

Fuel Investigation Report

An Investigation into Quality
Issues of Gasoline distributed in
Cayman Islands Retail Network



**Petroleum
Inspectorate
Department**

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Others who also contributed in meaningful ways include a few of the Auto Dealers/Garages, Gas Station Retailers, senior management of ESSO and RUBiS, J&R Industrial Services Limited and also members of the public.

Invariably such contributions are always valuable and particularly in this case, the wider involvement was instrumental to the outcome of this exercise.

List of Acronyms

PI	Petroleum Inspectorate
CYB	Cayman Brac
GCM	Grand Cayman
OI	Octane Index
AI	Anti-Knock Index
WAC	Water Authority Cayman
DEH	Department of Environmental Health
MMT	Methylcyclopentadienyl Manganese Tricarbonyl
US EPA	United States Environmental Protection Agency
RON	Research Octane Number
MON	Motor Octane Number
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
DI	Driveability Index
VR	Veeder Root
LCM	Little Cayman
TEL	Tetraethyllead
DOE	Department of Environment
PPE	Personal Protective Equipment
DVES	Department of Vehicle and Equipment Services
Site E1 – E10	ESSO Retail Sites (Gas Stations)
Site R1 – R14	RUBIS Retail Sites (Gas Stations)

Fuel Investigation Report

1. Introductory

Arising out of the increased number of complaints relating to suspected fuel quality issues across the three Islands, the Petroleum Inspectorate (PI) launched an investigation into the matter in August 2013. The scope of the investigation was essentially to determine whether fuel of dubious quality was being imported and marketed locally and further, assess the possibility of local contamination as a result of equipment integrity issues or poor operating procedures by fuel handlers. The investigation was a high level one, seeking to identify possible factors which can contribute to the problem, and was also structured to obtain an indication of whether gaps exist that can potentially lead to such issues recurring, if indeed such problem exists.

The Investigation was primarily focused on the two major oil companies and their local operations, that is, the various gas stations operated under their Brand/Franchise. This decision was taken on the basis that the complaints received were in relation to these particular sites (veracity was unverifiable) and given the 'limitations' which exist to include independently supplied gas stations in the exercise. Fuel marketed locally by the Oil companies is more easily traceable from source (Refinery/Terminal) to end users and given their stake (the Oil companies) in this investigation, their full cooperation was anticipated. The product (fuel) of primary concern was gasoline – both Regular and Premium (Super for ESSO) grades.

While the complaint of vehicular issues purportedly arising from fuel quality remains central to this exercise, it should be acknowledged that this is part of a wider issue which needs to be brought to the fore as it relates to adopting global energy standards. No attempt was made to duplicate information already considered in the draft National Energy Policy however this issue, (hence our investigation) is somewhat a precursor, creating an added push for a 'greener' Cayman relative to greenhouse gas emissions and fuel quality for cleaner and more efficient transport, as vehicles are a significant contributor to (ambient) air pollution.

2. Summary Findings

The quality of the fuel analyzed was found to be acceptable based on the key parameters tested. The condition of assets (equipment integrity) used locally as part of the supply chain shows variability based on the desktop review and the limited physical/visual inspection which was conducted, and requires follow-up action to address specific issues identified at some of the gas stations. Fuel quality issues can be experienced by motorists as a result of the state of some underground tanks, however, based on the few cases found, the product of concern was diesel and not gasoline, as was presumably anticipated. Measures were immediately taken to address the issues found in those few cases.

Because gasoline is a complex (chemical) mixture and its effects can vary based on its chemistry, vehicle type and age, geography, handling, etc., minimum standards should be developed based on collaboration with relevant stakeholders, coupled with empirical evidence available in the industry, to establish fuel quality standards for Cayman Islands. Prior to this exercise, there was an 'opening' for fuel of varying quality to be imported and marketed locally by all parties (in this case includes independent gas station and other possible 'smaller interests'), and while this exercise may have created a

disincentive to do so, it is not adequate to guarantee the quality of fuel sold on the island will be of acceptable quality, or at best, mitigate against fuel quality issues in future.

The fuel quality analysis indicates that the baseline parameter of the fuel meets standards test criteria and does not support the argument that certain key parameters of the fuel is not being met, hence the reason for the issue experienced by the public. One significant parameter can lead to traceable fuel quality issues, however based on information available to cross reference with analysis results, this parameter - Existent Gum was not suspected to be directly linked to the vehicular issues made know to Petroleum Inspectorate. However, because of its likely effects, effort continues to further review this topic as part of comprehensive solution to the gap which exists. Tank maintenance and cleanliness also requires attention, and other notable observations such as location specific technical issues, inventory management practices, (mild) anomalies in fuel color among other less pronounced observations were also flagged for follow up beyond this exercise.

Information flow from the industry to government and the public continues to be a factor of importance in addressing issues of general nature and was evident during this exercise. This is consistent across the entire sector and not only the two entities which were central to the investigation. Information, in many cases, basic non-proprietary information was difficult to obtain, which in a weak regulatory environment such as exists in the petroleum sector, can only be addressed by well-defined regulations. The impact of this shortcoming was managed during the exercise, however from a public awareness standpoint, it does need improvement.

In relation to the condition (age) of the assets, given that this were not generally determined to be a direct contributor to the issue at hand, but could potentially affect fuel quality going forward, action plans will be developed and agreed with responsible parties so that appropriate action can be taken within set timeframe to address instances where there were concerns.

Customers could have had their part in the issue at hand as there are some general contributing factors which fall within end users control. Typically, these factors are significant underlying causes for issues of this nature, however no actual instances were uncovered during this exercise, as such customer's influence in this particular issue could not be ascertained.

Overall, despite the limitations, the exercise produced useful findings and valuable data/information which is essential for renewed discussion in the area of fuel quality, and ultimately to develop a framework to address this issue going forward.

3. General Background

Fuel (product) is traditionally imported into Cayman Islands via the two established companies for general use, and particularly in this case for the motoring public via the network of branded gas stations. No fuel quality standards are imposed nor restriction exists as to where products can be sourced, and history shows that fuels to the Cayman Islands were sourced from various refineries including those in the US Gulf, Isla - Curacao and the now closed Hovensa in St Croix. Presently, the bulk of product is sourced from the USA; ESSO markets equity product, sourced from their own Exxon refineries in the USA while RUBiS (formerly Chevron and more commonly known as Texaco) markets third-party products sourced from USA and Trinidad (and possibly other ports). There is no requirement by the Petroleum Inspectorate under the Law for any entity to produce documents to verify the quality

or the source of product before it is brought on shore for local consumption. Information on quantities imported is however provided to the department.

Esso markets its fuel only on Grand Cayman, while Rubis markets in all three Islands, having Terminals in Grand Cayman (GCM) and Cayman Brac (CYB). Fuel is brought onshore (Ship to Shore transfer) via Esso Sea berth (subsea line) facility in Grand Cayman, and similar method for Rubis operations in Cayman Brac. Little Cayman receives fuel by 'packaged' transfer from Cayman Brac. Products arrive from international ports to these Terminals and are subject to preliminary (internal) checks to determine if it is 'accepted' or 'rejected' before it is discharged into the shore tanks. Routine checks and tests are done as part of their internal standard operating procedures before the product is distributed via Tanker Trucks into tanks at Gas Stations or consumer locations for consumption. The only product which has to be recertified (retested) locally before distribution/use is aviation fuel for obvious reasons.

At the gas station level, there are typically automated management systems, both electronic and manual to ensure the fuel is properly accounted for and also to ensure its quality is preserved up to the point of dispensing into customer's vehicles. Water, sediments, sludge and other particulate matters are typically trapped in properly functioning dispensing systems before delivery into vehicles. However it should be noted that the application of additives/chemicals or mixture of other fuels are not filtered by fuel dispensers and if deleterious in nature, will cause damage. Overall, strict procedures and processes are adhered to ensure the product integrity is preserved throughout the entire supply chain. Nonetheless, deviations, systems malfunctions, and/or human error can occur, which can result in product adulteration or contamination.

In relation to this issue, it has been common for the department to receive calls, though infrequently, from members of the public in relation to fuel quality issues. Details were usually scant, and it was previously the department's position to refer these to the Oil companies to resolve. Historically, most of the calls emanated from CYB customers. However, approximately two months prior to the investigation, the department received an increased number of calls from both GCM and CYB which prompted the investigation. In addition to the Oil companies that were engaged at the outset, efforts were made to reach out to gas station operators, auto garages and other stakeholders to obtain any relevant information they may have to expedite addressing the matter. To acknowledge, two auto dealership/garages responded with good information, but no firm conclusion could be drawn as supplemental information was required to further substantiate, particularly some specific technical issues related to the problem.

No formal log pre-existed to handle general complaints received by the department and in this particular case, a complaint log was not established to capture calls and details provided in a structured manner. However, informal records are generally kept for public issues directed to the department and based on the routine notes captured, some of the typical complaints received were:

- *"Car is performing poorly since fueling-up at XX Gas Station"*
- *"Engine/Fuel light on and car had to be taken to shop"*
- *"Encountered serious problems with my car and took it to mechanic/garage and they had to flush tank and change components (at significant costs) to get my car running again"*
- *"Car (Engine) is vibrating heavily and stuttering"*
- *"Having serious issues with vehicle starting in morning, during the day the problem goes away"*
- *"Vehicle is not developing power as it should" (high-end vehicle operators)*

The initial parameter of concern was the fuel Octane Index (OI), referred to as Antiknock Index (AI) or simply - Octane. This parameter was considered to be of primary concern since issues were symptomatic of the fuel not meeting the required octane specification. Key players in the automobile industry were very confident that this was the case and this influenced the decision to ensure it was an important parameter to be analyzed. Information provided to us suggested that a significant number of high-end (high compression) vehicles were affected, particularly their claim of noticeable reduction in vehicle performance (power) which is attributable to Octane index being outside (below threshold) established limits. There was no mention of any other fuel restrictions, save the OI requirement for the various brands of vehicle marketed locally. Further, based on useful dialogue with auto industry personnel, PI was further educated that the fuel warning light signal on the dashboard cluster is more commonly linked to this particular parameter, however we (PI) did not research this further. However, quality standard, or more appropriately the absence thereof, is understood to be robbing Cayman of certain makes and models of vehicles as a result of manufacturer's reluctance to offer such products in territories/regions which are lacking such regulations due to (performance) reputational concerns.

Fuel investigations generally involves a legal aspect to it to guarantee an avenue by which critical information can be obtained for review, and also to ensure such information is properly handled by recipient. Not the case in this instance, however Petroleum Inspectorate gave its assurance to the companies involved that any sensitive information provided will be treated with the confidentiality it deserves throughout the exercise.

4. Meetings and Consultation

In consultation with Ministry of PLAHI, Petroleum Inspectorate agreed to look further into the issue based on the widespread effect it seemed to be having across the Islands. Previously, the approach was to allow the Oil companies to tackle the issue and revert with their findings. Both ESSO and RUBiS were meaningfully engaged in the early stage and separate meetings were held with executives, local and overseas personnel, for both companies, in their technical capacity to discuss the issue at hand. In both meetings, the companies reiterated their stance on the assurance of the quality of product they are offering here in Cayman Islands. Highlights of the meetings were circulated to Ministry via email and included sensitive and competitive information of the two companies; as such those details are not included in the report.

Of importance, arising out of those meeting, both companies agreed to cooperate fully with any investigation government (Petroleum Inspectorate) sought to undertake. Further, RUBiS also confirmed their willingness to refund the costs of the fuel analysis, once this exercise was spearheaded independently by PI.

Having agreed to kick-off the investigation by analyzing fuel samples from the main fuel Terminals, a few Labs were consulted in Miami, Puerto Rico and Antigua to facilitate the testing of the samples. West Indies Oil Lab, Antigua was unable to facilitate the full tests and the Labs in Puerto Rico did not acknowledge our request. The most practical option (and most feasible) proved to be Labs in the US, namely Pan Air and Saybolt, two reputable labs located in Florida. However, due to a major setback encountered whereby the PI could not directly coordinate the preparation and shipment of the samples for testing, a local company currently certified to carry out this task was retained. DEH Laboratory was also consulted prior to engaging the third party company, however they were not 'Dangerous Goods' certified for the grades of petroleum products we were desirous of sending off for analysis. The local

company - J&R Services Limited was requested to obtain, prepare and ship the samples for testing on PI's behalf.

Samples were taken at both ESSO and RUBiS Terminal in Grand Cayman and witnessed by PI personnel – R. Mohammed. A working relationship existed between the local company J&R Services and Saybolt Lab which facilitated a smooth and expedited handling and testing of the samples, however PI maintained active contact with both entities during and after the test in the event clarification and follow-up work were needed.

It should go on record that Pan Air Lab was very cooperative also in advising PI some steps it may wish to consider in attempting to address the issue. They also indicated that both companies have been in discussion (and also had samples previously tested) in relation to the issue. For confidentiality reasons, no request was made to Pan Air Labs, nor did they divulge any information relating to the results/finding undertaken independently by the oil companies.

A few Retailers and other government agencies were also consulted, and The Chamber of Commerce through its President, also indicated their willingness to be involved in the efforts to ensure a comprehensive solution to the problem is developed.

During the course of the exercise, PI continued to receive and consider information (based on merit) relating to the issue and incorporated into this report as necessary.

5. Agency Collaboration

To realistically undertake this exercise, despite not being a complex investigation, necessitated support from other departments and entities. A few options were evaluated including utilizing a third party contractor to assist, however after careful consideration, being cognizant of austerity measures currently in place, it was agreed to solicit the help of other suitable government departments which can assist meaningfully with a 'technically minded' employee for phase three of the exercise. DEH and WAC were the two primary agencies considered and both were integrally involved in the exercise. In addition to the manpower support provided by WAC, assistance was also provided in the form of the observation flask which was a key apparatus used at the sampling stage of the exercise. DEH provided valuable assistance in the form of other needed apparatus (for reference sample, etc.) and were instrumental also in reviewing the methodology we drafted to use in the field, given their extensive background in lab procedures.

This exercise was another among a list of other initiatives PI department tangibly depends on these two agencies to accomplish its goals, underscored by the mutual understanding of the critical roles we perform in our respective areas/field, which intersect in some instances. Additionally, Planning Department's Director was also very supportive and did contribute in a significant way to the execution of this activity over in the Sister Islands.

6. Scope of Investigation

A simplified approach was taken in carrying out the investigation and it was envisaged to be carried out in three phases:

- Laboratory (certified) analysis of fuel samples from the main storage Terminals at Esso and Rubis Facilities

- Laboratory analysis of fuel samples taken at random retail sites based on the result of the foregoing phase
- Inspection of marketing (fueling) equipment at Gas Station to identify vulnerable areas which can lead to local contamination and also entailed a visual inspection of samples drawn from the (underground) storage tanks.

6.1 Phase 1

Having reviewed existing data/information on the issue and also lab results of earlier analysis provided to us by the oil companies, the first phase kicked off with analyzing samples from the (ocean) Terminals of the two companies.

The following are the set of parameters (and associated method employed) identified to be tested. These were decided by PI and subsequently discussed with the Oil companies.

API Gravity	(ASTM D-4052)
Copper Corrosion	(ASTM D-130)
Existent Gum	(ASTM D-381)
Octane Number Motor	(ASTM D-2700)
Octane Number Research	(ASTM D-2699)
Vapor Pressure	(ASTM D-5191)
Distillation	(ASTM D-86)
Particulate Contaminants	(ASTM D-5452)**

** This test was subsequently eliminated for cost reasons given the scope of planned third phase of the local investigation.

6.2 Phase II

This phase of the investigation as originally envisaged involved analysis of fuel samples drawn from select Gas Stations across the Islands for testing at approved/certified Labs. However, after careful consideration of the matter, particularly the significant cost associated with this activity, this phase was abandoned as it was determined that it will not add significant value to the investigation.

6.3 Phase III

This phase was essentially aimed at determining local factors (at the Gas Stations) which can potentially contribute to fuel quality issues. By virtue of the equipment being underground (buried), this inherently limited the scope of this exercise, but based on past experience of the team, certain observations will still provide valuable preliminary information to determine where escalation is required. One of the key activities of this phase was the visual inspection of fuel samples taken from the storage tanks at the gas stations. The sample was compared to a reference sample from the main Terminal and the overall objective was to have an indication of the condition of the tank, and other factors such water ingress, substance sitting on the tank bottom which may require further analysis, and assess any other visual indication (peculiar color, etc.) requiring further investigation. Other tasks in this phase included basic checks around tank farm, condition of slab, tank manhole/sump, liquid-tightness of components, condition of visible seals, etc. and other general conditions (which can provide an indication of level of maintenance, hence the state of affairs of the fueling equipment). The methodology which guided this phase is also included in the Appendix.

As outlined previously, options were explored in terms of the approach to take in executing this phase and while engaging a contractor/third party was considered a good alternative, CPI considered it was

beneficial for the department to be directly involved. An inter-agency team was thereby composed. Water Authority provided support by assigning a highly driven and capable employee to work along with the PI throughout this phase of the exercise. Department of Environmental Health (DEH) Laboratory Manager was accessible if needed during the exercise in addition to other support and useful guidance provided, and Ministry's liaison to PI, whose support was much needed, formed part of the core field team and was very involved in all aspects of the exercise. RUBiS' Technician was also on hand at all their sites primarily to witness the exercise and provide critical support which otherwise would have proven to be a significant challenge for the team. Given the nature of the exercise and associated risks, safety was of paramount importance to ensure the exercise was completed incident-free.

7. Results

7.1 Phase I

The results of the laboratory analysis performed on the samples are shown summarized below. This information was extracted from the certified copies of the result submitted by Saybolt Laboratories. Copies of the Certificate of Analysis (CoA) are shown in the Appendix.

The objective was of such that two distinct samples were to be taken from the two oil companies, one to represent Regular gasoline and the other, premium/super grade. The premium/Super grade is represented by the sample which is additized with MMT, to boost the Octane Rating. In the case of RUBiS, a composite sample was eventually used for both GCM and CYB based on indication from the company that CYB only offers Regular grade of fuel. Rubis GCM sample was therefore considered a blend/midgrade sample which did not negatively influence or mask the results in any significant way other than possible 'dilution' which was taken into account.

Extract of Lab Results of Fuel Sample Analysis

Lab: Saybolt

Test	Analysis	Unit	Method	Specification	Results			
					Rubis Grand Cayman	Rubis Cayman Brac	ESSO Terminal	ESSO Truck Sample
API Gravity @ 60°F	Gravity API	°API	ASTM D 4052	Report	54.1	52.0	58.0	57.9
Appearance	Appearance		ASTM D 4176	C+B	C+B	C+B	C+B	C+B
Distillation	Initial Boiling Point	°C	ASTM D 86	Report	35.8	36.6	33.9	33.1
Distillation	10% Evap.	°C	ASTM D 86	70.0 max.	50.8	61.5	50.5	51.2
Distillation	50% Evap	°C	ASTM D 86	77.0 - 121.0	95.1	111.0	102.8	103.7
Distillation	90% Evap.	°C	ASTM D 86	190 max.	171.3	158.6	150.3	150.1
Distillation	Final Boiling Point	°C	ASTM D 86	225.0 max.	217.0	191.4	194.5	195.2
Distillation	Recovery	v/v%	ASTM D 86	Report	98.3	97.6	97.0	97.7
Distillation	Residue	v/v%	ASTM D 86	2 max.	1.2	1.3	1.5	1.3
Distillation	Loss	v/v%	ASTM D 86	Report	0.5	1.1	1.5	1.0
Distillation	Evap @ 200 Deg. F	v/v%	ASTM D 86	Report	49.1	36.6	44.3	43.9
Distillation	Evap @ 300 Deg. F	v/v%	ASTM D 86	Report	79.5	82.7	89.3	89.4
Copper Corrosion	Copper Corrosion, 3 Hrs @ 122°F		ASTM D 130	1 max.	1A	1A	1A	1A
Vapor Pressure Air	Reid Vapor Pressure @ 100°F	kPa	ASTM D 5191	62 max	60.3	56.9	62.7	62.0
Existent Gum	Gum	mg/100ml	ASTM D 381	4 max	65.0	7.0	4.0	16.0
Research Octane #	RON (R)		ASTM D 2699	Report	97.4	97.7	99.0	99.5
Motor Octane #	MON (M)		ASTM D 2700	82.0 min.	84.9	85.4	86.8	86.9
Antiknock Index	(R+M)/2		Calc.	87.0 min.	91.1	91.6	92.9	93.2
Manganese (Mn)	(MMT)	mg/L	ASTM D 3831	(Report)	7	0.4	<0.1	13.7

Table 1

7.1.1 Lab Results

Analysis was carried out for select parameters for both premium and regular grades of gasoline as shown in the Table 1 above. The significant parameters for which 'dilution' could potentially impact the results were MMT (hence OI) and Existent Gum. An attempt is hereby made to provide brief explanation of the results of key parameters in non-technical terms where possible.

The results of the analysis of **API Gravity**, **Appearance** and **Copper Corrosion** were all found to be acceptable and within established tolerance range where applicable.

Vapor Pressure of the samples was found to be within acceptable range based on the prescribed standard test. This property is an indication of the fuel's tendency to evaporate and needs to be maintained within controlled (desirable) range to vaporize under the right conditions as needed (in the engine/combustion chamber). For simplicity, vapor pressure can also be considered a parameter of relevance while fuel is stored resulting in it vaporizing too easily. Importantly however, when fuel is introduced in the engine, this measure gives an indication of the balance needed to ensure adequate vapor is generated to have an efficient burn, while on the other extreme it is highly undesirable for too much vapor to be generated vehicle fuel system. Cayman's tropical climate would necessitate vapor pressures be in the lower to mid –range, possibly not exceeding 11.5 psi (76kPa) during cooler periods of

the year. The results were in the range of 8 – 9 psi which is acceptable as issues with vapor locking would have been much more prevalent.

Distillation, also a property of the volatility of fuel, gives an indication of the boiling range of fuel. The results of the analysis indicate that this parameter is well within range for the samples tested. Like vapor pressure, this parameter provides information, more pointedly, to ‘driveability’ issues, particularly at cold-start/warm-up or hot-start, and other issues such as vapor lock and variability in engine performance whilst its temperature varies. “Driveability Index” is also a standard parameter which is derived from the distillation results and this value was found to be acceptable also for all the samples. It is not the intention to delve too deep into the chemistry of these results, but another way of explaining this parameter is the indication of the amount of light and heavier fractions in the fuel hence the reason some of the specifications under the tests are capped at maximum values. US EPA also uses specific results under distillation as variables in complex emission modeling calculations.

Octane Index (Antiknock Index or Octane Rating) in most instances, is considered the most important performance characteristics of gasoline. This value is determined by laboratory analysis of two separate tests, Research Octane Number and Motor Octane Number as shown in the results and the Index is simply an average of the two numbers. In simple terms, this Index (which is based on an arbitrary scale indexed relative to fuel chemistry) is a measure of the fuel ability to be ignited at a precise moment in vehicle engine. Spontaneous ignition of the fuel any earlier than required in the engine results in what is termed ‘knock’ or ‘pinging’ and can result in damage to the engine over time, hence this property of the fuel is also appropriately referred to as anti-knock index. Quite a number of callers indicated that they believed this parameter was the responsible for their vehicular problems (possibly told that by their repair garage) and needed to be investigated. The results indicate that for both ESSO and RUBiS fuels, the Octane levels meet acceptable standards.

Existent Gum may be simply explained as the name implies, the gum-like materials existing or formed in gasoline. Oxidative degradation due to extended storage, or additions of non-volatile materials such as some additives, etc. are primarily responsible for existent gum, which can also be explained as ‘solids or long chain compounds’ that can precipitate in gasoline and cause issues with certain components such as injectors and induction system in engines. This parameter was found to be above the upper limit set by the standard test and while Esso provided explanation and somewhat ‘justification’ for their results, Rubis results which were significantly higher remains unexplained by the company. However, based on (details of) complaints received and the limited technical information obtained from garages and mechanics across the Islands, the symptoms were **not** indicative that this was likely a significant contributor to the problems most motorists experienced. This parameter has been flagged for follow-up monitoring and discussions.

MMT is the shortened name for manganese (compound) which is added to gasoline to improve its Octane rating. This parameter is tested to ensure the concentration of MMT is within acceptable limits as set by a particular jurisdiction. Due to absence of legally mandated limits in Cayman Islands, Rubis currently utilizes US EPA standards for this additive of up to 1/32 gram per US gallon, while ESSO utilizes treat rate consistent with allowable limits in Canada and Australia up to a maximum 18mg/Liter concentration. This parameter is also flagged by Petroleum inspectorate for further research, however so far it was found that, limits set (by US EPA) on the use of this additive is primarily driven by (inconclusive) public health concerns and not necessarily due to significant vehicle performance (damage to components), an argument which was strongly advanced during the review of the results. Much discussion and research continues globally on the use and impact of this additive and it has been

acknowledged that its impact is generally inconclusive in a number of jurisdictions. The automobile industry has however taken measures with regards to use of MMT and it was researched that certain manufacturers explicitly banned the use of MMT in their vehicles to avoid performance hence warranty issues.

Overall, the specifications (or limits) for the parameters tested are acceptable at this time by Petroleum Inspectorate, that is, we have no reason or basis to substantially challenge the limits established by the industry which is defined under ASTM D 4814 standard for gasoline. The Vapor Pressure and Existent Gum limits would require research and analysis to ensure practical limits are established for Cayman Islands and any limitation of the analysis will be thoroughly evaluated. By similar token, the actual test results were acceptable for all samples except the Existent Gum, but to reiterate, this could not be considered a root cause of the issues motorists were experiencing.

Distillation curves are normally plotted based on the results obtained and the graphs shows fairly normal curves which is also an indication that the samples meets minimum standards. Driveability Index (DI) referred above, which can be defined as an index for predicting the cold start and warm up performance of gasoline is calculated by:
$$DI = 1.5 \times T_{10} + 3.0 \times T_{50} + T_{90}$$
where T10, T50, and T90 are the 10%, 50%, and 90% evaporated temperatures determined by ASTM D86 Test. If temperatures are stated in degree Celsius, the maximum acceptable result is approximately DI = 591 (provided by ESSO) and for temperature values in Fahrenheit, maximum acceptable DI should be in range of 1200 – 1300 (US EPA)

To provide a brief description of parameters not discussed in detail above, API Gravity is the relative density of fuel in specific units derived and accepted within the petroleum industry. The range can be broad depending on the production or blend of gasoline; the 'heavier' (denser) the gasoline, the lower is the API Gravity in degrees and vice versa. Appearance refers to the physical appearance of the gasoline and the C+B as indicated under results is interpreted to be Clear and Bright, which is an acceptable result for this test. Copper Corrosion provides an indication of the corrosiveness of the fuel, particularly as a result of its sulfur content (and sulfur compounds).

7.1.2 Further Discussion on Individual Results

As outlined previously, both companies import one grade of product RUBiS – Regular; ESSO –Regular and Premium alternatingly) and additize their fuels locally to obtain the requisite Octane Index for the premium grade gasoline offered on the market. For reference also, typical ratings for gasoline grades are: Regular 87-88; Mid-grade 89-90, Premium 91-94.

Rubis GCM sample consisted of a blend of gasoline from the active Terminal storage tanks and gasoline loaded into their fuel tanker truck which has been additized with two separate additives. Note that both ESSO and RUBiS use the same octane additive and also other proprietary additives to improve the fuel performance and detergent properties.

RUBiS Cayman Brac sample consisted of a blend of gasoline from the active Terminal Storage and gasoline from one of the gas stations. At the time of taking the sample, no additives were being placed into the fuel in Cayman Brac and only Regular grade of gasoline is offered for sale in the Sister Islands by Rubis.

ESSO's two samples were of such that one was drawn from their storage tank to represent their Regular (5000) grade fuel and the second separate sample was drawn from their tanker truck and to represent its Super (8000) grade additized gasoline.

Both companies use the same octane additive Methylcyclopentadienyl Manganese Tricarbonyl – more easily referred as MMT to boost the Octane of their fuel using a closed loop injection process in their Terminals. ESSO treat (dose) their product at a higher rate than RUBiS and as outlined previously, discussions and research are ongoing on this particular topic.

The following sections attempts to provide more discussion on the fuels marketed by the individual companies, however to maintain our objective stance in this matter, it should be mentioned that, despite much fewer in the case of one company, complaints emanated from customers who claimed to have fuelled at both Brands.

7.1.3 RUBiS Fuels

The properties of Rubis fuel based on the parameters analyzed above were found to be acceptable with the exception of Existent Gum, particularly on Grand Cayman. The analysis takes into account non-volatile additions to the fuel and the test attempts to give an indication of materials which can likely remain in an engine after the fuel is processed and burnt. The analysis is so structured to take into account 'washing' (detergent effect) which takes place in an engine hence the result simulates materials that will potentially clog fuel component parts and also gives an indication of end product of combustion which likely under high temperature will be become deposit if not expelled thru' the exhaust effectively reducing the efficiency of the engine. As outlined previously, both Rubis and PI continued to investigate this parameter and while Rubis is yet to confirm the outcome of their research, the information obtained so far by PI indicates that such levels are generally undesirable. It was suggested and noted that in such a case of extraordinary results, the tests should have been repeated using another independent lab to determine if similar result were reproduced, however the consideration to have concurrent analysis by different lab will be considered for future analysis.

MMT content in the fuel on GCM as compared to CYB differed based on concentration; however the resulting effect were mildly conflicting. Theoretically, increasing concentration of MMT translates to increase in Octane Index (on the established arbitrary scale) until diminishing effect sets in, but based on the results of analysis, despite a higher concentration of MMT in GCM gasoline, the Octane Index was slightly lower than that of CYB. This however did not prompt a repeat of the analysis as a few other factors can reasonably explain the higher OI in CYB (such as the importation of higher octane refinery blend fuel). Rubis complies with US EPA standard for treat rate of MMT in Gasoline which is capped at 1/32 gram per US gallon.

7.1.4 ESSO Fuel

Esso markets fuel only on GCM hence the results showed consistency across all parameters analyzed. The vapor pressure of the terminal sample returned a higher value than the (Florida) limit which was used as reference for the test. The results however are generally acceptable based on general industry standards, and also the limit Esso Management has set for themselves based on research undertaken by their in-house product quality team/experts.

Existent Gum was also a point of concern for their sample, and with the comprehensive discussion and explanation provided (by Esso) on this parameter, it is decided that PI will monitor trends and continue

to research this property to ensure realistic limits are imposed when product quality standards are imposed in Cayman Islands.

Esso has adopted and acknowledged that it uses Canadian standards for treating its fuel with MMT and the results indicated that this is well within those set limits. Additionally, the company discussed other approaches which are used to obtain a base stock (blend stock) in their Terminal Tank which does not fall below threshold OI, in their effort to ensure this parameter is consistently above board.

7.2 Phase III – Field Inspection Exercise

Based on the methodology developed for this phase, below are the results observed, discussed and agreed by the team. The results are tabulated by brand/company for the various gas stations.

Field Inspection Tabulation Sheet									
Visual Analysis of Fuel (Underground Tanks) at Retail Location									
Date/Period: October 2013									
Site Reference	Date of Inspection	Product	Color	Clear/Bright	Hazy/Cloudy	Sediments	Water (Trace)	Other	Comments
ESSO									
Site E1	9-Oct-13	Diesel	Flourescent/Yellow	Yes	No	No	No		Petrofirst System in use
		Super	Light Yellow	Yes	No	Minute	No		VR indicates water in tank
		Regular	Light Yellow	Yes	No	Minute	No		VR indicates water in tank
Site E2	9-Oct-13	Super	Light Yellow	No	Yes	Yes	No		Foreign material in tank, follow up re'd; Retailer indicated previous comingling during delivery.
		Regular	Light Yellow	Yes	No	Minute	No		Follow up visual to be carried out in future
		Diesel	Flourescent/Yellow	No	Yes (mildly)	Yes	No		Follow up visual to be carried out in future
Site E3	10-Oct-13	Super	Light Yellow	Yes	No	Minute	No		
		Regular	Light Yellow	Yes	No	No	No		
		Diesel	Flourescent/Yellow	Yes	No	Minute	No		
Site E4	10-Oct-13	Super	Light Yellow*	Yes	No	No	No		* color mildly tainted pink, VR indicates water in tank
		Regular	Pale Gold (to pink)	Yes	Mildly	No	No		VR indicates water in tank
		Diesel	Flourescent/Yellow	Yes	No	Minute	No		
Site E5	10-Oct-13	Diesel	Flourescent/Yellow	Yes	No	No	No		
		Regular	Light Yellow	Yes	No	No	No		
		Super	Light Yellow	Yes	No	No	No		
Site E6	10-Oct-13	Diesel	Flourescent/Yellow	Yes	No	No	No		
		Regular	Pale Gold (to pink)	Yes	No	Minute	No		Mild color mismatch (w/ref. sample); VR indicates water in tank
		Super	Light Yellow	Yes	Mildly	Minute	No		Mild Fluid activity - warm period of day
Site E7	10-Oct-13	Diesel	Flourescent/Yellow	Yes	No	No	No		
		Super	Light Yellow	Yes	No	No	No		VR indicates water in tank
		Regular	Light pink/salmon	Yes	No	No	No		Mismatch between Site and reference sample Tanks buried deep, no water in sump
Site E8	10-Oct-13	Super	Light Yellow	Yes	No	No	No		
		Regular	Light Yellow	Yes	No	No	No		
		Diesel	Flourescent/Yellow	Yes	No	No	No		Water in diesel sump
Site E9	11-Oct-13	Super	Yellow (to gold)	Yes	Mildly	Yes	No		Tank component departing from vertical - indicates rotation of tank, to further discuss (Retailer indicates water table and ground water flow issues)
		Regular	Light Yellow	Yes	No	No	No		
		Diesel	Flourescent/Yellow	Yes	No	Minute	No		
Site E10 (Closed during exercise)	11-Oct-13								

VR = Veeder Root (Tank Monitoring/Inventory Management System)

Table 2 – ESSO Sites Observation Results

Field Inspection Tabulation Sheet									
Visual Analysis of Fuel (Underground Tanks) at Retail Location									
Date/Period: October 2013									
Site Reference	Date of Inspection	Product	Color	Clear/Bright	Hazy/Cloudy	Sediments	Water (Trace)	Other	Comments
RUBiS									
Site R1	09-Oct-13	Regular	Pale Yellow	Yes	No	No	No		Water in Tank Sump
		Diesel	Gold/Normal	Yes	No	Minute	No		Water in Tank Sump
Site R2	09-Oct-13	Regular	Pale Yellow	Yes	No	No	No		Pump Samples, no direct access to tank, No Water in Tank, Tank Sumps were inaccessible
		Diesel	Gold/Normal	Yes	No	No	No		Pump Samples, no direct access to tank, No Water in Tank, Tank Sumps were inaccessible
Site R3	09-Oct-13	Regular	Pale Yellow	Yes	No	No	No		Inconclusive sedimentation (1mm) in inspection instruments due to previous site contamination
		Premium	Pale Yellow	No	Yes	Minute	No		Increased fluid activity/molecular motion (due in part to warmer temp of day), top phase was a bit cloudy; Suspect biological activity but no sediment, follow up analysis required
Site R4	09-Oct-13	Diesel	Brown/Contaminated	No	Yes	Yes	No		Water in Fill Point (bucket)
		Premium	Pale Yellow	Yes	No	No	No		Increased fluid activity/molecular motion (due in part to warmer temp of day) VR indicated water in tank.
Site R5	09-Oct-13	Regular	Pale Yellow	Yes	No	Minute	no		Water in Tank Sump
		Diesel	Gold/Normal	Yes	No	Minute	no		Tank Sump laden with Water - suspect seawater
Site R6	10-Oct-13	Regular	Off Pale Yellow	No	Yes	Yes	No		Tank Sump laden w/water, 2 of 3 sample were C&B, but still slightly cloudy with sediments, to follow up
		Diesel	Brown/Contaminated	No	Yes	Yes	(2")		Tank Sump laden with Water - suspect seawater, suspect microbial activity in Tank, to follow up
Site R7	10-Oct-13	Regular	Pale Yellow	Yes	No	No	No		Crystal Clear + Bright
		Premium	Pale Yellow	Yes	No	No	No		Crystal Clear + Bright
Site R8	10-Oct-13	Regular	Gold/Normal	Yes	No	No	No		Crystal Clear + Bright
		Diesel	Pale Yellow	Yes	No	No	No		Pump Samples, no direct access to tank, Tank Sumps were inaccessible
Site R9	11-Oct-13	Regular	Pale Yellow	Yes	No	No	No		Pump Samples, no direct access to tank, Tank Sumps were inaccessible
		Diesel	Gold/Normal	Yes	No	No	(0.75")		Pump Samples, no direct access to tank, Tank Sumps were inaccessible
Site R10	11-Oct-13	Regular	Pale Yellow	Yes	No	No	No		
		Premium	Pale Yellow	Yes	No	No	No		No* - Was not as translucent as reference sample
Site R11	11-Oct-13	Diesel	Gold/Normal	Yes	No	No	No		No Access to Tank fill tube or sumps, vial was used to extract samples, crystal clear + bright
		Regular	Pale Yellow	Yes	No	No	No		No Access to Tank fill tube or sumps, vial was used to extract samples, crystal clear + bright
Site R12	22-Oct-13	Regular	Pale Yellow	Yes	No	No	No		No Access to Tank fill tube or sumps, vial was used to extract samples
		Premium	Pale Yellow	Yes	No	No	No		Product Low in Tank; slab significantly cracked, likely technical issues relating to tanks - movement, Slab damages
Site R13	22-Oct-13	Regular	Gold/Normal	Yes	No	No	No		VR indicates water in tank.
		Diesel	Pale Yellow	Yes	No	No	No		
Site R14	22-Oct-13	Regular	Pale Yellow	Yes	No	No	No		Tank Installation not fully compliant
		Diesel	Bright Red	Yes	No	No	No		Pump Samples, Tanks Sump accessible, no available sample point

VR = Veeder Root (Tank Monitoring/Inventory Management System)

Table 3 – RUBiS Sites Observation Results

7.2.1 Summary/Highlights of Observation by Company

The following provides an interpretation of the findings summarized in the Tables 2 & 3 above. Against the background of a few instances where photos of fuel samples were sent to the department, and information of claims that the fuel removed from affected vehicle tanks were highly discolored with offensive/stale odors (gasoline hardly smells pleasing and should never be inhaled) there was the expectation of some sites still having gasoline that meets this (visual) description. It turned out not to be the case at almost all of the sites, however there were cases of mild color variation between the reference sample and site samples.

It should be clarified at this stage, there is no established correlation between a particular fuel color and its quality. In various jurisdictions around the world, fuels are dyed for a number of purposes and these dyes do not alter the quality of the fuel in any substantial way. As such, in the cases where color variations were observed, the companies were requested to investigate further and revert with explanation for further review by PI.

In all the cases below except where expressly stated, poor or non-compliant condition of equipment (tanks) did not provide any direct indication of contributing to fuel quality issue, however to reiterate, an action plan is being developed to address issues which were observed nonetheless. Importantly also, the few sites where (diesel) fuel were found to be affected primarily due to water ingress to the tanks, the fuel was immediately ‘flushed’ to ensure customers were not affected beyond that point, and the situation continues to be monitored until permanent solutions such as tank top upgrades or tank replacements are effected.

7.2.1.1 RUBiS Sites

- All stations offer both grade of gasoline - Premium and Regular except Site R1, Site R2, Site R7 and the Sister Islands gas stations/fuel facilities.

- Gasoline quality – both grades were found to be fairly acceptable and consistent across all sites; fuel at higher volume sites (high sales/turnover) were distinctly ‘clear and bright’ as a good preliminary indicator that the fuel quality is good.
- Regular gasoline at Site R5 was found to be abnormal on first of three attempt of sampling. Two subsequent samples produced ‘acceptable’ results however the impact of site factors on product quality has been flagged, is being continuously monitored and subject to further review.
- Diesel quality was fairly consistent across all sites except Site R3 and Site R5. Observations indicate microbial activities due to presence of water in tanks.
- Instance of water in tank were few across Rubis network; significant presence (volume) of water was however found in Gasoline tank at Site R14.
- Tank manholes at a few sites where the sumps were accessible, were found to be water laden (likely) due to high water table and/or surface water capture due to poor seals.
- One site – Site R10, the product was found to be exceptionally low in the ‘Regular’ grade Tank (too much ullage promotes condensation in Tanks).
- Very light traces (minute) of sediment were found in a number of samples observed; acceptable traces which typically is captured in the filter mechanism before dispensing into vehicle (will not contribute to vehicle performance issues). Note that filter standards are typically 10 microns for gasoline, 20/30 microns for diesel commonly with water blocking properties.
- Underground tank installation in Cayman Brac and Little Cayman does not meet minimum industry standards – these are unapproved installation and need attention to ensure environmental standards – not currently contributing to fuel quality issues.
- Tanks at Site R3 are non-compliant single-wall tanks and require upgrading.
- Diesel found in the tank at Site R14 was red in color and not consistent with terminal reference sample. No reference sample (from Terminal) was available at this site due to the inability to transport this substance (dangerous goods) on Aircraft.
- Most of Sites are fitted with functioning Inventory Management and Leak Detection (VR) system except Site R9, Site R7, Site R10 and the sites in the Sister Islands. Site R5 is fitted with the VR system but was out of order at the time of the exercise. No major discrepancies were found between Veeder Root reports and actual tank verification done (for water in tanks).
- Very mild variability in color of gasoline grades was observed however would require more complex analysis to determine reason for variability.

As part of its efforts to ensure the quality of fuel delivered into customer’s vehicle, Rubis has also invested in additional equipment to condition the fuel at its retail sites, and this is being done on a periodic basis since this issue surfaced.

7.2.1.2 ESSO Sites

- All of Esso branded stations offers both grade of gasoline – Regular (5000) and Super (8000), and also diesel fuel.
- All gas stations are fitted with Inventory Management and Leak Detection System except Site E2.
- The colors of gasoline samples were fairly consistent across all sites with that of reference terminal samples except at three sites – Site E4, Site E6 and Site E7. Color variation can be attributable to a number of factors including product adulteration and require further investigation which is underway.
- Diesel samples were consistent across all sites based on color of reference sample

- Traces (minute) of sediments were found in tanks at most of the sites (likely due to internal tank wall being metal).
- Water in tanks and tank sumps was **not** found to be a common problem at almost all the sites.
- Regular gasoline at one site – Site E2 was found to be abnormal towards the bottom of tank with materials suspected to be linked to microbial activity or comingling and follow up inspection will be carried out.
- One tank installation, the Super (8000) gasoline tank at Site E9 showed some abnormality indicative of tank movement. This item has also been flagged for follow up review.

7.2.2 Equipment at Gas Stations

The equipment list of assets in place at the various gas stations was also reviewed as part of this exercise and a few sites were found where action needs to be taken in the short to medium term as mentioned in the foregoing highlights. This requirement is however in its preliminary stage based on our tabletop review as other assessments will be required to determine the priority and urgency with which remedial action should be taken.

Other requirement related to our review includes ensuring all sites are fitted with Inventory management and monitoring systems and ensuring effective maintenance and calibration of these systems are carried out on a periodic basis. There were also a few (technical) cases related to soil stability, ground water and tank movement which are borderline to this investigation and will be addressed directly with the Oil companies

Most sites are also fitted with Monitoring Wells, a requirement imposed by Water Authority and enforced by PI, and this adds essential redundancy for monitoring of tanks (for leaks).

Generally, the ages of equipment across the network were found to be acceptable as the life of underground tanks and lines can range from fifteen (15) to forty (40) years if properly installed and maintained, and where soil conditions are favorable. Based on the review in relation to the exercise/investigation, there are no indications at this stage that this is an area of critical concern which could have contributed to fuel quality issues. However, further assessment will be carried out at sites where other (external) factors were observed to be affecting particular equipment, and also cases where the condition of the installations were flagged.

Only at one site there was substantial evidence to explain water in the tank and this was for diesel fuel. This matter is currently being reviewed with the relevant parties. It should also be pointed out that microbial activities affect most grades of (petroleum) fuel, however its effect is found to be much more pronounced in the case of diesel fuel. To reiterate, this was immediately addressed and continues to be monitored, so this should not be an issue for customers.

8. Discussion on Findings:

The investigation into complaints of fuel quality issues affecting motorists (vehicles) predominantly during the 2nd and 3rd Quarters of 2013 did not provide substantial evidence to suggest the quality of the fuel analyzed was significantly “off-spec”, based on tolerance ranges of typical parameter in standard grades of fuel (gasoline in this case). Nonetheless, in the absence of legally mandated fuel quality standards, the industry exercises much self-compliance to meet internationally recognized and established fuel quality standards. Adherence to quality standards is further reinforced through commercial/legal relationships between local entities, and particularly in the Aviation industry by international aviation organizations for obvious reasons. Adherence includes additional product stewardship requirement to provide assurances of the highest order, that minimum quality standards are consistently met for these fuels. Gasoline standards are driven by the extent of the local fuel (marketing) company’s commitment to deliver a consistently high quality of fuel to create an overall good driving experience for their customers.

Both formal and informal discussions were held prior to and during the period of the investigation and while the primary concern was OI - the parameter responsible for, or the broad measure of the performance of gasoline, the results confirmed the Oil Companies position that this is acceptable. The results of other parameters which could impact the performance of fuel showed that the baseline quality of the fuel on Island is acceptable. It should be noted that the fuel sampled for the purpose of this exercise may not be representative of the batch of fuel in use at the time the issue surfaced, and this was considered an inherent limitation of the exercise.

Phase 1 results were confidentially discussed in detail with the Oil companies for their respective analysis , with broad inputs from Pan Air Lab, Saybolt Lab, US EPA representative, ESSO product quality ‘guru’ and Rubis technical personnel and there was general acceptance of the result.

MMT which engaged lots of discussion among the results of other parameter will be reviewed and will include wider stakeholder group involvement, particularly Department of Environment (DoE) which monitors GHG emissions in the Islands. Independent research by PI has revealed that there are also performance (mechanical) issues related to the use of MMT, and higher concentration will increase possibility of damage to vehicle engine components, as such the department will continue to research this and pay closer attention to details of issues being experienced by motoring public. Existent Gum, like other parameters also require further discussion, but generally, discussions on fuel quality standard never attains steady-state or equilibrium, thus is always ongoing.

MMT has been in use as an antiknock additive in fuel for decades, however it has been subjected to much debate and discussion across the fuel and auto industry. While MMT was banned in the USA prior to the ban on Lead (TEL) in gasoline, waivers can be issued for its use in certain states. Because of the ongoing debate and research which continues, it is likely a matter for individual Jurisdictions to consider in regards to its use and concentration limits. One important finding during the investigation was, some auto manufacturers have banned its use in their vehicles, however it could not be ascertained whether the fuel companies, being aware of the continued debate on MMT, provided any public awareness that this additive is being used in their fuel.

Phase 3 exercise, which extended over a three-day period, was non-disruptive to the operations at Gas Station, so Operators were free to continue to sell fuel while the exercise was being conducted. Approved apparatus and Personnel Protective Equipment (PPE) were used in the process of extracting samples from the tank and results were recorded based on observation as shown in Tables 2 & 3. As outlined in the method statement, all efforts were made to extract samples from the storage (underground) tank from suitable access point for visual inspection. After exhausting all options, in cases

where this was not possible, samples were taken from the Dispensers to conduct the visual inspection. While the findings were not generally startling, it did highlight cases where systematic improvement and compliance enforcements are needed.

For the records also, both companies indicated that the octane additive – MMT did not alter the color of the base fuel to which it was added. Notwithstanding, every effort was made to consistently compare ‘like for like’ gasoline grade for each sample taken.

During the investigations, the topic of Ethanol was introduced to the discussions. Ethanol blend produces the similar effect as MMT for OI in gasoline, and popular for its accompanying environmental benefits. The use of ethanol blend fuel here in Cayman requires a proper assessment before it can be deemed suitable or unsuitable, and as with any change, there are likely to be conditional requirements. At the outset however, ethanol has its challenges in “wet” environment hence careful review is required before its introduction. So far, both oil companies have gone on record indicating that they have no immediate plans to market ethanol blended fuel and PI will be keen to commence discussion on this to ensure all systems are in place if and when this fuel is introduced. It should be noted that there is inherently no issue with ethanol blended fuel.

8.1 Customer’s role in the Issue

Customers, or more appropriately motorists are not exculpated from the issue. While discussion on this particular topic can be elaborate and debatable, brief focus will only be placed on the bits and pieces of information we have gleaned in regards to possible customer’s implication in the issue. Given the millions (exaggerated for emphasis) of over-the-counter additives which are available on the market; poor fuel handling practices of customer, for instance storing for extended periods or obtaining free gas from a friend who claims the fuel is “scientifically” blended to be appropriate for use in vehicle; obtaining fuel from unapproved sources which likely may not have all ‘check and balances’ to assure quality; dosing and other means of boosting fuel for enhanced performance, and other such cases, can significantly contribute to the fuel issues being experienced.

Two very important points to clarify in this regards are:

- PI is not an authority or certifying agency on additives available to be used in vehicles. As such, it was not an objective or the intention to approve or disapprove any of these products available to the general public.
- Secondly, our investigation could not conclude what effect the factors above could have had on this particular issues, not ruling out that customers really had no part in this, a situation which was well beyond their control.

While the general lack of (technical) details relating to specific issues encountered by customers limited the extent to which we could have formed a preliminary opinion on the issue, such information if available would still be valuable to guide us going forward in relation to developing fuel quality standards and adopting best practices.

9. Limitations of the Investigation

This exercise was the first of its kind undertaken by the department and naturally was not without challenges and some limitations. Because fuel quality standards and compliance are relatively complex matters, as far as possible, much care and attention was given to ensure the investigation was relatively adequately structured to accomplish its goal. Resources – time, manpower and funds were limited and this set the primary boundary, the first line of challenges and limitation to the investigation. Secondly, a non-dedicated approach was taken in order to balance the other priorities and demands of the department and this led to the investigation being somewhat protracted.

Some of the areas related to the investigation which the department considered to be lacking are:

- Complaints from the public lacked specific details to allow the department to identify trends or common factors in regards to the issue
- Department previously deflected these complaints to the Oil Companies or gas station so there was no established system or process internally to follow or to basically log complaints
- Many callers wanted to remain anonymous, prevented follow-up to obtain further details
- Bloating of the issue (too many ‘experts’, speculations on the issue, etc.)
- Customers were cross-fuelling from the competitive gas stations – traceability of their fuel source was lacking to almost non-existent
- There are no means of identifying or tracking whether fuel is entering the market through other channels and in what quantities. By extension, the quality of these fuels is not verified nor is it likely to verify the chain of custody of fuel.
- During Phase I, samples were taken from the ‘working’ terminal tanks, hence any tank which may have contained fuel but was not being used at the time to supply customers were not necessarily sampled. (This was not the case at the Retail Sites/Phase III)
- Information flow did limit the investigation not only on the basis of obtaining same, but also in some cases the time it took to do so. A distinction can be drawn between the two companies in the way responses were provided in terms of their willingness, efficiency and openness in communications. One example where basic information was requested and is yet to be provided relates to non-proprietary information on Tanker/Vessels used to transport fuel, however was otherwise confirmed.
- Naturally, our weak regulatory environment imposed limitations, however this was taken into account in setting about the exercise.

The foregoing generally could have contributed to the investigation being more streamlined and expedited. Lastly, a unique limitation as it relates to this issue is the relatively high consumption (hence turnover) of fuel here in Cayman Islands when considered relative to their active storage capacity. Fuels are typically in continuous blends in the storage tanks at the terminals because product (gasoline) is imported at least once a month for both companies which in itself is beneficial in that it limits issues associated with products stored over long period of time, guaranteeing fresh products to consumers. The limitation lies in the fact that where ‘off-spec’ fuel is imported and sold to the public, by the time there is the recognition of an issue which could be tied to fuel quality, the specific batch of fuel is either substantially depleted, or blended/diluted with ‘new’ product of similar grade. Testing of fuel in this case may not easily link symptoms to known parameters (results either masked or non-detect) and damages sustained by vehicles are then attributed to other likely parameters which ideally may not be the case. Because such a large body of knowledge exists in the area of fuel quality and possible effects (of each parameter), a means of determining the constituent composition of each batch of fuel has to be ‘gate-checked’ before blending with existing fuel for such investigation to be more meaningful. Issues

and subsequent effects are then more easily traceable based on empirical data, allowing the root cause of problems such as these to be more precisely determined.

9.1 Field Limitations and Lessons Learnt

In addition to general limitations outlined above, there were some challenges encountered during the exercise which proved to be valuable lessons learned for the team. We did not consider however that these challenges significantly impacted the accomplishment of the goal which was set for this phase of the investigation. However, users/readers of the information contained in this report are advised to seek clarification from PI if necessary, where apparent conflict seems to exist.

Some of the challenges which effectively are lesson learnt were:

- Observation vessel (which was a modified utensil for this exercise) became difficult to flush effectively due some challenges encountered in the field. Sediments clung to the bottom and had to be frequently flushed with both fuel and air to ensure subsequent sampling were not affected/tainted. In future, at least 2 – 4 of this apparatus will be required to avoid hiccups.
- Sampling observation would have been improved if there were dedicated utensils for gasoline and diesel samples, and separate units for samples from Rubis and Esso.
- Apparatus used to observe samples must be same size and type as utensil in which reference sample is held
- Professional photography is desirable (or tips provided to the team for future exercise to ensure photographs are of a consistent quality.
- Reference Samples obtained need to be clearly labeled and sufficient back up quantity should be on hand; one reference sample container fell and broke and no other was available during exercise.
- Some means of labeling each site sample before photographing is highly desirable.
- Representative from each site or the Oil Companies should be available throughout to witness the exercise

10. Recommendations

Following are the key recommendations arising out of the investigation:

- Establish a committee to develop fuel quality standards for fuel imported to the Island. Focus is to be on gasoline fuel in the first instance. This committee should include key stakeholders to ensure a balanced approach is taken, however the Oil Companies and Petroleum Inspectorate necessarily need to drive this process.
- Periodic random sampling and certified analysis of fuel should be conducted for **all** imported fuel used in the retail network. The process will be supervised by the Petroleum Inspectorate Department; however the cost needs to be covered by the fuel importer.
- Fast track Regulations and Policies relating to Fuel Quality to allow effective monitoring and enforcement of fuel quality standards.
- Establish a formal complaint process in the online environment to effectively capture public complaints in a structured manner.

11. Conclusion

The results of the investigation were not indicative that the quality of fuel on the market was questionable. Clearly however, there is the possibility of fuel being imported of varying standard and composition which could have negative impact on customer vehicles. Without empirical evidence, it is difficult in this case to arrive at firm conclusion on the extent other parameters could possibly be contributing to some of the vehicular issues experienced, however one subtle indicator, the number of complaints received within the last four to six weeks, have tapered off significantly, except in Cayman Brac where the issue still seems to be lingering.

Absence of Regulation leaves an open door on the issue and because of the complex nature of fuel quality issues, the Oil companies simply cannot be coerced into complying with fuel standards unless a comprehensive approach is taken to address such an issue, backed by legislation. However, despite robust regulations, importers of fuel for consumption have a moral obligation to ensure the quality is acceptable and should make the public aware of any peculiarities of their fuel without having to divulge truly sensitive competitive information. This requirement is further reinforced by the fact that liability for issues related to their fuel (quality) in most instances, remains with the (primary) importer.

This exercise does not attempt to create any bias in consumer's choice of fuel and this decision remains at the level of the public. With the impetus created, the public can request information from the Oil companies in regards to their fuel (quality) and also should demand specific information in regards to issues which require mechanical intervention on their vehicles. The exercise also prompted the need to collaborate with fuel marketers to create increased customer awareness on fuel quality available in the Cayman Islands and also assist customers to better understand their role and diligence required on customer's part to ensure the quality of fuel used in their vehicles is acceptable.

Appendices

Copies of Lab Results

Method Statement for Field Exercise

Petroleum Inspectorate/Water Authority Collaboration – 3rd Stage Investigation of Fuel Quality Issues

Objective and Method

Field Verification Exercise at Retail Outlets (Gas Stations)

Objective: Simplified analysis of fuels in underground tanks (or above ground where applicable) to visually determine any indication of contamination. Contamination in this context can be defined as discoloration, haziness/cloudiness, particulate matter/sediments or trace water content. Note there may be some subjectivity in the checks/tests; however photography will also be used to supplement results/findings.

Smell test is out of scope for this exercise.

Method/Approach

- Reference sample will be obtained from Bulk Terminals.
- Secure/Cordon off Tank Area with Safety Cones, Exclusively No Smoking or use of Cellphones within the zone
- Prior to taking fuel sample, water dip will be taken for each tank
- Field Sample will be drawn from each tank at each site (preferably from dip point close to turbine – turbulence will be beneficial)
 - Note dedicated bailer will be used at Esso and Rubis locations for gasoline and diesel at each site
 - Fuel will be drawn using the bailers only, product will not be taken from the Dispensers*
 - Bailer to be lowered to the lowest point into tank wait 4 seconds and then retrieved, allowing product to stop dripping before decanting into observation flask (with funnel).
 - Product to settle in flask before observing; comparison will to be first made against reference sample
 - Clear and bright check will then be done
 - Sample will then be swirled to observe any water droplets or sediments (in vortex). Settling can also give an indication of sediments
- Label indicating Site Name and Product (and Tank Designation we assign) placed on inspection utensil and photographed.
- Fill in simplified inspection/analysis form as required
- Return product to Tank (if decision made to retain portion of sample, Retailer must be notified and sample will be placed in sealed approved container and labeled)
- Record comments and other general observation related to site (e.g. water in manhole, rusted vents, vent caps damaged, damaged/missing entry boot, dust cap not properly locking/sealing, etc.)
- Any fuel which may be considered ‘suspect’ and beyond the scope of this exercise, will be further considered for official lab testing (third party will be consulted)

- Note that during warmer hours of the day, more Gasoline vapors will be generated, so samples must be handled at all times, holding downwind to avoid inhalation.

*Exception only allowed in circumstances where it is impossible to draw a sample from tanks and CPI will verify in all instances that this is the case.

PPE and Miscellaneous Items

Long Sleeve clothing preferred

Safety Boots

Safety Helmet

Safety Goggles

Respirator*

Hi-Vis Vests

Safety Cones

Nitrile Gloves

Camera

Label Maker

Metal Funnel

Absorbent Pads

Water Finding Paste- Kolor Kut (Gas Stations to provide)

Dip Sticks (Gas Stations to provide)

Special Notes

IN ANY EMERGENCY, EXERCISE TO BE ABANDONED TEAM WILL EXIT SITE WHERE NECESSARY. CONTACT 911 AS REQUIRED

First Aid Kit Available in CPI Vehicle

MSDS Available on Hand

Expanded View of Field Observation Templates

Catalog of Photographs