INCIDENT INVESTIGATION REPORT

Fuel Tank Product Release

Prepared for:

Utility Regulation & Competition Office (OfReg)

22 December 2020

SPENERGY
5145 Shiloh Road
Suite 111
Cumming, GA 30040
Ph: 770-369-9195
Fx: 678-325-7337
www.spenergycorp.com

TapRoot® Investigation – Rubis Cayman Islands Limited, Jackson Point Terminal Fuel Release from Tank No. 32198

Grand Cayman, Cayman Islands

December 22, 2020

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1. General

Incident Location: Rubis Cayman Islands Limited - Jackson Point Terminal

Incident Classification: Spill - Environmental Release

Incident Categorization/Severity: Major

Incident Date: 15 November 2019

Incident Time: 20:30

Date Incident Discovered: 15 November 2019

Date Investigation Started: 10 February 2020

Date Investigation Completed: 11 June 2020

Notification of Authorities: OfReg

Spill Release Info:

Product	Unit of Measure	Quantity Released	Released By	Quantity Recovered	Recovered By:	Potential Quantity Released to Environment
Diesel Fuel	Imperial Gallons	3858	Tank #32198	172	IBC Container	3,686*

Spill Release Notes: Tank #32198 contained 981,714 imperial gallons at time of incident. Quantity released represents amount of fuel which (based on records provided) was NOT transferred to another tank within the terminal and/or customer during emergency response procedures.

* Potential quantity released to environment could be in excess of 3,686 due to inconsistencies identified with RCIL inventory reconciliation records and unexplained loss variations prior to the incident.

Incident Description:

On 15 November 2019 at approximately 20:30, Tank #32198 was found to be leaking fuel on its western side adjacent to the dike wall at the base of the tank between the tank lining and external steel ring by the Security Guard (Third Party Contractor) onsite at RCIL while monitoring security checkpoints throughout the RCIL Jackson Point Terminal. There were no personal injuries or fatalities reported.

High Level Causal Factors:

- Human Performance Difficulties
- Standards, Procedures and Administrative Controls (SPAC)
- Training
- Quality Control
- Communications
- Management System
- Work Direction

2. Definitions

Amphoteric Metal: A metal that is susceptible to corrosion in both acidic and alkaline environments.

Anode: The electrode of an electrochemical cell at which oxidation occurs. (Electrons flow away from the anode in the external circuit. It is usually the electrode where corrosion occurs, and metal ions enter solution.)

Anode Bed: One or more anodes installed below the earth's surface for the purpose of supplying cathodic protection current. For the purposes of this standard, an anode bed is defined as a single anode or group of anodes installed in the electrolyte for the purposes of discharging direct current to the protected structure.

Cathodic Protection (CP): A technique to reduce the corrosion rate of a metal surface by making that surface the cathode of an electrochemical cell.

Causal Factor (TapRooT® Definition): A mistake, error, or failure that directly leads to (or causes) an Incident or fails to mitigate the consequences of the original error.

Corrosion: The deterioration of a material, usually a metal, that results from a chemical or electrochemical reaction with its environment.

Corrosion Potential: (represented by the symbol E_{corr}) The potential of a corroding surface in an electrolyte measured under open-circuit conditions relative to a reference electrode. [also known as electrochemical corrosion potential, free corrosion potential, open- circuit potential]

Corrosion Probe: An electrical resistance instrument that determines the corrosion rate on its metal electrode or electrodes by measuring and converting the measurements to metal loss.

Corrosion Rate: The time rate of change of corrosion. (It is typically expressed as mass loss per unit area per unit time, penetration per unit time, etc.)

Current: (1) A flow of electric charge. (2) The amount of electric charge flowing past a specified circuit point per unit time, measured in the direction of net transport of positive charges. (In a metallic conductor, this is the opposite direction of the electron flow.)

Current Density: The electric current flowing to or from a unit area of an electrode surface.

Deep Anode Bed: One or more anodes installed vertically at a nominal depth of 15 m (50 ft) or more below the earth's surface in a drilled hole for the purpose of supplying cathodic protection current.

Differential Aeration Cell: A concentration cell caused by differences in oxygen concentration along the surface of a metal in an electrolyte. [See *concentration cell*]

Direct Current (DC) Decoupling Device: A device used in electrical circuits that allows the flow of alternating current in both directions and stops or substantially reduces the flow of direct current.

Dissimilar Metals: Different metals that could form an anode-cathode relationship in an electrolyte when connected by an electron-conducting (usually metallic) path.

Distributed-Anode Impressed Current System: An impressed current anode configuration in which the anodes are "distributed" along the structure at relatively close intervals such that the structure is within each anode's voltage gradient. This anode configuration causes the electrolyte around the structure to become positive with respect to remote earth.

Driving Potential: Difference in potential between the anode and the steel structure.

Electrical Survey: Any technique that involves coordinated electrical measurements taken to provide a basis for deduction concerning a particular electrochemical condition relating to corrosion or corrosion control.

Electrode: A material that conducts electrons, is used to establish contact with an electrolyte, and through which current is transferred to or from an electrolyte.

External Circuit: The wires, connectors, measuring devices, current sources, etc., that are used to bring about or measure the desired electrical conditions within an electrochemical cell. It is this portion of the cell through which electrons travel.

Foreign Structure: Any metallic structure that is not intended as a part of a system under cathodic protection.

Galvanic Anode: A metal that provides sacrificial protection to another metal that is more noble when electrically coupled in an electrolyte. This type of anode is the electron source in one type of cathodic protection.

Galvanic Corrosion: Accelerated corrosion of a metal because of an electrical contact with a more noble metal or nonmetallic conductor in a corrosive electrolyte.

Galvanic Couple: A pair of dissimilar conductors, commonly metals, in electrical contact in an electrolyte.

Galvanic Current: The electric current flowing between metals or conductive nonmetals in a galvanic couple.

Groundbed: One or more anodes installed below the earth's surface for the purpose of supplying cathodic protection current. For the purposes of this standard, a groundbed is defined as a single anode or group of anodes installed in the electrolyte for the purposes of discharging direct current to the protected structure.

Impressed Current: An electric current supplied by a device employing a power source that is external to the electrode system (An example is direct current for cathodic protection.)

Impressed Current Anode: An electrode, suitable for use as an anode when connected to a source of impressed current. (It is often composed of a substantially inert material that conducts by oxidation of the electrolyte and, for this reason, is not corroded appreciably.)

Microbiologically Influenced Corrosion (MIC): Corrosion affected by the presence or activity, or both, of microorganisms.

On-Grade Storage Tank: A storage tank constructed on sand or earthen pads, concrete ringwalls, concrete slabs, or asphalt pads.

Oxidation: (1) Loss of electrons by a constituent of a chemical reaction; (2) corrosion of a material that is exposed to an oxidizing gas at elevated temperatures.

Polarization: The change from the corrosion potential as a result of current flow across the electrode/electrolyte interface.

Polarization Decay: The change in electrode potential with time resulting from the interruption of applied current.

Polarized Potential: (1) (general use) The potential across the electrode/electrolyte interface that is the sum of the corrosion potential and the applied polarization. (2) (cathodic protection use) The potential across the structure/electrolyte interface that is the sum of the corrosion potential and the cathodic polarization.

Rectifier: A device for converting alternating current to direct current. Usually includes a step-down AC transformer, silicon or selenium stack (or other rectifying elements), meters, and other accessories when used for cathodic protection purposes.

Reference Electrode: An electrode having a stable and reproducible potential, which is used in the measurement of other electrode potentials.

Release-Prevention Barrier: A second steel bottom (when used in a double-bottom or secondary containment system), synthetic materials, clay liners, and all other barriers or combination of barriers placed under an on-grade storage tank to prevent the escape of the stored liquid into the environment and to contain or channel released liquid for leak detection.

Resistivity: The electrical resistance between opposite faces of a unit cube of material.

Resistor: An electrical device that limits the quantity of electricity flowing in an electrical circuit by resisting the flow of current through it.

Root Cause (TapRooT® Definition): The most basic **cause** (or **causes**) that can reasonably be identified. that management has control to fix and, when fixed, will prevent (or significantly reduce the likelihood of) the problem's recurrence.

Shallow Groundbed: One or more anodes installed either vertically or horizontally at a nominal depth of less than 15 m (50 ft) for the purpose of supplying cathodic protection current.

Structure-to-Electrolyte Potential: The potential difference between the surface of a buried or submerged metallic structure and the electrolyte that is measured with reference to an electrode in contact with the electrolyte.

SnapCharT™: A diagram of the sequence of events of an incident or the process being observed in an incident investigation. It is similar to a process flowchart, a multi-linear event sequence diagram, or an event and causal factors chart.

Tank Foundation: Material beneath an on-grade storage tank that supports the weight of the tank. This may include concrete slabs, concrete ring walls, compounded fill (such as sand or earth), and pilings.

Tank Pad: Material immediately adjacent to the underside of the tank bottom of an on-grade storage tank.

Voltage: An electromotive force or a difference in electrode potentials expressed in volts.

3. Executive Summary

The investigation team would like to thank all relevant parties for their cooperation and assistance during the investigation. This report has been prepared by SPENERGY on behalf of the Cayman Islands Utility Competition and Regulation Office (OfReg) to provide technical expertise and support services for OfReg's incident investigation into the diesel fuel leak from Tank #32198 on 15 November 2019 at the Rubis Cayman Islands Limited (RCIL) Jackson Point bulk fuel storage terminal.

Throughout the investigation, there were a variety of areas considered in the evaluation of causal factors that either could have, had the potential to have, and/or had a relevant impact on the incident. Those factors could have either mitigated or prevented the incident altogether. Such factors included procedures, training, quality control, management systems (i.e. Standards, Policies, or Administrative Controls (SPAC)), communications, human engineering, equipment design, human performance difficulties and work direction.

The approach and methodology utilized in order to determine the safeguard failures, causal factors and their subsequent root causes identified in this report is the TapRooT® System. In short, the TapRooT® System is an advanced, proven system for root cause analysis of incidents and major events. TapRooT® Root Cause Analysis is used to improve performance by analysing and fixing problems to prevent major accidents, quality issues, equipment failures, environmental damage, and production issues.

As a result, the investigation identified several Causal Factors of the incident which consist of the following:

CAUSAL FACTOR #1:
Identified in the SnapChart™ on 3 separate occasions (in 2014, 2015 and 2017) as a **"Condition"** element of the Cathodic Protection Annual Survey performed during that time as defined in Appendix A entitled **"Interview with Operations Manager revealed that they were unable to receive appropriate assistance from Contractor in addressing recommendations".**

According to the National Association of Corrosion Engineers (NACE) industry standard, Cathodic Protection surveys are required to be performed annually by qualified personnel. The recommendations provided from these survey's should be followed and actioned to ensure adequate corrosion control of tanks and its related equipment. Tank #32198 suffered a bottom plate failure resulting from severe rust and degradation due to corrosion. On each Cathodic Protection Annual Survey dating back to 2013, RCIL was informed of the need to address issues or take necessary measures in order to ensure adequate Cathodic Protection for the tank as Tank #32198 did not meet requirements set forth by NACE industry standard.

However, there was not sufficient information provided by RCIL in order to ascertain that these recommendations were implemented and/or actioned. Reasoning provided by RCIL management was that they were unable to secure appropriate assistance and/or support from Contractors during these times in order to action items identified. Further, no other information and/or details were provided to ascertain if RCIL undertook alternative measures to address issues identified in order to remedy these concerns, thus, the equipment remained inadequate and/or non-compliant in its ability to provide adequate corrosion control for Tank #32198. Based on the aforementioned details, conclusions indicate equipment failure due to a lack of appropriate preventative maintenance to the Cathodic Protection system for the tank.

CAUSAL FACTOR #2:

Identified in the **SnapChart™** as a **"Condition"** element in Appendix A entitled **"No formal Internal Inspection of tank bottom plate was performed while Tank was empty."** The condition was a result of when the tank had a change in service in July 2015 where the type of fuel in Tank #32198 was changed from High Sulphur Diesel to Ultra Low Sulphur Diesel.

RCIL acknowledged the application of relevant industry standards such as API 653, in which they incorporate, utilise and follow as a part of their standard operating practice. However, in this particular instance, a repair was authorised by RCIL and made to the tank bottom plate which was found after the sandblasting process. This in itself is a clear indication of high corrosion given the age of the tank bottom plate and previous trends resulting from the Cathodic Protection Annual Surveys of which RCIL was also aware of. No information was provided by RCIL to indicate that appropriate measures were taken in accordance with API recommended practices for internal tank bottom inspections. Also, there was no information provided as to if at this time RCIL followed any internal procedures in order to appropriately address managing this change. Further, it was also noted by RCIL management that the tank needed to be placed back in service in service in order to receive fuel from an impending tanker that was awaiting to off-load fuel. Based on the aforementioned details, conclusions indicate that appropriate measures were not taken to adequately prepare for this change and ensure compliance to recommended practices and industry standards relative to internal inspections.

CAUSAL FACTOR #3:

Identified in the SnapChart as a **"Condition"** element in Appendix A entitled "**No formal training (content or learning activities) of Cathodic Protection system maintenance and management relevant to NACE standards were provided."**

RCIL management indicated that current third-party contractor (Accurate Enterprises Ltd) provided RCIL operations personnel with training relative to completion of its monthly checklist for Cathodic Protection. However, it was indicated that the training was "informal" and the personnel were instructed on how to complete the form. That being noted, no content and/or information relevant to how RCIL personnel were trained and/or topics covered were provided to ascertain the level of comprehensiveness of the training. As such, and based on the records provided, the documentation completed by RCIL operations personnel was inconsistent and/or not completed properly. Therefore, it was not clear as to if the operations personnel appropriately understood as to when measurements were considered out of tolerance according to requirements set forth by NACE standards and/or parameters indicated on the Cathodic Protection Annual surveys. That being noted, evidence suggests that RCIL operations personnel did not receive adequate training and/or sufficient competency development activities specific to Cathodic Protection system maintenance and management requirements in order to adequately maintain and manage its Cathodic Protection system.

In addition to each causal factor listed above, there were a number of Safeguard Failures identified. Failed safeguards are often directly linked to Causal Factors, as such, these Safeguard Failures include the following:

SAFEGUARD FAILURES #1 and #2:

During the Cathodic Protection Annual Survey completed in 2013 by third-party contractor Spectro Engineering Limited, the Rectifier for Tank #32198 was found off and was also left off. It is noted that Rectifier's should always be energized to ensure safe operation and corrosion control.

SAFEGUARD FAILURES #3

During the Cathodic Protection Annual Survey completed in 2014 by third-party contractor Southern Cathodic Protection Company, the Rectifier for Tank #32198 was found off. It is noted in the Cathodic Protection Annual Survey submitted by Southern Cathodic Protection Company that Rectifier's should always be energized to ensure safe operation and corrosion control.

SAFEGUARD FAILURES #4

In 2015, Tank #32198 underwent a change in service from High Sulphur Diesel to Ultra Low Sulphur Diesel. However, no records were provided for managing the change of service. RCIL records indicate that they utilise a process to manage change in critical equipment, assets and/or activities of which this specific activity would qualify to be managed and properly documented. It is noted that the document submitted by RCIL outlines works carried out, however, this document was inadequate to determine if this change was properly managed and documented prior to the change taking place.

SAFEGUARD FAILURES #5

There was no record of a Cathodic Protection Annual Survey being performed in 2016 and 2018. The performance of these survey's is a requirement based on industry standards as they are critical to assess the operation, maintenance and performance of the corrosion control equipment.

SAFEGUARD FAILURES #6

RCIL's Oil Spill Response Plan procedures manual is outdated based on current operations. This document is critical when managing oil spill response activities of which should be reviewed and updated at least annually with details relevant to the current operation of which management and staff should be trained.

Based on the information received from RCIL, records reviewed and interviews conducted up to the time of the submission of this report, conclusions based on the findings resulting from the causal factors, safeguard failures and subsequent root causes indicate that this incident and cause of failure to the tank bottom plate would be considered **Preventable**.

The basis of this conclusion of preventability of this incident was a direct result of the facts of the information provided by RCIL and the sequence of events that took place dating back to 2013 demonstrated in Appendix A. **The information provided and sequence of events demonstrate areas in which RCIL received sufficient notice and/or warnings related to the high level of risk due to corrosion for Tank #32198 of which sufficient measures were not taken by RCIL to action and/or address issues identified with the tank.**

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4. Technical Synopsis

A physical inspection of Tank #32198 performed by the investigation team indicated the fuel leak was a result in the failure caused by severe rusting in several areas of several tank bottom plates in the Tank. The leak resulted in a spill/environmental release of fuel to the ground in and around the tank and adjacent area on the western side of the tank.

Cathodic Protection

The criteria used to establish effectiveness of the cathodic protection system is as published by National Association of Corrosion Engineers (NACE) in their recommended practices. The NACE potential criteria used was a minimum -0.850 volts instant off, with respect to the saturated copper/copper sulfate reference electrode, 100 millivolts or more of polarization decay between the "instant off" and "depolarized" potential or 100 millivolts or more of polarization formation between the "native" and the "instant off" potential. Since 2013, each Cathodic Protection Annual survey that was performed up until the time of the incident indicated that Tank #32198 Cathodic Protection system did not meet National Association of Corrosion Engineers (NACE) requirements. In addition to NACE, these surveys are also required to be performed in accordance with the American Petroleum Institute (API) recognized standards. The relevant standards of these organisations relative to Cathodic Protection are also in use and in force under Cayman Islands regulatory requirements. These standards are:

- **API RECOMMENDED PRACTICE 651** - Cathodic Protection of Aboveground Petroleum Storage Tanks, 3rd Edition (API 651)

- **NACE SP0169-2013** - Standard Practice Control of External Corrosion on Underground or Submerged Metallic Piping Systems (NACE SP0169-2013); and

- **NACE SP0193-2016** - Application of Cathodic Protection to Control External Corrosion of Carbon Steel On-Grade Storage Tank Bottoms (NACE SP0193-2016)

RCIL acknowledged that they follow the standards set forth by these organisations and as such, are incorporated in its standard operating practices and guidelines to manage and maintain its Cathodic Protection system. It was further noted that RCIL personnel were not able to reference the specific NACE standards as indicated above in which they follow when asked by the investigation team. The only specific standard that was referenced was API 653, however, it was not clear to the investigation team as to which edition of API 653 was being referenced.

In regard to NACE requirements, NACE standards outline that annual cathodic protection surveys are recommended to ensure the effectiveness of cathodic protection. Inspection and tests of cathodic protection systems at facilities should be made to ensure their proper operation and maintenance. All Cathodic Protection Annual surveys submitted to the investigation team by RCIL were performed by qualified independent third-party contractors. All of which indicated that Tank #32198 at RCIL was at a high risk of corrosion based on measurements taken at the time when each survey was performed. The measurements taken during each survey indicated that Tank #32198 did not meet NACE requirements and thus was not adequately protected for corrosion control. In addition, no information or records were provided by RCIL which indicated that the Cathodic Protection system for Tank #32198 had been adequately maintained, managed and/or was operating in accordance with requirements defined in NACE SP0169-2013 and/or NACE SP0193-2016.

Tank #32198 utilises an impressed current Cathodic Protection system and thus, all sources of impressed current should be checked at intervals not exceeding two months. Evidence of proper function may be current output, normal power consumption, a signal indicating normal operation, or satisfactory electrical state of the protected structure. RCIL provided records which demonstrated information was collected on a monthly basis, however, the data collected was insufficient and/or the records were incomplete. NACE standard practice further indicates that a satisfactory comparison between the rectifier operation on a bimonthly basis and the rectifier operation during the annual survey implies the protected status of affected structures is similar. Based on the records submitted, the only similarity that existed was that Tank #32198 Cathodic Protection system did not meet the satisfactory standards according to NACE.

NACE standard practice also indicates that the tank bottom should be examined for evidence of corrosion whenever access to the bottom is possible. This may be during repairs or modifications, or in conjunction with inspections required by API Standard 653. Examination for bottom-side corrosion may be done by coupon cutouts or by nondestructive methods such as ultrasonic inspections or electromagnetic flux leakage. In 2015, Tank #32198 underwent a service change from High Sulphur Diesel to Ultra Low Sulphur Diesel, however, RCIL personnel indicated that the recommended examinations of the tank bottom were not performed.

Further to record keeping activities, API Recommended Practice 651 - Cathodic Protection of Aboveground Petroleum Storage (API 651) is also referenced by NACE and vice versa. As such, the following should be prevalent and/or demonstrated by RCIL of which based on the records provided, were not sufficient.

For reference, API 651 indicates the following:

Cathodic Protection systems Design (API 651 extract):

- *Design and location of insulating devices, test leads and other test facilities, and details of other special corrosion control measures taken.*
- *Results of current requirement tests, where made, and procedures used.*
- *Native structure-to-soil potentials before current is applied.*
- *Results of soil resistivity tests at the site, where they were made, and procedures used.*
- *Name of person conducting surveys.*

Cathodic Protection Installation (API 651 extract):

a. *Impressed current systems:*
   1. *Location and date placed in service.*
   2. *Number, type, size, depth, backfill, and spacing of anodes.*
   3. *Specifications of rectifier or other energy source.*
   4. *Interference tests and the parties participating in resolution of any interference problems.*

b. Galvanic anode systems:
   1. *Location and date placed in service.*
   2. *Number, type, size, depth, backfill, and spacing of anodes unless part of factory-installed system.*

In maintaining corrosion control facilities:

- *Repair of rectifiers and other DC power sources.*
- *Repair or replacement of anodes, connections, and cable.*
- *Maintenance, repair, and replacement of coating, isolating devices, test leads, and other test facilities.*

API 651 standard also outlines that records sufficient to demonstrate the need for corrosion control measures should be retained as long as the facility involved remains in service. In addition, records related to the effectiveness of cathodic protection should be retained for a period of 5 years unless a shorter period is specifically allowed by regulation. It is noted that API standards indicate NACE standards for reference and application of use for installation, management and maintenance of Cathodic Protection systems.

In both 2014 and 2015, the Cathodic Protection Annual survey's performed by Southern Cathodic Protection Company listed recommendations for Tank #32198. If those recommendations were not implemented (of which RCIL provided no information to demonstrate they were), the anticipated conclusion of the long term effects would be that the tanks corrosion rate would increase thus causing failure of the tank bottom plate due to corrosion given the environment the tank is in. It is noted that the corrosion rate would settle at some natural value based on the corrosivity of the sand in the absence of a maintained cathodic protection system. Additionally, RCIL personnel was unable to identify the Corrosion Rate of Tank #32198 which is a requirement under API 653.

In 2017, the Cathodic Protection Annual Survey was performed by Matergenics (Formerly Exova Pittsburgh Laboratories). This survey in particular highlighted that significant concern for Tank #32198 of which the following statements were noted on page 5 (**Section 4.0 CONCLUSIONS AND RECOMMENDATIONS**) of the report:

> *2. Potential measurements taken at Tanks No. 32193, 32194, 32195, 32196, 32198 and 32199 revealed that at least - 850 mVCSE in INSTANT OFF criteria is not satisfied. All potential readings indicate that Tanks are not protected. Considerations should be given to perform a condition assessment and repair the CP system.*
>
> *3. Client has to plan for the condition assessment of the Tanks No. 32193, 32194, 32195, 32196, 32198 and 32199 to quantify and mitigate the risks associated with inadequate CP. It is very important that condition assessment has to be performed under the supervision of a NACE Certified Corrosion/Cathodic Protection Specialist.*

RCIL indicated that they were unable to receive sufficient support from the Contractors in order to address issues identified. RCIL did not provide information suitable to determine if these recommendations we actioned and/or implemented or suitable corrosion control measures were taken.

The recommended condition assessment and corrosion risk assessment was recommended due to the criteria of which the Cathodic Protection system met at that time which is as follows:

- When enough Cathodic Protection current is applied, the tank bottom will exhibit one potential and the anodic sites will cease to exist.

- If the Cathodic Protection system is inoperable, potential differences exist and aggressive corrosion attack will result at the anodic sites.

- Soil chemistry, Microbiologically Induced Corrosion (MIC), pH, and presence of chlorides in the soil will provide evidence for accelerated corrosion if there is a deficiency in cathodic protection.

It is very important to note that the voids or air gaps formed between the tank bottom plates and the tank foundation due to filling and refilling of the storage tanks prevent the Cathodic Protection current from reaching the bottom plates at these areas. Vapor phase corrosion inhibitors (VCI) by themselves or in combination with Cathodic Protection can be used for the protection of the bottoms of the above-ground storage tanks. Otherwise, corrosion attack could be noticed at voids or air gaps.

Given the fact that Tank #32198 is located in a marine environment, strong factors were present relative to Microbiological Induced Corrosion (MIC) given the tanks bottom plate failure and repair identified in 2015 during its change in service. That being noted, NACE Standards provide the following as guidance as it relates to MIC:

- **In the marine environment, Microbiological Induced Corrosion (MIC) could be a reasonable cause of failure, so minimum NACE CP -950 mVCSE criteria should be used instead of *minimum NACE CP -850 mV_{CSE} criteria. See Following Extracts :***

NACE SP0169-2013 Extract:

6.2.1.4 Special Conditions Applicable to Steel and Gray or Ductile Cast-Iron Piping Systems

6.2.1.4.1 When active MIC has been identified or is probable, (e.g., caused by acid-producing or sulfate-reducing bacteria), the criteria listed in Paragraphs 6.2.1.2 and 6.2.1.3 might not be sufficient. Under some conditions, a polarized potential of –950 mV CSE or more negative[63-65] or as much as 300 mV of cathodic polarization might be required.[66]

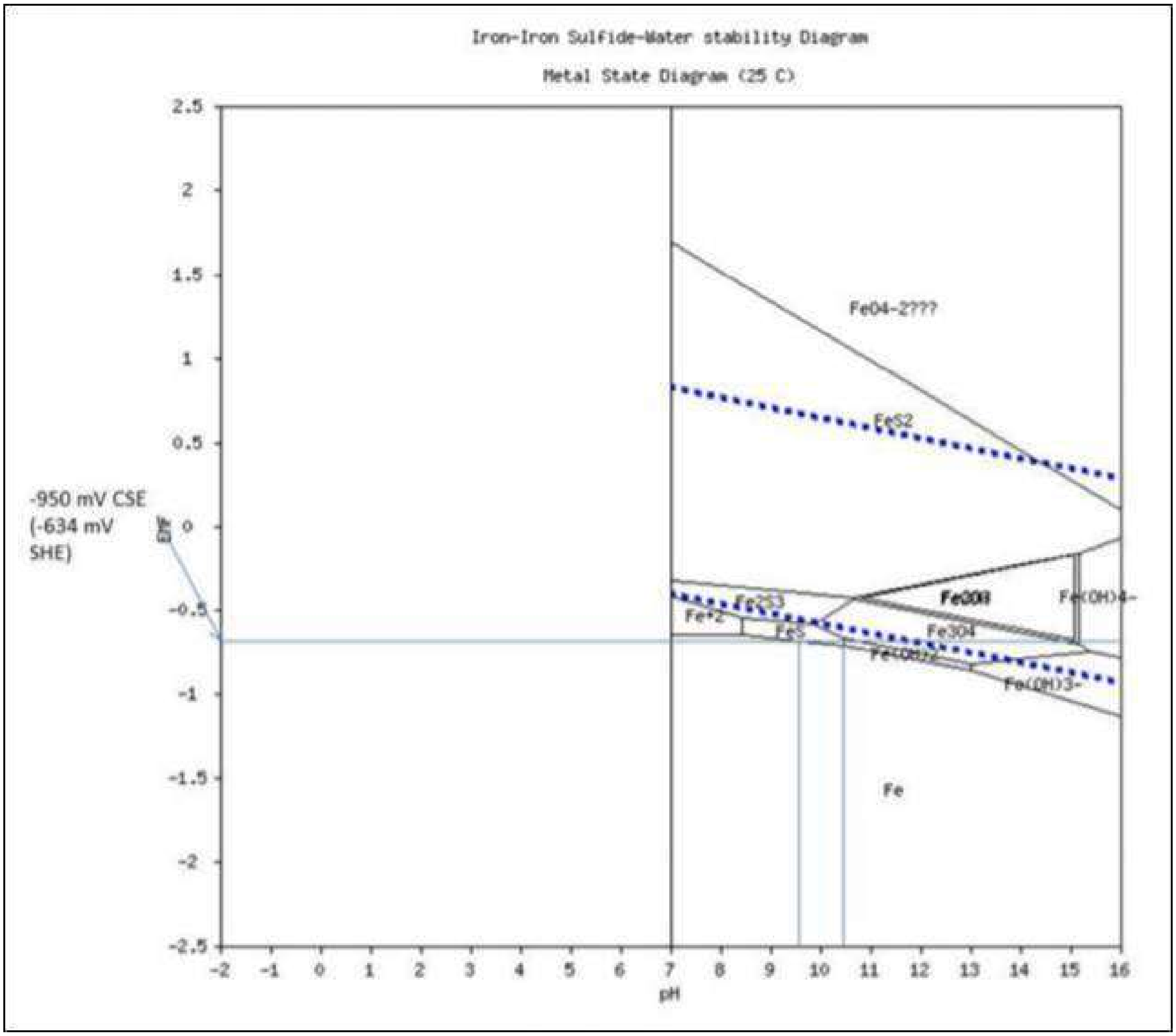
6.2.1.4.2 At elevated temperatures (> 40 °C [104 °F]), the criteria listed in Paragraphs 6.2.1.2 and 6.2.1.3 may not be sufficient. At temperatures greater than 60 °C (140 °F), the polarized potential of –950 mV CSE or more negative might be required.[63,66-68]

6.2.1.4.3 On mill-scaled steel, cathodic polarization greater than 100 mV might be required.[66]

NACE SP0193-2016 Extract:

4.5.7 When active MIC has been identified or is probable, (e.g., caused by acid-producing or sulfate-reducing bacteria), a polarized potential of at least –950 mV, or as much as 300 mV of polarization relative to a CSE must be maintained to achieve effective CP.[7]

One of the main factors in corrosion acceleration owing to MIC is the formation of the iron sulfide. The cathodic potential of *-950 mV$_{CSE}$* recommended for cathodic protection under risk of MIC appeared to have effect of reducing the probability of deposition of iron sulfide, so *minimum NACE CP -950 mV$_{CSE}$ criteria* is considered in the presence of anaerobic conditions. Note the below Iron-Iron Sulfide-Water Stability Diagram:



- From the above Iron-iron sulfide-water stability diagram, stability regions for iron sulfide (FeS), ferric sulfide (Fe_2S_3), and pyrite (FeS_2) can be seen.
- As can be seen, above the potential *-950 mV$_{CSE}$*, a wide range of sulfide compounds are stable.
- It can be observed that at potential *-950 mV$_{CSE}$* and below, iron sulfide is marginally stable at a small pH range of around 9.5 to 10.5. Below this potential, no sulfide compound is stable.
- Thus, cathodic polarization below *-950 mV$_{CSE}$* has the effect imposing an environment where iron sulfides are not thermodynamically stable.

For Tank #32198, MIC may be a reasonable cause of the failure, however, standardized testing (i.e. failure analysis) must be conducted to confirm MIC as a primary cause of the failure. The failure analysis would entail an extraction of two or three samples from the tank bottom and soil samples at the perforation location. Once samples are collected it would need to be sent to a certified laboratory to analyse and perform Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) in order to determine the primary cause and whether the failure is due to MIC specifically.

The most recent Cathodic Protection Annual Survey performed at RCIL was in July 2019 by third party local contractor Accurate Enterprises Ltd (AEL). AEL provided a recommendation for Rectifier #5 (which is the Rectifier that is connected to Tank #32198) to "Replace Anode Bed". The Cathodic Protection Annual Survey's that were performed indicates a clear trend of anode depletion since 2017 and proper measures should have been taken of which there was no evidence provided by RCIL which indicate that those measures were in fact being taken and/or actioned.

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INTERNAL INSPECTIONS

In 2015, the tank was emptied for a change in service of which API Standard 653 - Tank Inspection, Repair, Alteration and Reconstruction should have been complied with as a result of the findings at that time resulting from sandblasting activities. Those findings should have resulted in RCIL's performance of Formal Internal Inspection in accordance with API 653. More specifically **Section 6.4 – Internal Inspection** which was not followed. See extract below.

API 653 Extract:

6.4 Internal Inspection

6.4.1 General

6.4.1.1 Internal inspection is primarily required to do as follows,

a) Ensure that the bottom is not severely corroded and leaking.

b) Gather the data necessary for the minimum bottom and shell thickness assessments detailed in Section 6. As applicable, these data shall also take into account external ultrasonic thickness measurements made during in service inspections (see 6.3.3).

c) Identify and evaluate any tank bottom settlement.

6.4.1.2 All tanks shall have a formal internal inspection conducted at the intervals defined by 6.4.2. The authorized inspector who is responsible for evaluation of a tank must conduct a visual inspection and assure the quality and completeness of the nondestructive examination (NDE) results, if the internal inspection is required solely for the purpose of determining the condition and integrity of the tank bottom, the internal inspection may be accomplished with the tank in-service utilizing various ultrasonic robotic thickness measurement and other onstream inspection methods capable of assessing the thickness of the tank bottom, in combination with methods capable of assessing tank bottom integrity as described in 4.4.1. Electromagnetic methods may be used to supplement the on-stream ultrasonic inspection. If an in-service inspection is selected, the data and information collected shall be sufficient to evaluate the thickness, corrosion rate, and integrity of the tank bottom and establish the internal inspection interval, based on tank bottom thickness, corrosion rate, and integrity, utilizing the methods included in this standard. An individual, knowledgeable and experienced in relevant inspection methodologies, and the authorized inspector who is responsible for evaluation of a tank must assure the quality and completeness of the in-service NDE results.

5. Incident Classification

Based on the findings resulting from this investigation, this incident is classified as a **Spill** given the fact that there was an actual release of fuel to the environment. Incidents are classified for investigation purposes by their consequence, however, OfReg does not have an established guideline, criteria and/or matrix to categorize incidents. Further to the aforementioned classification, utilization of industry standard practices for incident investigation and reporting, this incident is categorized as **Major**.

Categorizing this incident as major is a direct result of primary elemental factors that exist based on industry standard practices where incident classifications and categorizations are defined. The primary elemental factors that are present as a result of this incident are as follows:

- Petroleum or Petroleum product spills to land or secondary containment between 50 Barrels (bbls) or 1,746 IG and 500 bbls or 17,486 IG; and

- Any uncontrolled or unintended release that requires immediate notification to a government agency.

Classification and categorization requirements for this report are based upon the potential and/or actual consequences of the incident. Given the significant consequential nature of this incident, a TapRoot® investigation was completed. Conclusions for the classification and categorization of this incident were based upon interviews conducted with RCIL personnel and documentation received and/or reviewed up to the time of submission of this report.

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6. Regulatory Requirements and Standards Impacted

Based on the interviews conducted and findings resulting from this incident investigation, there were relevant Cayman Islands regulatory requirements and/or recognised industry standards which could be considered to be potentially impacted and/or compromised. Most notably, the regulatory requirements outlined pursuant to **Section 12 Sub-Section (1)(a)(iii)** of **The Dangerous Substances Law (2017 Revision)** ("DS Law") which outlines the avoidance of pollution and safe conduct of activities for Operators within the Cayman Islands.

In addition, the DS Law under guidance of the Chief Fuels Inspector recognises several relevant International Codes & Standards. The established codes, standards, international bodies and organisations whose specific materials and extracts are adopted in part in the Cayman Islands and have the force of law to enable the Chief Fuels Inspector to carry out the functions of the Office under the DS Law which can be considered to be potentially impacted and/or compromised are as follows:

1. **American Petroleum Institute (API);**
2. **National Association of Corrosion Engineers (NACE);**
3. **Steel Tank Institute (STI); and**
4. **Occupational Safety and Health Administration (OSHA)**

It is noted that extracts of the specific section(s) or reference are detailed in the various documents and relevant templates that are in use by OfReg. As a result of the aforementioned details, this incident investigation focused on several key technical standards and/or recommended practices as part of an objective fact-finding strategy to arrive at the causal factors and subsequent root causes of the incident. More specifically, the code to which the tank was reconstructed in 2010 and should be maintained.

Tank #32198 was originally constructed in 1999 by Tampa Tank Inc. to API 650 standard - Welded Steel Tanks for Oil Storage. In April 2010, Tank #32198 was reconstructed by Anderson Servicios S.A. to API 653 standard - Tank Inspection, Repair, Alteration and Reconstruction (3rd Edition). That being noted, further repairs, alterations and reconstructions should comply in accordance with API 653 standard. As noted previously, Cathodic Protection systems should be managed and maintained in accordance with NACE SP0169-2013 and NACE SP0193-2016 in conjunction with API 651.

OfReg provides regulatory oversight for the petroleum industry in the Cayman Islands. As the regulator, OfReg also indicates direction as to which international bodies and organisations and their respective version of the standard and/or recommended practice operating companies are to follow.

OfReg currently references the following API Standards for utilization and reference by operating companies in the Cayman Islands:

1. API Standard 650 - Welded Steel Tanks for Oil Storage, 11th Edition, June 2007 with addenda up to August 2011 and errata October 2011

2. API Recommended Practice 651 - Cathodic Protection of Aboveground Petroleum Storage Tanks, 3rd Edition, January 2007

3. API Recommended Practice 652- Linings of Above Ground Petroleum Storage Tanks, 3rd Edition, October 2005

4. API Standard 653 - Tank Inspection, Repair, Alteration and Reconstruction, 4th Edition, April 2009 with addenda up to January 2012

API Standard 653 outlines same as noted in the excerpt below from API Standard 653 (4th Edition):

> ***1.2 Compliance with This Standard***
>
> *The owner/operator has ultimate responsibility for complying with the provisions of this standard. The application of this standard is restricted to organizations that employ or have access to an authorized inspection agency as defined in 3.3. Should a party other than the owner/operator be assigned certain tasks, such as relocating and reconstructing a tank, the limits of responsibility for each party shall be defined by the owner/operator prior to commencing work.*
>
> ***1.3 Jurisdiction***
>
> *If any provision of this standard presents a direct or implied conflict with any statutory regulation, the regulation shall govern. However, if the requirements of this standard are more stringent than the requirements of the regulation, then the requirements of this standard shall govern.*

It is important to note that API 651 references the utilization of NACE standards for Cathodic Protection systems and corrosion control. These references incorporate the inclusion of NACE SP0169-2013 and NACE SP0193-2016. Based on the aforementioned details, RCIL's application of these standards would be required to be incorporated as a part of their operating practices. These standards were critical to ascertain the details of the incident investigation and subsequent findings as to which regulatory requirements and standards that could be considered to be potentially impacted and/or compromised.

7. Incident Overview

The Security Guard, a RCIL third-party contractor, was performing normal monitoring duties on 15, November 2019 at approximately 20:30. As he proceeded to the area in which Tank #32198 is located, he discovered a fuel leakage at the base of the tank where fuel was identified to be continuously migrating across the ground on the western side the tank. After assessing the area, he proceeded to notify RCIL based on the contact numbers he was provided. It was noted that several persons from RCIL were contacted by the security guard, however, initial phone calls were not answered. After approximately 30 minutes, contact was made with RCIL Administrator who then made contact with RCIL operations personnel.

Once RCIL personnel arrived onsite, they assessed the tank's impacted area and proceeded to implement an action plan for spill prevention, control, countermeasures and related emergency response activities to address the incident. RCIL submitted its account of the activities performed by its personnel during this time. See Appendix D, document entitled Incident & Accidents Information and Reporting Form | F0S-05.

In short, the emergency incident response activities primarily entailed transferring fuel from Tank #32198 into other tanks, storage containers and to RCIL customers (i.e. CUC) as quickly as possible while minimizing environmental impact due to the incident.

RCIL completed and ceased its emergency spill prevention, control and countermeasure response activities On 17 November 2019 at approximately 23:30. This consisted of a full system shut down after which Tank # 32198 was declared empty. On 18 November 2019, RCIL personnel commenced with their internal fuel inventory reconciliation process in order to ascertain estimated amount/volume of fuel lost due to the incident. Inventory reconciliation was completed the following day and RCIL personnel concluded that 3,686 Imperial Gallons (IG) of diesel fuel was unaccounted for. **An assumption was made by RCIL that this unaccounted for fuel is trapped between the tank bottom plate and the tank lining, however, there is no evidence that has been provided by RCIL that the tank lining is in tact and has not failed as well.**

Conditions surrounding the incident indicate that it was a relatively clear evening, however, visibility was low at night. RCIL records indicated that Tank # 32198 received approximately 865,686 IG of fuel from Tanker Silver Extrema on 11 November 2019. Records received from RCIL also indicate that Tank # 32198 contained approximately 981,714 IG of diesel fuel on the day of the incident. Based on the interviews conducted, information received, and physical inspection of the tank confirmed that there was a loss of containment due to severe rust and steel degradation in several areas of the tank bottom plates in Tank # 32198. RCIL inventory reconciliation reports indicate that at least 3,686 IG of diesel fuel was unaccounted for and a November 2019 month-to-date loss variation of 1,140 gallons were not explained.

8. TapRoot® Investigation Approach and Methodology

TapRoot® investigations are based on process and not intended to be used to apportion blame. For that reason, no names of persons directly involved in the incident have been included. When investigating this Spill, the overall objective of the investigation was to determine preventability of the incident and the relevant actions and/or inactions that ultimately may have caused the incident. There were questions that needed to be answered such as:

1. Was the tank and its related equipment properly maintained and managed prior to the time of the incident?
2. Did RCIL personnel responsible for activities associated with maintenance and management the tank and its related equipment receive sufficient training prior to the incident?
3. Did RCIL have a suitable training and/or competency development program in place for its operations personnel who were responsible for managing and maintaining the tank and its related equipment prior to the incident?
4. Did the tank and its related equipment have any failures prior to the incident? If so,
    1. Were the failures identified by an independent auditor/evaluator or by RCIL personnel?
    2. What were the identified failures?
    3. Did RCIL take sufficient action to understand why these failures occurred?
    4. Did RCIL take sufficient measures to address, manage and/or correct failures?
    5. If sufficient measures were taken by RCIL to address, manage and/or correct failures, did RCIL implement strategies, procedures and/or processes to prevent these failures from re-occurring?
5. Did RCIL have a procedure, process and/or operating practice in place to properly manage and maintain the tank and its related equipment prior to the incident?
6. Are RCIL procedures and/or processes consistent with internationally recognised industry standards, best and/or recommended practices?
7. Did RCIL have an independent audit, evaluation and/or survey of the tank and its related equipment specific to corrosion control prior to the incident? If so,
    1. When did the independent audits, evaluations and/or surveys take place?
    2. Who performed these independent audits, evaluations and/or surveys?
    3. Was the performance of the independent audits, evaluations and/or surveys consistent with internationally recognised industry standards, best and/or recommended practices and corresponding RCIL procedures?

4. Did the independent audits, evaluations and/or surveys identify areas or concern relative to critical corrosion control equipment?
5. Did RCIL take sufficient measures to address areas of concern, implement recommendations and/or guidance resulting from these independent audits, evaluations and/or surveys of the tanks and its related equipment specific to corrosion control prior to the incident?

8. Was the design of the tank's corrosion control equipment adequate and/or given the environment in which it is located prior to the incident?
9. Were any repairs made to the tank and/or its related corrosion control equipment prior to the incident?
10. Did RCIL do everything reasonably within their control to prevent/avoid the incident altogether?

With these questions, the investigating team selected several safeguard failures, causal factors and root causes based on the interviews performed and information provided by RCIL up to the time of the submission of this report.

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9. Incident Investigation Team

Spenergy's incident investigation team was led by Terence Spencer who served as the Lead Investigator. Additional support was also provided by OfReg Fuels Inspectors in order to coordinate activities relative to scheduling of interviews, collection collation of information received.

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10. Information and Data Collection

In preparation of this Report, the investigation team requested various records, information and data from RCIL. What was and was not submitted by RCIL was essential in order to establish a clear understanding of Tank # 32198's operability, maintenance history, RCIL's management activities and relevant training RCIL personnel received associated with Tank # 32198 and related standards, processes and industry best practices. The various methods used to collect this relevant information is as follows:

Witness Interviews

The persons selected by the investigation team to be interviewed as witnesses to the incident were determined to be either on the scene at the time the incident was discovered or RCIL personnel who carried out activities in response to this incident. Interviewee's selected by the investigation team are as follows:

1. Security Guard – Onsite at the time the spill was discovered.
2. RCIL Operations Manager - Incident first responder
3. RCIL Operations Coordinator
4. RCIL Aviation Superintendent
5. RCIL Maintenance Supervisor
6. RCIL Managing Director

RCIL Terminal Management & Maintenance Records

The RCIL management and maintenance records selected by the investigation team for review was determined by its relevance and applicability to the incident and RCIL's capacity as an operator in the Cayman Islands market. The records requested by the investigation team include the following:

1. RCIL Oil Spill Response Plan
2. RCIL's Incident Command System Matrix.
3. RCIL's Training Program and Training Matrix for its Jackson Point Operations Personnel.
4. Records of all training provided by RCIL on Emergency Response Procedures to its Part-time and Full-time Contractors prior to the fuel release incident on 15 November 2019.
5. RCIL Emergency Response Procedure
6. RCIL Tank # 32198 calibration chart (Tank Strapping Table)
7. Daily Inventory Management System Report with all inventory readings from 01 to 18 November 2019 for Tank # 32195, # 32198 and # 32199.
8. RCIL Operations Manual.
9. RCIL Maintenance Manual.
10. Inventory Management/Stock control records from 14 to 18 November 2019 for Tanks # 32199 and # 32195 including all movements in/out of the tanks.

11. Inventory Management/Stock control records from 1 September 2019 to 11 November 2019 for Tank # 32198, including all movements in/out of the tank.
12. Physical tank gauging records, dates and times for:
    - Tank # 32198 – From 14 to 15 November 2019
    - Tank # 32199 – From 15 to 18 November 2019
    - Tank # 32195 – From 15 to 18 November 2019
13. All maintenance records and reports for Tank # 32198 for the last six years (15 November 2013 to 15 November 2019). The records must include, but are not limited to routine maintenance reports, tank cleanings, repairs and routine inspections
14. All Cathodic Protection records including annual surveys, reports, repairs conducted over the last six years up until 15 November 2019. The reports and documents were to be based on an industry approved standard or method of determining the frequency of such testing, repairs, surveys and reporting are to be conducted.
15. All training records, along with certificates pertaining to tank farm operations and maintenance for RCIL Operations Personnel
16. Certification records for Contractors involved with repair and/or maintenance activities for Cathodic Protection systems

<u>Records submitted by RCIL are as follows:</u>

1. Incidents & accidents information and reporting form I FOS-05 dated 20 November 2019 (Validation and Approbation)
2. Tank # 32198 Construction Drawings
3. Tank # 32198 Works 2015 – Tank Cleaning
4. Tank # 32198 SAAB Radar Event Records dated from 12 November 2019 to 17 November 2019
5. Tank Inventory Reconciliation - S184 Daily Report - Product in Storage Tanks for:
    - Tank # 32198 - from 1 September to 18 November 2019
    - Tank # 32199 - from 14 to 18 November 2019
    - Tank # 32195 - 14 to 18 November 2019
6. Volume Summary Report
7. API 653 Inspection Report dated 07 June 07
8. Project Files for Tank 32198 Repairs completed in 2010
9. 2020 Training Requirements
10. RCIL Employee Training Attendance Roster and Qualification Completion Log for Safety Induction Training
11. Tank 32198 Visual Tank Inspection Record dated, 23 June 2016, 28 March 2018, 4 May 2018, 15 June 2018 and 13 December 2018
12. Tank # 32198 Fuel storage - Tank annual visual inspection form/ FOF-07 dated 5 August 2019

13. RCIL Oil Spill Response Plan Volume I
14. RCIL Oil Spill Response Plan Volume II
15. NACE Certification for Contractors involved with repair and/or maintenance activities for Cathodic Protection systems
16. Operations Maintenance Program Cathodic Protection Checklist for:
    - Rectifier 5 from 2017 to 2019
    - Rectifier 3 from 2017 to 2019

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11. Key Observations

1. The investigation team requested interviews with relevant and requisite RCIL personnel in order to ascertain information relative to the incident. Based on RCIL Organisational Chart, there is a locally based Engineer & HSE Focal Point. This individual was not made available by RCIL to be interviewed. Based on this individuals job title and data collected, this member of personnel would have relevance to the incident given the findings associated with this incident.
2. Information responses and/or documentation requested by the investigation team and provided by RCIL had taken considerably long which is not customary in standard investigation practices of this magnitude. These details should normally be made timely (i.e. within 48 hours) in order to ensure the investigative process can be completed timely.
3. Safeguard failures were considered an important contributing factor of causing this incident.
4. During the interview process, the security guard who discovered the spill did not receive any formal training on basic procedures relative to spill prevention, control and countermeasure activities in the facility other than the provision of a list of RCIL personnel to contact in the event of an emergency. He also noted that he was active in assisting and supporting RCIL during the performance of their spill, prevention, control and countermeasure activities which could present a potential safety risk in the event this individual suffered injury during this time. RCIL personnel noted that they do not perform any formal training on these types of activities with any of their third-party contractors related to spill, prevention, control and countermeasures.
5. Interviews between RCIL front line operations personnel and management revealed a lack of consistency in the comprehension of and/or general knowledge in the application of RCIL procedures relative to industry standards/recommended best practices as well as which specific standards the company is to follow in regards to specific areas of maintenance and management of tanks and related equipment.
6. The Cathodic Protection Annual Surveys indicated different numbers for the Rectifier connected to Tank #32198. Tank #32198 is connected to Rectifier #5, however, the Cathodic Protection Annual survey completed by Southern Cathodic Protection Company states Rectifier #3. Proper equipment identification is a requisite in NACE standards in order to ensure proper record keeping activities.

12. Location

RCIL Jackson Point Terminal

Tank # 32198 | Tank where leak was identified.
Tank # 32199 | Tank that received fuel via tansfer from Tank # 32198 during respone efforts.
Tank # 32195 | Tank that received fuel via tansfer from Tank # 32198 during respone efforts.

13. Source of Leak

Photo: Western side of Tank # 32198

Inset: Source of the Diesel Fuel Leak in Tank # 32198.

14. SnapCharT® Sequence of Events

See Appendix A

15. Immediate Actions Taken

Based upon feedback received from interviews conducted with RCIL personnel, the immediate actions taken after RCIL first responder arrived onsite to execute spill prevention, control, and countermeasure activities included the following:

- Transfer of fuel from Tank # 32198 to Tank # 32199 via utilization of the gravity feed transfer method. As per RCIL inventory records, 493,761 IG of fuel was transferred to Tank # 32199 from Tank # 32198 during this process.

- Transfer of fuel from Tank # 32198 to Tank # 32195 via utilization of a pneumatic pump and terminal loading rack. As per RCIL inventory records, 239,925 IG of fuel was transferred to Tank # 32195 from Tank # 32198 during this process.

- Transfer of fuel via 8” underground pipeline from Tank # 32198 to Tank # 5 at Caribbean Utilities Company (CUC). As per RCIL inventory records, 239,705 IG of fuel was transferred to Tank # 5 from Tank # 32198 during this process. CUC records indicated that approximately 236,715.2465 IG @ 60°F of fuel was received from Tank # 32198 during this process.

- Transfer of fuel from Tank # 32198 to the facility’s Oil Water Separator (OWS) via Tank # 32198’s Water Drain Off tank (WDO). As per RCIL inventory records, 4,465 IG of fuel was transferred out of Tank # 32198 through to the WDO.

- Physical collection of fuel that was spilled on the ground around Tank # 32198. Physical collection activities included trenching a quarter of the circumference of the tank to pool fuel and prevent further migration across the ground surface. The equipment used during these efforts included spill absorbent pads and booms. Fuel collected and/or recovered during this activity was transferred to Intermediate Bulk Container (IBC) Totes and pumped to the oil water separator. It was noted that approximately 172 gallons was collected and stored in the IBC Totes.

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16. Root Causes

As a result of the interviews conducted, information collected and review of data received, there were several Root Causes based on the Causal Factors which were identified which should be addressed.

The Root Causes relative to the findings related to Causal Factor #1 (**“Interview with Operations Manager revealed that they were unable to receive appropriate assistance from Contractor in addressing recommendations”)** were identified as follows:

CAUSAL FACTOR #1 | ROOT CAUSE #1 - There was no Preventative Maintenance performed on the equipment. No records were provided to illustrate repairs were made other than the adjustments made by the Third-Party Contractors performing the Cathodic Protection Annual Survey’s.

CAUSAL FACTOR #1 | ROOT CAUSE #2 - Preventative maintenance program in place for the equipment needs improvement.

CAUSAL FACTOR #1 | ROOT CAUSE #3 - Corrective actions resulting from independent audits, inspections and surveys were not implemented.

CAUSAL FACTOR #1 | ROOT CAUSE #4 - Process to address corrective actions resulting from independent audits, inspections and surveys needs improvement.

CAUSAL FACTOR #1 | ROOT CAUSE #5 - Communication of Standards, Policies or Administrative Controls (SPAC) need improvement.

The Root Causes relative to the findings related to Causal Factor #2 **(“No formal Internal Inspection of tank bottom plate was performed while Tank was empty.”)** were identified as follows:

CAUSAL FACTOR #2 | ROOT CAUSE #1 - Preparation for internal inspections was inadequate as there was no internal inspection performed.

CAUSAL FACTOR #2 | ROOT CAUSE #2 - Inspection instructions and techniques relevant to the appropriate application of industry standards need improvement.

CAUSAL FACTOR #2 | ROOT CAUSE #3 – Continuing/Refresher training of internal inspections and the application of API 653 standard needs improvement.

CAUSAL FACTOR #2 | ROOT CAUSE #4 - Formal internal inspection procedure was not utilised but should have been.

The Root Causes relative to the findings related to Causal Factor #3 **("No formal training (content or learning activities) of Cathodic Protection system maintenance and management relevant to NACE standards were provided.")** were identified as follows:

CAUSAL FACTOR #3 | ROOT CAUSE #1

Training of RCIL operations personnel for proper application of NACE standard for its Cathodic Protection system was not analysed properly.

CAUSAL FACTOR #3 | ROOT CAUSE #2

Training and competency development activities relevant to proper application of NACE standards, requirements and procedures needs improvement. More specifically the following areas also needs improvement:

- Continuing training needs improvement.
- Testing needs improvement.
- Practice / repetition needs improvement
- Instruction needs improvement
- Lesson plan needs improvement
- Learning objective needs improvement

CAUSAL FACTOR #3 | ROOT CAUSE #3

Accountability of personnel responsible for training and competency development for the application of NACE standards for Cathodic Protection needs improvement

CAUSAL FACTOR #3 | ROOT CAUSE #4

Employee communication of Standards, Policies and Administrative Controls needs improvement

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17. Other Issues

Based on an evaluation and review of the documentation and records submitted by RCIL, the investigation team identified several records relative to RCIL operational activities which were either incomplete, not signed, illegible and/or contained errors (i.e. loss variations) which were not explained. Record keeping activities are essential and paramount in the operation of petroleum facilities as they are critical in order to address equipment problems, operational issues and performance trends in order to proactively manage and maintain assets throughout the facility.

At the time of physical inspection by the investigation team, the tank was identified to be in relatively poor condition. There was severe rust and degradation in several areas outside of the tank. Most glaring concern was the safety rails at the top of the tank which were almost rusted away in its entirety thus creating a safety concern as well. This level of rust was also indicative of poor maintenance and management of Tank #32198 via a suitable "chip and paint" program which should address areas external to the tank and mitigate areas of rust from expanding.

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18. Recommendations

As a result of the Root Causes relative to the findings related to the Causal Factors identified in this report, there are recommendations that if implemented, would prove beneficial in order to mitigate and/or eliminate the potential reoccurrence of this incident. It is further noted that the recommendations provided should serve as guidance on operating practices. Proper evaluation of recommendations should be performed by the respective operating entity to ensure compliance with local laws and industry best practices to ensure applicability and feasibility prior to implementation.

The recommendations associated with the Root Causes relative to the findings related to Causal Factor #1 (**"Interview with Operations Manager revealed that they were unable to receive appropriate assistance from Contractor in addressing recommendations")** are indicated as follows:

CAUSAL FACTOR #1 | ROOT CAUSE #1 RECOMMENDATION

It is recommended that RCIL incorporate guidelines within its existing operating procedures set forth by the specific industry standards that are recognised by OfReg for Cathodic Protection. These standards include NACE SP0169-2013, NACE SP0193-2016 and API 651. Most notably, the application of the requirements outlined in Section 10: Operation and Maintenance of CP Systems and Section 11: External Corrosion Control Records of NACE SP0169-2013 as well as Section 11: Operation and Maintenance of Cathodic Protection Systems and Section 12: Recordkeeping of NACE SP0193-2016 is considered to be the most suitable for RCIL as the minimum baseline local operating procedural requirement. Further considerations for inclusion in RCIL operating procedures for NACE SP0169-2013, NACE SP0193-2016 and API 651 are indicated in Section 4. Technical Synopsis section of this report.

It is also recommended that the implementation of these requirements should be properly documented and communicated to both operations personnel and third-party contractors which should include guidelines complete with roles and responsibilities for personnel performing each activity in order to ensure all activities are in compliance with the standards.

CAUSAL FACTOR #1 | ROOT CAUSE #2 RECOMMENDATION

Root Cause Recommendation #1 above applies. In addition, it is recommended that RCIL implement guidelines outlined in all relevant sections that are applicable to its operation of NACE SP0169-2013, NACE SP0193-2016 and API 651 within its local operating procedures.

CAUSAL FACTOR #1 | ROOT CAUSE #3 RECOMMENDATION

It is recommended that RCIL establish a formal process in order to monitor, track and manage action plans and workflows associated with proper execution of corrective actions resulting from independent audits, inspections and surveys. The process should ensure the proper documentation of activities associated with addressing each item complete with relevant details, current status and date of completion. In addition, it is also recommended that RCIL establish, assign and/or reinforce its internal accountability requirements for its personnel with responsibilities of actioning items associated with the execution of action plans to address corrective actions resulting from independent audits, inspections and surveys.

CAUSAL FACTOR #1 | ROOT CAUSE #4 RECOMMENDATION

Root Cause Recommendation #3 above applies.

CAUSAL FACTOR #1 | ROOT CAUSE #5 RECOMMENDATION

It is recommended that RCIL enhance its communication of SPAC to its local management and operations personnel in order to reinforce industry best practices, policies and administrative controls. These communications should provide clear instruction on compliance and reference the standard and revision that applies. It is also recommended that RCIL management reinforce accountability of its operations personnel with regards to preventative maintenance activities for its Cathodic Protection system and associated procedures which the operation follows.

The recommendations associated with the Root Causes relative to the findings related to Causal Factor #2 **("No formal Internal Inspection of tank bottom plate was performed while Tank was empty.")** are indicated as follows:

CAUSAL FACTOR #2 | ROOT CAUSE #1 RECOMMENDATION

It is recommended that RCIL incorporate and/or reinforce guidelines within its existing operating procedures set forth by API 653 for its internal inspection process. More specifically, RCIL's preparation activities for internal inspections should follow **Section 6.6 - Preparatory Work for Internal Inspections** of the API 653 standard.

CAUSAL FACTOR #2 | ROOT CAUSE #2 RECOMMENDATION

It is recommended that RCIL implement suitable training and competency development activities for its operations personnel specific to API 653 standard. The training and competency development activities should outline key elements of API 653, **Section 6 - Inspections** as well as the proper application of the API 653 standard to its local operating facility complete with roles and responsibilities of operations personnel. The training and competency development activities should also incorporate continuous refresher training inclusive of table-top and field activities.

CAUSAL FACTOR #2 | ROOT CAUSE #3 RECOMMENDATION

Root Cause Recommendation #2 above applies.

CAUSAL FACTOR #2 | ROOT CAUSE #4 RECOMMENDATION

It is recommended that RCIL institute and/or follow a formal internal inspection procedure that is in compliance with the guidelines set forth by API 653, **Section 6.4 – Internal Inspections.** Further considerations for inclusion in RCIL internal inspection operating procedures for API 653 are indicated in Section 4. Technical Synopsis of this report.

It is also noted that API 653 standard for inspections outlines formal guidance in Appendix/Annex C of the API 653 standard entitled **Checklists for Tank Inspections**. Appendix/Annex C contains sample checklists illustrating tank components and auxiliary items that should be considered for internal and external inspection of tanks. This information is provided as guidance to the owner/operator for developing an inspection assessment schedule for any specific tank installation. The checklist format facilitates the recording of inspection findings.

The recommendations associated with the Root Causes relative to the findings related to Causal Factor #3 **("No formal training (content or learning activities) of Cathodic Protection system maintenance and management relevant to NACE standards were provided.")** are indicated as follows:

CAUSAL FACTOR #3 | ROOT CAUSE #1 RECOMMENDATION

It is recommended that RCIL Management analyse, enhance and/or implement content and learning activities within its current training matrix that is consistent with NACE standards for Cathodic Protection system maintenance and management for its operations personnel. These training and competency development activities should address the following areas:

- Continuous/refresher training of NACE standards for Cathodic Protection system maintenance and management
- Testing via tabletop exercises and field activities of NACE standards for Cathodic Protection system maintenance and management
- Practice and repetition with adequate observation and feedback of NACE standards for Cathodic Protection system maintenance and management
- Instruction via NACE qualified personnel to include documented lesson plans and learning objectives of NACE standards for Cathodic Protection system maintenance and management

CAUSAL FACTOR #3 | ROOT CAUSE #2 RECOMMENDATION

Root Cause Recommendation #1 above applies.

CAUSAL FACTOR #3 | ROOT CAUSE #3 RECOMMENDATION

It is recommended that RCIL Management outline, reinforce and communicate requirements for accountability of personnel (third party contractors and/or RCIL operations personnel) responsible for training and competency development of NACE standards.

CAUSAL FACTOR #3 | ROOT CAUSE #4 RECOMMENDATION

It is recommended that RCIL enhance its communication of its SPAC to its local management and operations personnel in order to reinforce compliance with NACE standards. These communications should provide clear instruction on NACE recommended best practices and reference the standard and revision (if applicable) that applies.

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19. Revisions

Rev 1. Original issue 22 April 2020

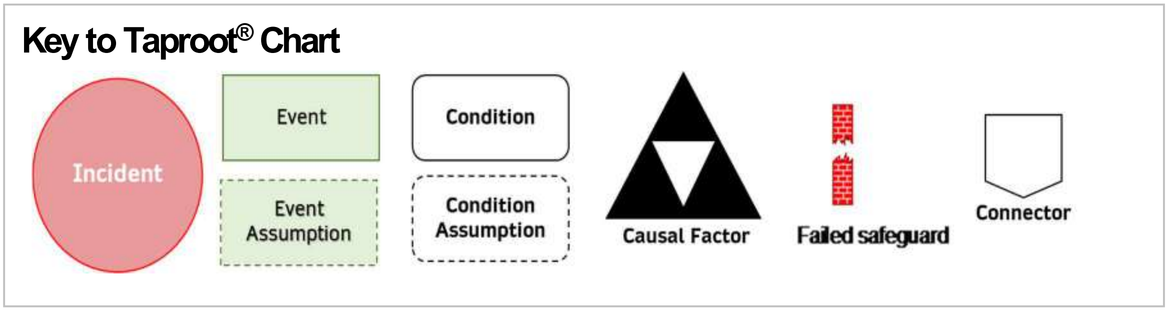
Rev 2. 17 August 2020

Rev 3. 28 September 2020

Appendix A - SnapCharT® Sequence of Events

TapRoot® SnapCharT™ of the Incident

A SnapCharT™ is a diagram of the sequence of events of an incident or the process being observed in an incident investigation. It is similar to a process flowchart, a multi-linear event sequence diagram, or an event and causal factors chart.



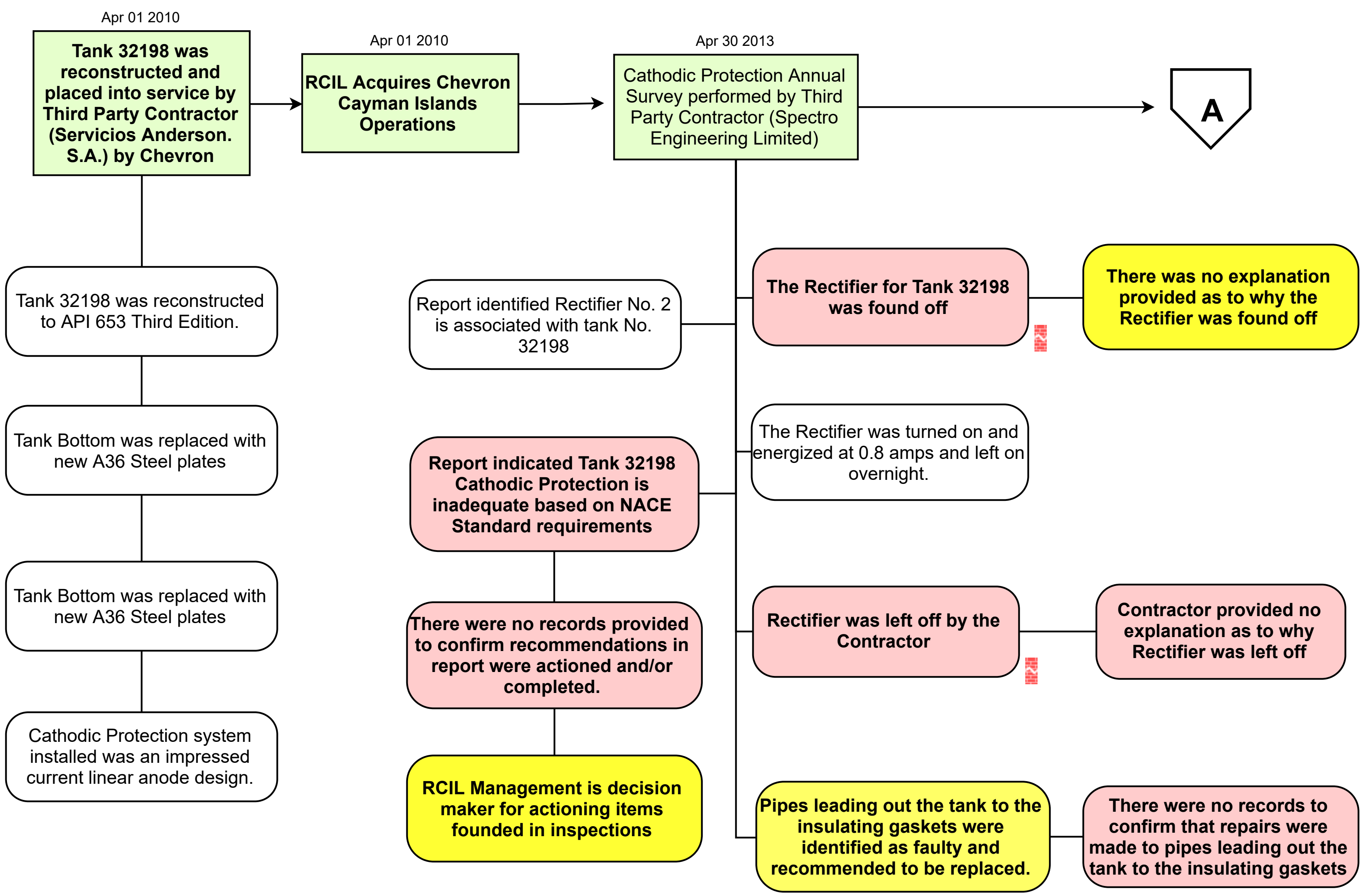
TapRoot® SnapCharT™ Shape Definitions	
Incident:	**Used to represent what is usually the worst thing that happened.**
Event:	**Used for descriptions of what or who does what**
Event Assumption:	**Used for unproven descriptions of what or who does what based on collection of evidence during the investigation.**
Condition:	**Used for known information about an event.**
Condition Assumption:	**Used for an unproven information about an event based on the collection of evidence during the investigation.**
Causal Factor:	**A mistake, error, or failure that directly leads to (or causes) an Incident or fails to mitigate the consequences of the original error.**
Failed Safeguard:	**A safeguard looks at the process or system that allows a hazard to reach a target**
Connector:	**Used when a SnapCharT® is too wide for one page. The connector shows the beginning and end of a break.**

TapRoot® SnapCharT™ Notes:

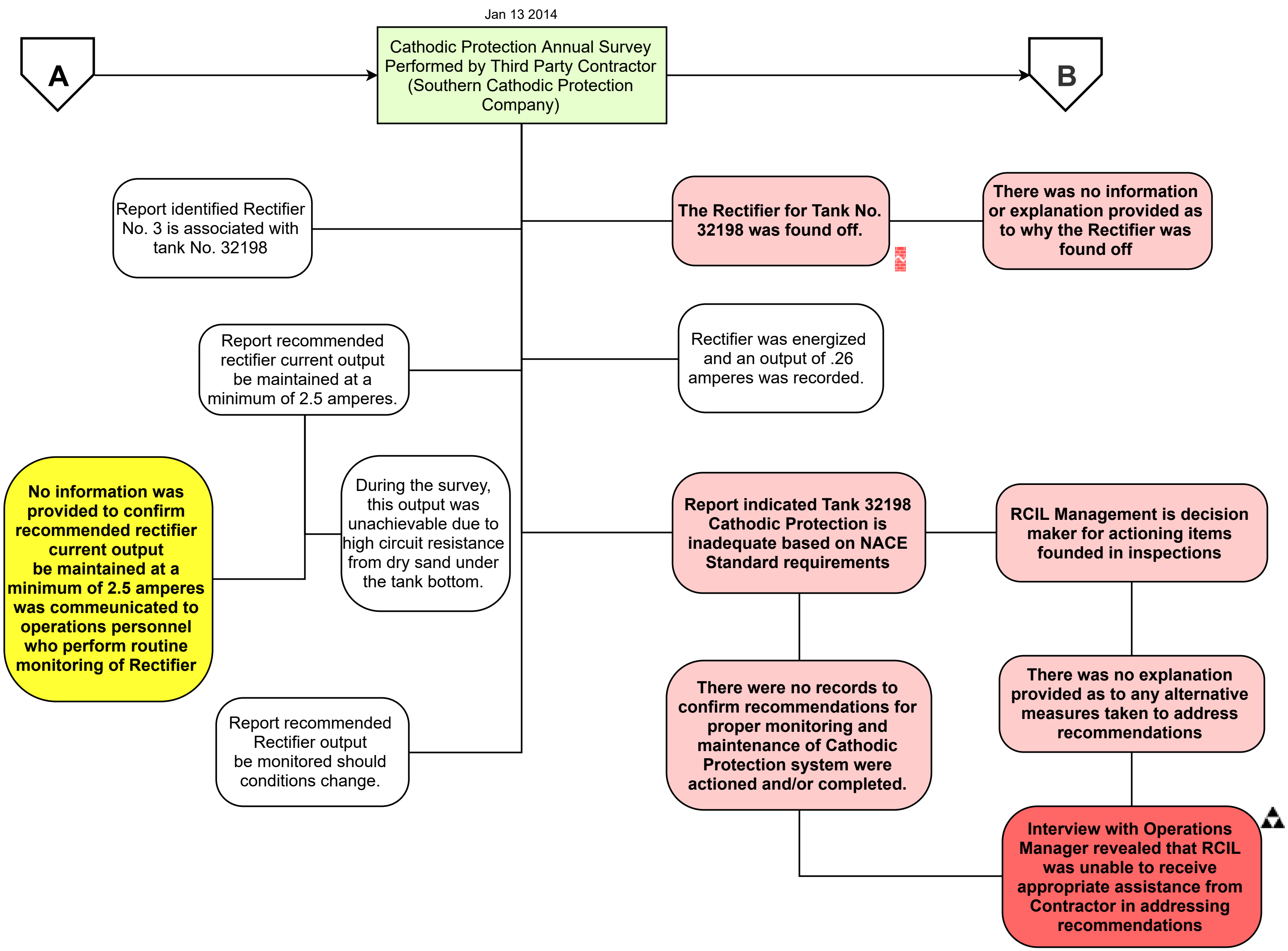
The differences between connecting Events, Incidents and Conditions are as follows:

- Arrows connect events and incidents to show a progression through time.
- Lines connect conditions.

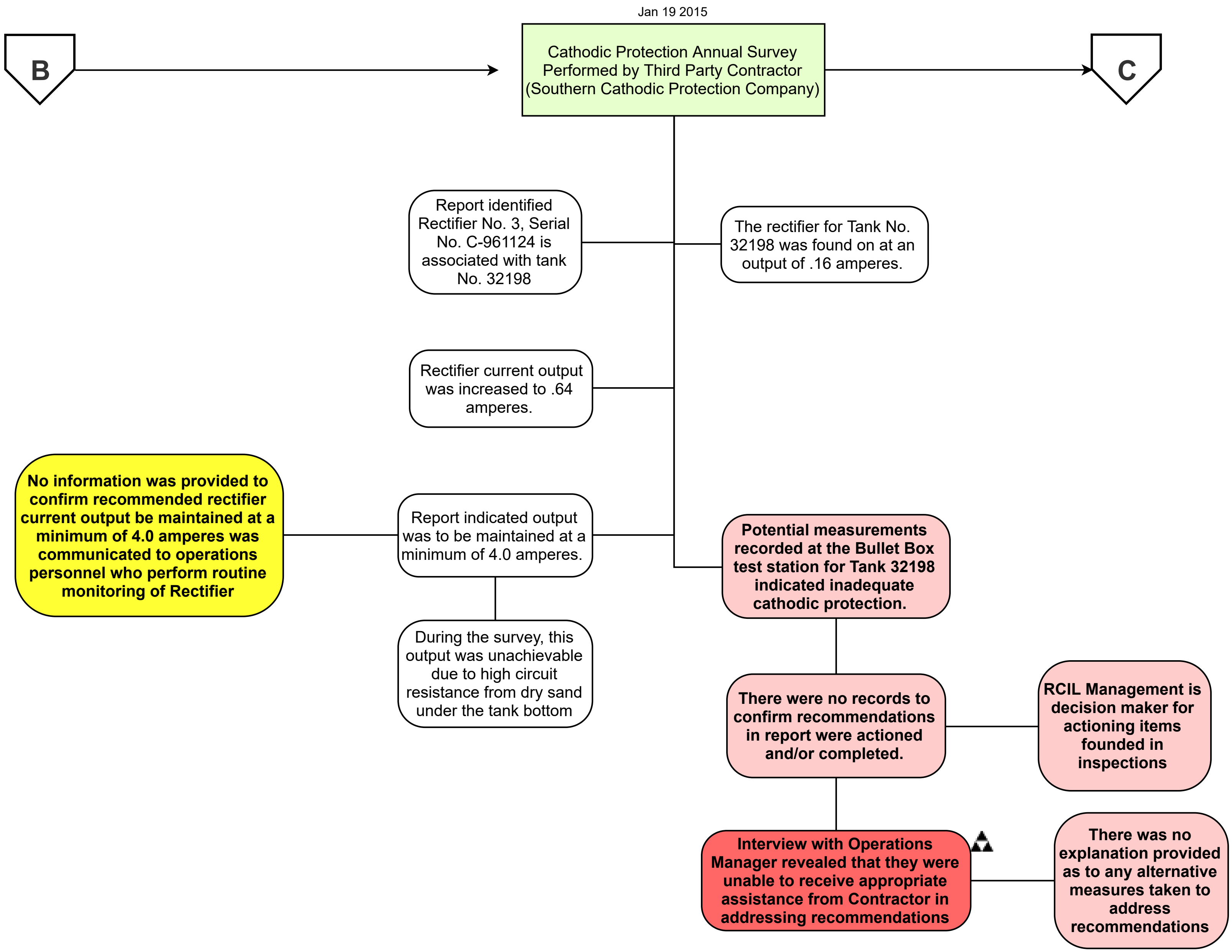
SnapCharT™ Sequence of Events - RCIL Incident Investigation



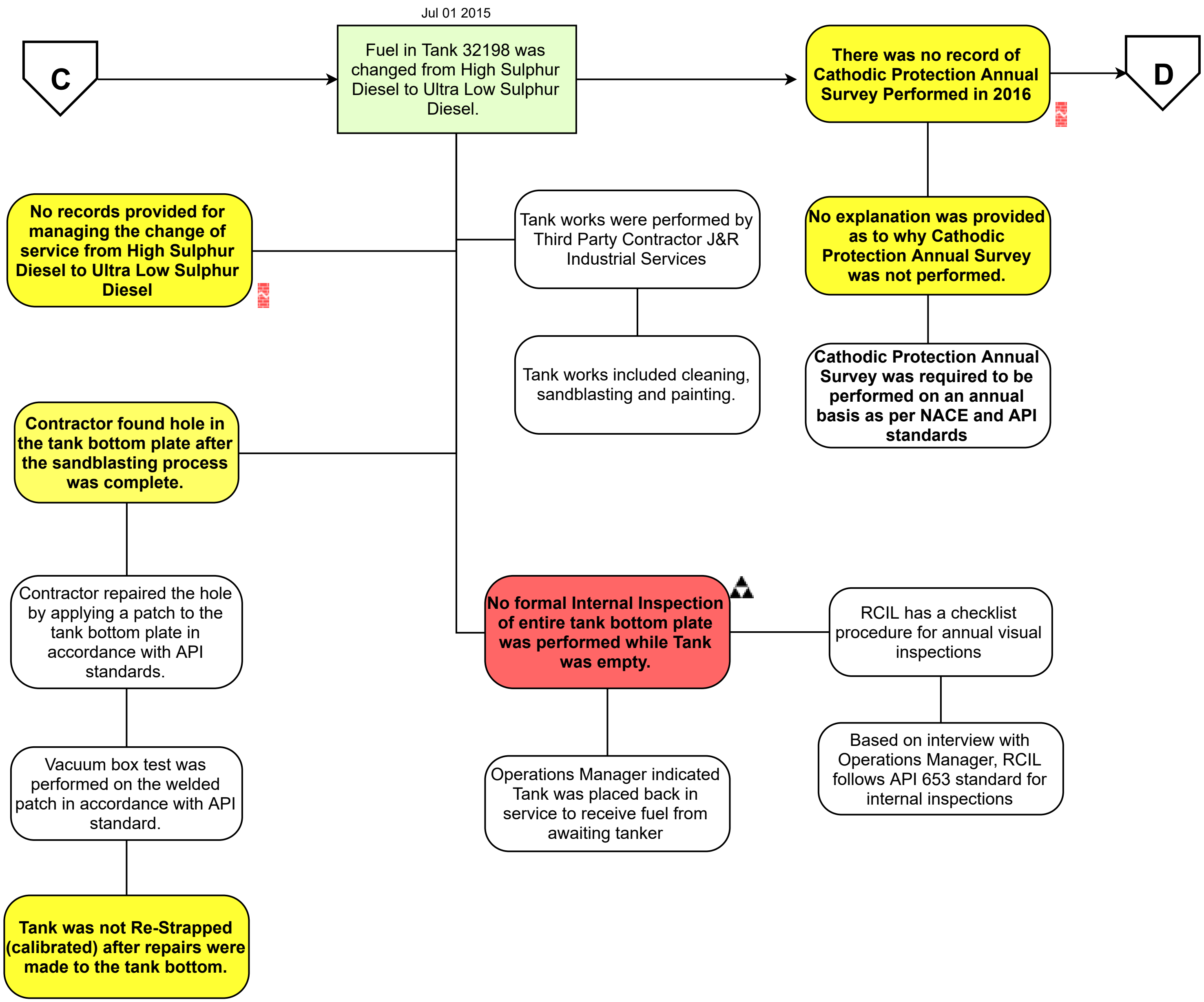
SnapCharT™ Sequence of Events - RCIL Incident Investigation



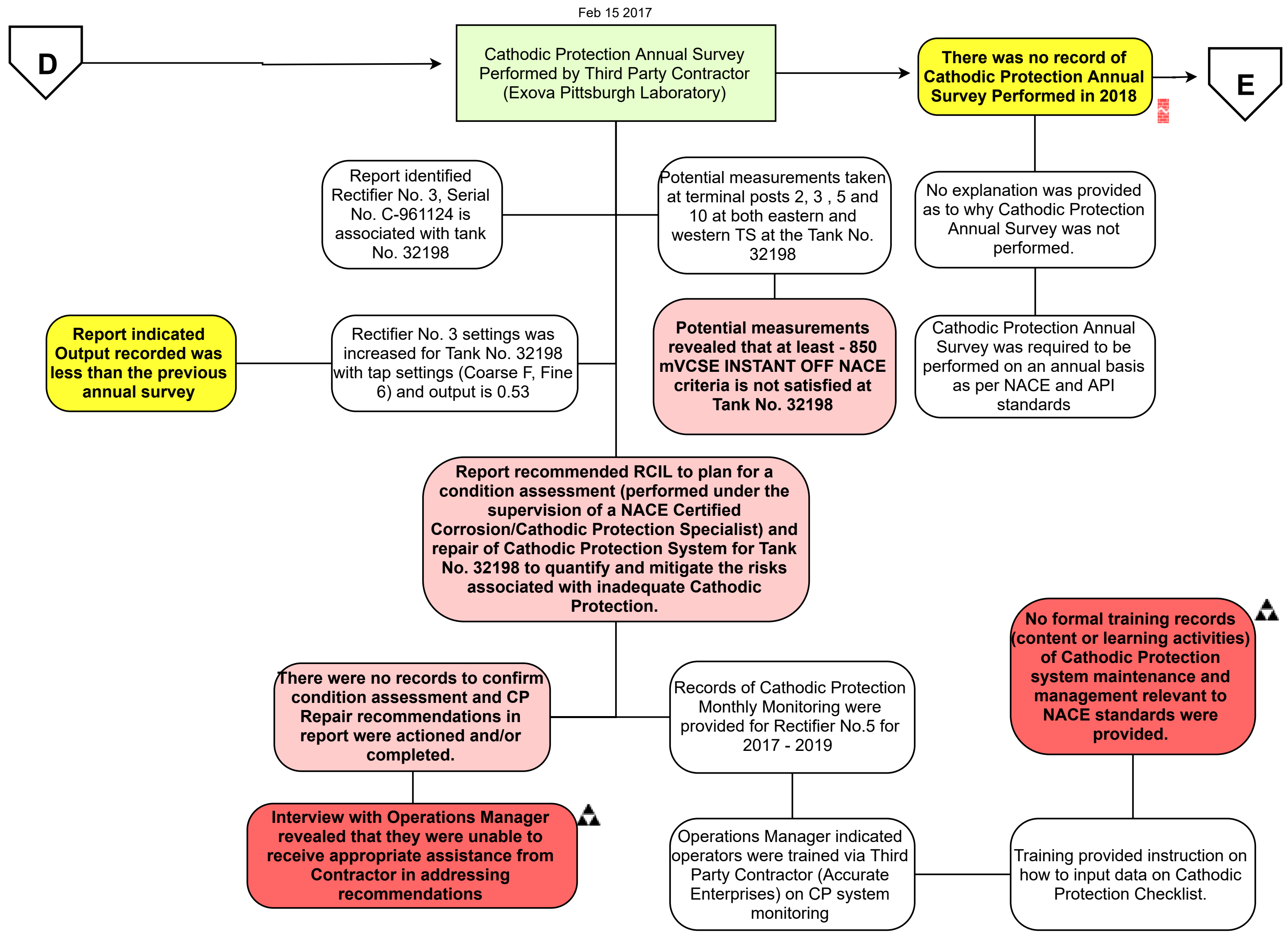
SnapCharT™ Sequence of Events - RCIL Incident Investigation



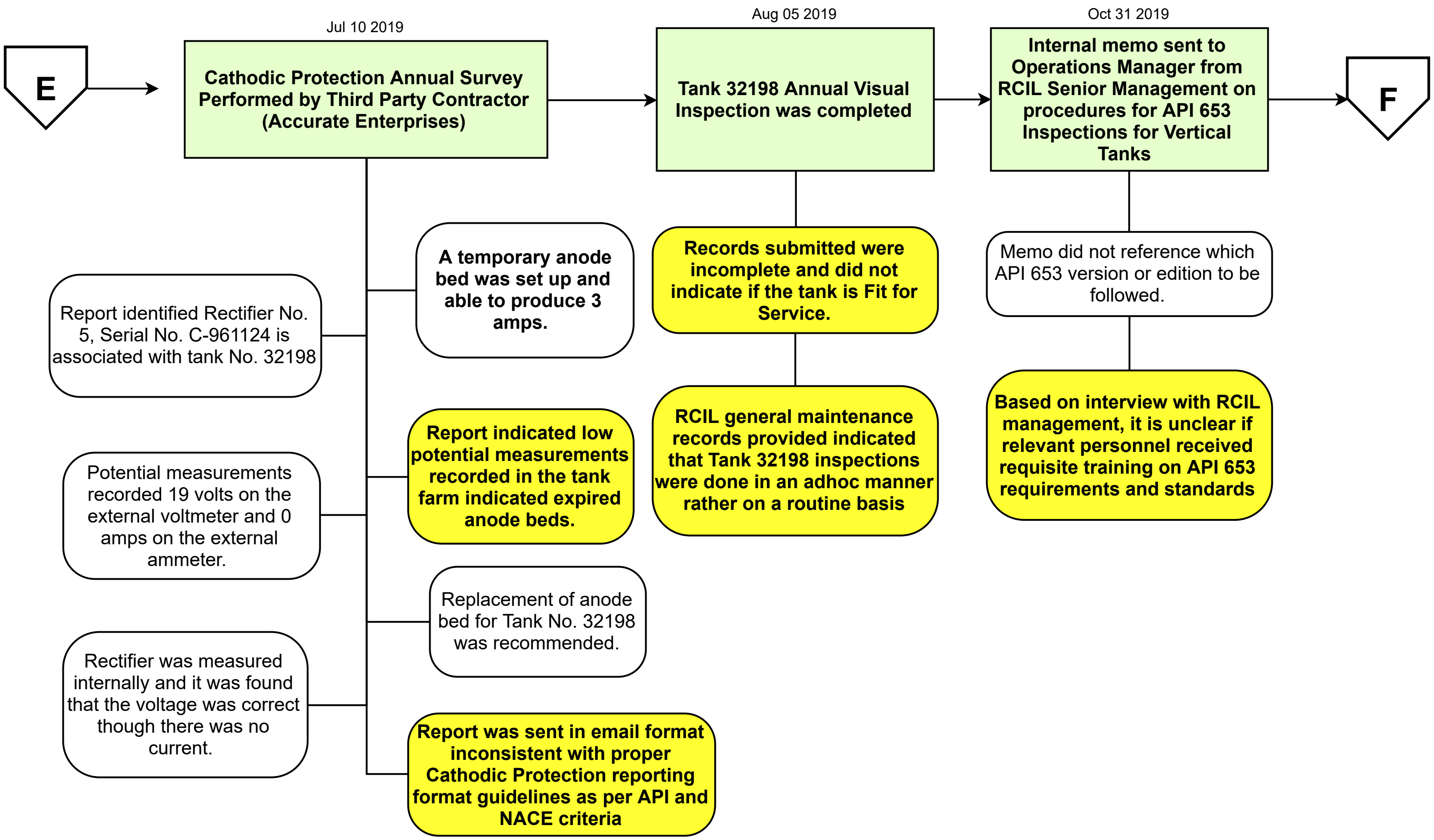
SnapCharT™ Sequence of Events - RCIL Incident Investigation



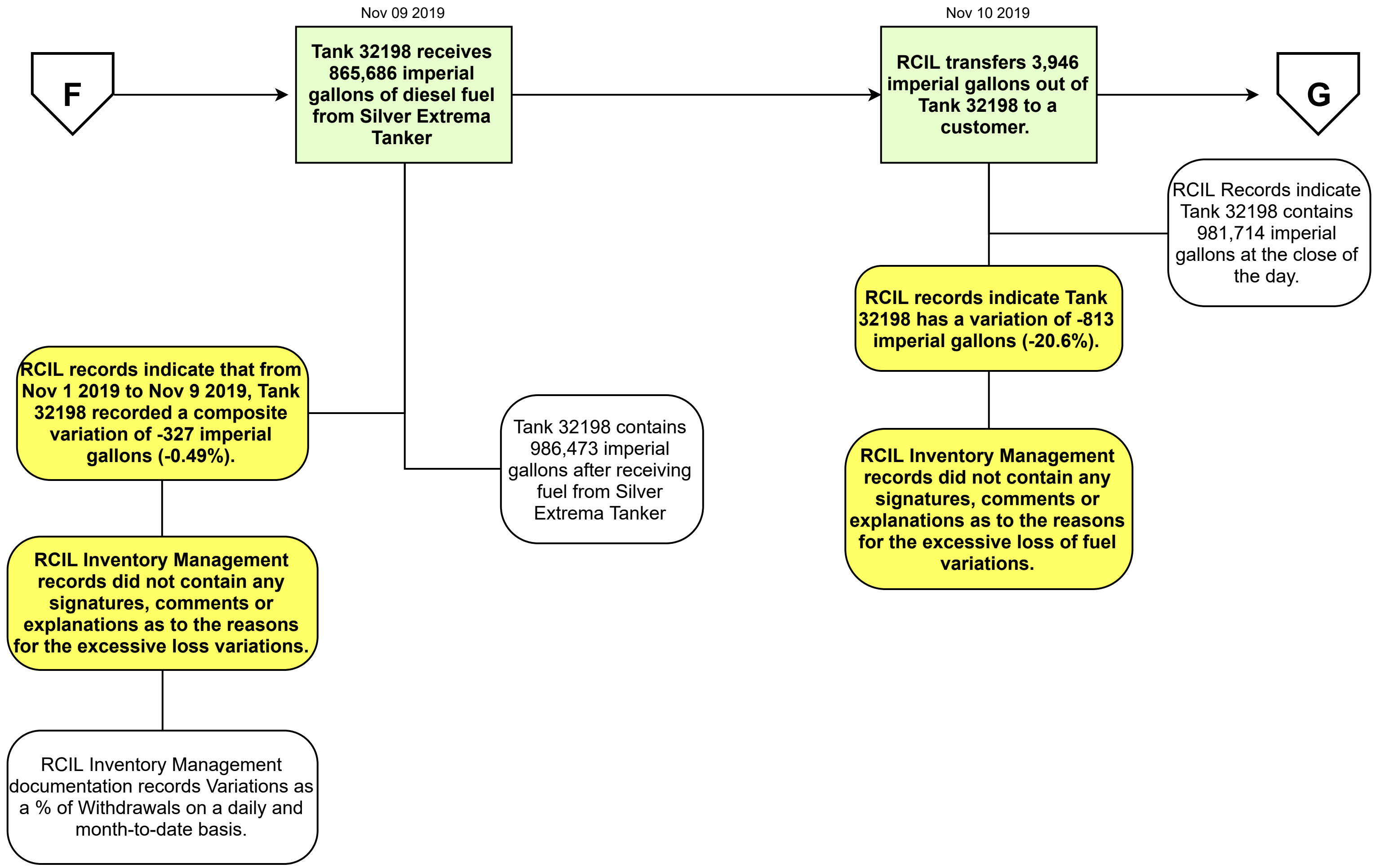
SnapCharT™ Sequence of Events - RCIL Incident Investigation



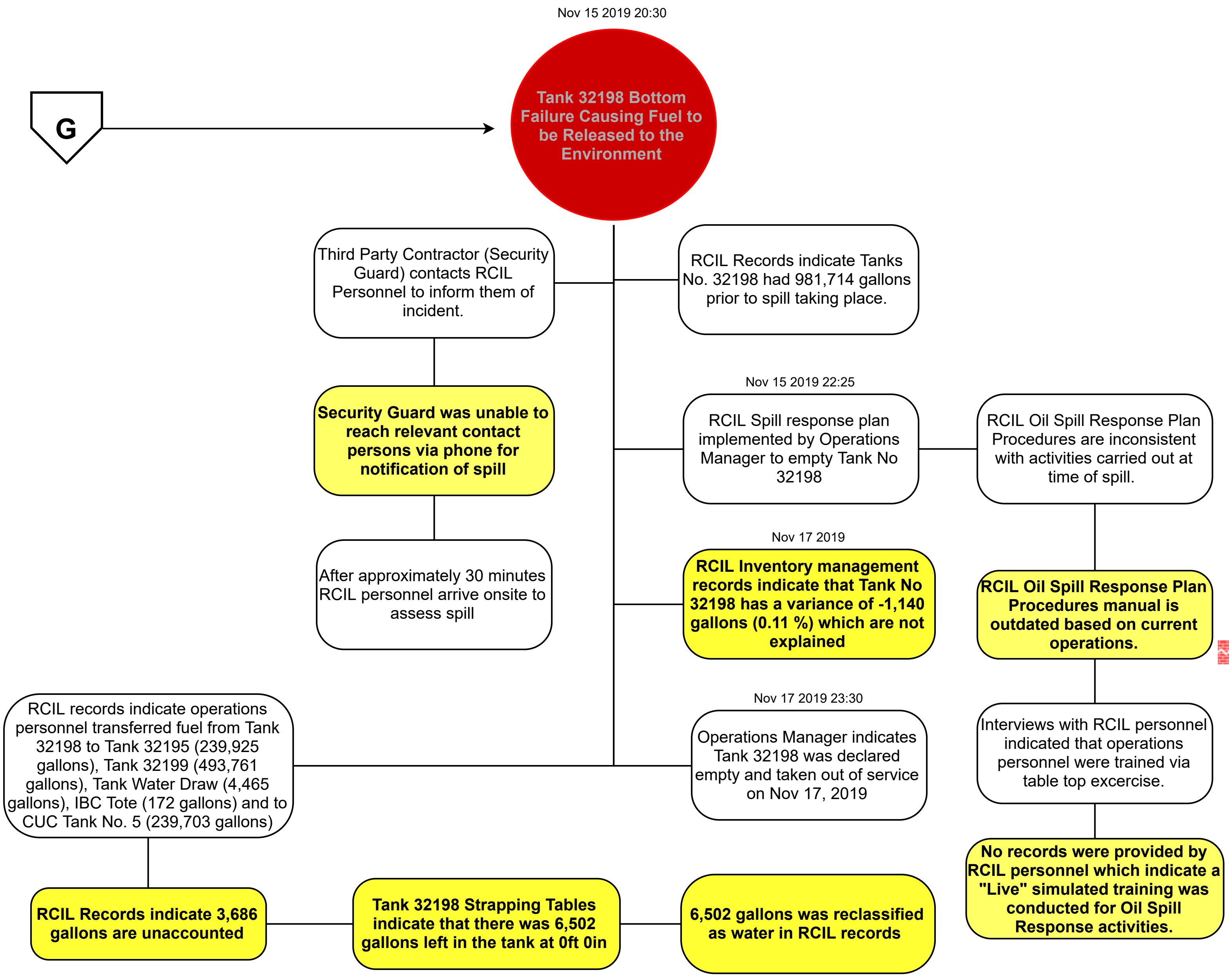
SnapCharT™ Sequence of Events - RCIL Incident Investigation



SnapCharT™ Sequence of Events - RCIL Incident Investigation



SnapCharT™ Sequence of Events - RCIL Incident Investigation



Appendix B - Photographs

Tank #32198 Bottom Plate Failure | **Tank #32198 Bottom Plate Failure**

Tank #32198 Bottom Plate Failure | **Tank #32198 Bottom Plate Failure**

Tank #32198 Bottom Plate Failure | **Tank #32198 Bottom Plate Failure**

	
Tank #32198 Bottom Plate Failure	**Tank #32198 Bottom Plate Failure**
	
Tank #32198 Rectifier # 5	**Tank #32198 Bottom Plate Failure**

	
Areas of Rust on External Tank Shell	**Areas of Rust on External Tank Shell**
	
Areas of Rust on External Tank Shell	**Areas of Rust on External Tank Shell**

Appendix C - TapRoot® SnapCharT™ Attachments/Records

where engineering begins....

CATHODIC PROTECTION SURVEY REPORT

JACKSON POINT TERMINAL

RUBIS GRAN CAYAM

6. RESULTS ANALYSIS

Upon arrival at Jackson point Bulk Storage Terminal, Rectifier No. 1 that services the underground piping within the terminal was found off. The T/R was energized and a current output of zero (0) amps was recorded. The reason for this could be broken cables or anode depletion. As such, only natural structures to soil potential readings were taken. Flange insulation tests were conducted using a RFIT, which deemed the insulation faulty. When the Transformer rectifier is fixed, the insulating gaskets at the flanges where the pipe comes above ground should be replaced.

Test Locations	Dead Side -mV	Live Side –mV	Comments
Pipes behind T/R #1			
Pipe #1	586	589	Replace Gasket
Pipe #2	586	588	Replace Gasket
Pipe #3	585	589	Replace Gasket

(see appendix #1)

Rectifier No. 2 is associated with tank No. 32198. The unit was found off and natural potentials were recorded. The T/R was turned on and energized at 0.8 amps and left on overnight. The readings indicate that the tank is not adequately protected. The unit was left off. However, the pipes leading out the tank the insulating gaskets are faulty and should be replaced.

Rectifier No. 3 is associated with tank No. 32199.The unit was found energized at an output of 5.5 amps. Structure to soil potential measurements recorded suggest that the tank is below the NACE criteria of -850mV or more negative with reference to a

where engineering begins....

TANK #: 32198			
TEST LOCATIONS (portable Ref. Electrode)	STRUCTURE TO SOIL ON POTENTIAL (-mV)		COMMENTS
North	680		
South	692		
West	685		
East	664		
North West	684		
North East	658		
South West	688		
South East	652		
JUNCTION BOX			
Anode	Current (Amps)		Comments
Anode 1			
Anode 2			
Anode 3			
Main Anode Cable			
Cathode			
Permanent Ref. Electrode	Potential Reading (-mV)		
	ON	INSTANT OFF	
C1	424	403	Not Working
C2	423	214	
C3	424	412	Not Working

where engineering begins....

TRANSFORMER RECTIFIER #3		**Location** :
Type: Oil cooled		**Serial No**. C-961124
Model #: CXYSE		**D.C amps:** 8
D.C volts: 30		**Phases:** 1
A.C volts: 115/230		**Hertz:** 60
A.C amps: 3.36/1.68		**AMB Temp:** 50
Present Output	5 Volts	0.8 Amps
Cathode Reading	0.5 Amps	
Anodes	**Anode Outputs**	**Shunt Readings**
Main Cable		

Comments:

T/R for Cathodic Protection on tank #32198____

CATHODIC PROTECTION SYSTEM RESURVEY JACKSON POINT BULK STORAGE TERMINAL

FOR

<u>Rubis Caribbean, Ltd.</u>

430 South Church Street
Grand Cayman, Cayman Islands

Prepared By:

Southern Cathodic Protection Company
780 Johnson Ferry Road, N.E., Suite 225
Atlanta, Georgia 30342
(404) 252-4649

January 2014

The rectifier for Tank No. 32198 was found off. When energized an output of .26 amperes was recorded. Potential measurements recorded at the Bullet Box test stations indicate inadequate cathodic protection. The rectifier current output should be maintained at a minimum of 2.5 amperes. This output was unachievable due to high circuit resistance from dry sand under the tank bottom. Rectifier output should be monitored should conditions change.

Rectifier No. 4 was found on with new anodes and junction box. The rectifier was energized and the current output was measured to be 5.2 amperes. The fine tap setting was increased from two to three and output was increased to 7.5 amperes. The rectifier cover hinges and DC meters were determined to be broken. Potential measurements were recorded and adequate cathodic protection was reported for each of the three permanent reference electrodes using the 100 millivolt polarization criterion.

Structure-to-electrolyte potential measurements were recorded from the Rubis Terminal to the Esso Terminal on the 8" underground receipt fuel line. All of the potential measurements recorded were indicative of adequate cathodic protection. All insulators tested for electrical effectiveness were determined to be effective.

4.0 RECOMMENDATIONS

In order to assure continued cathodic protection within the Jackson Point Bulk Storage Terminal and on the underground receipt fuel pipeline, the following recommendations are offered:

1. The existing Jackson Point Bulk Terminal anode ground bed, installed in 1984, has reached its useful design life. It is not considered economical to attempt cable repairs and selective anode replacement. It is recommended to redesign the anode ground bed and install new anodes for only the underground fire protection piping, drain lines and vapor piping. Independent impressed current cathodic protection systems should continue to be installed and monitored on tanks that have new bottoms.

2. Conduct an API-653 inspection prior to placing Tank Nos. 32200 and 32201 back into service.

3. Continue to monitor the cathodic protection systems for Tank Nos. 32199, 32198 and 32193.

SOUTHERN CATHODIC PROTECTION

SHEET 1 OF 1

CORROSION SURVEY DATA

SURVEY TYPE: CATHODIC PROTECTION

STRUCTURE (S) SURVEYED: JACKSON POINT BULK STORAGE TERMINAL

OWNER: RUBIS CARIBBEAN, LTD.

LOCATION: GRAND CAYMAN, CAYMAN ISLANDS

SURVEYED BY: JFF REF. ELECTRODE: CU/CUSO4 DATE: DECEMBER 18, 2013

TEST NO.	TEST LOCATION	S/S -MV 1	S/S -MV 2	S/S -MV 3	S/S MV 4	AS NOTED -MV
	TANK NO. 32199					
01	C-1	1138	296	194	102	
	C-2	869	295	190	105	
	C-3	567	470	270	200	
	TANK NO. 32198					
02	LEFT BULLET BOX					
	COUPON WITH JUMPER IN PLACE	495	--	--	--	
	STRUCTURE	497	--	--	--	
	RIGHT BULLET BOX					
	COUPON WITH JUMPER IN PLACE	171	--	--	--	
	STRUCTURE	171	--	--	--	
	TANK NO. 32200 (OUT OF SERVICE)					
03	C-1	369	367	309	58	
	C-2	255	252	198	54	
	TANK NO. 32201(OUT OF SERVICE)					
04	C-1	3505	691	202	489	
	C-2	511	393	358	35	
05	TANK NO. 32193					
	C-1	319	293	283	10	
	C-2	417	+002	+252	250	
06	8" RECEIPT LINE FROM SUBMARINE LINE					
	RUBIS TERMINAL AT COTT TEST STATION					1269
	ESSO TERMINAL AT INSULATING FLANGE LINE					1247
	TERMINAL					1298

NOTES: S/S = STRUCTURE-TO-ELECTROLYTE POTENTIAL
-MV = NEGATIVE MILLIVOLTS
1. "ON" POTENTIAL; 2. "INSTANT OFF" POTENTIAL
3. NATIVE; 4. POLARIZATION

SOUTHERN CATHODIC PROTECTION

CATHODIC PROTECTION RECTIFIER OPERATING RECORD

STRUCTURE (S) PROTECTED: TANK NO. 32198 (74' DIA.)

OWNER: RUBIS CARIBBEAN, LTD.

LOCATION: GRAND CAYMAN, CAYMAN ISLANDS

RECTIFIER UNIT DESIGNATION: NO. 3

RECTIFIER LOCATION: JACKSON POINT BULK STORAGE TERMINAL

RECTIFIER DATA

MANUFACTURER: RTS MFG. DIV. MODEL NO. CXYSE 30-8 QZ SERIAL NO. C-961124

D.C. RATING: 30 VOLTS 8 AMPERES INSTALL DATE: 1999

RECORD OF MEASUREMENTS AND INSPECTIONS

DATE	TAP SETTINGS		D.C. OUTPUT			REMARKS	BY
	COARSE	FINE	VOLTS	AMPS			
4/5/00	A	6	4.75	2.9	INT.	FOUND ON - OIL ADEQUATE AND CLEAR	RHE
			4.48	2.9	EXT.		
5/9/01	A	6	5.00	1.8		AS FOUND-OIL LEVEL ADEQUATE AND CLEAR	JFF
7/02	A	6	4.00	5.0		RE-CONNECT TO 32198	CKM
7/16/02	A	6	5.00	3.2		FOUND ON-OIL LEVEL ADEQUATE AND CLEAR	JFF
7/1/03	B	1	5.00	6.4		INCREASED OUTPUT	JFF
2/28/05	B	1	6.50	2.2		FOUND ON - AMMETER BROKEN	JFF
3/4/05	C	1	12.3	5.52		FINAL OUTPUT - HASP SEVERELY CORRODED	JFF
2/27/06	C	1	12.4	0		REPLACED FUSE - CABLE BROKE AT TANK	JFF
5/16/07	C	1	--	--		FOUND OFF - TANK OUT OF SERVICE	JFF
10/7/08	C	1	12.0	0		FOUND OFF - WIRES BROKE AT TANK	JFF
12/1/10	B	1	4.93	5.2		REMOVED SHORT CIRCUIT-NEW ANODES	JFF
11/15/11	B	1	6.40	1.40		FOUND ON	JFF
11/15/11	B	4	9.17	2.68		INCREASED OUTPUT	JFF
12/18/13	B	4	9.17	2.68		INCREASED OUTPUT	JFF
12/18/13	B	4	5.72	.26		FOUND OFF- OIL LEVEL ADEQUATE AND CLEAR	FJE

CATHODIC PROTECTION SYSTEM RESURVEY REPORT

JACKSON POINT BULK STORAGE TERMINAL

FOR

Rubis Cayman Islands Limited

430 South Church Street
Grand Cayman, Cayman Islands

Prepared By:

Southern Cathodic Protection Company
780 Johnson Ferry Road, N.E., Suite 225
Atlanta, Georgia 30342
(404) 252-4649

January 2015

Rectifier output voltage was verified by measuring the voltage across the output terminals using the digital multimeter. The ammeter accuracy was verified by measuring the voltage drop across a calibrated shunt and calculating current using Ohm's Law.

3.0 RESULTS AND ANALYSIS

The data collected during the resurvey has been tabulated and is included in Appendices A and B. The criteria used to establish effectiveness of the cathodic protection system is as published by NACE International in their recommended practices. The NACE potential criteria used was a minimum -0.850 volts instant off, with respect to the saturated copper/copper sulfate reference electrode, 100 millivolts or more of polarization decay between the “instant off” and “depolarized” potential or 100 millivolts or more of polarization formation between the “native” and the “instant off” potential.

Upon arrival in the Jackson Point Bulk Storage Terminal Rectifier No. 1 was found off. The rectifier was energized and a current output of zero amperes was measured, similar to what was reported during our last survey in December 2013. The oil was adequate and clean. The rectifier output was measured to be 26.0 amperes in July 2002. As reported in our last survey in December 2013, cable breaks and consumption of the anodes is the reason for zero current output. Due to zero current output, potential measurements were not recorded on the underground structures within the Terminal.

The rectifier output for Tank No. 32193 was found to be lower than the output measured in December 2013. The rectifier output has decreased to 2.66 amperes from 3.63 amperes. Potential measurements recorded utilizing permanent reference electrode C-2 indicated adequate cathodic protection. The anode hoop current measurements indicate all of the hoops are operating properly. The rectifier current output should be maintained at a minimum of 2.0 amperes.

The rectifier for Tank Nos. 32200 and 32201 was found energized at an output of .50 amperes, slightly lower than the .81 amperes measured in 2013. The reduction in rectifier output is most likely due to the change in circuit resistance associated with the tanks being empty and the bottom plates not being in full contact with ground. The rectifier current output should be inspected should product be placed back into either tank, as the circuit resistance of the system will change.

The rectifier for Tank No. 32198 was found on at an output of .16 amperes. Potential measurements recorded at the Bullet Box test stations indicate inadequate cathodic protection. The rectifier current output was increased to .64 amperes. The output should be maintained at a minimum of 4.0 amperes. This output was unachievable due to high circuit resistance from dry sand under the tank bottom. Rectifier output should be monitored should conditions change.

The rectifier for Tank No. 32199 was found on. The current output was measured to be 6.4 amperes. The output was increased to 7.5 amperes in December 2013. The rectifier cover hinges were determined to be broken. Potential measurements were recorded and adequate cathodic protection was reported for each of the three permanent reference cells using the 100 millivolt polarization criterion.

Structure-to-electrolyte potential measurements were recorded from the Rubis Terminal to the Sol Terminal on the 8" underground delivery fuel line. All of the potential measurements recorded were indicative of inadequate cathodic protection. The above ground insulator in the Rubis Terminal was visually inspected for electrical effectiveness. It was determined that the flange insulation kit had been removed. The insulator at the Sol Terminal was determined to be effective.

4.0 RECOMMENDATIONS

In order to assure continued cathodic protection within the Jackson Point Bulk Storage Terminal and on the underground receipt fuel pipeline, the following recommendations are offered:

1. The existing Jackson Point Bulk Terminal anode ground bed, installed in 1984, has reached its useful design life. It is not considered economical to attempt cable repairs and selective anode replacement. It is recommended to redesign the anode ground bed and install new anodes for only the underground fire protection piping, drain lines and vapor piping. Independent impressed current cathodic protection systems should continue to be installed and monitored on tanks that have new bottoms.

2. Conduct an API-653 inspection prior to placing Tank Nos. 32200 and 32201 back into service.

3. Monitor the cathodic protection systems for Tank Nos. 32199, 32198 and 32193.

4. Ensure the impressed current cathodic protection systems are operated continuously and maintained properly. A cathodic protection maintenance program must be initiated to include:

    a. Monthly rectifier surveillance. Continue to record rectifier voltage and amperage by Rubis personnel in a permanent log book.

b. Ensure continuous operation of the cathodic protection system rectifiers. Do not turn the rectifiers off for any extended period of time. Report any significant change in rectifier output (+/-20%) to Southern Cathodic Protection Company.

5. Ensure the cathodic protection system on the underground receipt fuel pipeline is maintained properly. The cathodic protection maintenance program must include:

    a. Ensuring that the test stations remain in place.

    b. Maintaining electrical isolation of the fuel pipeline. **Replace the flange insulation kit in the Rubis Terminal.**

    c. Adequate signage along the pipeline right-of-way between the terminals.

6. Have the entire system resurveyed annually by a qualified corrosion engineer.

SOUTHERN CATHODIC PROTECTION

SHEET 1 OF 1

CORROSION SURVEY DATA

SURVEY TYPE: CATHODIC PROTECTION

STRUCTURE (S) SURVEYED: JACKSON POINT BULK STORAGE TERMINAL

OWNER: RUBIS CAYMAN ISLANDS LTD.

LOCATION: GRAND CAYMAN, CAYMAN ISLANDS

SURVEYED BY: TH REF. ELECTRODE: CU/CUSO4 DATE: JANUARY 20, 2015

TEST NO.	TEST LOCATION	S/S -MV 1	S/S -MV 2	S/S -MV 3	S/S MV 4	AS NOTED -MV
	TANK NO. 32199					
01	C-1	2485	540	318	222	
	C-2	1906	520	351	169	
	C-3	1620	867	436	431	
	TANK NO. 32198					
02	LEFT BULLET BOX					
	COUPON WITH JUMPER IN PLACE	322	--	--	--	
	RIGHT BULLET BOX					
	COUPON WITH JUMPER IN PLACE	081	--	--	--	
	TANK NO. 32200 (OUT OF SERVICE)					
03	C-1					
	C-2					
	TANK NO. 32201(OUT OF SERVICE)					
04	C-1					
	C-2					
05	TANK NO. 32193					
	C-1	383	290	269	21	
	C-2	606	075	+043	118	
06	8" DELIVERY FROM SUBMARINE PIPELINE (SHORTED)					
	RUBIS TERMINAL AT COTT TEST STATION					684
	SOL TERMINAL AT INSULATING FLANGE LINE					746
	TERMINAL					1523

NOTES: S/S = STRUCTURE-TO-ELECTROLYTE POTENTIAL
-MV = NEGATIVE MILLIVOLTS
1. "ON" POTENTIAL; 2. "INSTANT OFF" POTENTIAL
3. NATIVE; 4. POLARIZATION

CATHODIC PROTECTION (CP) SYSTEM RESURVEY REPORT OF JACKSON POINT BULK STORAGE TERMINAL

PREPARED FOR:

Dustin R. Kersey
D.Kersey@Rubis-Caribbean.com
Work: (345) 949-2412
Website: www.rubiscaymanislands.com

Rubis Cayman Islands Limited

430 South Church Street
Grand Cayman, Cayman Islands

Project No. O750042

Mehrooz Zamanzadeh, PhD
Fellow of NACE, Fellow of ASM
NSACE Certified Corrosion/Coating/Materials Selection / Design/Cathodic Protection Specialist
I-phone: 412-952-9441

Anil Kumar Chikkam
Cathodic Protection Engineer and Failure Analyst

Michael John
Cathodic Protection Tester and Sales Executive

EXECUTIVE SUMMARY:

CP survey findings reveal that the Rectifier Output for Tank No. 32193 is 3.68 Amps, Tank No. 32194 is 4.36 Amps, Tank No. 32198 is 0.53 Amps and Tank No. 32199 is 9.5 Amps. Rectifier output current for Tanks can be increased without exceeding the rectifier maximum rating to satisfy *at least -850 mV_{CSE} INSTANT OFF NACE CP criteria*. It is advisable that client should monitor and record the rectifier output on a monthly basis. Report any significant change in rectifier output to Exova.

Potential measurements revealed that at least - 850 mV_{CSE} INSTANT OFF criteria is not satisfied at Tanks No. 32193, 32194, 32195, 32196, 32198 and 32199. Potential readings taken at permanent reference electrode C2 of Tank No. 32193 showed huge error which indicates that permanent reference electrode C2 has to be replaced.

Potential measurements taken at Grey 10" South East (SE) of Tanks (plant side), White 10" - 3' South West (SW) of REF #1, Two 6" lines south of workshop, Two 10" Lines (diesel) - West of Shop revealed that *at least - 850 mV_{CSE} in INSTANT OFF criteria* is not satisfied

Client has to plan for the condition assessment of the Tanks No. 32193, 32194, 32195, 32196, 32198 and 32199 to quantify and mitigate the risks associated with inadequate CP. **It is very important that condition assessment has to be performed under the supervision of a NACE Certified Corrosion/Cathodic Protection Specialist.**

At your request Exova will perform condition assessment and CP repair. Corrosion assessment and mitigation would take place under supervision of **Dr. Zee**, a NACE Certified CP, coating and materials & design specialist.

1.0 INTRODUCTION

Rubis Cayman Islands engaged **Exova** to perform cathodic protection (CP) resurvey of the existing cathodic protection (CP) systems at the Jackson Point Bulk Storage terminal.

The summary of previous data is as follows:

- The existing cathodic protection system for the Jackson Point Bulk Terminal was installed in 1984.
  - The cathodic protection system consists essentially of twenty-three (23) prepackaged 3" x 60" graphite anodes, originally energized by one J.A. Electronics 60 volt; 16 ampere D.C. oil immersed, explosion-proof rectifier.
  - J.A. Electronics rectifier was replaced in 2002 with a Universal Rectifiers 70 volt, 35 ampere unit.

- External steel surfaces of ground storage tank bottoms and the associated underground fire protection piping are receiving cathodic protection.

	Tank No. 32198	**Tank No. 32199**	**Tank No. 32200**	**Tank No. 32201**	**Tank No. 32193**	**Tank No. 32194**
Year of Construction	**1999**	**2000**	**2001 (out of service)**	**2001 (out of service)**	**--**	**2015**
Anode Type	Independent Impressed current	Independent Impressed current commissioned in JAN 2013	Independent Impressed current	Independent Impressed current	Independent Impressed current	Independent Impressed current

- In 2015, Rectifier No. 5 output for Tank No. 32193 with tap settings (Coarse 2, Fine 3) is 2.66 Amps which is less than the data collected in 2013 (3.63 Amps). Potential measurements taken with respect to permanent reference electrodes (C1 and C2) installed at Tank No. 32193 revealed that CP criteria of 100 millivolt polarization is satisfied on only one reference cell (C2).

- In 2015, Rectifier No. 3 output for Tank No. 32198 with tap settings (Coarse B, Fine 4) is 0.16 Amps which is less than the data collected in 2013 (0.26 Amps). Potential measurements recorded at the Bullet Box test stations indicated inadequate CP. Rectifier output setting was changed to (Coarse D, Fine 4) Tap settings and the output current noticed was 0.64 Amps. Optimal output was not achievable due to high circuit resistance from dry sand under the tank bottom.

- In 2015, Rectifier No. 4 output for Tank No. 32199 with tap settings (Coarse A, Fine 3) is 6.4 Amps which is less than the data collected in 2013 (7.5 Amps). Potential measurements taken with respect to permanent reference electrodes (C1, C2 and C3) installed at Tank No. 32199 revealed that CP criteria of 100 millivolt polarization is satisfied on all reference electrodes.

- Potential measurements recorded from the Rubis Terminal to the Sol Terminal on the 8" underground delivery fuel line indicated inadequate cathodic protection. The above ground insulator in the Rubis Terminal was visually inspected for electrical effectiveness. It was determined that the flange insulation kit had been removed. The insulator at the Sol Terminal was determined to be effective.

2.0 TEST PROCEDURES

Structure-to-soil potential measurements were obtained using Fluke voltmeter. To determine the level of polarization, “ON” and “Instant OFF” potentials were recorded. The most negative potential observed during the “ON” cycle was recorded as the “ON” potential. The least negative potential observed during the first two seconds of the “OFF” cycle was recorded as the “Instant OFF” potential.

Voltage was measured by reading across the output lugs. Current output was measured by reading voltage drop across the calibrated shunt and calculating the current using the shunt size.

3.0 RESULTS AND ANALYSIS

NACE SP0193-2016 section 4.3 criteria was considered to check the effectiveness of the CP system. The data collected during the resurvey has been tabulated and is included in Appendix A.

In 2017 CP resurvey, tap settings of Rectifier No. 5 was increased from C2,F3 to C2,F5. Rectifier output for Tank No. 32193 with tap settings (Coarse 2, Fine 5) is 3.68 Amps. Potential measurements taken with C2,F3 and C2,F5 tap settings with respect to permanent reference electrodes (C1 and C2) installed at Tank No. 32193 revealed that CP criteria is not satisfied. Also, potential measurements taken at four compass headings (North, South, East and West) at the Tank No. 32193 showed that *at least -850 mV_{CSE} NACE CP criteria* is not achieved.

In 2017 CP resurvey, rectifier output of Tank No. 32194 with tap settings (Coarse 1, Fine 3) is 4.36 Amps. Previous data was not available as the tank was being installed during the last survey. Potential measurements with respect to permanent reference electrodes (C1, C2 and C3) installed at Tank No. 32194 revealed that CP criteria is not satisfied. Also, potential measurements taken at four compass headings (North, South, East and West) at the Tank No. 32194 showed that *at least -850 mV_{CSE} NACE CP criteria* is not achieved.

Potential measurements taken at four compass headings (North, South, East and West) at the Tanks No. 32195, 32196 and 32198 showed that *at least -850 mV_{CSE} NACE CP criteria* is not achieved. In 2017 CP resurvey, tap settings of Rectifier No. 3 was increased from CD,F4 to CF,F6. Rectifier output for Tank No. 32198 with tap settings (Coarse F, Fine 6) is 0.53 which is less than the data collected in 2015 (0.64 Amps at tap setting CD, F4).

Potential measurements taken at terminal posts 2, 3 , 5 and 10 at both eastern and western TS at the Tank No. 32198 showed that *at least -850 mV_{CSE} NACE CP criteria* is not achieved.

In 2017 CP resurvey, Rectifier output for Tank No. 32199 is 9.5 Amps which is higher than the data collected in 2015 (6.4 Amps) at the same tap settings. Potential measurements taken with respect to permanent reference electrodes (C1, C2 and C3) installed at Tank No. 32199 revealed that CP criteria is not satisfied. Also, potential measurements taken at four compass headings (North, South, East and West) at the Tank No. 32199 showed that *at least -850 mV_{CSE} NACE CP criteria* is not achieved.

Potential measurements taken at Grey 10" South East (SE) of Tanks (plant side), White 10" - 3' South West (SW) of REF #1, Two 6" lines south of workshop, Two 10" Lines (diesel) - West of Shop revealed that *at least - 850 mV$_{CSE}$ in INSTANT OFF criteria* is not satisfied.

4.0 CONCLUSIONS AND RECOMMENDATIONS

As per NACE SP0193-2016 section 4.3, the following criteria is the basis for the cathodic protection survey:

- ✓ A negative (cathodic) voltage of at least -850 millivolts with the cathodic protection current applied. This potential is measured with respect to a saturated copper/copper sulfate reference electrode contacting the electrolyte. Voltage drops other than those across the structure-to-electrolyte boundary must be considered for valid interpretation of this voltage measurement.
- ✓ A negative polarized potential of at least -850 millivolts relative to a saturated copper/copper sulfate reference electrode.
- ✓ A minimum of 100 millivolts of cathodic polarization between the structure under test and a stable reference electrode contacting the electrolyte. The formation or decay of polarization can be measured to satisfy this criterion.

It is very important to note that in some locations, steel structures may be electrically continuous with the copper grounding grid, creating a complex mixed-metal system. The 100mV criterion described above does not apply to mixed-metal systems. The recommended CP criteria for mixed-metal systems is either utilizing the -850mV Instant-OFF potential criterion or the 100mV polarization of the most electro-negative metal in the system.

Based on the on-site inspection and cathodic protection evaluation, the following conclusions and recommendations are provided:

1. Potential readings taken at permanent reference electrode C2 of Tank No. 32193 showed huge error which indicates that permanent reference electrode C2 has to be replaced.
2. Potential measurements taken at Tanks No. 32193, 32194, 32195, 32196, 32198 and 32199 revealed that at least - 850 mV$_{CSE}$ in INSTANT OFF criteria is not satisfied. All potential readings indicate that Tanks are not protected. Considerations should be given to perform a condition assessment and repair the CP system.
3. Client has to plan for the condition assessment of the Tanks No. 32193, 32194, 32195, 32196, 32198 and 32199 to quantify and mitigate the risks associated with inadequate CP. It is very important that condition assessment has to be performed under the supervision of a NACE Certified Corrosion/Cathodic Protection Specialist.
4. At your request Exova can assist you on the above important condition assessment and mitigation considerations.

APPENDIX A – RECTIFIER AND CP SURVEY DATA

Rectifier:	**Tank 32193**					
RUBIS Rectifier ID:	Tank 32193					
Serial #:	023294	**Type:**	Universal; Air-Cooled			
Output Rating:	20V / 5A	**A/C Input:**	115V	1φ	60 Hz	
Shunt Size:	50 mV / 10A	**Tap Setting As Found:**	C2/F3			
Shunt Voltage (mV):	18.4	**Tap Setting As Left:**	C2/F5			
DC Current Output (A):	3.68	**Employee:**	Michael	Date:	2/15/2017	
DC Voltage Output (V):	15.1					
Protected Structures:	Tank 32193					
Comments:	Low Oil, Tapped up REC					

Junction Box:	Tank 32193 **as found**	**as left**
Shunt Size:	.01 ohm	
Anode #:	*Current Reading (mV):*	
1	2.9	6.9
2	5.0	9.8
3	3.7	5.9
4	4.8	8.4
5	4.5	7.1

Rectifier:	**Tank 32198**					
RUBIS Rectifier ID:	Tank 32198					
Serial #:	C-961124					
Output Rating:	30V / 8A	**A/C Input:**	230V	1φ	60 Hz	
Shunt Size:	50 mV / 10 A	**Tap Setting As Found:**	CD/F4			
Shunt Voltage (mV):	2.64	**Tap Setting As Left:**	CF/F6			
DC Current Output (A):	0.53	**Employee:**	Michael	Date:	2/15/2017	
DC Voltage Output (V):	11.4					
Protected Structures:	Tank 32198					
Comments:	Tapped out Rectifier NO REFERENCE CELLS UNDER TANK					

Junction Box:	Tank 32198
Shunt Size:	50/50
Anode:	*Current Reading (mV):*
1	1.2
2	0.2

Rectifier:	**Tank 32199**					
RUBIS Rectifier ID:	Tank 32199					
Serial #:	84043					
Output Rating:	40V / 16A	**A/C Input:**	230	1φ	60 Hz	
Shunt Size:	N/A	**Tap Setting As Found:**	CA/F3			
Shunt Voltage (mV):	24.9	**Tap Setting As Left:**	CA/F3			
DC Current Output (A):	9.5	**Employee:**	Michael	Date:	2/15/2017	
DC Voltage Output (V):	8.1					
Protected Structures:	Tank 32199					
Comments:	JBOX needs bolting up to support. JBOX is just supporting itself by conduit. 3 bolts were previously broken off and 1 bolt missing					

Junction Box:	Tank 32199
Shunt Size:	.01 ohm
Anode #:	*Current Reading (mV):*
1	1
2	2.45
3	1.9
4	3.1
5	3.3
6	6.1
7	10.4
8	18.4
9	7.4
10	14.1
11	12.7
12	10.3
Total	**91.15**

Rectifier:	**Tank 32194**				
RUBIS Rectifier ID:	Tank 32194				
Serial #:	135716	**Type:**	Universal; Air-Cooled		
Output Rating:	30V / 8A	**A/C Input:**	115V	1φ	60 Hz
Shunt Size:	50 mV / 10A	**Tap Setting As Found:**	C1/F3		
Shunt Voltage (mV):	21.8	**Tap Setting As Left:**	C1/F3		
DC Current Output (A):	4.36	**Employee:**	Michael	Date:	2/15/2017
DC Voltage Output (V):	5.1				
Protected Structures:	Tank 32194				

Junction Box:	Tank 32194
Shunt Size:	.01 ohm
Anode #:	*Current Reading (mV):*
1	9.0
2	6.8
3	5.0
4	5.9
5	7.2
6	3.8
7	2.2
8	10.3
9	1.8
Total	**52**

REF. NO.	Test Location Description	Test Location GPS Coordinates		Structure to Soil Potential (V)		Picture ID	Notes	Potential (V) (Rectifier OFF for 1 hour) **Previous Data**	Polarization (V)
		Latitude	**Longitude**	**ON**	**OFF**				
	Tank 32195								
	North			-0.592	-0.580				
	East			-0.620	-0.605				
	South			-0.570	-0.548				
	West			-0.592	-0.580				
	Tank 32196								
	North			-0.633	-0.620				
	East			-0.621	-0.610				
	South			-0.600	-0.580				
	West			-0.650	-0.633				
	Tank 32198								
	North			-0.728	-0.699				
	East			-0.710	-0.680				
	South			-0.730	-0.696				
	West			-0.720	-0.686				
	Tank 32198 (Eastern TS)					W/ Red Button Pushed			
	Terminal Post 2			-0.458	-0.420		-0.530		
	(yellow wire)								
	Terminal Post 3			-0.734	-0.695		-0.840		
	(orange/yellow wire)								
	Terminal Post 5			-0.735	-0.698		-0.841		
	(blue/black wire)								
	Terminal Post 10			-0.729	-0.694		No Change		
	(Big Green wire)								
	Tank 32198 (Western TS)					W/ Red Button Pushed			
	Terminal Post 2			-0.447	-0.415		-0.450		
	(yellow wire)								
	Terminal Post 3			-0.727	-0.692		-0.740		
	(orange/yellow wire)								
	Terminal Post 5			-0.726	-0.693		-0.741		
	(blue/black wire)								
	Terminal Post 10			-0.726	-0.693		No Change		
	(Big Green wire)								

From: Colin Everett <colin.everett@aelcayman.com>
Sent: Thursday, July 18, 2019 12:18
To: Marnus Ehlers <M.Ehlers@rubis-caribbean.com>
Cc: Robin Holmes <ael@candw.ky>
Subject: Rubis rectifier survey Jackson Terminal July 10/2019

Please see results from the recent rectifier Cathodic Survey completed at Jackson Point on Wednesday July 10/2019.

Starting from the south side of the terminal and moving north;

Rectifier 1 – This small rectifier beside rectifier 3 is not labeled. It was de-energized when first surveyed, and when Darryl cleared the short it was turned on and later surveyed. The voltage and current output were recorded to be low, so the fine taps were raised to increase voltage and current to acquire more protection from the anode bed. The voltage was increased slightly, though the current maxed out immediately. This could be a lower resistance in the anode bed caused by higher than normal precipitation, though more likely a 'half wave' situation where the diode could be failing, or the windings are shorted. Also, it was observed that the voltmeter and ammeter showed no values when surveyed, though when measured internally, the rectifier was producing both voltage and current. Rectifier should be properly labeled to determine what tank it is intended to protect.

Recommendation – Check historical rectifier data taken by Rubis staff over the past year. If it is determined that the rectifier is half waving, take rectifier apart and check diode as well as windings to rule out short. Replace external voltmeter and ammeter. Label to indicate structure rectifier is protecting. Find target output.

Rectifier 2 – This rectifier is labeled #2 and is on tank 193. Rectifier has no AC power. Unable to find breaker.

Recommendation – Reconnect to AC. Let polarize and re-survey. Determine target output.

Rectifier 3 – This rectifier is labeled #3 and is on the south side of terminal next to unlabeled rectifier. It was de-energized at the time of original survey but was re-energized and surveyed after polarization. Rectifier is producing low voltage but unable to turn up as current is near maximum levels. Possible half wave situation. Low potentials recorded with reference to $CUSO_4$ half cell at tank indicate expired anode bed.

Recommendation – Check diode to rule out half wave situation. Find target output. Replace anode bed.

Rectifier in yard – This large rectifier is located in the pipeyard. Though energized, this rectifier was found to show only voltage on the external gauges, and no current value. When measured internally, it was found to not have any current output at all. This indicates an open circuit somewhere in the positive (anode) lead or an expired anode bed. Steps were taken to set up a temporary, small anode bed and it was able to produce almost 4 amps. Very low potentials recorded in pipeyard indicate an expired anode bed.

Recommendation – Install new anode bed.

Rectifier 4 – This rectifier is one of two on the north side of the terminal. It was found to be de-energized. After trouble shooting the rectifier it was discovered that the fuse on the DC side of the rectifier was no longer operational. Due to the age of the rectifier, the particular type and design of fuse is no longer available on the island. When temporarily fixed, the rectifier was able to operate though it was not able to take potentials or wait for the system to polarize due to possible safety concerns.

Recommendation – Contact manufacturer to obtain new fuse. Turn on, let system polarize then resurvey.

Rectifier 5 – This rectifier sits furthest north in the terminal. It was found to read 19 volts on the external voltmeter and 0 amps on the external ammeter. After measuring the rectifier internally, it was found that the voltage was correct though there was no current. A temporary anode bed was set up and able to produce 3 amps. This, as well as low potentials recorded in the tank farm indicate expired anode beds.

Recommendation – Replace anode bed.

Please see attached rectifier survey sheets.

As discussed, there were a few discrepancies in past survey reports, enough for me to be hesitant to rely on them to make any recommendations on the Brac site without actually surveying it. Let me know if thats something we can set up.

There are many options here. We can provide you with a turnkey operation with training but before we start quoting material we should have a quick meeting to determine which direction you would like to go.

Let me know when you are available.

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Recommendation – Replace anode bed.

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As discussed, there were a few discrepancies in past survey reports, enough for me to be hesitant to rely on them to make any recommendations on the Brac site without actually surveying it. Let me know if thats something we can set up.

There are many options here. We can provide you with a turnkey operation with training but before we start quoting material we should have a quick meeting to determine which direction you would like to go.

Let me know when you are available.

Colin

S184 Daily Report - Product in Storage Tanks

Tank Inventory Reconciliation

(251) Rubis Caribbean, Cayman Island — 2/17/2020

T26 - Jackson Point Terminal — 12:30 PM

Tank **32198** ***Diesel*** — U. S. Gallons (USG)

Tank Input:

Date (dd/mm/yyyy):			09/11/2019
Tank Number:			32198
Ambient Temperature:			87.4 (F)
API Gravity:			37.9
API Coefficient:			0.9893
	Ft	**In**	**16ths**
Tank Gauge: Content:	36	6	10
Water:	0	0	0

Tank Information:

Tank Alias:		K598
Product in Tank:		Diesel
Tank Type:		Horizontal
Tank Type:	1,085,845	(IMG)
Stock in Tank(c):	986,473	(IMG)
Ullage: at End-of-Day	99,372	(IMG)
In Barrels (Bbls)	2,841	(BBL)

	Ft	**In**	**16ths**
Tank Total Height:	40	3	0

Tank Volume (Current):	**@ Ambient**
1. Ending Inventory	
a. Product in Tank	986,473
b. Water in Tank	0
c. Ending Stock-in-Tank (a - b)	986,473
2. Withdrawals	0
3. Transfers Out	0
4. Maximum Stock (1c + 2 + 3)	986,473
5. Product in tank at Start-of-Day	120,787
6. Receipts	865,686
7. Transfers In	0
8. Maximum Stock (5 + 6 + 7)	986,473
9. Variation - Beginning	-327
10. Variation - This Day (4 - 8)	0
11. Variation - Ending (9 + 10)	-327
12. Variation as a % Withdrawals	0%

Tank Volume (Month-to-Date):	
Opening Stock	188,041
Withdrawals	66,927
Transfers Out	0
Transfers In	0
Receipts	865,686
Variation	-327
Closing Stock	986,473
Variation as a % Withdrawals	-0.49%

Doc#	Receipts	Description	Classification	Gallons Amb
0	EX Tanker	silver etrema	BEC	865686
		EX Tanker		865686

Prepared and Certified By: ____________________ Approved By: ____________________

Reason forExcessive Variation:

Comment:

Tank Inventory Reconciliation

(251) Rubis Caribbean, Cayman Island 2/17/2020

T26 - Jackson Point Terminal 10:59 AM

Tank **32198** ***Diesel*** U. S. Gallons (USG)

Tank Input:			
Date (dd/mm/yyyy):			15/11/2019
Tank Number:			32198
Ambient Temperature:			84.4 (F)
API Gravity:			37.9
API Coefficient:			0.9905
	Ft	**In**	**16ths**
Tank Gauge: Content:	36	4	8
Water:	0	0	0

Tank Information:		
Tank Alias:		K598
Product in Tank:		Diesel
Tank Type:		Horizontal
Tank Type:	1,085,845	(IMG)
Stock in Tank(c):	981,714	(IMG)
Ullage: at End-of-Day	104,131	(IMG)
In Barrels (Bbls)	2,978	(BBL)

	Ft	**In**	**16ths**
Tank Total Height:	40	3	0

Tank Volume (Current):	**@ Ambient**
1. Ending Inventory	
a. Product in Tank	981,714
b. Water in Tank	0
c. Ending Stock-in-Tank (a - b)	981,714
2. Withdrawals	0
3. Transfers Out	0
4. Maximum Stock (1c + 2 + 3)	981,714
5. Product in tank at Start-of-Day	981,714
6. Receipts	0
7. Transfers In	0
8. Maximum Stock (5 + 6 + 7)	981,714
9. Variation - Beginning	-1,140
10. Variation - This Day (4 - 8)	0
11. Variation - Ending (9 + 10)	-1,140
12. Variation as a % Withdrawals	0%

Tank Volume (Month-to-Date):	
Opening Stock	188,041
Withdrawals	70,873
Transfers Out	0
Transfers In	0
Receipts	865,686
Variation	-1,140
Closing Stock	981,714
Variation as a % Withdrawals	-1.61%

Prepared and Certified By: ______________________ Approved By: ______________________

Reason forExcessive Variation:

Comment:

S184 Daily Report - Product in Storage Tanks

Tank Inventory Reconciliation

(251) Rubis Caribbean, Cayman Island — 2/17/2020

T26 - Jackson Point Terminal — 11:01 AM

Tank **32198** ***Diesel*** — U. S. Gallons (USG)

Tank Input:

Date (dd/mm/yyyy):			17/11/2019
Tank Number:			32198
Ambient Temperature:			0 (F)
API Gravity:			37.9
API Coefficient:			1.0040
	Ft	**In**	**16ths**
Tank Gauge: Content:	0	0	0
Water:	0	0	0

Tank Information:

Tank Alias:		K598
Product in Tank:		Diesel
Tank Type:		Horizontal
Tank Type:	1,085,845	(IMG)
Stock in Tank(c):	0	(IMG)
Ullage: at End-of-Day	1,085,845	(IMG)
In Barrels (Bbls)	31,048	(BBL)

	Ft	In	16ths
Tank Total Height:	40	3	0

Tank Volume (Current):	**@ Ambient**
1. Ending Inventory	
a. Product in Tank	6,502
b. Water in Tank	6,502
c. Ending Stock-in-Tank (a - b)	0
2. Withdrawals	0
3. Transfers Out	981,714
4. Maximum Stock (1c + 2 + 3)	981,714
5. Product in tank at Start-of-Day	981,714
6. Receipts	0
7. Transfers In	0
8. Maximum Stock (5 + 6 + 7)	981,714
9. Variation - Beginning	-1,140
10. Variation - This Day (4 - 8)	0
11. Variation - Ending (9 + 10)	-1,140
12. Variation as a % Withdrawals	0%
Tank Volume (Month-to-Date):	
Opening Stock	188,041
Withdrawals	70,873
Transfers Out	981,714
Transfers In	0
Receipts	865,686
Variation	-1,140
Closing Stock	0
Variation as a % Withdrawals	-0.11%

Doc#	Receipts	Description	Classification	Meter Start	Meter End	Net Gallons
1	Transfer Ou	To TK 95	DUTY PAID	0	239925	239925
2	Transfer Ou	To Tk 99	DUTY PAID	0	493761	493761
3	Transfer Ou	To CUC	DUTY PAID	0	239705	239705
4	Transfer Ou	To WDO	DUTY PAID	0	4465	4465
5	Transfer Ou	To IBC Tote	DUTY PAID	0	172	172
6	Transfer Ou	Under 32198	DUTY PAID	0	3686	3686
			Transfer Out			981714

Prepared and Certified By: ____________________ Approved By: ____________________

Reason forExcessive Variation:

Comment:

Tank **32198** ***Diesel*** U. S. Gallons (USG)

Tank Input:			
Date (dd/mm/yyyy):			18/11/2019
Tank Number:			32198
Ambient Temperature:			0 (F)
API Gravity:			37.9
API Coefficient:			1.0040
	Ft	**In**	**16ths**
Tank Gauge: Content:	0	0	0
Water:	0	0	0

Tank Information:		
Tank Alias:		K598
Product in Tank:		Diesel
Tank Type:		Horizontal
Tank Type:	1,085,845	(IMG)
Stock in Tank(c):	0	(IMG)
Ullage: at End-of-Day	1,085,845	(IMG)
In Barrels (Bbls)	31,048	(BBL)

	Ft	**In**	**16ths**
Tank Total Height:	40	3	0

Tank Volume (Current):	**@ Ambient**
1. Ending Inventory	
a. Product in Tank	0
b. Water in Tank	0
c. Ending Stock-in-Tank (a - b)	0
2. Withdrawals	0
3. Transfers Out	0
4. Maximum Stock (1c + 2 + 3)	0
5. Product in tank at Start-of-Day	0
6. Receipts	0
7. Transfers In	0
8. Maximum Stock (5 + 6 + 7)	0
9. Variation - Beginning	-1,140
10. Variation - This Day (4 - 8)	0
11. Variation - Ending (9 + 10)	-1,140
12. Variation as a % Withdrawals	0%

Tank Volume (Month-to-Date):	
Opening Stock	188,041
Withdrawals	70,873
Transfers Out	981,714
Transfers In	0
Receipts	865,686
Variation	-1,140
Closing Stock	0
Variation as a % Withdrawals	-0.11%

Prepared and Certified By: ____________________ Approved By: ____________________

Reason forExcessive Variation:

Comment:

Object - Area of Application

This document details RCIL actions for the cleaning of the tank 32198 which is being changed from storage of HSD to ULSD.

Summary

1. INTRODUCTION

The purpose of this document is to outline the works carried out on tank 32198 in 2015. During this year Rubis & CUC had come to an agreement that a complete switch from High Sulphur Diesel (HSD) to Ultra Low Sulphur Diesel (ULSD) would be beneficial for the country. Lower Emissions and removal of a requirement to have HSD on hand for CUC and ULSD on hand for Retail service would consolidate and increase overall Diesel storage capabilities. These action would bolster the infrastructure security of the supply of diesel to CUC and hence power for the country.

2. OPENING & CLEANING OF TANK 32198

HSD that was stored in Tank 32198 was conveyed to CUC and the tank was opened, gas freed and cleaned. During the cleaning process it was observed that the paint coating on the bottom and first ring of the tank was blistering or peeling off of the steel. As a result of these findings RCIL took the decision to sandblast and recoat the interior of the tank before returning it to service.

3. WORKS CARRIED OUT ON TANK 32198

After sandblasting and cleaning of the tank was complete, a hole in the bottom of the tank was discovered. The entire sandblasted surface was hand wiped with mineral spirits and no other defects were found. In fact, the rest of the tank seemed to be in very good condition. At this time API standard for patching a tank, were consulted and plans were made to place a patch over the hole and have a welder install the patch plate.

Once the floor patch was installed and the bottom and first ring of the tank were repainted a vacuum box test was used to test the welds of the floor patch. Pressure was maintained across the entire patch during the vacuum box testing. The tank was closed and returned to service to receive ULSD product from the incoming tanker.

Figure 1: Hole in Floor

Figure 2: Profile of Hole

Figure 3: Vacuum Box Testing

Figure 4: Vacuum Pressure

CHEVRON CARIBEAN INC.

OC

GEORGE TOWN - GRAN CAYMAN

TANk No 32198

BOTTOM CALIBRATION

HEIGHT FT	HEIGHT in	VOLUME IMP. GALLONS	INCREASE GALON/(1/16 in)
0	0	6502	
	1/4	6991	130
	3/8	7333	136
	1	8686	135
	1 1/4	9266	140

CYLINDRICAL CALIBRATION

HEIGHT FT	HEIGHT in	VOLUME IMP. GALLONS	HEIGHT FT	HEIGHT in	VOLUME IMP. GALLONS	HEIGHT FT	HEIGHT in	VOLUME IMP. GALLONS	HEIGHT FT	HEIGHT in	VOLUME IMP. GALLONS
0	1 1/4	9266	3	5	97552	6	9	186364	10	1	275756
	2	10919		6	99725		10	188596		2	277992
	3	13151		7	101898		11	190829		3	280228
	4	15383		8	104071	7	0	193061		4	282464
	5	17616		9	106244		1	195294		5	284700
	6	19848		10	108418		2	197526		6	286937
	7	22081		11	110591		3	199759		7	289173
	8	24313		0	112764		4	201991		8	291409
	9	26545	4	1	114937		5	204223		9	293646
	10	28777		2	117157		6	206456		10	295882
	11	31010		3	119389		7	208688		11	298118
1	0	33243		4	121622		8	210921	11	0	300354
	1	35476		5	123854		9	213153		1	302591
	2	37709		6	126087		10	215386		2	304827
	3	39942		7	128319		11	217618		3	307063
	4	42174		8	130552	8	0	219851		4	309299
	5	44407		9	132784		1	222086		5	311535
	6	46640		10	135017		2	224322		6	313772
	7	48873		11	137249		3	226558		7	316008
	8	51107	5	0	139482		4	228794		8	318244
	9	53341		1	141714		5	231031		9	320480
	10	55574		2	143947		6	233267		10	322717
	11	57808		3	146179		7	235503		11	324953
2	0	60042		4	148412		8	237739	12	0	327189
	1	62275		5	150644		9	239976		1	329426
	2	64508		6	152876		10	242212		2	331662
	3	66742		7	155109		11	244448		3	333898
	4	68975		8	157342	9	0	246684		4	336134
	5	71209		9	159574		1	248920		5	338370
	6	73442		10	161806		2	251157		6	340607
	7	75676		11	164039		3	253393		7	342843
	8	77909	6	0	166271		4	255629		8	345079
	9	80143		1	168504		5	257866		9	347315
	10	82333		2	170736		6	260102		10	349552
	11	84507		3	172969		7	262338		11	351788
3	0	86681		4	175201		8	264574	13	0	354024
	1	88855		5	177434		9	266811		1	356260
	2	91029		6	179666		10	269047		2	358497
	3	93203		7	181899		11	271283		3	360733
	4	95378		8	184131	10	0	273519		4	362969

CYLINDRICAL INCREASES

in	IMP. GALLONS
1/16	140
1/8	280
3/16	419
1/4	559
5/16	699
3/8	839
7/16	979
1/2	1118
9/16	1258
5/8	1398
11/16	1538
3/4	1677
13/16	1817
7/8	1957
15/16	2097

STRAPPED BY: SERGIO VAIDES.

PREPARED BY: EDGAR A. GUARDIA C.

CYLINDER CALIBRATED ACCORDING TO API MPMS Chapter 2 Section 2A / 2002 y Chapter 2 Section 2B / 2002

BOTTOM CALIBRATED ACCORDING TO API MPMS Chapter 2 Section 2A Numeral 2.2A.16.7 / 2002 y API Standard 653 Addendum 4, Appendix B / 2009

MEASURING DEPTH CHART

PRODUCT SERVICE: DIESEL

REFERENCE GAUGE HEIGHT : 41 ft 4 - 3/8 in

TYPE OF TANK: VERTICAL CYLINDRICAL

DIAMETER : 74,038 Ft

CYLINDRICAL HEIGHT : 40,282 Ft

CAPACITY: 1085845 IMP. GALLONS

CONSTRUCTION MATERIAL: CARBON STEEL

BOTTOM TYPE: CONICAL DOWN

ROOF TYPE: FLOATING SCREEN FIXED CONICAL

Cylinder Calibration: External

Bottom Calibration: Internal

LIQUID HEAD STRESS: 34,7 ° API (60 °F)

LIQUID TEMPERATURE: 88,8 ºF

RECALIBRATED TANK

CALIBRATION DATE: MARCH 24, 2010

A TOTAL OF 945,72 IMPERIAL GALLONS HAS BEEN DEDUCTED FROM THIS TABLE BETWEEN 2 FT 9 - 9/32 in AND 4 FT 1 - 7/32 in., FOR ROOF DISPLACEMENT BASED ON A FLOATING WEIGHT OF 7950,00 POUNDS AND AN OBSERVED LIQUID GRAVITY OF 36,9 °API AS OBSERVED UNDER CONDITIONS OF THE LIQUID IN WHICH THE ROOF IS FLOATING. GAUGE LEVEL ABOVE OF 4 FT 1 - 7/32 in., REFLECT THIS DEDUCTION BUT SHOULD BE CORRECTED FOR ACTUALLY OBSERVED GRAVITY OF THE LIQUID AT PREVAILING TEMPERATURES AS FOLLOWS:

FOR 36,9 ° API OBSERVED, NO CORRECTION

FOR EACH DEGREE BELLOW OF 36,9 °API OBSERVED, ADD 11,24 IMPERIAL GALLONS

FOR EACH DEGREE ABOVE OF 36,9 °API OBSERVED, SUBTRACT 11,24 IMPERIAL GALLONS

CRITICAL AREA : FROM 2 FT 9 in TO 4 FT 2 in.

2020 Training Requirements

	Name	Comprehensive Safety Training	Aviation Safety & Quality Control	Ship Shore Interface (Lead Jettyman)	FIRST AID & CPR	BASIC FIRE TRAINING	Gauging Above Ground Storage Tanks	Marine Receipt Training (to include floating hose receipt)	Meter Calibration	LX Training	Smith Driver Improvement Training	Static electricity Awareness	Product Control Testing	Hazardous Material / Environmental Awareness	Offloading at Customer Site (C&I)	Service Station Offloading	Shell Aviation competence Education (ACE)	Master Meter & Pressure Control Aviation	Inter Plane Refueling
Operations Manager	Dustin Kersey	X	X		X	X					X						X		
Aviation Superintendent	Greg Campeau	X	X		X	X				X	X	X		X			X	X	X
Operations Coordinator	Norman Graham	X	X	X	X	X	X	X		X	X	X							
Scheduler/Dispatcher	Paul Lyn	X		X	X	X	X	X				X							
Terminal Operator	Nicholas Bodden	X		X	X	X	X	X			X	X		X					
Terminal Operator 2	Steven Haye	X			X	X	X	X						X					
Terminal operator 3	Jerome Lindsay			X	X	X	X	X									X		
Driver 1	Roger Tatum				X	X					X	X		X	X	X			
Driver 2	Hopeton Sinclair				X	X						X			X	X			
Driver 3	Franklin Martinez					X					X	X		X	X	X			
Engineer	Marnus Ehlers					X													
MaintenanceTechnician	Leroy James	X			X	X					X	X		X					
MaintenanceTechnician 2	Ray McGregor	X			X	X					X	X		X					
Crewman 1	Willard Hurlston		X		X	X					X	X		X			X		X
Crewman 2	Dannie Walton		X		X	X					X						X	X	
Crewman 3	Charles McLean		X		X	X					X	X	X	X			X	X	X
Crewman 4	Marvin Connelly					X						X							X
Crewman 5	Geoffrey Bush		X		X	X					X	X		X				X	X
Crewman 6	Shawn Silburn		X		X	X					X	X	X	X			X	X	
Crewman 7	Kevin Watson	X	X		X	X					X	X	X				X	X	
Crewman 8	Marvin Boothe	X	X		X	X						X		X			X		
Crew Chief 2	Desmond Edwards	X	X		X	X					X	X	X				X		X
Aviation Billing	Miriam Linton				X	X				X	X								

X - Means Training is Up to Date

(blue) Training not required for designated title

(white) Training gap to be filled

Appendix D - Records

Incidents & accidents information and reporting form / FOS-05

Affiliate: Rubis Cayman Islands Limited	**Date of event : November 15th 2019**
Place of event: Jackson point Terminal	**Gravity level : **Up to 4**

Event description: While the terminal was closed, during the night, tank 32198 began leaking Diesel from the bottom of the tank where it sits on the concrete foundation ring.

Event chronology (detail measures implemented to ensure safety, first aid arrival, etc.....)

Time	***Description***
15th Nov 21:30	The patrolling security guard witnessed fuel dripping out of tank 32198 and begins protocols to inform appropriate staff.
22:04	Operations Manager is informed of the issue and heads to the terminal.
22:25	Operations staff begin arriving on site. An inspection of the site was performed and once it was deemed safe to proceed, teams were established to contain and recover fuel as well as begin transfer of Diesel product out of tank 32198 to tanks 32195 & 32199.
22:56	Managing Director is informed of the situation by the Operations Manager and heads to the terminal. Rubis Caribbean Operations support are subsequently informed of the situation and provide technical review and guidance for managing the situation. A trench is dug around a quarter of the tank to contain discharging fuel. A pneumatic pump is placed and constantly attended to collect product released to a IBC tote. Spill containment equipment was deployed to prevent and control product migration across the ground surface. Valves are opened to begin gravity feeding product from tank 32198 to tank 32199. A second larger pneumatic pump was setup and activated to pump product from tank 32198 to tank 32195 at the same time as gravity feed to tank 32199 was going on. Piping modifications are installed to allow for the loading rack pump to be used to pump product from tank 32198 to tank 32195 at a faster rate. In parallel gravity feed to tank 32199 continued. When tank 32198 & 32199 reached equilibrium so gravity feeding was stopped to tank 32199. Loading rack pump continued to transfer product to tank 32195 only. Transfer continues throughout the night.
16th Nov 7:00	CUC contacted to determine if they could take product in parallel with the transfer of product to tank 32195.
8:48	Transfer to CUC started. At this time loading rack transfer to tank 32195 and transfer to CUC are going on concurrently.
22:41	OfReg notifies RCIL that they will visit the site for inspection on the 17th.
23:00	Tank 32195 reached safe fill and product transfer using loading rack pump is switched to tank 32199. Concurrently CUC transfer continues until 23:15 when CUC requests to stop receiving fuel.Transfer to Tank 32199 continues throughout the night.
17th Nov 12:00	An MOC is executed by the RCIL Management team to all Tank 32195 & Tank 32199 to be filled

	to the High High Levels to ensure that all of the product could be transferred out of tank 32198. In the end the MOC was not executed.
3:45	Fuel transfer from tank 32198 to tank 32199 is stopped and fuel is diverted again to tank 32195 which is filled to High Level.
4:00	Tank 32198 is at a height of 3 feet 3 inches and all visible leaking from the tank has stopped.
5:07	Fuel transfer from tank 32198 to tank 32195 is stopped and fuel is diverted again to tank 32199 to contain remaining product from tank 32198
7:15	Loading rack pump can no longer remove product from tank 32198. Pneumatic pump is installed to transfer the heel of tank 32198 to tank 32199.
11:45	Water is removed from the bottom of tank 32198 using the pneumatic pump until Diesel is being draw from the tank. Then the pneumatic pump is connected to tank 32199 to transfer the remaining fuel.
23:30	All systems shut down and tank 32198 is empty. A final walk through of the terminal is completed to ensure that all equipment is ready for normal operations to resume the following day.
Nov 18th	Product reconciliation started and could only be established after receiving from CUC the final volumes transferred to tank 5.
Nov 20th	The unaccounted Diesel Volume establishes at 3,686 IG (0.38% of total volume initially contained in tank 32198). Only after the opening of the Tank will a final assessment be possible to confirm that the vast majority of this volume is contained between the steel bottom of the tank and the protective containment liner in the foundation. This tank bottom had been replaced in 2010 and an API 653 inspection was scheduled for Jan 2020 (10 year interval).

Consequences (human fatality, material, environmental…) of the event:

Human: No Human Consequences
Equipment: Tank 32198 integrity is compromised & will require inspection & repair
Product: up to 3,686 IG of ULSD
Environment: Local Regulators to advise after final reconciliation is made possible

Validation **Date: 20th November 2019** **Name editor: Dustin R. Kersey** **Visa Editor:** [signature]	**Approbation :** **Date: 20th November 2019** **General Manager name: Nicolas De Breyne** **General Manager visa:** [signature]

Diffusion: Rubis Energie Fuels & HSSE Technical Manager, Rubis Energie LPG Technical Manager, Rubis Energie Insurance Officer.
Note: Rubis Energie Management immediately informed of any significant incident / accident. Moreover, for all significant or noteworthy incidents/accidents, cause analysis and approved action plan forwarded to the Rubis Energie Technical Management.