



Aerial Flare Stack Inspection Report

12th June 2018

Contents

1- Preface.....	3
2- Inspection Report for the Flare Stack.....	4
3- Flare Stack Data	5
4- About Carbon Deposition	6
5- Flare Tip.....	7
a) Carbon Deposits.....	8
b) Burn-outs and Discolorations	10
c) Misaligned guide	12
d) Abrasions, coating anomalies & signs of corrosion.....	13
6) Carbon Deposition Results	18
7) Flare Components	19
a) Abrasions & Coating anomalies.....	21
b) Flare base & components corrosion.....	22
c) Missing cable tray cover	24
8) Flare Stack Spacing.....	25
9) Conclusion.....	27
10) Recommendations	27

1- Preface

Aerostar Drone Solutions (Aerostar) was requested to perform an Aerial Inspection on the Flare Stack (Serial Number 11170) located at Minehead 03-06-049-18 W5M Compressor Station.

The information provided from these inspections can be used by Husky Energy to assess any integrity issues that were detected. It should be noted that when a customer requests Aerostar to perform a full Aerial Flare Stack Inspection a full detailed report is provided and the following items are addressed during this type of inspection;

- Flare Tip visual anomalies such as corrosion, cracking or carbon build up
- Combustion Efficiency (i.e. Black smoke)
- Visual signs of corrosion or integrity issues on the Flare Stack
- Pilot gas line inspection for any visual anomalies
- Visual anomalies on Auto Ignition Wires
- Any requested tasks by customer for additional inspections

It should be noted that while Flare Stack Inspections performed by UAV's/Drones are a relatively new technology, there are many advantages that should be considered;

- Significant reduction in risk to personnel
 - Personnel are not required to climb or utilize a man basket with a picker/crane to inspect the Flare Stack
- Flare Stack can remain in service to minimize any downtime associated with the inspection
- A significant reduction in operating costs associated with this type of inspection (in some cases cost savings can be as much as 50%)
- There is significant difference in time required to perform such inspections utilizing a UAV/Drone. In most cases the inspection can be completed in under 3 hours versus 4 to 6 hours using historical methods and pending weather conditions
- While utilizing more 'Hands On' inspection procedures may still be required during the life of the project, these instances can be significantly reduced by performing more aerial inspections using a UAV/Drone

2- Inspection Report for the Flare Stack

This inspection performed by Aerostar was completed on 12th June 2018 and the criteria listed above were used for the inspection. Please note that when a full or partial (i.e. for specific components) inspection is requested and completed each one of the items listed in the inspection criteria are completed and full documentation including any photographs are provided. The weather at the time of inspection was 9° Celsius with overcast conditions.

It should also be noted that potential risks for inspecting the flare tip were provided by the operations staff at this facility.

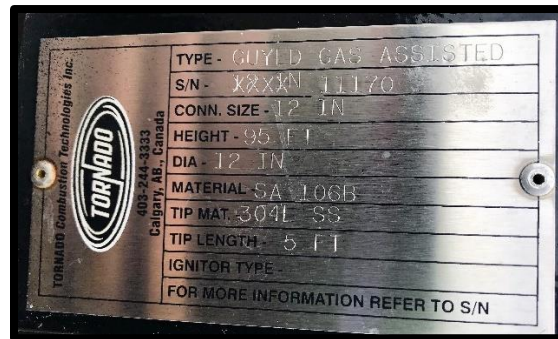
The main risk provided is that when there is an issue in the Gas Plant and it shuts down, the volume of gas going to the flare increases significantly thus causing a potential risk to the UAV during the inspection procedure.

To mitigate this risk, Aerostar utilizes high powered cameras that allow greater zoom capability which allows close-up photographs to be taken at a much safer distance. In this case, the UAV was approximately 10 m away from the flare stack during the inspection procedure. Also, please note that only a sample collection of photographs was used for this report and all the photographs taken will be provided to Husky Energy.



3- Flare Stack Data

Flare Stack Height	95 feet
Flare Stack Diameter	12 inches
Type	Guyed Gas Assisted



4- About Carbon Deposition

Carbon particles discharged from flare stacks have been known to cause fires in areas where combustible materials exist like forests, farm lands and facility structures, etc. The main cause of carbon deposition in flare stacks is inefficient combustion of the hydrocarbon vapours being vented. Therefore, at Aerostar we have customized our inspections by using both Thermal/Infrared Scanning and Photo Imagery to detect the existence of carbon deposits or the probability of carbon particles being deposited within the Flare Tip. For example, during a live flare stack inspection if carbon deposits are detected on the flare tip components using Photo Imagery then a Thermal/Infrared Scan is performed to analyze the combustion chamber within the flare tip. The size of the combustion chamber will show the depth at which carbon deposition could be taking place within the Flare Tip. If no carbon deposits are detected on the Flare Tip components, then this is a leading indicator of efficient combustion and no carbon deposition is taking place within the Flare Tip itself.

Please note that for this plant a thermal scan was conducted on this Flare and it was operational.

We use the following Probability Scale for measuring the degree of carbon deposition on flare stacks;

Color Coding	Classification	Interpretation	Action Required (Recommendation)
	Light	Zero to minimal build-up	Continually monitor on an annual basis
	Moderate	Some evidence of carbon build-up with creep on the Flare Tip and/or Ignitor Components	Cleaning recommended within 6 months; NOTE: Additional caution should be taken during fire season.
	Heavy	Large deposits of carbon and continuous deposition on Flare Tip and/or Ignitor Components; and the Thermal/Infrared Scan indicates probability of carbon build up within the Flare Tip	Immediate action should be taken

Please note that if the flare stack is out of service and extinguished then visual confirmation using Photo Imagery is completed and then ranked accordingly using the same Probability Scale.

5- Flare Tip

- There were indications of light carbon build-up at several locations at the flare tip.
- There were indications of burnouts and discolorations.
- There were indications of abrasions and coating anomalies.
- There were signs of corrosion on the flare stack.
- Pilot guide was found in a misaligned condition.



a) Carbon Deposits

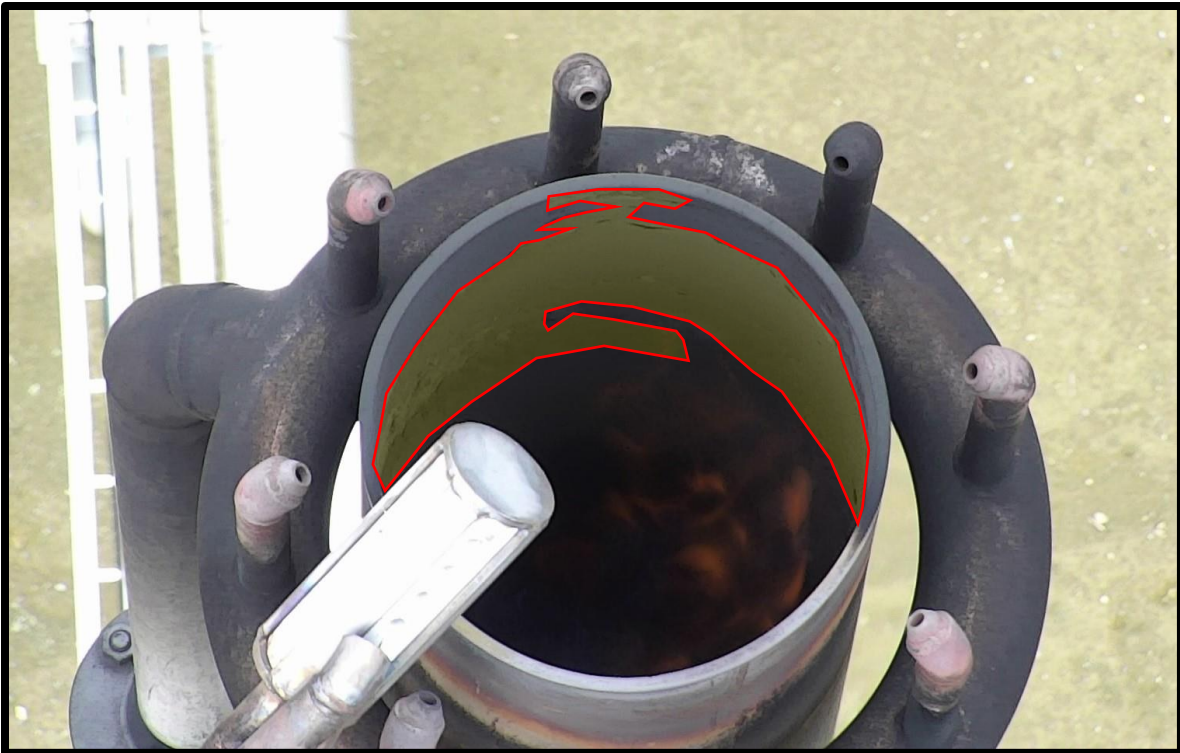


Figure 1

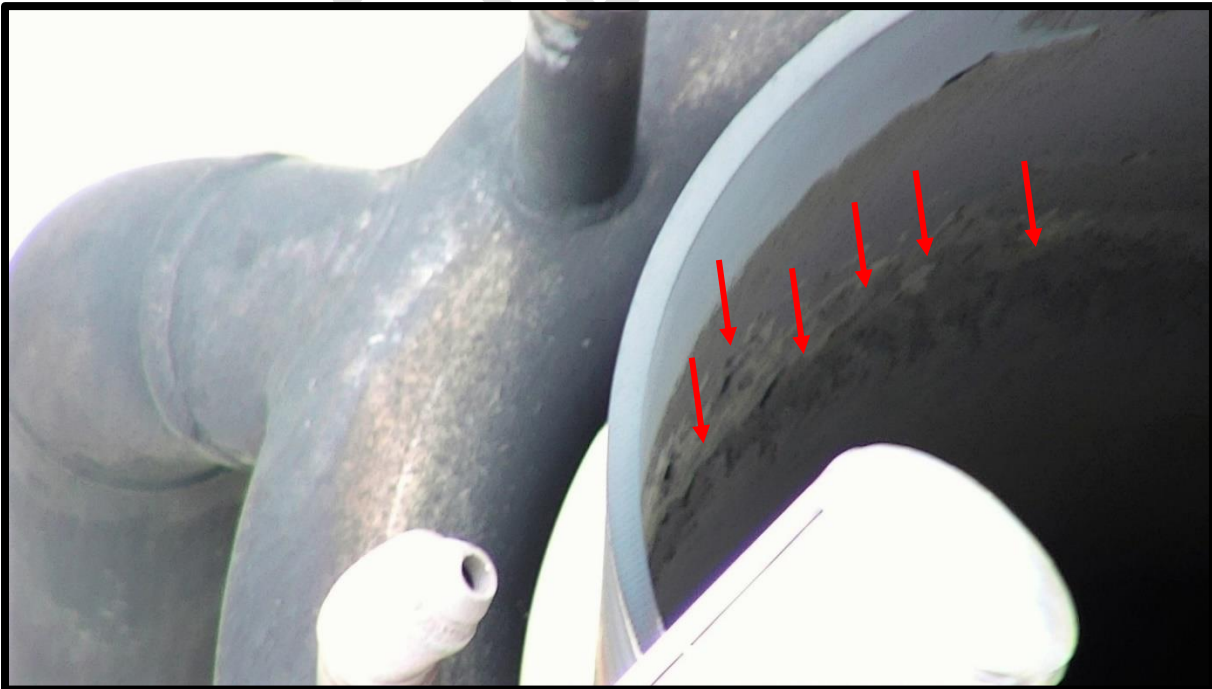


Figure 2

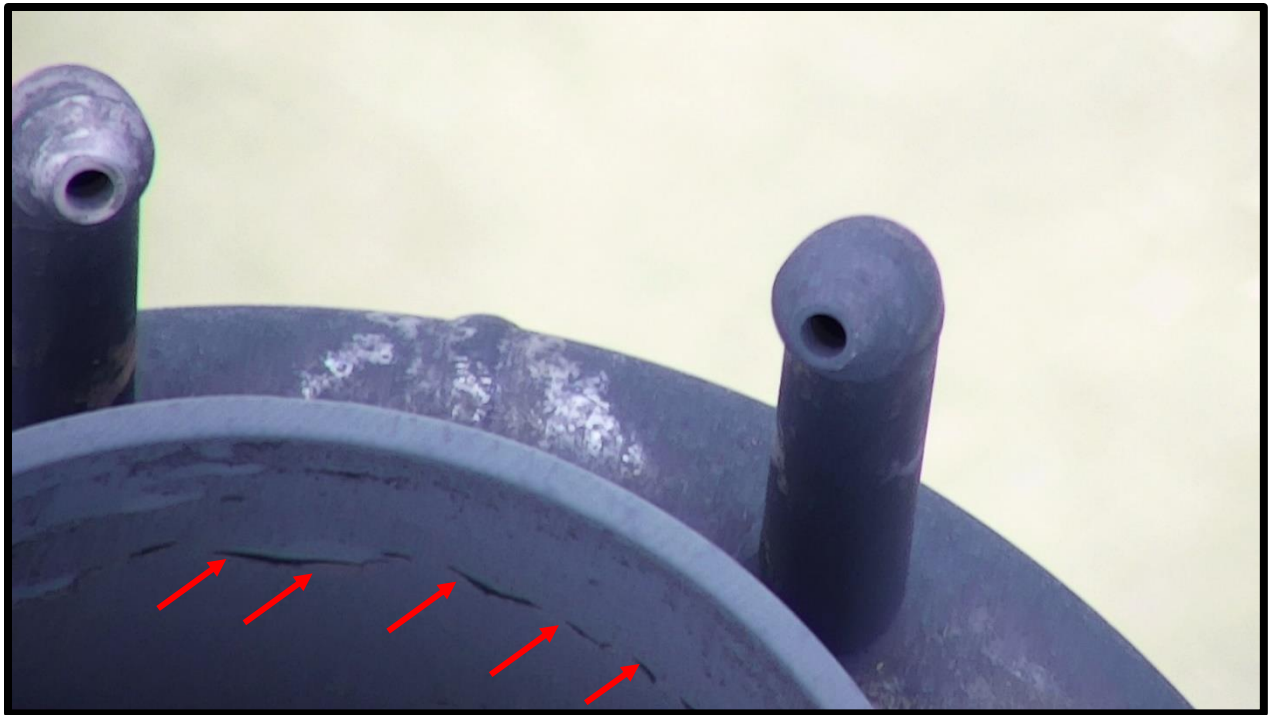


Figure 3

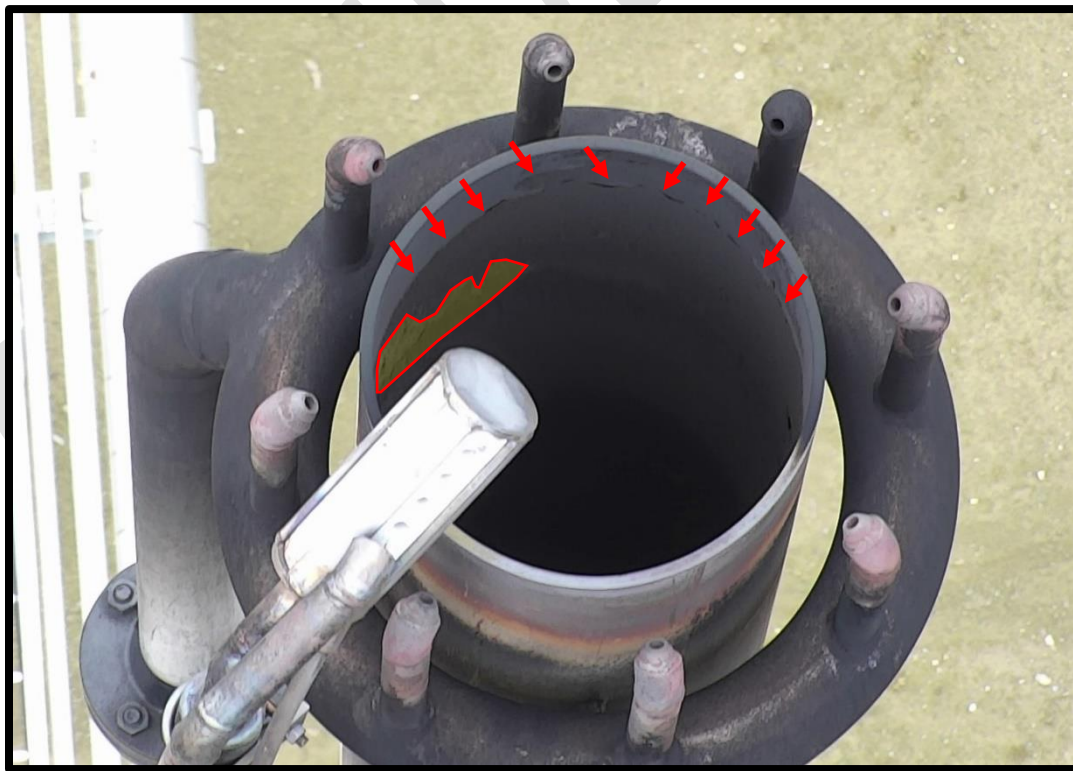


Figure 4

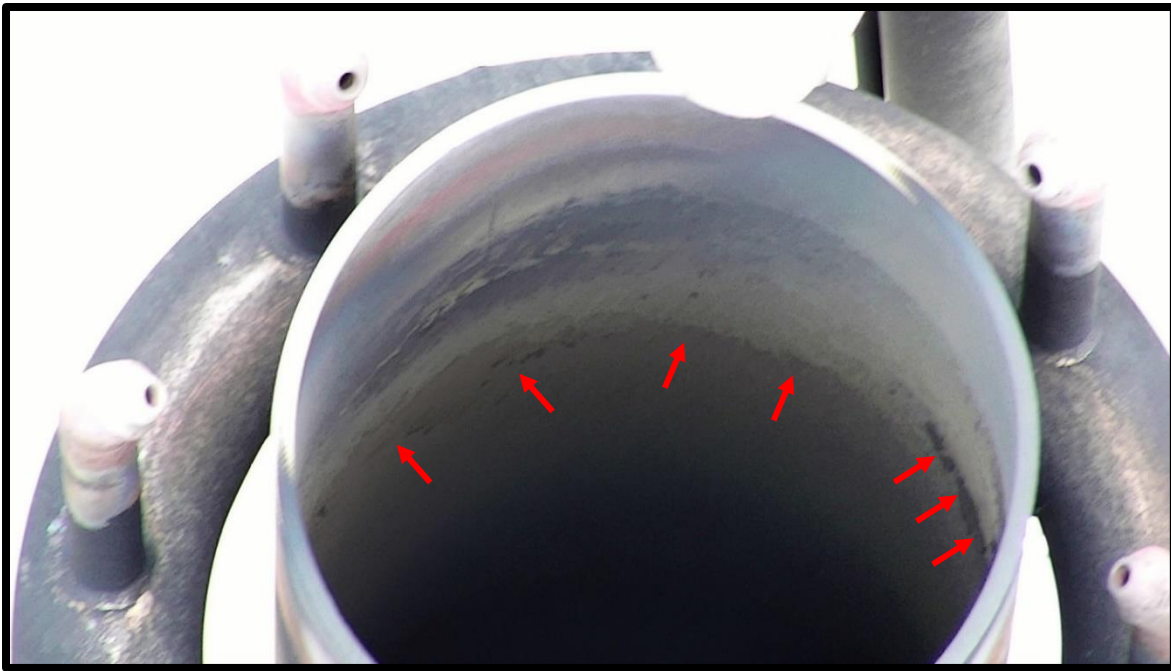


Figure 5

 Carbon Build up

b) Burn-outs and Discolorations



Figure 6



Figure 7



Figure 8



Figure 9

c) Misaligned guide



Figure 10

d) Abrasions, coating anomalies & signs of corrosion



Figure 11



Figure 12



Figure 13



Figure 14

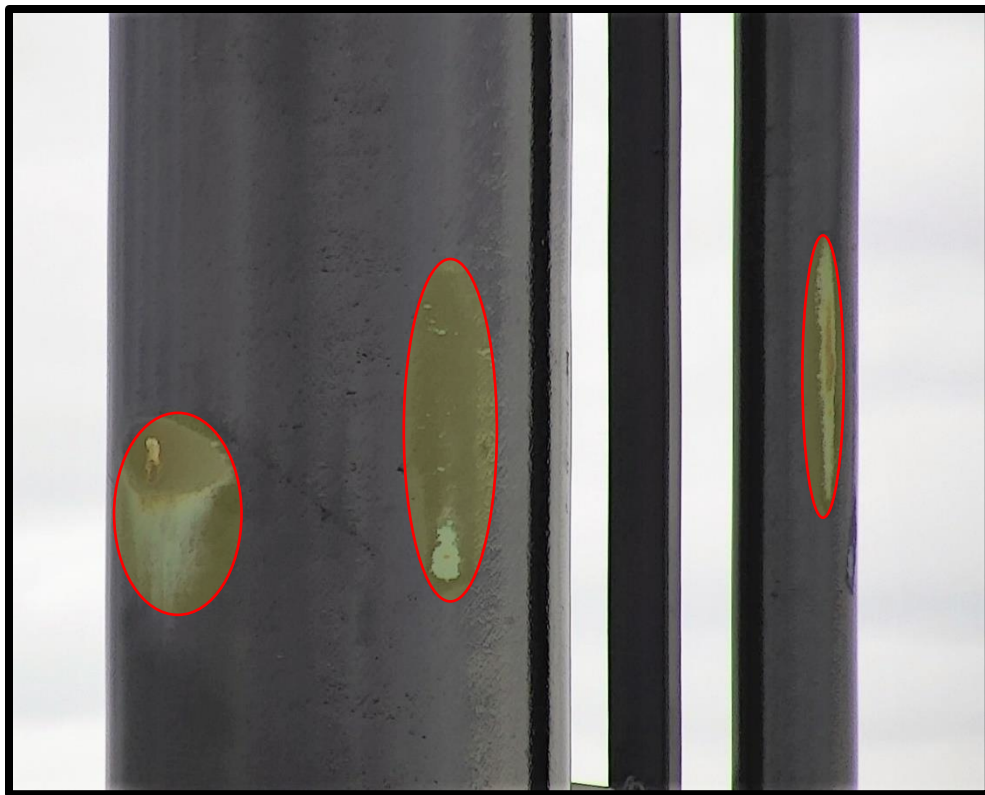


Figure 15



Figure 16



Figure 17

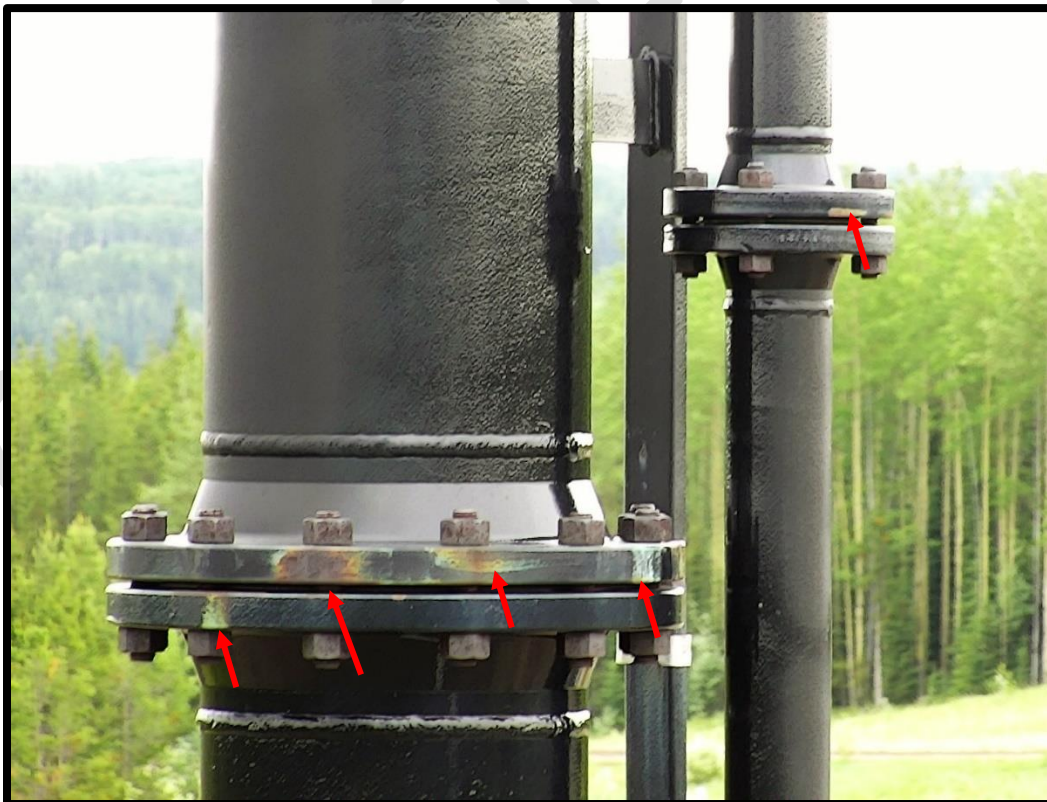


Figure 18

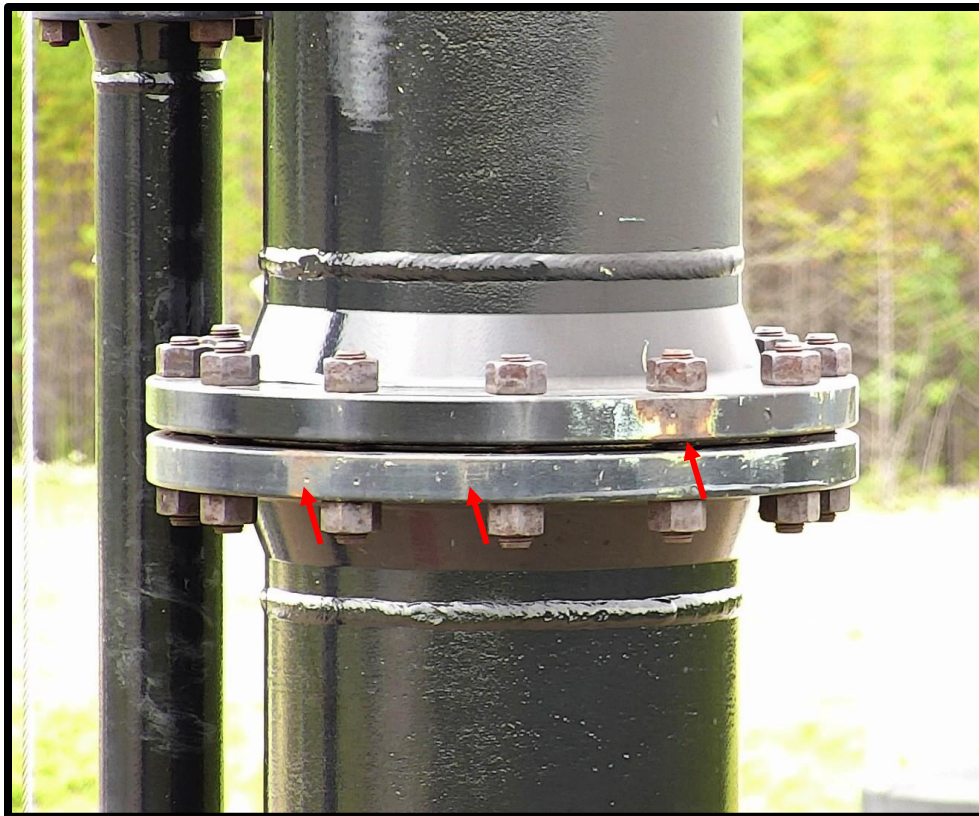


Figure 19



Figure 20

6) Carbon Deposition Results

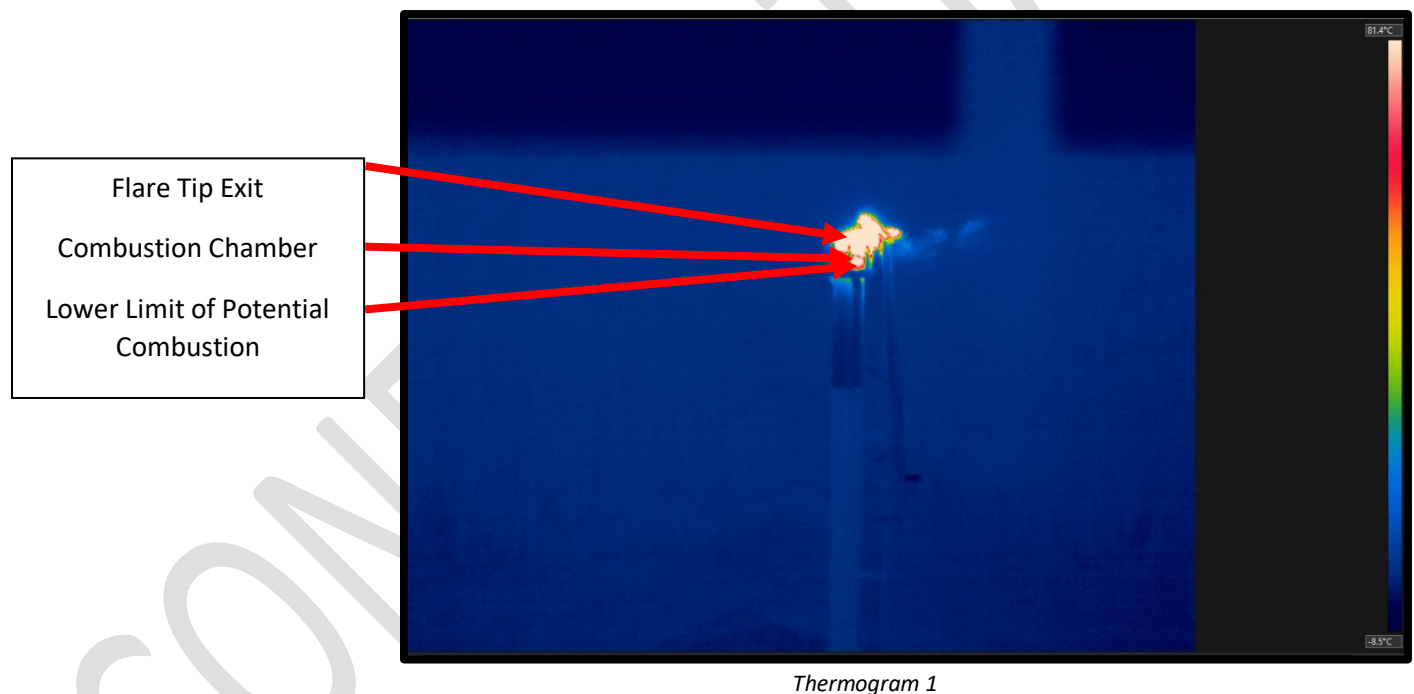
It was noted during the Aerial Inspection of this Flare Stack that there were indications of minimal carbon deposition found on the flare outlet and pilot chamber (internally and external edge).

Due to the levels of deposition of carbon this would be categorized as **LIGHT**.

Therefore, the recommendation would be to continually monitor on an annual basis with additional caution to be taken during fire season.

Remaining items inspected;

- During the inspection combustion showed no indications of black smoke.
- 360 Degree Orbit was completed to capture the entire portion of the flare tip.



Thermal/IR Scan yielded no apparent signs of cracks or other anomalies on the Flare Tip Shroud

7) Flare Components

Diagram “Flare Tip Components” is attached to this report for reference and shows the major flare tip components.

A sample of all the pictures taken showing the detailed components will be provided by Aerostar along with this report.

Component	Observation	Recommendation
Pilot, Ignitor and relevant components	<ul style="list-style-type: none"> Light carbon build-up 	<ul style="list-style-type: none"> continually monitor on an annual basis with additional caution to be taken during fire season
Pulley Assembly (Ground level Winch and elevated welded pulley)	Good condition	N/A
Local Control Panel - Ground	Good Condition	N/A
Anchoring Components	Good Condition	N/A
Ground Anchoring Components	Good Condition	N/A
Piping elements (Flanges and bolting)	Indications of corrosion on the base piping elements components and on the main stack flanges	Affected areas and components to be coated/painted to avoid expansion of corrosion
Flare stack	<ul style="list-style-type: none"> Abrasions and Coating anomalies Indications of burn-outs Pilot guide was found in a misaligned condition 	<ul style="list-style-type: none"> Affected areas by abrasions to be coated/painted to avoid expansion of corrosion and anomalies Pilot assembly alignment to be checked and repaired.
Flare Base	<ul style="list-style-type: none"> Signs of corrosion on the flare base and its components as well as won the gas supply line. Missing cable tray cover 	<ul style="list-style-type: none"> Affected areas to be coated/painted to avoid expansion of corrosion Cable tray to be covered for snow and rain
Aircraft Warning Light	N/A	N/A
Other components	Good Condition	N/A

Note: Continually monitor on an annual basis.



Figure 21



Figure 22



Figure 23

Overview of the flare base and its components

a) **Abrasions & Coating anomalies**



Figure 24



Figure 25

b) Flare base & components corrosion

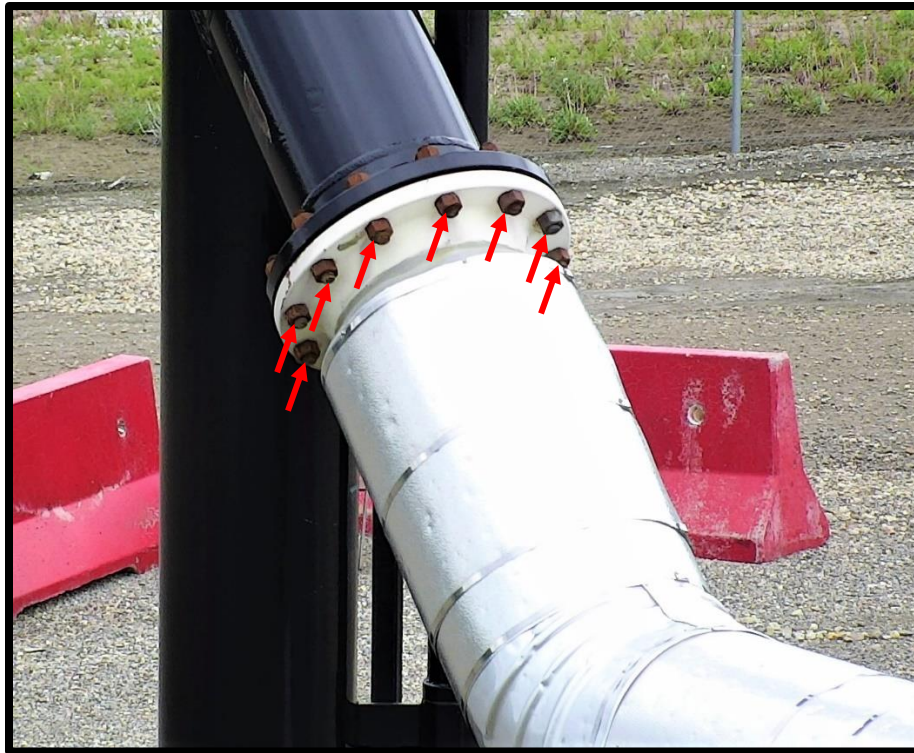


Figure 26

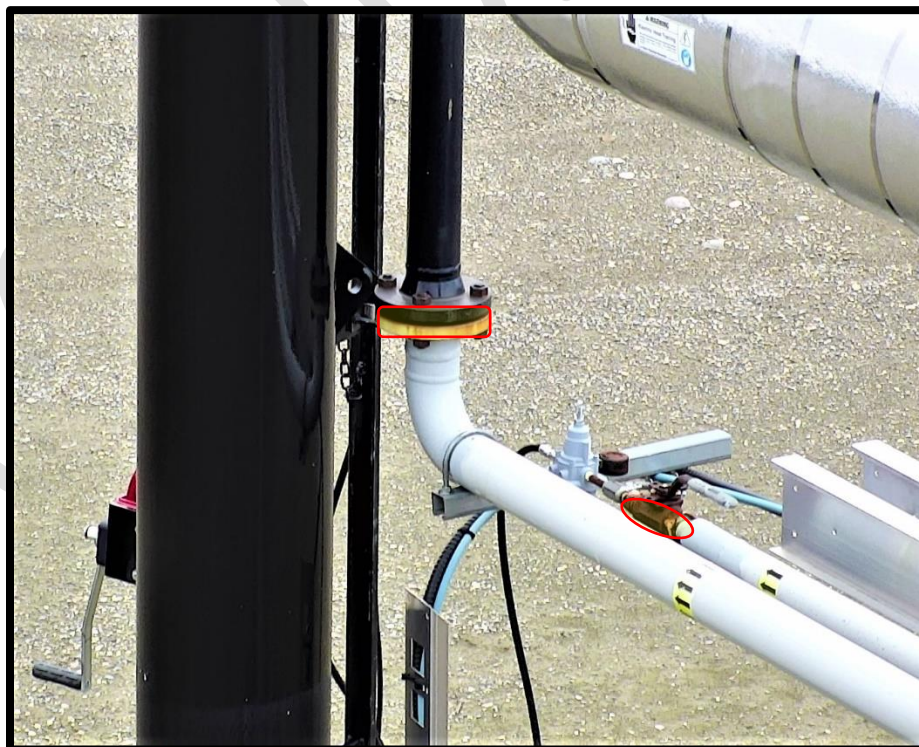


Figure 27

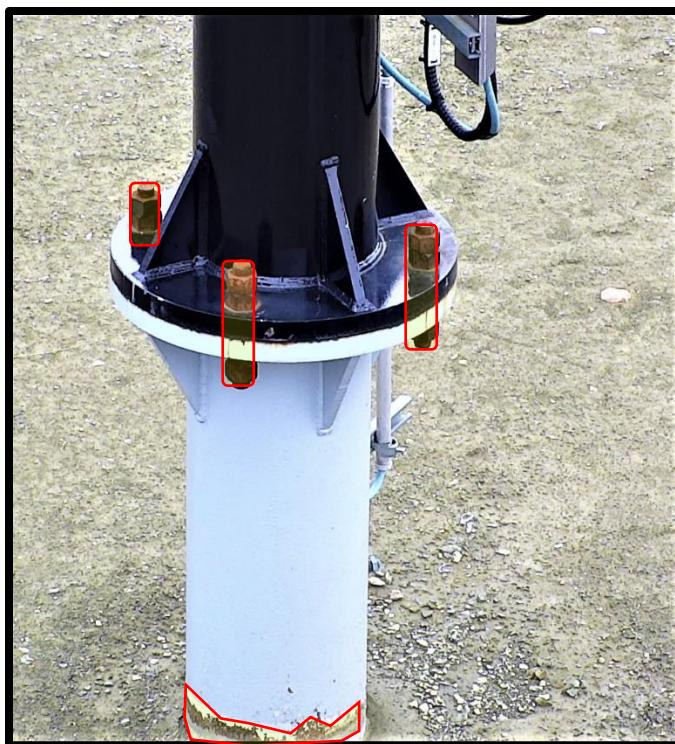


Figure 28



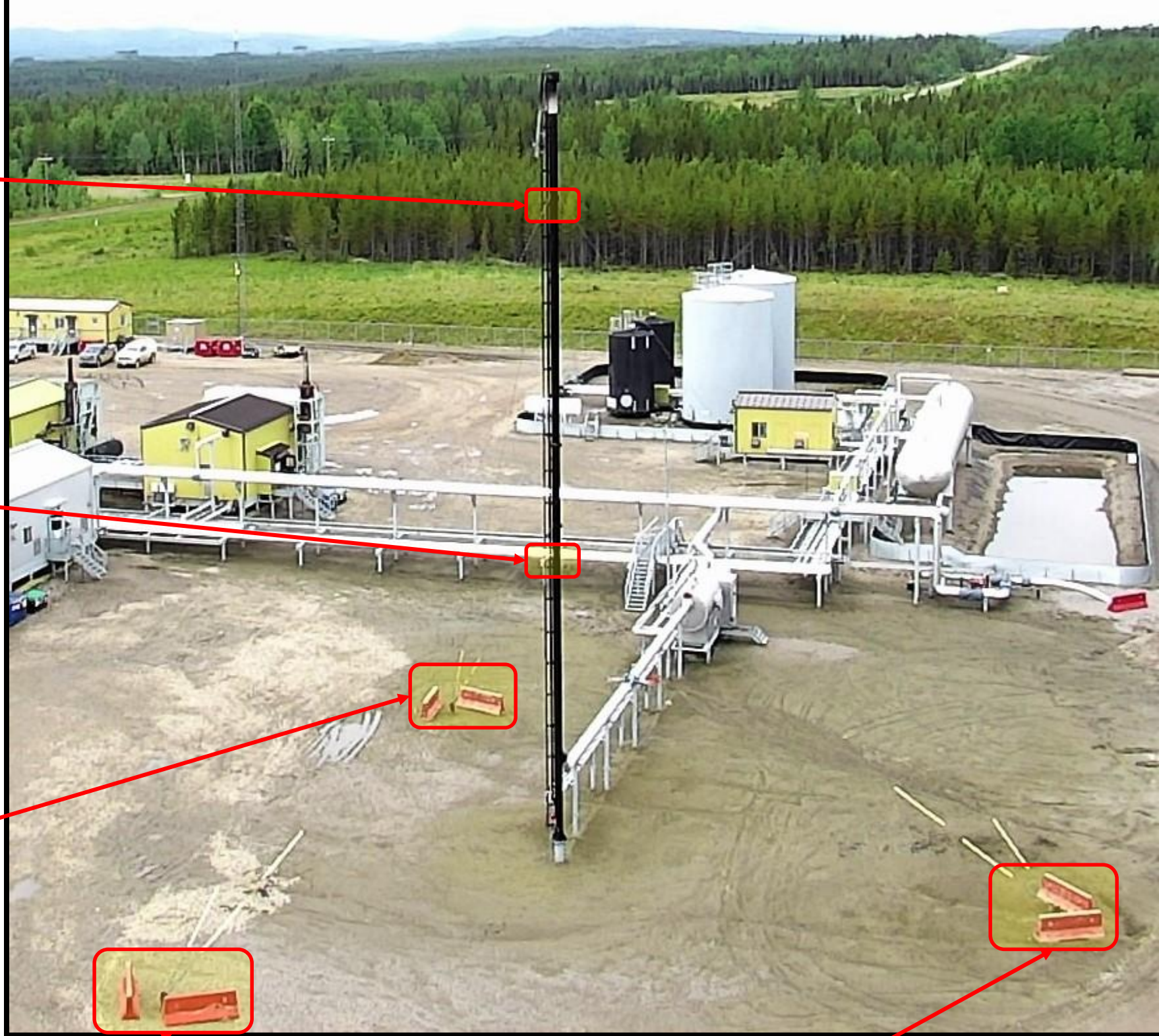
Figure 29

c) Missing cable tray cover



Figure 30





8) Flare Stack Spacing

- Please note that in figure below the Flare Stack is shown with the respective spacing requirements
- The Alberta Forest and Prairie Protection Regulation states that “No person shall flare gas at the end of a vertical pipe unless the base of the vertical pipe is located at least 30 meters, or such other distance as may be specified by a forest officer, from any timber, vegetation or combustible material.”
The area around flares and incinerators must be free of fire hazards
- The red ring indicates the 30 meters (98.4 feet) radius required by AER.
- The yellow ring indicates the distance to the closest combustible material/vegetation of 33.6 meters (110.2 feet)

The AER recommended zone seems clear of combustible vegetation.

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Husky Energy, Ltd. | Minehead Compressor Station 03-06-049-18 W5M | Flare Spacing Map



Flare Stack Inspection Data

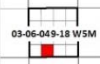
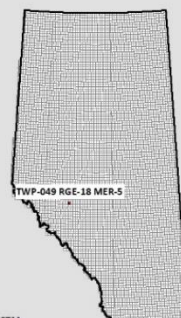
- + Flare Stack
- Flare Spacing
 - Forest & Prairie Protection Act: Section 14 - 30m Clear Spacing
 - Nearest Combustible Vegetation
 - Approx. U/G Pipeline



By: C. Gordon
Date: 06.18.2018

Scale: 1:500
Projection: NAD 1983 UTM Zone 11N
Datum: NAD 1983

Data Sources:
03-06-049-18 W5M Compressor Station, Husky Energy Ltd., Image acquired by
Aerostar Drone Solutions Inc. (P&I, 1/1/2018)
List of Wells in Alberta Shapfiles - 5137 (June 14 2013) (Download), Maps, Map Viewers, and Shapfiles
Canadian Pipeline Graphics File (October 25 2017) (Download), All Products and Services Catalogue (May 10 2017)
<https://www.alberta.ca/providing-information/data-and-reports/maps-mapviewers-and-shapfiles>
AES V1.3 Program (March 2015) (Download), AES (2017)
URL: <http://www.alberta.ca/products/property/ats.html>
Contains information licensed under the Open Government Licence - Alberta



Scale: 1:12,000,000
Projection: NAD 1983 10TM
Datum: NAD 1983

9) Conclusion

In summary, the deficiencies detected were as follows;

- Carbon build up detected on the Flare Tip, the classification would be **LIGHT**.
- There were indications of burnouts and discolorations.
- There were indications of abrasions and coating anomalies.
- There were signs of corrosion on the flare stack.
- Pilot guide was found in a misaligned condition.
- The flare base shows:
 - Signs of corrosion on the flare base and its components
 - Missing cable tray cover
- Thermal/IR Scan yielded no apparent signs of cracks or other anomalies on the Flare Tip Shroud

It should be noted that all equipment associated with the Flare Stack at this location is well maintained and no other concerns were noted during the inspection procedure.

10) Recommendations

- Current levels of carbon build-up do not warrant immediate cleaning of the carbon build-up.
- Areas affected with corrosion (on the flare stack, flare base and piping elements) to be coated/painted to avoid expansion of corrosion.
- Cable tray cover to be installed to avoid damage of cables from snow and rain water.
- Pilot assembly alignment to be checked and repaired.
- Continually monitor carbon build up & vegetation growth on an annual basis with additional caution to be taken during fire season and during the late spring or early summer seasons to capture any potential fire risk from carbon build up, vegetation growth