Conductivity
Date
0
200
400
600
800
1000
1200
05/03/99
05/04/99
05/11/99
05/13/99
05/18/99
05/19/99
05/20/99
05/25/99
05/26/99
06/02/99
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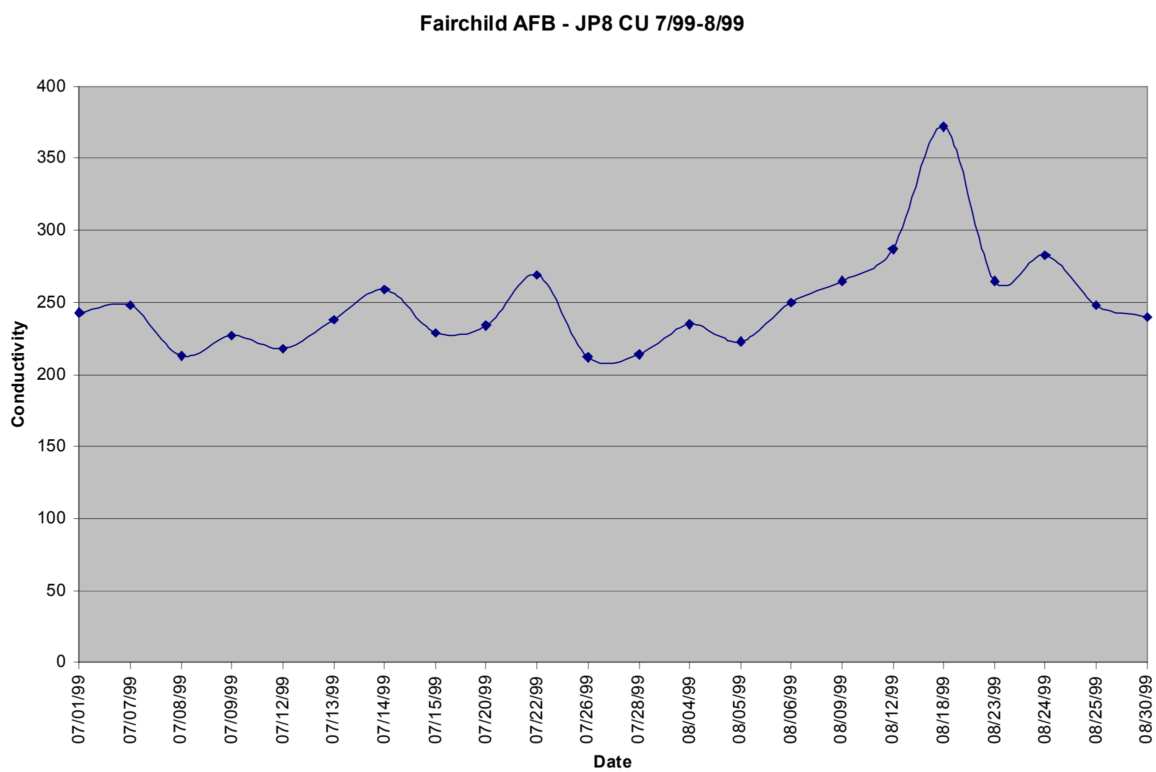
06/29/99
06/30/99



Fairchild AFB - JP8 CU 7/99-8/99
Conductivity
Date
0
50
100
150
200
250
300
350
400
07/01/99
07/07/99
07/08/99
07/09/99
07/12/99
07/13/99
07/14/99
07/15/99
07/20/99
07/22/99
07/26/99
07/28/99
08/04/99
08/05/99
08/06/99
08/09/99
08/12/99
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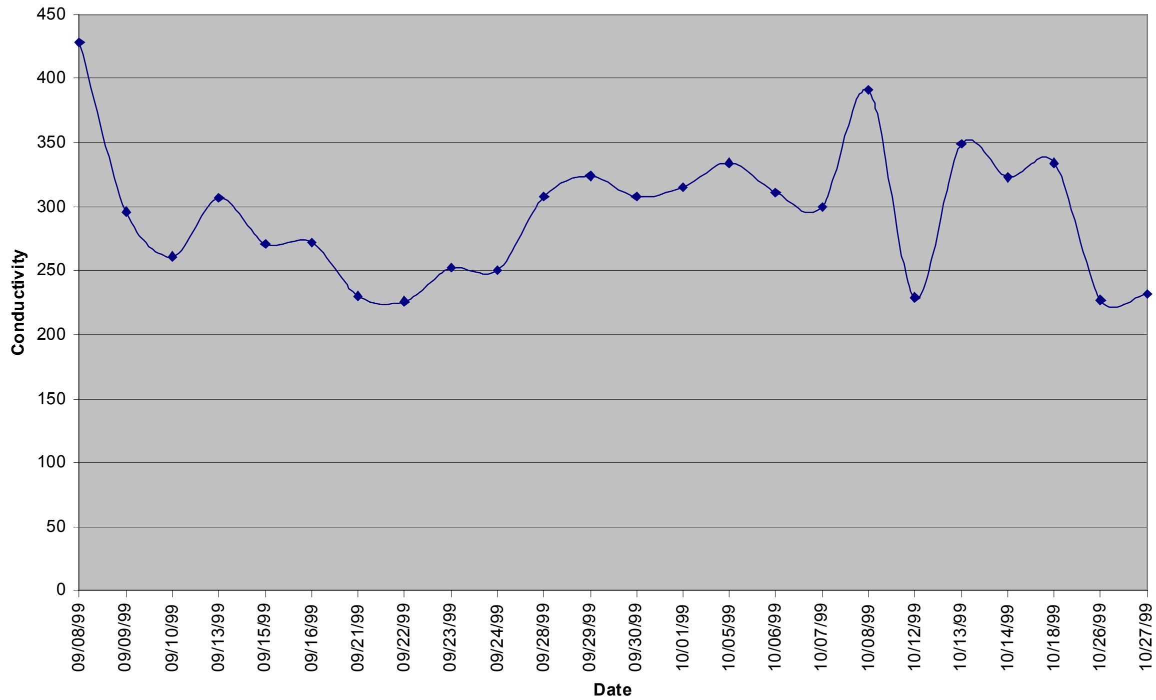
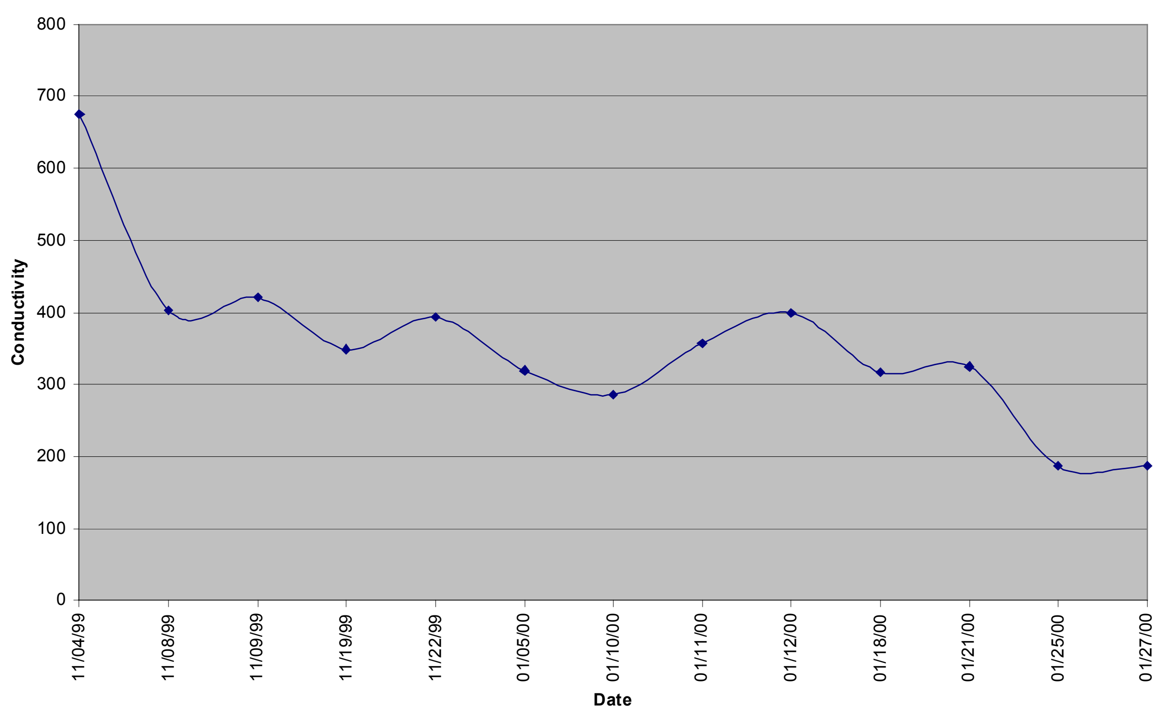
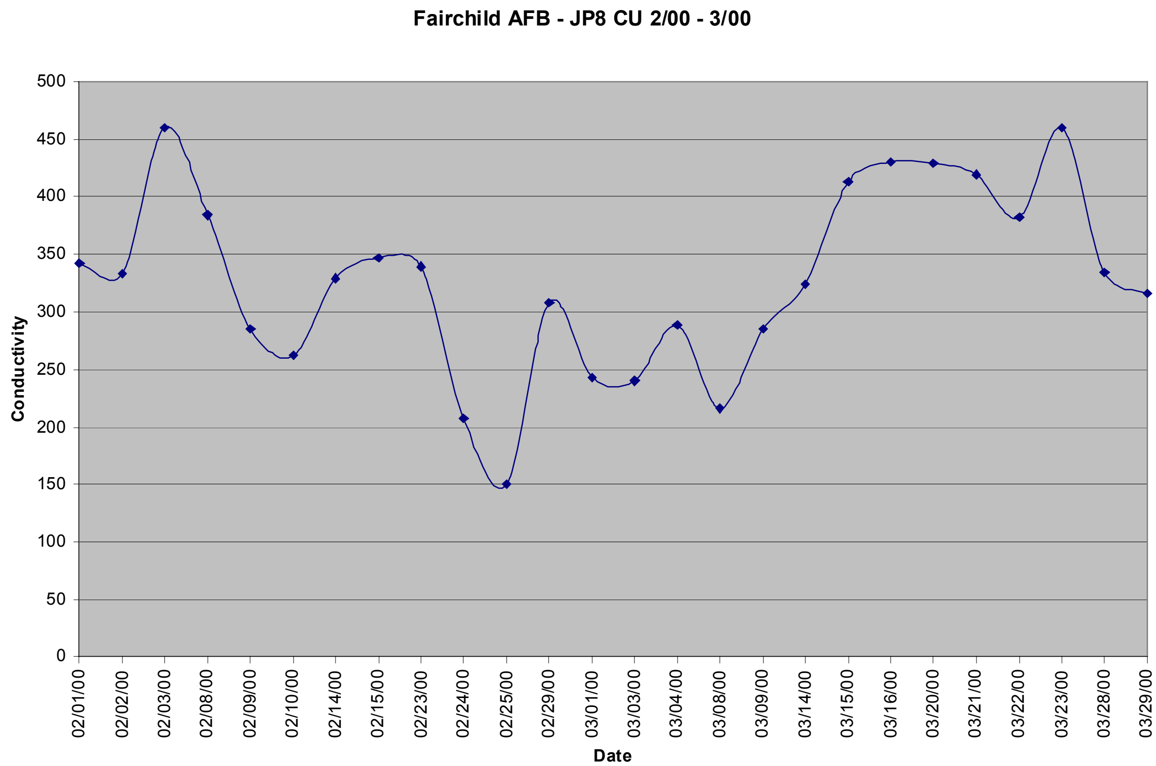
08/23/99
08/24/99
08/25/99
08/30/99

Fairchild AFB - JP8 CU 9/99 - 10/99



Fairchild AFB - JP8 CU 11/99 - 1/00




Fairchild AFB - JP8 CU 2/00 - 3/00
Conductivity
Date
500
450
400
350
300
250
200
150
100
50
0
02/01/00
02/02/00
02/03/00
02/08/00
02/09/00
02/10/00
02/14/00
02/15/00
02/23/00
02/24/00
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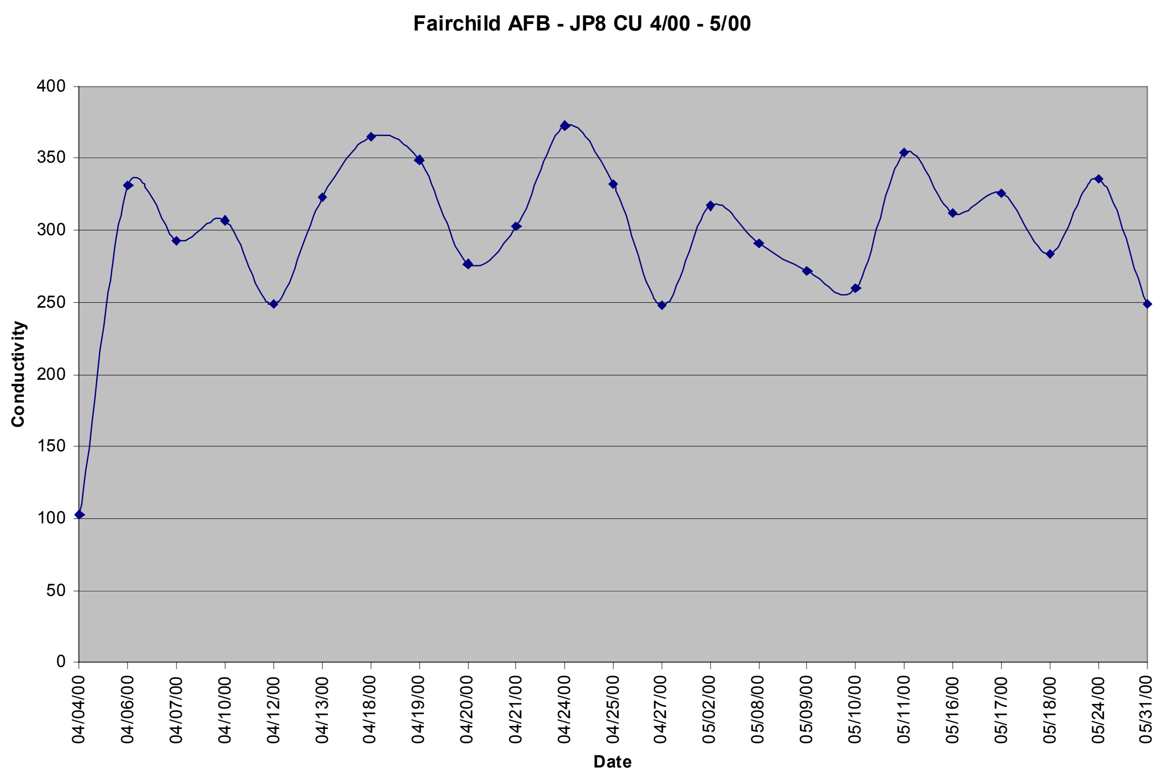
03/28/00
03/29/00


Fairchild AFB - JP8 CU 4/00 - 5/00
Conductivity
Date
400
350
300
250
200
150
100
50
0
04/04/00
04/06/00
04/07/00
04/10/00
04/12/00
04/13/00
04/18/00
04/19/00
04/20/00
04/21/00
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04/27/00
05/02/00
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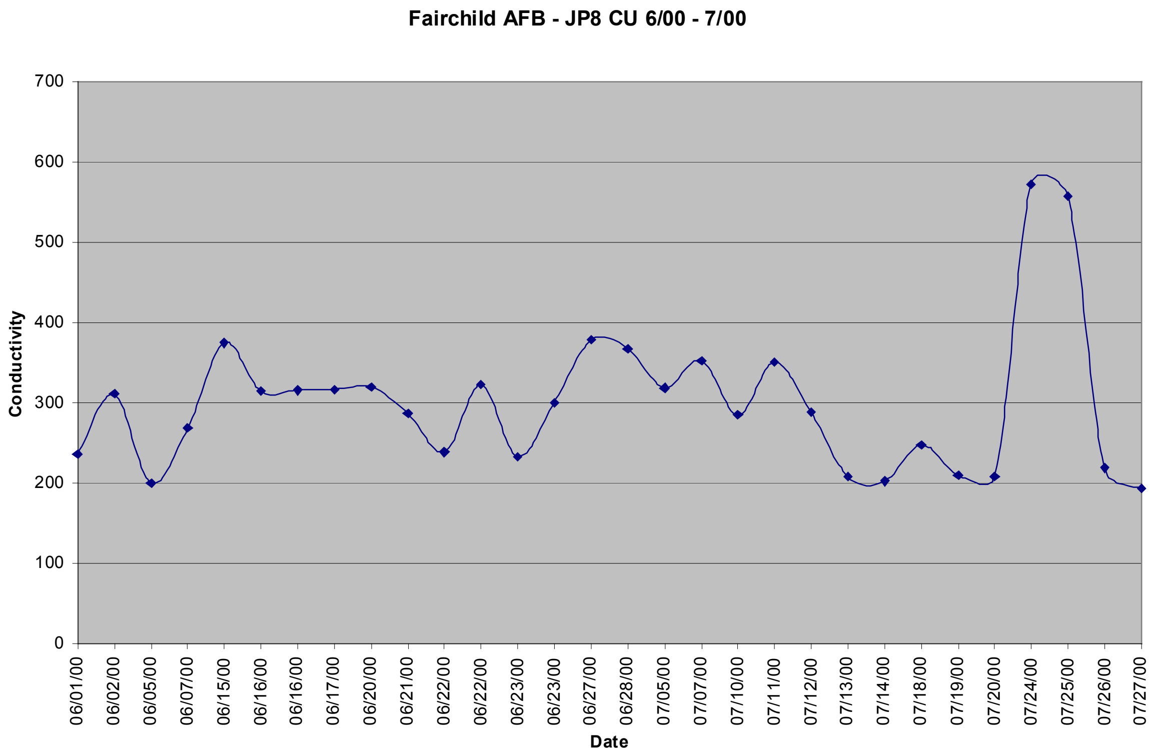
05/24/00
05/31/00


Fairchild AFB - JP8 CU 6/00 - 7/00
Conductivity
Date
0
100
200
300
400
500
600
700
06/01/00
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06/05/00
06/07/00
06/15/00
06/16/00
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06/17/00
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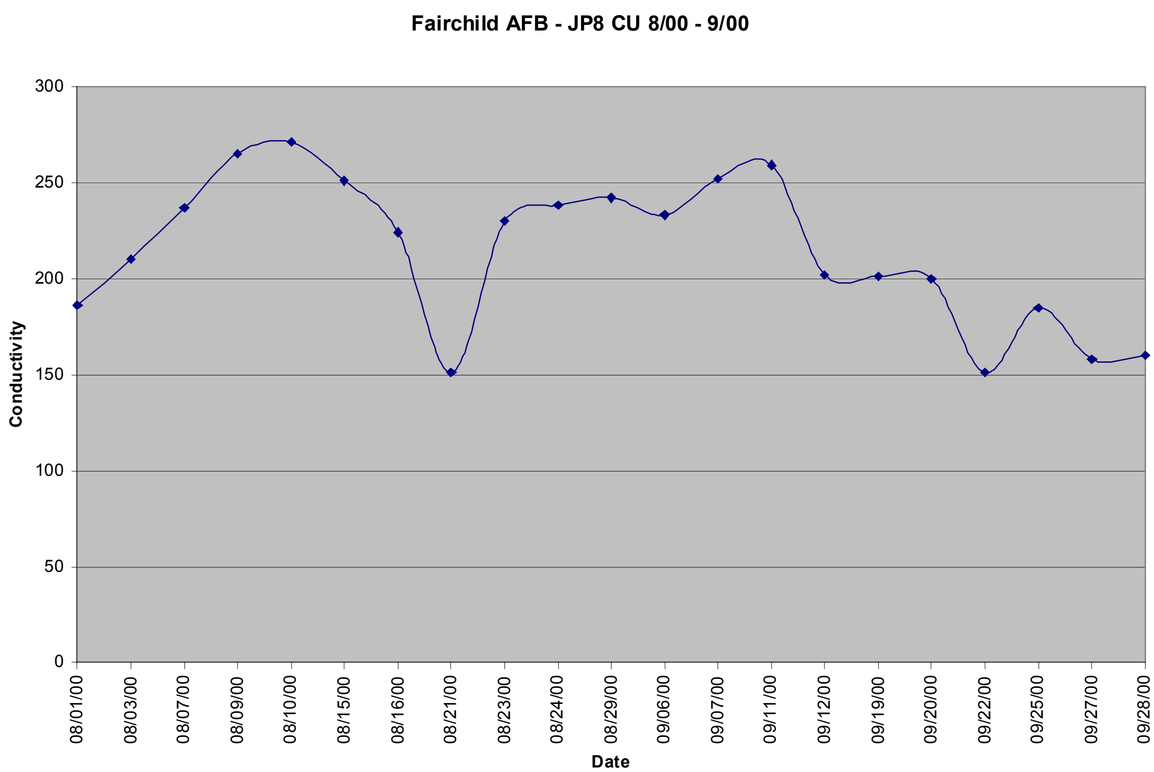
Fairchild AFB - JP8 CU 8/00 - 9/00
Conductivity
Date
0
50
100
150
200
250
300
08/01/00
08/03/00
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08/09/00
08/10/00
08/15/00
08/16/00
08/21/00
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08/24/00
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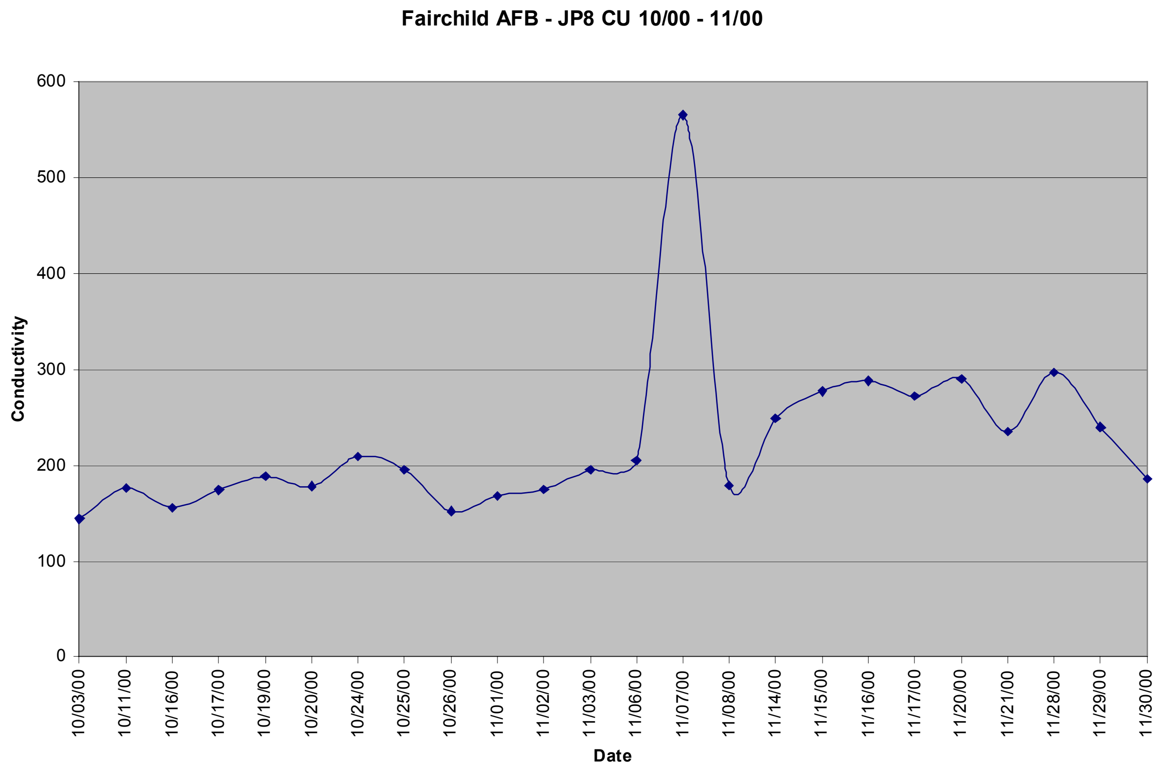
09/28/00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300
200
100
0
10/03/00
10/11/00
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10/17/00
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10/20/00
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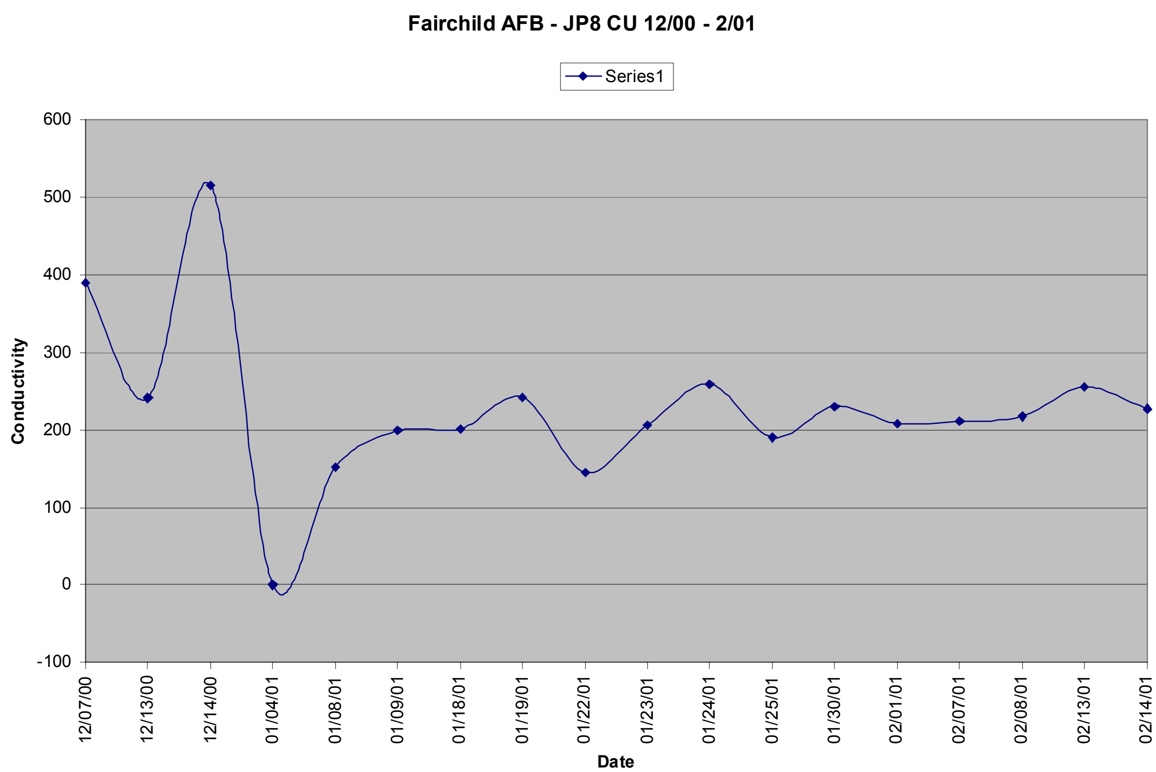
11/30/00
Date


Fairchild AFB - JP8 CU 12/00 - 2/01
Series1
Conductivity
600
500
400
300
200
100
0
-100
12/07/00
12/13/00
12/14/00
01/04/01
01/08/01
01/09/01
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01/23/01
01/24/01
01/25/01
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02/07/01
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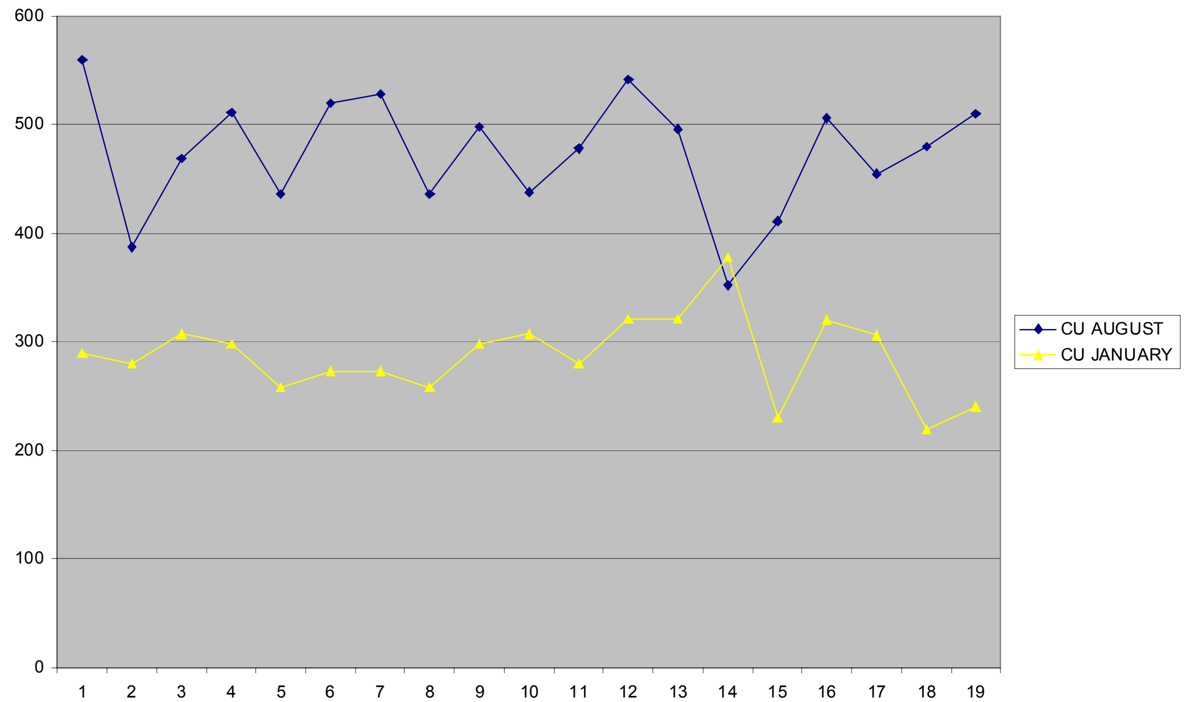
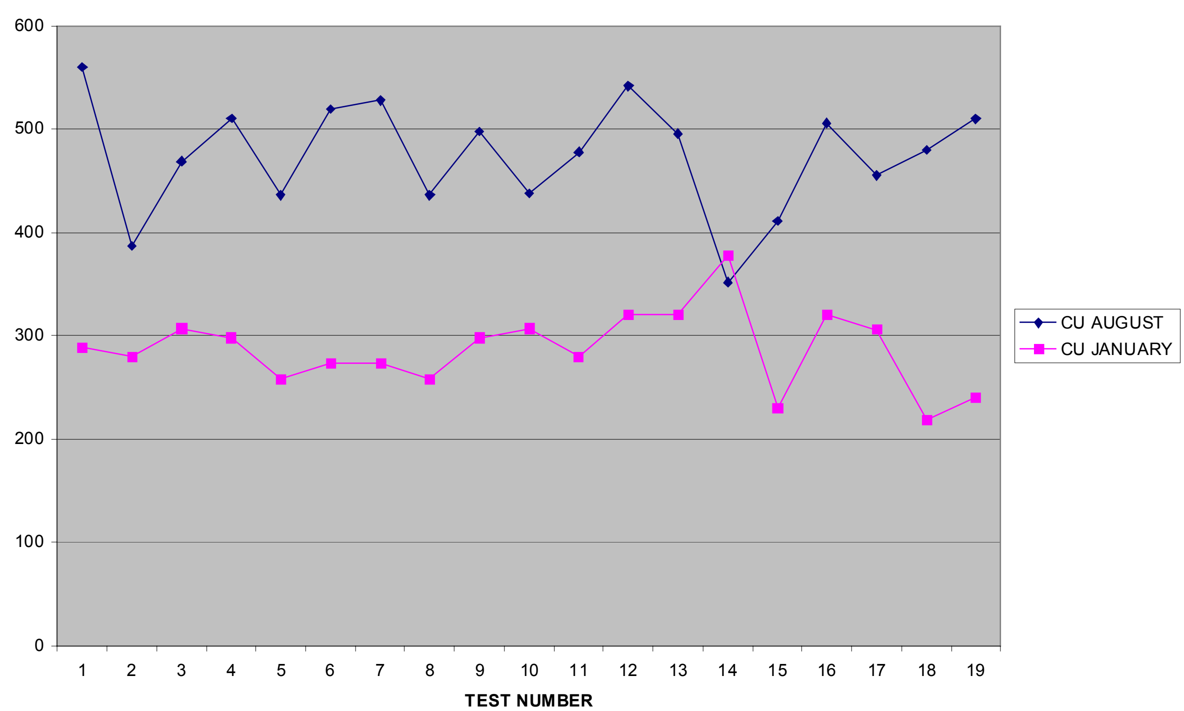
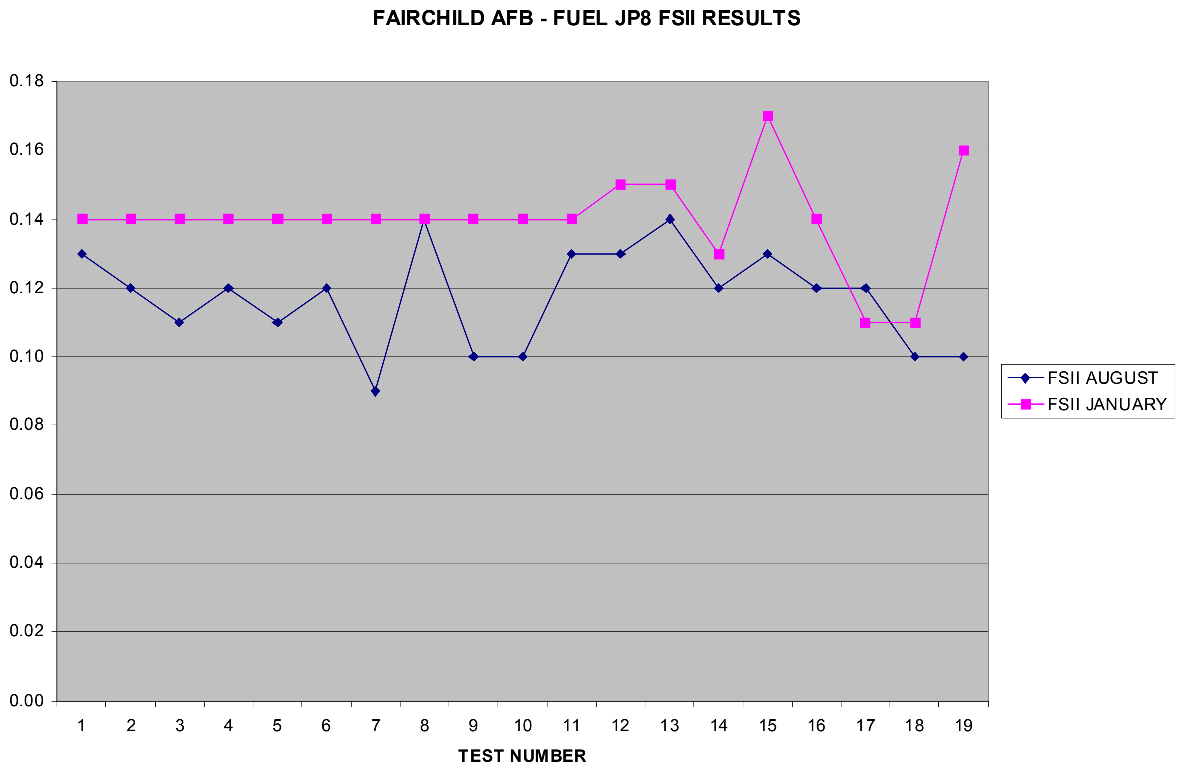
02/13/01
02/14/01
Date

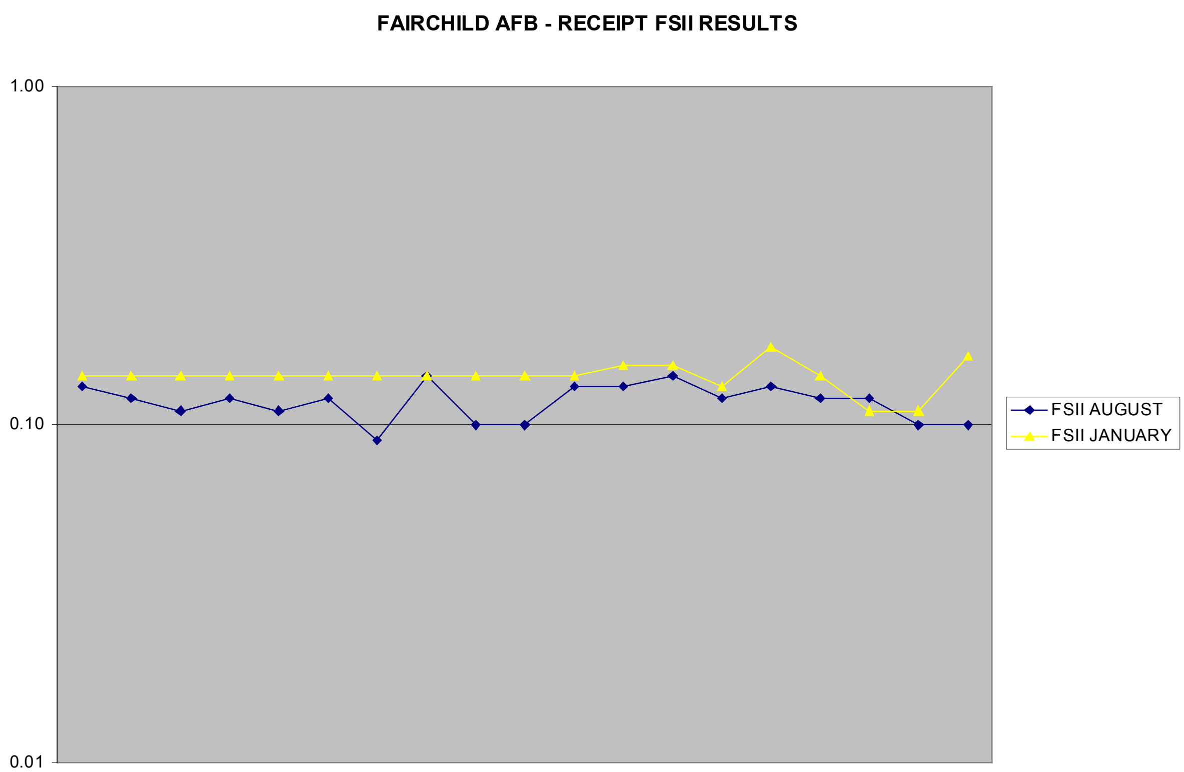
FAIRCHILD AFB - FUEL JP8 CU RESULTS



FAIRCHILD AFB - RECEIPT CU RESULTS




FAIRCHILD AFB - FUEL JP8 FSII RESULTS
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
TEST NUMBER
FSII AUGUST
FSII JANUARY


FAIRCHILD AFB - RECEIPT FSII RESULTS
1.00
0.10
0.01
FSII AUGUST
FSII JANUARY

Appendix E-29

US Oil & Refining Co.

3001 Marshall Avenue
Tacoma WA 98421

Mr. Thomas T. Hullinger, P.E, Laboratory Manager, phone: 253-383-1651
Mr. Rich Smith, Manager, Engineering, Phone: 253-383-1651

The field investigation team met with representatives from US Oil & Refining Company and was invited to tour the refinery. Mr. Thomas T. Hullinger, Laboratory Manager met the team and briefed us on the history of the privately owned company. The business was established in 1957 and has 150 employees. They refine 36,000 bbls of North Slope Alaska crude each day. They produce gasoline, kerosene, diesel, bunker fuels, and asphalt. The production yields about 10,000 bbls of vacuum gas oil a day. From this they produce Jet A for Boeing and JP-8 for McChord. Jet fuel is manufactured continuously and they ship two to three times per week. The increased demand for JP-8 at McChord has pushed the refinery to the limit and they operate at maximum capacity. During 1996, US Oil bought the Buckeye pipeline that historically supplies McChord AFB. They constructed a one-mile section of 6-inch diameter pipeline to connect the refinery to the old Buckeye line. The Buckeye pipeline previously pushed product from barge deliveries at the port to McChord. There was a history of water problems during this period, which seems to have been abated with the direct line from the refinery.

Mr. Rich Smith provided the refinery tour. U.S. Oil produces a straight run jet fuel, and they use a "Merichem" caustic for removal acid and color bodies. The Merichem process does not require a water wash. Salt towers are used to extract moisture. Following caustic treatment, the fuel passes through two clay beds that are installed in series. An anti-oxidant is injected down stream of the clay filters, and the product is then held in one of the two 30,000 BBL tanks for Quality analysis and certification. Corrosion Inhibitor (Unicor J), Fuel System Inhibitor, and Static Dissipater Additive are injected as the product is put into the dedicated pipeline for transfer to McChord. A Blend-Pak Plus Injector System made by Gates City Equipment, Atlanta, GA is used to inject the additives. Injected quantities are metered and closely monitored, and the system shuts down automatically when variances are unacceptable. No F/S vessels are provided for pipeline transfers, though F/S vessels are provided at the truck rack where Jet A is loaded for Boeing. Bottom water and sediment are drained from the tanks "religiously" prior to each pipeline shipment. Only 60 feet of the 14.5 miles pipeline is above ground. Pipeline Drag Reducer is not used in this dedicated JP-8 supply line, though it was not clear whether or not it is used in the movement of Alaskan crude.

The Refinery personnel were candid, courteous, and professional but could offer no explanation about the substance that shut the filters down at McChord on February 13, 2001.

Appendix E-30

McChord AFB, WA

62 AW/LGSF
1197 A Street Building P28
McChord AFB, WA 98438

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Fuels Superintendent: MSgt Michael Holgate, Phone: 253-982 –3719, Fax: 253-982-2094,michael.holgate@mcchord.af.mil
QC&I Supervisor: MSgt Daniel Hockaday, Phone: 253- 982-2725, Fax: 253-982-2094, daniel.hockaday@mcchord.af.mil
LFM Supervisor: MSgt Bruce Cada, Phone: 253-982-3162
RFM Supervisor: TSgt David Bible, Phone: 253-982-2620

AJ Investigation Team: Larry R. Dipoma (C4e) and E. Mac Fishburn (C4e).

AJ Incidents

McChord AFB first encountered AJ during the fall of 1999 when it was noticed in the fillstand F/S sumps at bulk storage. There are three old Warner Lewis horizontal vessels installed on the bulk storage fillstands with Banner NSN 4330-00-983-0998 elements. Mr. Terry Brown, Bulk Storage Supervisor, said when they noticed the substance, he didn't realize what it was and learned later that it was likely AJ. This experience motivated the Bulk Storage personnel to implement an aggressive tank bottom water-draining program beginning the fall of 2000. They drain or perform a product recovery after every receipt and twice a week minimum on inactive tanks. This effort is likely the reason why no AJ has been seen in the F/S vessels downstream of the bulk tanks since the fall of 1999. However, on February 13, 2001, the receipt F/S on the six-inch pipeline from the US Oil and Refinery was overwhelmed with a dark brown sticky substance. There are two 600-gpm API 1581 Group II Class B Facet horizontal F/S installed on the receipt line at the custody transfer point. Mr. Brown explained that the F/S differential pressure began increasing on each of the last three receipts, which were 7,000 bbls each. The F/S vessels are in parallel and are rotated every other receipt. When the differential pressure reached the maximum allowable of 15 psi, the F/S vessels were shut down, and upon removing the elements from the first vessel, operating personnel found the elements completely coated with the dark brown sticky material. The elements from the second vessel, which had also reached the maximum on differential pressure, were not completely covered, as was the case with the elements from the first vessel. An element from the first vessel having an abundance of the dark brown material was forwarded to the US Air Force Fuels Laboratory at Wright Patterson for an analysis. A second element was provided to the product supplier, the U.S. Oil & Refining Company. No finding had been reported at the time of our visit.

During our visit to the U.S. Oil & Refining facility, they recovered one of the filter elements containing the dark brown, tar-like substance from storage in their laboratory. With their permission, we cut a swatch of material from the element for forwarding to the SwRI laboratory. We examined the element in great detail and attempted to dissolve the substance with hot water without any luck. We were unable to come to any conclusion concerning the substance. In its original liquid state, the heavy liquid penetrated the pleated paper filter and lodged in the outer coalescer sock portion of the element. It is assumed that a portion of the material washed through the element during the three 7,000 bbl transfers, as the differential pressure increased steadily.

Product Receipts and Issues
Approximately 80% of the JP-8 product is received from US Oil and Refining via the 6-inch pipeline. This is a dedicated pipeline that extends from the refinery to McChord AFB, a distance of approximately 14.5 miles. The remaining 20% of product comes from the Manchester DFSP and is delivered by tank truck. Tank trucks are received from Manchester three days a week. The pipeline-receiving rate is 435 gpm and the hydrant transfer rate is 1,000 gpm. Two or three pipeline shipments are received each week. Product is received with an average temperature of 46ºF in January and an average temperature of 69ºF in August.

The bulk storage supervisor, Mr. Terry Brown, is commended for developing a local form for use in recording the differential pressure on pipeline receipts. This form highlighted the pressure increase during the three receipts. Bulk storage personnel routinely record the fuel temperature and differential pressure and meter readings hourly during pipeline receipts. This provides insight into flow rates related to the pressure and temperature each hour, which are very valuable when attempting to analyze what may have occurred.

Bulk Storage
There are four above ground steel tanks equipped with floating pans and geodesic domes. **Tank #A-5, a 12,000-bbl tank, has a leaking geodesic dome. Because of frequent rainstorms and high winds in the Tacoma area, removing water from this tank is often a daily chore.** The capacities of the four tanks are 5,000 bbls, 12,000 bbls, 17,000 bbls and 20,000 bbls, providing a total capacity of 54,000 bbls. Bulk Storage personnel monitor these tanks closely for water. As an example, on the March 28, 2001, 60 to 70 gallons of a milky emulsion was removed from the leaking tank #A-5 while a total of 300 hundred gallons were removed from the other four tanks. It was reported that most of the water removed was entrained water in a fuel emulsion.

This system has an automatic tank gauging system that measures water at the datum plate near the side of the tank. All four tanks were reported as having cone down bottoms with a 7% slope. The suction lines are located directly above the center sumps. For the largest tank, it would require 9,000 gallons of water to reach the ATG system; consequently, this system no value for the early detection of water in bulk tanks.

Assigned Refueling Equipment
There are ten R-11 refuelers and four R-12 Hydrant Servicers assigned. There are five Kovatch and five Oshkosh refuelers. Absorption media elements were installed June 2000-October 2000.

Hydrant System
Two Type III constant pressure hydrant systems are used primarily for support of wide body aircraft. Each system has two above ground 10,000-bbl operating tanks. Tanks M-3 and M-4, completed two years ago, do not have the typical suction line over the sump. It was also noted, that the pump room in one system is without heat. The hydrant system supervisor reports that no heat in the pump room is better because of the reduction in thermal expansion when the systems are inactive.

Products Stored
JP-8.

Product Quality Data
The average FSII receipt content ranged from 0.10 to 0.14% with an average of 0.12%, and the fuel conductivity ranged from 68 to 128 CUs in January with an average of 76 CUs and from 119 to 193 CUs with an average of 137 CUs in August.

Aircraft Maintenance Questionnaire
The Aircraft Maintenance Questionnaire was provided to Fuel Cell Repair and Engine Maintenance personnel. The C141B and C17 reported they had witnessed AJ on C17 aircraft 602. The point of contact is Mr. Charles Boyle, McChord AFB commercial 253-982-3237.

Appendix E-31

Hill AFB, UT

75 ABW/LGSF
7536 Wardley Road

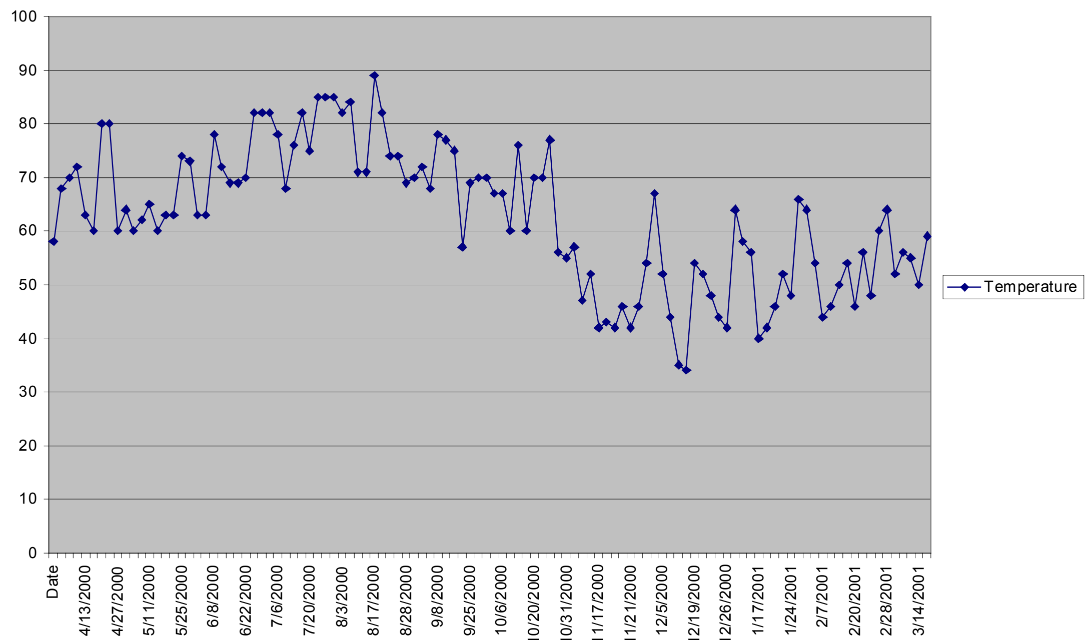
Hill AFB, UT 84056-5733
Fuels Superintendent: MSgt Doug Collins, Phone: 801-586-4295
QCI Supervisor: Mike Durfey
QSR: Gordon Evans

AJ Investigation Team: Larry R. Dipoma (C4e).

AJ Incidents

The first "recent" finding of AJ occurred during late December 2000, following a lull in flying activities resulting from "snow days" and the Christmas break, when small amounts of AJ were found in the filter housing of Kovatch R-11 refuelers (98L079 and 98L080) following a rapid increase in filter differential pressure. Water absorption media elements were in use and high differential pressures cause premature requirement to change elements in other trucks, including Oshkosh R-11, though no AJ was observed in the other refuelers. The weather during December cycled from very cold to warm with rain and then to very cold again. The JP-8 is refined at the Sinclair refinery in Wyoming at temperature above 40°F degrees during the Winter and cools as it is transported by truck through the mountain passes to as low as 20°F upon arrival at Hill AFB. A graph below showing bulk tank temperatures indicates fuel in bulk fuel in bulk storage generally warms to above forty degrees; however, there was a period during mid-December 2000 when bulk JP-8 temperatures dropped below 40°F.

Hill AFB JP-8 Tank Temperature



A couple of years earlier when receiving by pipeline, personnel who had been at Hill AFB reported that they frequently saw AJ-like material; however, the fuel received by tank truck from the Sinclair Refinery in Wyoming is cleaner and drier.

Product Receipts and Issues

JP-8 is received at Hill AFB without filtration, though a filtration system is currently being installed. Hill AFB normally receives eight to ten 7,000-gallon tank trucks that are pulling 3,000-gallon tank wagons. The product originated from the Sinclair Refinery in Rawlins, Wyoming, and as mentioned above, is subject to significant cooling during winter transport though the mountains that separate Wyoming and Utah. During the period of the visit, Hill was receiving approximately 18 trucks and tank wagons per day to support a flying surge to make up for lost time earlier during the winter. The additional workload clearly strained the available storage manpower.

Once each six months, Hill AFB receives JP-8 by pipeline to exercise that receipt mode. The pipeline is a 6-inch diameter line that comes from the Chevron Refinery near Salt Lake City. While no pipeline drag reducer (PDR) is used in this line, it was reported that the Pioneer Pipeline from Sinclair's Rawlins Refinery, which does use PDR in diesel movements, connects to the Chevron line and provides approximately 100,000 bbls of Jet A to Delta Airlines at the SLC Airport each month. Additionally, fuel is occasionally pumped from SLC Refineries through the Chevron Pipeline to Pasco, Washington. Hill AFB is unique in that three additives are injected on base as the fuel is received: Corrosion Inhibitor, SDA, and FSII. Prior to injection, the fuel is filtered through one of two clay filters (manufactured by Eaton Metal Products). These on base clay filters are set in parallel and only one of the two filters is equipped with a pressure differential gauge. The three additives are injected using a Hammonds injector (model # D25XFCPHHHC / 1400-D25-1S-1S). The three additive streams are manifolded into a common nipple prior to injection, in effect mixing the additives prior to injection. The three additives enter the pipeline upstream of the paddle wheel that powers the injector pistons. While there are no specific indications of problems at Hill AFB resulting from the use of a single injection point for the three additives, the more common and recommended procedure is to inject the additives at three separate points. Neither of the two FSII storage tanks is equipped with moisture control, such as a desiccant or nitrogen blanket. Fuels personnel did not know the pumping rate, diameter of the pipeline, nor pipeline surface information needed to compute a Reynolds Number or flow rate at the point of injection.

Two 40,000-gallon, horizontal tanks (Tanks # 39 and # 40), which receive from bulk storage without filtration, supply the refueling truck fillstands. Storage operators usually drain from one pint to one quart of “orange colored water” from the tanks each morning. A sample was taken from the low point drain and was found to be clear and bright. The fill stands are equipped with two vertical F/Ss (manufactured by Keene Corporation, model #330 V600 manufactured in 1974). These old DoD Standard F/S vessels use the old DoD elements, FSN 4330-983-0998. This old style element was marginally effective for use with JP-4 and is ineffective for use with JP-8. The filter vessels should be replaced with API/IP Standard 1581 qualified vessels. Currently, this is the first filtration that JP-8 delivered by tank truck is subjected to before it enters the flight line refuelers. Most of the jet fuel issued by Hill AFB is JP-8+100. The +100 additive is injected downstream of the fillstand F/S vessels.

Bulk Storage

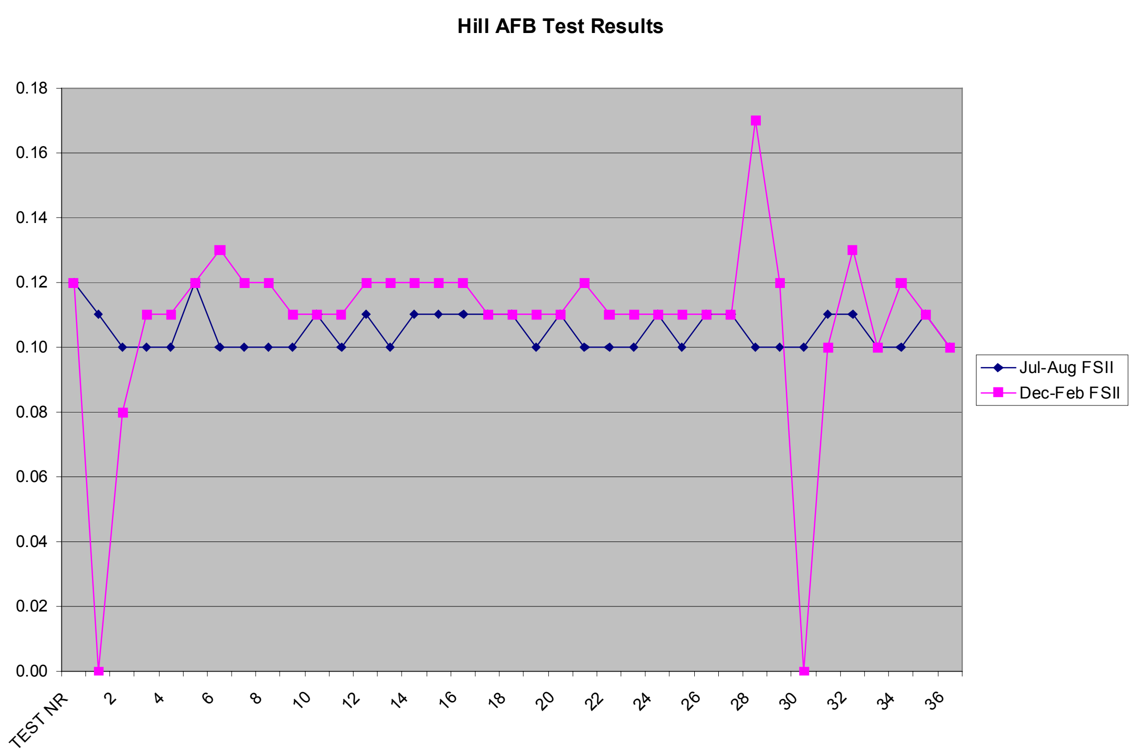
JP-8 is stored in four bulk tanks. The two largest (a 25,000-bbl tank and a 55,000-bbl tank) have fixed-roofs with floating pans. The two smaller tanks (an 18,000-bbl tank and a 12,000-bbl tank) have geodesic domes with floating-roofs. All four tanks have the self-cleaning design sloped to the center with the suction line directly over the sump, and fully epoxy coated. The BS&W drains or product recovery systems are totally ineffective and have been abandoned. Water is drained into a bowser through a long hose that goes over the tank dike. The sump of the tank designated as the issue tank is drained daily and the other tanks are drained weekly. Samples were taken from the bowser connected to the issue tank. The first one-quart sample, drained from the low point was a yellowish mixture of water and FSII, with no fuel interface. A drum thief was used to obtain a more representative sample. The fuel phase of the latter sample was unusually yellow, though the water phase seemed unremarkable. A thin layer of substance at the fuel water interface appeared typical of microbial growth. Major Dave Sonntag took this sample for testing to the bioenvironmental health laboratory.

Assigned Refueling Equipment:

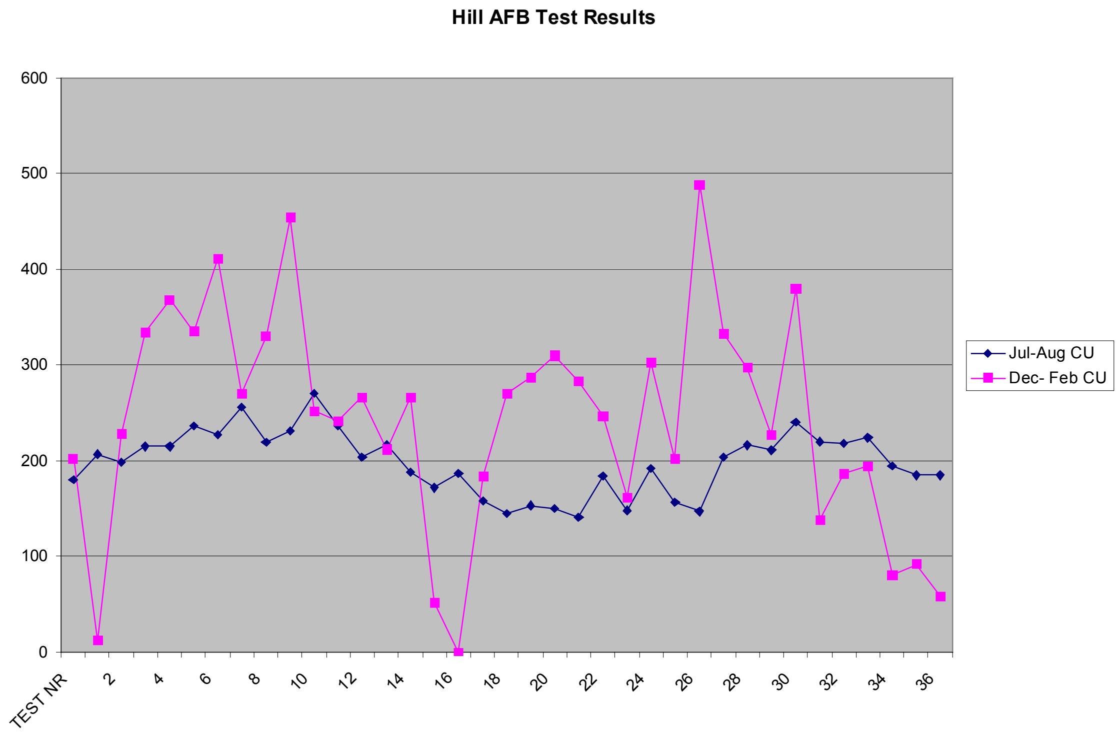
Hill AFB has fifteen assigned R-11 refuelers. Seven of these are 1989 model Oshkosh refuelers, three are 1991 model Oshkosh refuelers, and the remaining five are Kovatch 1998 vintage refuelers. According to Fuels Management personnel, AJ has only been found in the 1998 Kovatch model R-11. However, the refueling vehicle maintenance manager stated that he finds AJ in the filter vessels of all the refuelers. Since his records showed that he had recently changed the filters elements in a Kovatch R-11, #98L083, he was asked if we could examine the filter element. The filter showed no evidence of AJ; however, what was a matter of concern is that the element was the filter coalescer type (63387TB) and not a water absorption type. This situation is exacerbated by the fact that refueler 98L083 is a designated JP-8+100 truck. Water absorption elements should be used for this application in accordance with T.O. 42B-1-1 because JP-8+100 disarms coalescer elements. The elements change information was reviewed for all fifteen vehicles and it appeared that one other R-11 (98L081) might have the old coalescer type elements based on the change dates in the automated maintenance record. Later, it was determined that the elements, whichever type, had been changed earlier, but the automated report had not been updated. Water absorption elements were apparently installed in most of the R-11 refuelers during September and October of 1999. Since that time, the records reflect that two Oshkosh and three Kovatch R-11 experience premature filter failure (9 months or less installed time).

Products Stored
JP-8 and JP-10.

Product Quality Data
A visual sample was drawn from one truck at the beginning of the delivery and was found to be clear and bright. A review of product receipt records for 216 deliveries showed that FSII levels on receipt range for 0 to 0.17%, with the vast majority (>90%) being 0.10% to 0.12%.



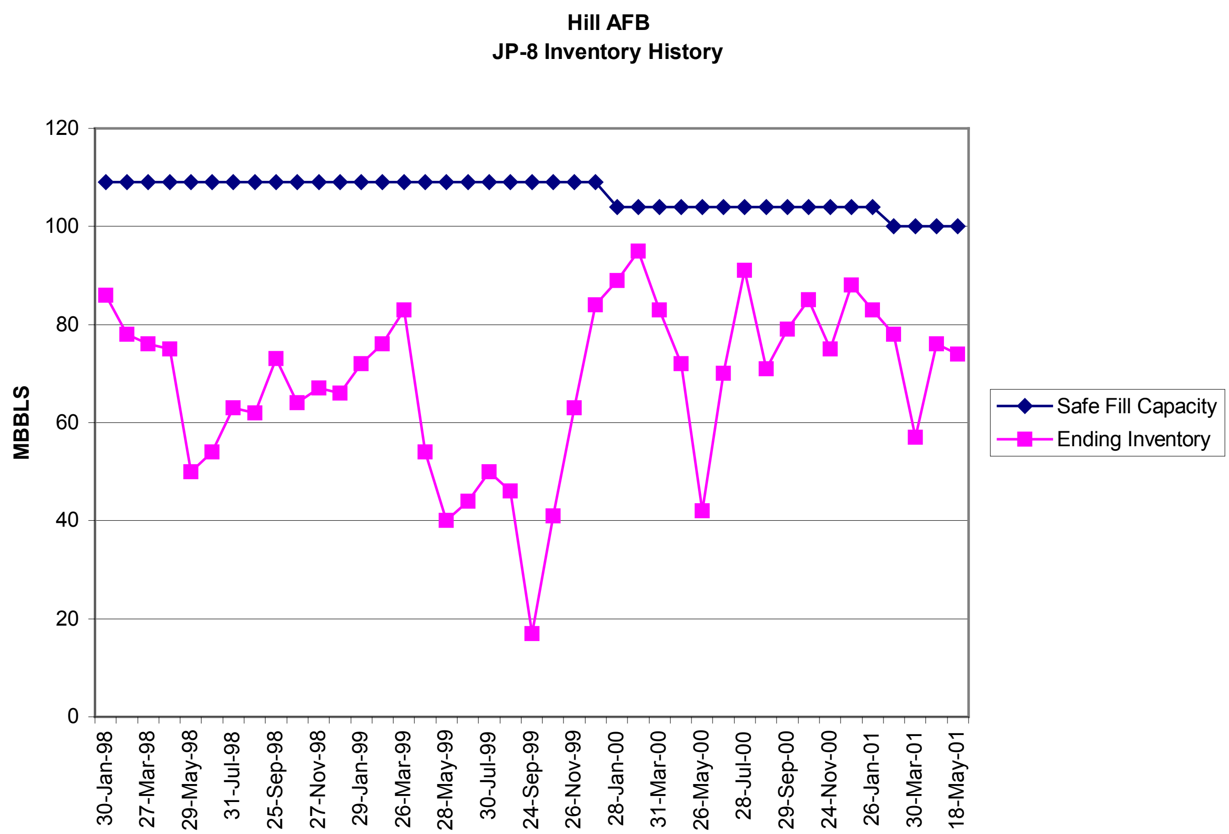
Conductivity levels range widely from 0 to 499 CUs, though the average appeared to be in the low 200 CU ranged.



The JP-8 at Hill AFB is relatively dry. Less than 4% of 814 samples reviewed showed any water at all in the AEL testing of flight line refueling equipment. Five of the 814 samples failed having from 15 ppm to 20 ppm of water. Approximately, 15,000 to 20,000 gallons of JP-10 are downgraded to JP-8 each year. Hill AFB personnel also reported that they had an unusual experience a year or so ago with filtration time test failures. Fuel samples that had set in the laboratory for a short period failed filtration time dramatically (test would run out of time) but if samples of the same fuel were allowed to set over night they would pass the test the following day. Settling time or perhaps gradual warming seemed to be the significant factor, since fuel setting for a short period and warmed rapidly failed the test. During this period, fuel was loaded at the Sinclair Refinery at 44°F and cooled significantly during transport to 20°F by the time it arrived at Hill AFB.

Aircraft Maintenance Questionnaire:

Hill AFB provides depot level maintenance for F-16, A-10, and C-130 aircraft. We visited the LA Bioenvironmental Health Office and spoke with Karen Thompson, the LA Safety Office and spoke with Augie Pierman. We learned that a contaminated sample had recently been taken from a Puerto Rico ANG C-130. We were able to obtain the sample, which contained three-phases of material: a fuel top, an unremarkable water/FSII bottom (with some type of sediment), and what appeared to be a microbial layer at the fuel-water interface. We visited the C-130 engine shop and spoke with Doug White, and the C-130 depot maintenance area and spoke with Phil Younger. All of the above individuals where shown a “classic” sample of AJ from one of the Hill AFB R-11s. refuelers) and all unanimously reported that they had never seen similar materials inside aircraft.



Appendix E-32

NAS CORPUS CHRISTI, TX

FISC JAX SOUTH TEXAS Message Address: NAS CORPUS CHRISTI TX//19000//
CORPUS CHRISTI SITE CODE 1954
1101 D STREET STE 143
NAVAL AIR STATION

		COMMERCIAL
CORPUS CHRISTI TX 78419-5021	Facsimile (24 Hour)	(361) 961-3372
Supply Officer	CDR J GUEVARA	(361) 961-3661
Fuel Branch Supervisor/COR	MR CLYDE CRUMLEY crumley.c.w@nrst.navy.mil	(361) 961-3372
Contract Dispatch	DOSS AVIATION (24 Hours)	(361) 937-8872

Though a small operation with two 6,000-bbl tanks, NAS Corpus Christi has an aggressive fuel filtrations program. The fuel is filtered upon receipt into Tank One. After settling and draining any bottom water and sediment, the fuel is transferred from Tank One through a filter separator and then through a water absorption monitor into Tank Two. As the fuel is issued from Tank Two to the fillstand it is filtered once again through the separate filter separator and water absorption monitors. The two fixed-roof storage tanks have inverted cone bottoms. Fuel is drained manually into a bucket to check for water and then placed in the fuel reclamation tank. Doss Aviation provides along side fuel servicing aircraft using a fleet of new Isometrics built Refueling trucks. These are equipped with Beta Systems filter vessels that use the I-63887TB coalescers and the SO-6336S separators, and provide the fourth filtration prior to the fuel entering aircraft.

NAS Corpus Christi has no history of AJ. While it may be argued that this is because it is located in a warm climatic area, temperatures do drop into the 30ºF range on some occasions. There are two other key difference common to most Navy turbine fuel storage facilities that may be a factor is precluding AJ formation at NAS Corpus Christi. First, the product is stored in fixed-roof tanks that are not subject to rainwater intrusion. Second, the fuel goes multiple, three-stage filtrations (coalescer, separation, and absorption).

Appendix F: Gammon Correspondence on R-11 Modification

Subj:	**Fw: Conversion Kits**
Date:	8/2/2001 10:59:30 AM Central Daylight Time
From:	*gammontech@gammontech.com (Gammon Technical Products)*
Reply-to:	*gammontech@gammontech.com (Gammon Technical Products)*
To:	*c4eeee@aol.com*

----- Original Message -----
From: Gammon Technical Products
To: c4elarry@satx.rr.com
Sent: Thursday, July 26, 2001 9:23 AM
Subject: Conversion Kits

Our telephone conversation yesterday inspired me to do some thinking – a rare event it seems.

The conversion kits that we have devised so far for mobile ex-Air Force filter separators have been controlled by the need to use standard, stock separators made by Velcon. The reason is obvious; the small quantities we needed could not interest Velcon to invest in anything of a special design.

The net result is that we could have created conversion kits that would have supported higher flow rates. What I am saying is that once we know for sure the internal geometry of the Oshkosh vessel, we can then optimize by use of a non-standard diameter and/or length of the Teflon coated screen separator. The potential production volume for these special elements would surely interest Velcon.

Another possibility is to investigate the use of a new type synthetic media separator that Velcon has proven to have greater flow performance than the Teflon coated screen types. The only disadvantage of this product is that it is not capable of being cleaned for reuse more than twice. There is no limitation on separators using Teflon.

So the bottom line is that I see a possibility of achieving a flow rate that is much closer to 600 gpm than with our current designs. Necessarily, Velcon will have to agree to run a performance test, probably to API-1581, Third Edition.

We are prepared, at no cost to the government, to study the above possibilities beginning as soon as an Oshkosh R-11 is made available to us for a one day survey.

Best regards,

Howard M. Gammon
HMG:bd

GAMMON
Technical Products, Inc.

FUEL HANDLING
AND QUALITY CONTROL
EQUIPMENT

July 24, 2001
FAX: 1-210-493-5035
TOTAL NO. OF PAGES: 5

Mr. Larry Dipoma
1149 E. Commerce Street
Suite 210
San Antonio, Texas 78205

SUBJECT: Upgrading Filter Separators

Dear Larry:

In our telephone conversation yesterday, July 23, I explained that we can upgrade filter separators on trucks using an inverted manifold. We have encountered at least 16 different vessel variations depending up the manufacturer of the vessel, as well as the year that the vessel was produced. For example, there are at least 8 different variations of the old Condec vessels. Unfortunately, we do not have adequate documentation to be sure that any one of our conversions was on an Oshkosh truck but this is, obviously, a ridiculous situation for us to be in. The only thing we can do is to tell you that we will design a conversion kit for the Oshkosh R-II after we make a few measurements.

The attached drawing, identified as Figure 2, shows a typical conversion. You will recall that I explained that the Victaulic clamp that we used is one that is specially designed with a tooth arrangement so that it embeds into the aluminum to prevent separation. Figure 3 shows the modification that must be made in the vessels.

It will also be necessary to cap off some of the existing coalescer mounts, because we have to make room for the separators. We do this with any one of (3) different caps, depending upon the design of the vessel. The most common one is type "F" shown on Figure 4. The mechanic pushes the cap on the mounting stub and then drills two holes through the stop plate. He then can insert the bolts and apply the nuts to hold it in place. Depending upon the design of the vessel, the ultimate flow rate that we can certify to API-1581, Third Edition, Class C ranges from 360 to 480 GPM. Hopefully, we will be able to get 480 GPM through the Oshkosh trucks.

Continued......

2300 HIGHWAY 34, P.O. BOX 400, MANASQUAN, NJ 08736-0400
TELEPHONE (732) 223-4600 FAX: (732) 223-5778
EMAIL: gammontech@gammontech.com

The separator elements that we use are the Teflon coated type made by Velcon Filters, Inc.. The manifold is made entirely of aluminum, and the hardware is stainless steel.

A word is necessary about the use of Victaulic clamps. Groove end couplings are currently the subject of a major flap. People are saying that Victaulics are unreliable because they leak. This bad reputation is caused directly by people ordering Victaulic clamps and or gaskets without specifically stating that they require the gasket to be made of fuel resistant material. All standard Victaulic gaskets are made of EPDM, which is useful for water service but worthless for jet fuel. So if the Air Force orders one of our conversion kits, we guarantee that the gasket will be correct for jet fuel. You will note that I have faxed this letter and attachments to you, and we will also mail a copy.

Best regards,

Howard

Howard M. Gammon
GAMMON TECHNICAL PRODUCTS, INC.

HMG:bd
Enc: Figures 2, 3 and 4

INSTRUCTIONS

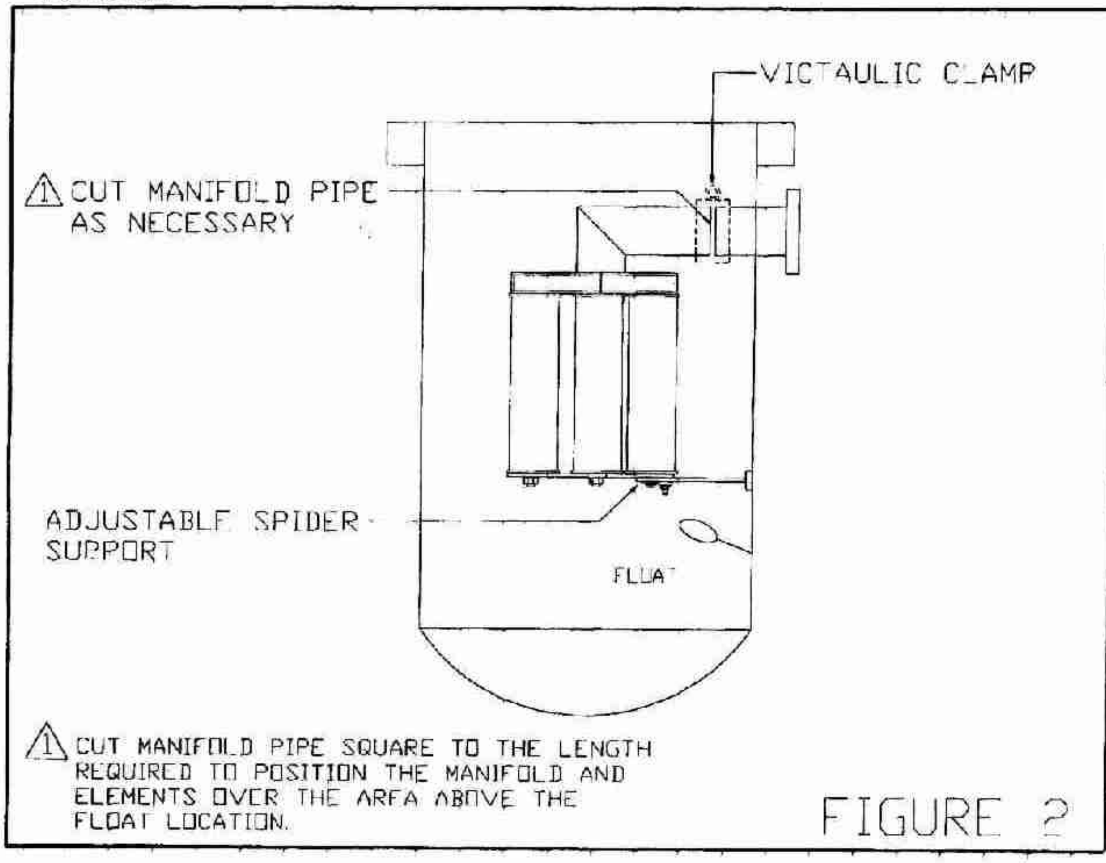


FIGURE 2

INSTRUCTIONS

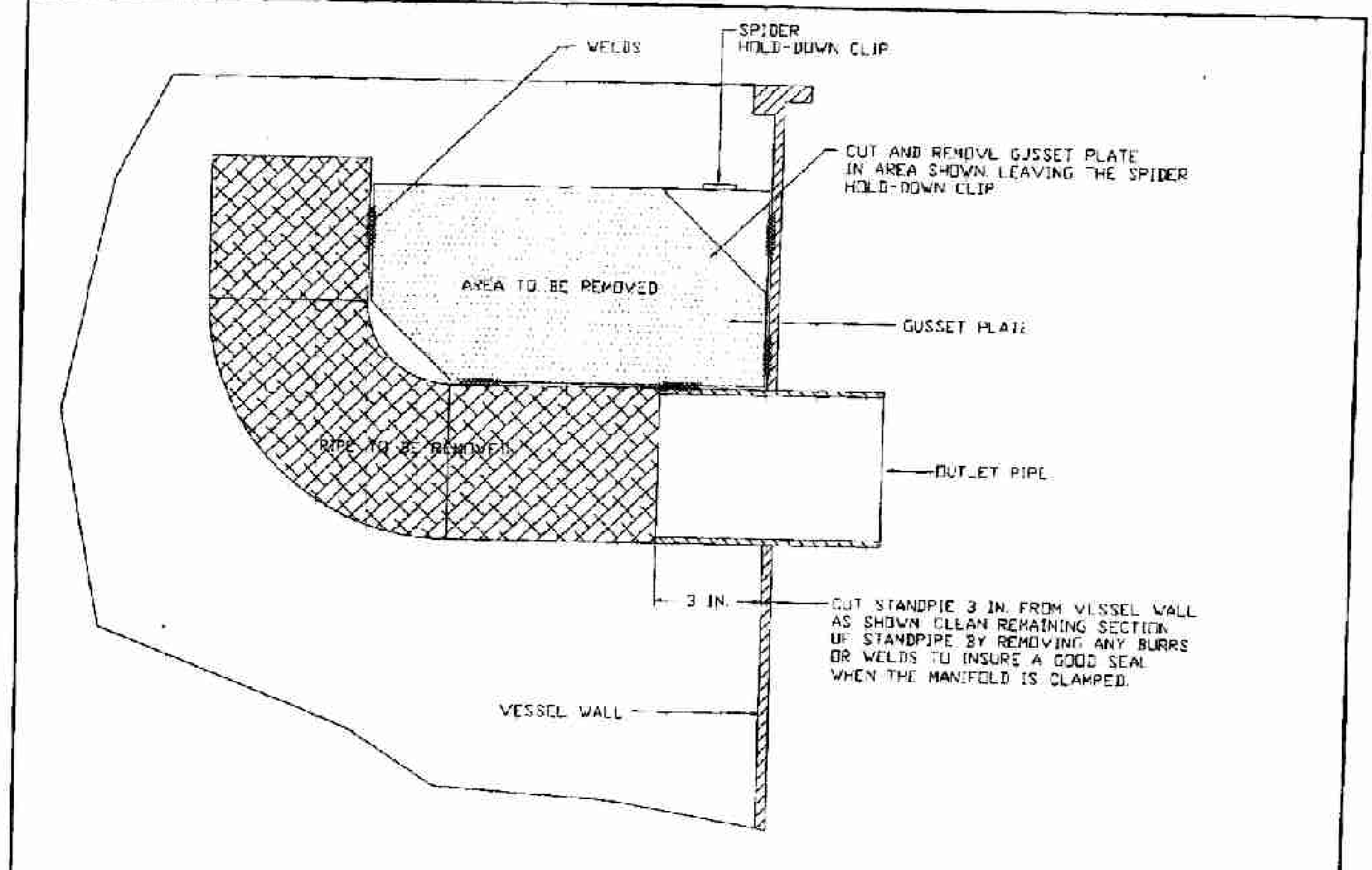
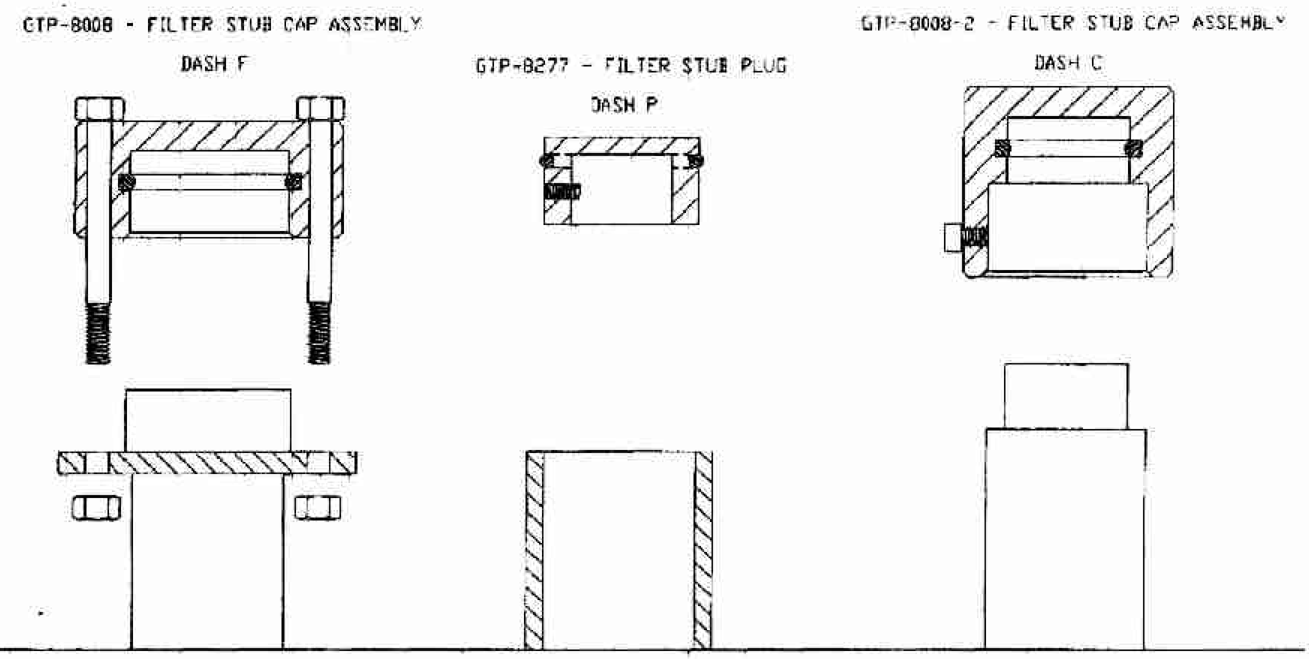


FIGURE 3



COALESCER STUBS

FIGURE 4