FINAL INVESTIGATION REPORT ON HARD LANDING INCIDENT DUE VIBRATIONS TO M/s HELIGO CHARTERS PRIVATE LIMITED BELL 412 HELICOPTER VT-HLG ON 13/03/2019 AT VIJAYAWADA AIRPORT

GOVERNMENT OF INDIA
O/o, DIRECTOR AIR SAFETY, WESTERN REGION,
NEW INTEGRATED OPERATIONAL OFFICE COMPLEX,
SAHAR ROAD, VILE PARLE (EAST), MUMBAI-400099

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OBJECTIVE

This investigation is performed in accordance with The Aircraft (Investigation of Accidents and Incidents) Rules 2017 of India.

The sole objective of this investigation is to prevent aircraft accidents and incidents. It is not the purpose of this investigation to apportion blame or liability.

FOREWORD

This document has been prepared based on the evidence collected during the investigation, opinions obtained from the experts, and laboratory examination of various components. Consequently, the use of this report for any purpose other than for the prevention of accidents or incidents could lead to erroneous interpretations.

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1.	**Aircraft**	**Type**	Bell 412
2.		**Nationality**	Indian
3.		**Registration**	VT-HLG
4.	**Owner**		M/s Abu Dhabi Aviation, UAE
5.	**Operator**		M/s Heligo Charters Private Limited
6.	**Pilot In-Command**		Airline Transport Pilot's License Holder (Helicopter)
7.	**Extent of Injuries**		Minor
8.	**Date and Time of Incident**		13/03/2019 1840hrs IST
9.	**Place of Incident**		Vijayawada Airport
10.	**The geographical location of the site**		16°32'01"N, 080°48'12"E
11.	**Last point of Departure**		Vijayawada Airport (VOBZ)
12.	**Intended Place of Landing**		Vijayawada Airport (VOBZ)
13.	**No. of Passengers On-Board**		0
14.	**Type of Operation**		Training Flight
15.	**Phase of Operation**		Start-up
16.	**Type of Incident**		Hard Landing due to Vibrations

All timings in this report are in IST.

SYNOPSIS:

On 13.03.2019, Bell 412 helicopter, registered VT-HLG, was being utilized to conduct training operations from Vijayawada Aerodrome, Andhra Pradesh and the sortie planned was a training flight in Night VFR for one of the pilots of the organization by a Type Rated Instructor of the same organization. Just before hovering on the bay, the helicopter developed severe vertical airframe vibrations that resulted in reduced pilot control. In an attempt to mitigate the vibrations, the Pilot Monitoring raised the collective and came into a hover, however, the vibrations continued to increase in severity. In response, the pilot lowered the collective to set the helicopter back down onto the bay. This resulted in a heavy landing and caused damage to the helicopter. After landing, in an attempt to shut down the engine by using the fuel shut-off switch, the pilot monitoring had accidentally operated both the governor switches from automatic to manual and immediately back to automatic due to which the helicopter experienced Main rotor over speed and over-temperature on the No.1 engine. After the switch-off, the crew exited the helicopter with minor injuries.

The Director General of Civil Aviation ordered the investigation of the incident by appointing Investigator - In - Charge vide order no. DGCA.15018(17)/3/2019-DAS dated 19th March 2019 under Rule 13(1) of The Aircraft (Investigation of Accidents and Incidents) Rules 2017.

The probable cause of the incident was found to be due to Bolts mounted at incorrect locations while installing the pylon corner mounts. Inadequate communication between the crew and lack of knowledge of the OSN are considered contributory factors to the incident.

1 FACTUAL INFORMATION

1.1 History of Flight

M/s Heligo Charters Private Limited, Bell 412 Helicopter, VT-HLG is operated usually from Juhu Aerodrome for various charter operations. After completion of the scheduled 300hrs and 100hrs maintenance inspection, the helicopter was operated for 13.5 hours from the date of release, i.e., 25.02.2019 till the day of the incident flight, i.e.,13.03.2019. During this period, the Pilot monitoring of the incident flight had conducted several flights in the capacity of PIC, Co-Pilot, and Instructor

On 13.03.2019, the helicopter was planned to be operated at Vijayawada Aerodrome, Andhra Pradesh and the sortie planned was a training flight in Night VFR for one of the pilots of the organization by a Type Rated Instructor of the same organization. The instructor occupied the left seat as Pilot Monitoring and the pilot under training occupied the right seat as Pilot Flying. The sortie was the first flight of the day for both the crew and the helicopter.

Pre-flight external checks and pre-start internal checks were carried out by the crew. Due clearance from the ATC for a start-up was obtained by the crew at 1830hrs and the start of both engines was carried out at 1840hrs. The engine start-up was normal. While performing the system checks, the crew encountered an error in the Autopilot system and pilot monitoring explained to the Pilot flying about the error present in the AUTOTRIM system and how to deal with it when encountered on future revenue flights. The Auto trim was reset by the crew and continued with further checks on the helicopter. During the pre take-off checks, shortly after increasing the main rotor rpm to 100%, the helicopter began to vibrate excessively. The pilot flying raised doubts about the flight controls not being centred.

However, in response to the increasing vertical airframe vibrations, suspecting that they were due to ground resonance, the pilot monitoring called out that he was taking over the controls and raised the helicopter into a hover. As

the helicopter left the ground, the vertical airframe vibrations increased and made it difficult for the PIC to control the helicopter. Due to loss of controllability, the pilot monitoring had put the helicopter down resulting in a heavy landing. The helicopter touched the ground hard with a large tilt to the right.

The pilot under training called out to shut down the engines and the PIC accidentally toggled the governor switches from automatic to manual mode instead of the Fuel cut-off switches during which the rotor RPM had increased to an Overspeed of 111%, Inter Turbine Temperature of No. 1 engine increased to an Over temperature of 1025 C Degrees and both engines N2 (power turbine rpm) reached 111%. Later both engines were shut down and both pilots exited the helicopter with minor injuries. Incident occurred at 1840hrs IST, after sunset.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor	2	0	0
None	0	0	-

1.3 Damage to Aircraft

The helicopter had sustained damage due to the heavy landing. Inspection revealed that the cross tubes had yielded and spread across and the tunnel skin area on the right side was damaged. A small amount of debonding was found on the spindle bearings of one of the main rotor blades. None of the parts of the helicopter were detached from the structure. There was no fire during or after the incident.

Figure 1: Damage on aft cross tube area

Figure 2: Dent on the bottom skin surface

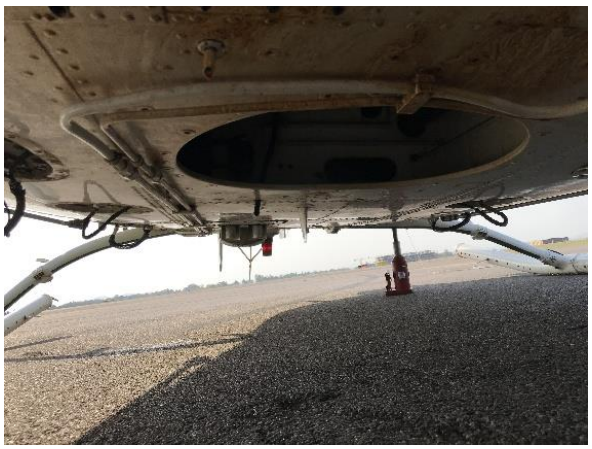


Figure 3: Underbelly picture showing yielded skid landing gear

Figure 4: Damage to Crossbeam

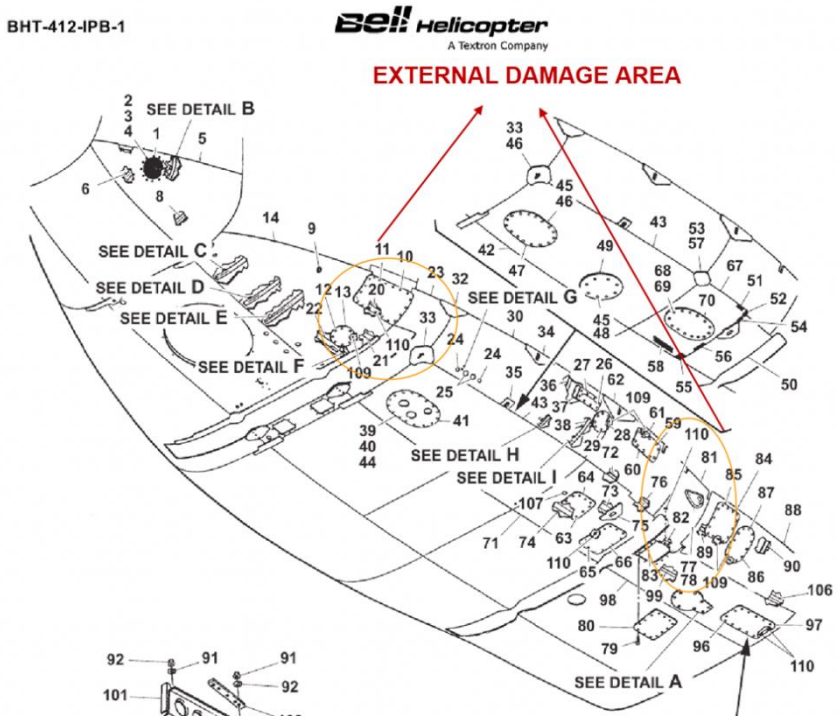


Figure 5: External Damage Area

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

1.5.1 Pilot Flying (Right Seat)

Age	58 years 04 months Male
License	ATPL – H
Date of Issue	07/10/2013
Valid up to	06/10/2020
Category	Helicopter
Date of Class I Medical Exam	01/09/2018
Class I Medical Valid up to	11/09/2019
Date of Issue of FRTO Licence	31/08/2006
FRTO Licence Valid up to	30/08/2021
IR rating	IR: 10/01/2019
Total Flying Experience	8227:45hrs
Total Flying Experience as PIC on Type	3131:30hrs
Total Flying Experience in the last 1 year	315:15hrs
Total Flying Experience in last 6 months	166:10hrs
Total Flying Experience in last 28 days	25:40hrs
Total Flying Experience in last 7 days	Nil

Total Flying Experience in last 24 hours	Nil
Duty Time last 24 hours	Nil
Rest before the incident flight	More than 7 days
Ratings	As PIC: Alouette III / Chetak, Bell 412 As FO: Agusta Westland 139

The pilot flying had undergone a breath analyser test for alcohol at Vijayawada at 18:13 hrs on 13.03.2019 before carrying out the planned sortie and the test was negative. Pilot flying had also had adequate rest before he reported for duty. Upon scrutiny of the records, it was found that there were no exceedances in the Flight Duty Time Limitations as per the CAR.

1.5.2 Pilot Monitoring (Left Seat)

Age	48 years 03 months Male
License	ATPL – H
Date of Issue	20/10/2008
Valid up to	19/10/2021
Category	Helicopter
Date of Class I Medical Exam	23/07/2018
Class I Medical Valid up to	26/07/2019
Date of Issue of FRTO Licence	16/02/2004
FRTO Licence Valid up to	15/02/2024
IR rating	IR: 14/01/2019
Total Flying Experience	8054:34 hrs
Total Flying Experience as PIC on Type	1489:20 hrs

Total Flying Experience in the last 1 year	350:10 hrs
Total Flying Experience in last 6 months	188:05 hrs
Total Flying Experience in last 28 days	14:00 hrs
Total Flying Experience in last 7 days	02:40 hrs
Total Flying Experience in last 24 hours	Nil
Duty Time last 24 hours	Nil
Rest before the incident flight	94 hours
Ratings	As PIC: Alouete III / Chetak, Bell 212, Bell 412, Bell 230, Agusta 109S. Agusta Westland - 139 As FO: Agusta Westland - 139

The pilot monitoring had undergone a breath analyser test for alcohol at Vijayawada at 18:16hrs on 13.03.2019 before carrying out the planned sortie and the test was negative. Pilot Monitoring had adequate rest before he reported for duty. Upon scrutiny of the records, it was found that there were no exceedances of Flight Duty Time Limitations. The pilot monitoring was accorded approval as instructor vide letter no AV-22017/51 (H)/2011-FSD dated 11th January 2018.

1.5.3 Aircraft Maintenance Engineer

Age	46 years 01-month, Male
License	AME License
Date of Issue	11/01/2016
Category	B.1 Helicopter Turbine
Company Authorization Valid up to	31.12.2018

Aircraft Type Rating	Category B1 Bell 212/Agusta AB212 (PWC PT6) Bell 412/Agusta AB412 (PWC PT6) Agusta AW 139 (PWC PT6)

The aircraft maintenance engineer was working as a licensed engineer in the organization on company's payroll. The AME had obtained Category B1 rating maintenance of Bell 412 Turbine engine helicopter with Pratt and Whitney PT6 engines. The AME was the licensed, qualified, and authorised personnel by organization who had performed and certified the removal and installation of Pylon corner mounts in January 2017.

1.6 Aircraft Information

The details provided below are as on the day of the incident flight.

Aircraft Registration	VT-HLG
Type of Aircraft	Bell 412
Helicopter Serial No.	36272
State of Manufacturing	CANADA
Manufacturing year	2000
Owner	M/s Abu Dhabi Aviation P O Box no 2723, Adjacent to Abu Dhabi International Airport, Abu Dhabi, UAE
Operator	M/s Heligo Charters Private Limited
Certificate of Airworthiness number and issue date	6602, 05.03.2014
ARC number and Validity	HLG/6602/ARC 6TH /2019/019 Valid up to 13/02/2020
A/c TSN	3813: 37 hrs

Maximum All Up Weight authorized	5398 Kg	
Minimum crew necessary	Two	
Engine Type	# 1 (LH) PT6T-3D	# 2 (RH): PT6T-3D
Engine Sl no.	# 1 (LH): CP-PS THO429	# 2 (RH): CP-PS THO430
Last major check 300hrs inspection	On 15/02/2019 at 3799:17hrs Airframe hours	
Helicopter All-up Weight	5054 Kg	
Fuel On-board before Flight	952.5 Kg	
Type of Fuel	ATF	

On 02.02.2019, a defect with error code 2E 38 of the autopilot system, which refers to 'Yaw Servo Fail' was entered in the tech logbook. The yaw actuator assembly was replaced, and the helicopter was released for service.

On 14.02.2019, approximately after 10 hours of flying from the replacement of the Yaw Actuator Assembly, an autopilot defect was entered in the tech-log book with error codes 1E110, 2E110, 1E245, and 2E245, which read as 'No Roll Trim' and 'Read EEPROM'. Along with the autopilot defect three other defects were also entered into the tech-log book which referred to Co-pilot Horizontal Situation Indicator (HSI), Distance Measuring Equipment (DME - Navigation), and Mast Torque.

On the next day, i.e.,15.02.2019, a callout was raised by the continuing airworthiness manager of the organization to conduct a 300hrs and 100hrs maintenance inspection to be carried out on the helicopter, which was completed on 24.02.2019 and later released for service. During this scheduled inspection along with the replacement of several other components, the replacement of the main rotor mast assembly was also carried out as it was due for an overhaul.

The rectification of all the snags entered on 14.02.2019 was also carried out during this inspection. With regards to the snag on the Autopilot system, the troubleshooting and rectification of the snag were carried out in accordance with the Manufacturer's Maintenance Manual Chapter - 96, Table 96-14. The table gave the probable causes for the error codes as wiring damage of the roll trim motor or control position sensor, faulty roll trim motor, and lastly faulty DAFCS computer. However, the snag was cleared by the rated AME only by cleaning the electrical connections of the #1 and #2 AFCS computers and a ground run for an AFCS check. The details of this ground run were not written separately in the worksheets as comments but were included within other comments in the worksheets and Certificate of release (CRS), at a later stage with the initials of the AME.

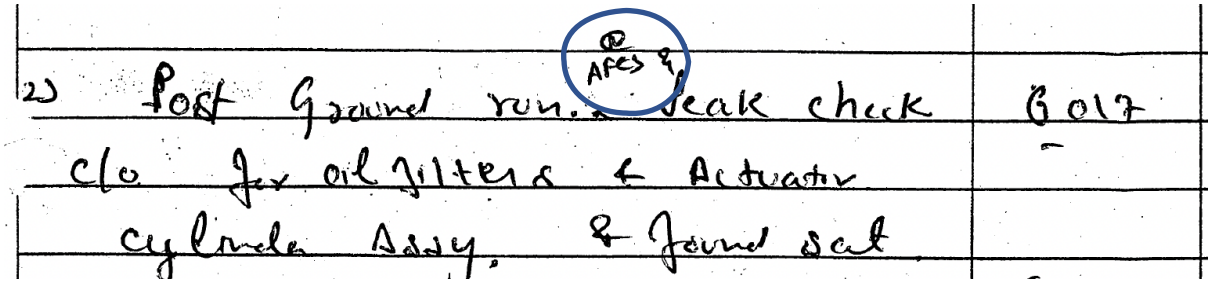


Figure 6: Details of rectification of the Autopilot snag added to the CRS, at a later stage.

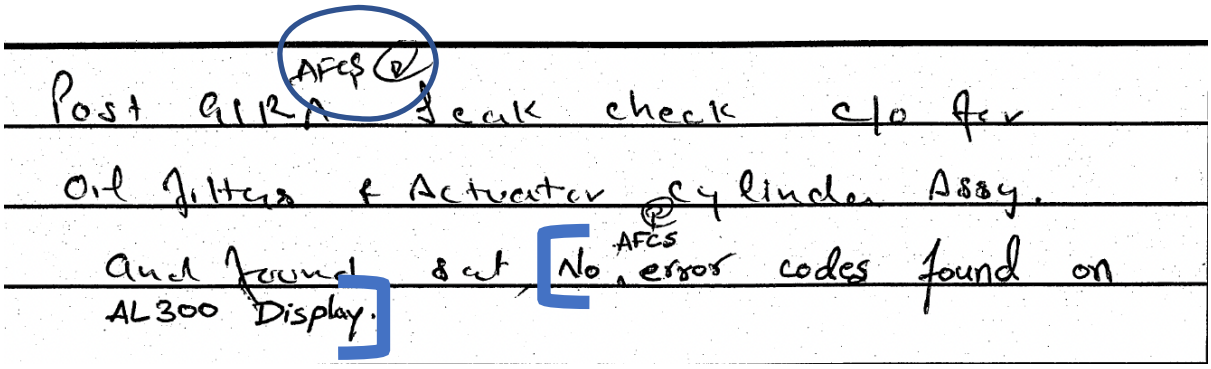


Figure 7: Details of rectification of the Autopilot snag added to the Worksheet, at a later stage.

The helicopter was operated for a total of 13 hours 46 mins after the major inspection i.e., 24.02.2019, and before the incident i.e., 13.03.2019. The Pilot monitoring had operated the helicopter on 25.02.2019, 26.02.2019, 01.03.2019,

05.03.2019, 06.03.2019, 09.03.2019, and 11.03.2019 as PIC, Co-pilot, and Instructor with various other crew members of the organization. During all these sorties mentioned above no snags were found reported. On 13.03.2019, the first flight of the day was the incident flight. The loading of the helicopter was as per the standards and the CG was found to be within limits.

1.7 Meteorological Information

Meteorological information is provided by Indian Meteorological Department in every 30 minutes. The weather at Vijayawada, as per Indian Meteorological Department, was reported as follows.

Time	1830	1900
Wind	000/ 00 Knots	000/ 00 Knots
Visibility	5000 meter	5000 meter
Clouds	No Cloud	No cloud
Precipitation	Nil	Nil
Temperature	32 ºC	31 ºC
Dew Point	21	25
eQNH	1012 hPa	1013 hPa

The Meteorological report was available with the crew for briefing before the flight. The details of the actual weather were found not recorded on the ATC Tape Transcript as the clearance was only given for startup and no clearance was given for taxi.

1.8 Aids to Navigation:

Not a factor in the incident.

1.9 Communication

There was always two-way communication established between the SMC and the helicopter.

1.10 Aerodrome Information

Vijayawada International Airport (IATA: VGA, ICAO: VOBZ) is a Public International Airport serving Andhra Pradesh Capital Region. The airport is located at Gannavaram in Vijayawada. The elevation of the airport is 82 ft, and it has one runway: runway 26/08. The aerodrome category for rescue & firefighting is CAT-06. Operations under IFR and VFR are both permitted.

1.11 Flight Recorders

The helicopter was fitted with CVR and DFDR. The CVR data was downloaded at the Operator's facility, whereas the Raw data of DFDR was forwarded to the manufacturer for decoding. The relevant portion of the CVR & SMC tape transcript of Vijayawada airport along with correlated DFDR data is reproduced below.

CVR elapsed Time	**CVR transcript**	**DFDR Parameters with Elapsed time**
1.55.35	Pre-Start checks started	**178.10.10** Rotor Brakes tested
		178.10.16 Fire T handle and selector switch tested
1.57.07	Engine One start announced	**178.11.34** Gas Producer RPM registered above 50 percent of No.1 engine
1.57.22	Engine two start announced	**178.13.00** Gas Producer RPM registered above 50 percent of No. 2 engine
1.57.29	The Pilot replied to the ATC call "Victor Lima Golf, Vijayawada sunset time is one eight one six" as "Copied Sir vicinity in the aerodrome allowed sir VFR"	--
01.59.58	While performing System checks Stick	**178.14.34** Cyclic Stick movement started.

	Centering Callout is given by the Pilot Flying	**178.14.41** Cyclic Stick movement ended
2.00.32	Pilot Monitoring starts explaining the AUTOTRIM error being present in the AFCS system and how to tackle it when passengers are onboard.	**178.15.23** AFCS test Initiated.
		178.16.16 AFCS fault registered with master caution.
		178.16.24 AFCS engaged in ATT mode. Master caution extinguished
2.01.44	After System checks, Pilot flying initiates increasing the RPM	**178.16.26** Rotor RPM starts increasing above 80% to 101% and remains steady.
--	--	**178.16.54** A slight Collective movement registered (3% to 9.7%) and lowered immediately. No significant movement in Cyclic registered.
		178.16.54 ***Vertical acceleration begins to vary***. A small reduction in Vertical acceleration (g) 1.02g to 0.792g of the helicopter registered for the first time and subsided on its own.
02:02:22	The pilot flying prompts "is it in the center."	--
02:02:24	Pilot Monitoring calls out and takes over the controls	**178.17.01** Two Slight Movements of Collective registered. ***Larger Vertical Acceleration Oscillations started to register*** with the lowest value of 0.48g at **178.17.04** Lateral Cyclic movement registered from +30% to +10%

		178.17.04 Large Collective movement registered from 15 to 54 percent in less than 2 seconds indicating the pickup. Lateral Cyclic registered movement from +10% to -7% in one second. Pedal position registered movement from -16% to -113% in six seconds Rotor Speed decreased momentarily from 101% to 97% percent indicating increased drag during pickup. Mast Torque registered a sharp increase from 22% to 93% in less than 2 seconds and registered a maximum of 101.2%
--	--	**178.17.10** A rough oscillatory input to the Collective lever, Cyclic (Lateral and longitudinal), and the Rudder Pedals are registered for 10 seconds Vertical acceleration oscillations persist, and a corresponding longitudinal acceleration oscillation is also found to have registered.
02:02:37	The pilot flying shouts "shut down shut down"	**178.17.21** Rotor RPM registered a maximum of 111.8% Engine 1 & 2 Power Turbine registered a maximum of 111 % RPM Engine 1 ITT registered a maximum of 1025 degrees, whereas, Engine 2 ITT registered a maximum of 816 degrees
02.02.40	Engine rpm increasing heard	

Graphical Representations of the DFDR Data output are attached as Annexure 'A' to this report.

1.12 Wreckage and impact information

After the helicopter was lifted from the ground by the crew, it moved from the original parking position on the bay and made a hard landing approximately 20ft away from the original parking position with a large tilt to the right. The helicopter turned left by 20 degrees and landed at a heading of 287. None of the

parts of the helicopter were found detached from the structure and no other damage to the surroundings was also found caused due to this occurrence. The damage to the helicopter skid landing gear and the associated skin structure was indicative that the helicopter had landed heavily.

1.13 Medical and pathological information

Both the crew had undergone pre-flight medical examination before operating the flight at Vijayawada and tested negative for alcohol.

1.14 Fire

There was no fire.

1.15 Survival Aspects

The incident was survivable.

1.16 Tests and research

The transmission is mounted on the helicopter at four corners with four vibration isolation mounts placed between the airframe and the transmission. The two aft mounts are also supported by two friction dampers.

After the incident had occurred, based on the manufacturer's inputs, the operator carried out a hard landing inspection and an engine overspeed inspection. During the hard landing inspections, an inspection of the Pylon Corner Mounts and the Friction Dampers were carried out by the operator along with the representative of the manufacturer. A total of 4 Pylon Corner mounts (2 forward and 2 aft) Part no 204-031-927-107, and 2 Aft Friction Dampers, Part no 204-031-920-3, were sent to the manufacturer for lab testing and analysis.

The above-mentioned components were overhauled components which were installed on the helicopter on 16.01.2017 during the compliance of 5000hrs/ 5years Inspection at 2806:34 airframe hours after which there was no scheduled or unscheduled inspection carried out on them. At the time of the removal both the Pylon Corner mount assembly and the friction dampers, had 1007 hours of component time.

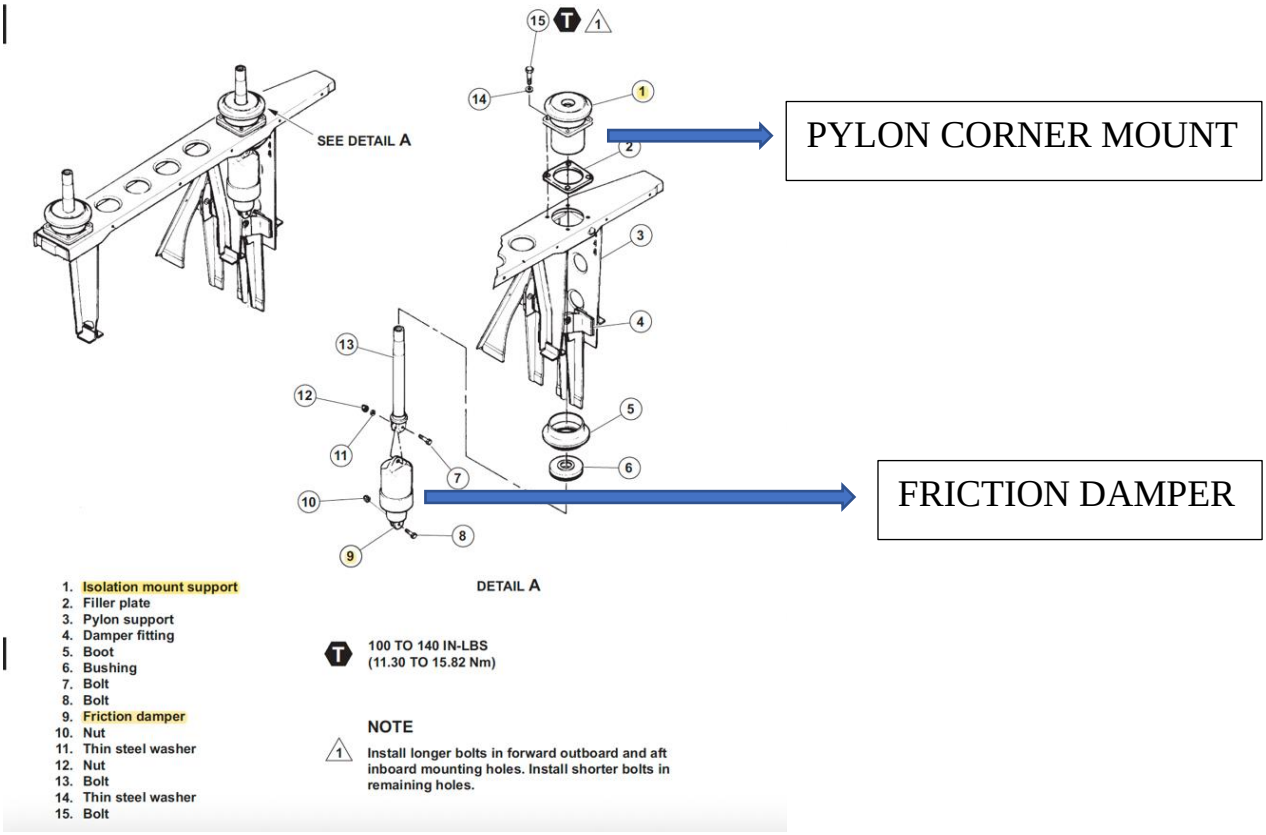


Figure 8: Pylon Corner Mount and Friction Damper

Figure 9: RH Forward Mount

Figure 10: RH Forward Mount

Figure 11: RH Aft Mount

Figure 12: RH Aft Mount

Figure 13: LH Forward Mount

Figure 14: LH Forward Mount

Figure 15: LH Aft Mount

Figure 16: LH Aft Mount

Figure 17: RH Aft Friction Damper

Figure 18: LH Aft Friction Damper

1.16.1 Corner Mounts

As per the report of the laboratory, a visual inspection of the four pylon corner mounts showed no apparent defects or damage to the structure. All the mounts had small amounts of white residue on the elastomer. Spectroscopy of the same showed that the residue was paraffin wax, which is consistent with the dampers having undergone large oscillatory motions. Stiffness measurements indicate age hardening, but there are no signs of elastomer degradation.

The corner mounts were also subjected to static and dynamic stiffness testing. The stiffness measurements for each of the corner mounts were in good agreement with one another and well above the minimum stiffness requirements for a new damper, indicating that there was no degradation of the elastomer, and the condition of the corner mounts was as expected for a fielded component.

The mounting hardware (bolts) was also sent to the manufacturer along with the corner mounts with the fasteners fitted in the location which is corresponding to the location installed on the helicopter before removal. There are four mounts in the assembly, 2 forward and 2 aft. Four bolts are used to fix each mount on the helicopter as shown in Figure 19. These bolts used on every mount are of two different lengths, AN175 bolts (-11 and -12). The maintenance manual calls out the proper dash number required for each mounting location.

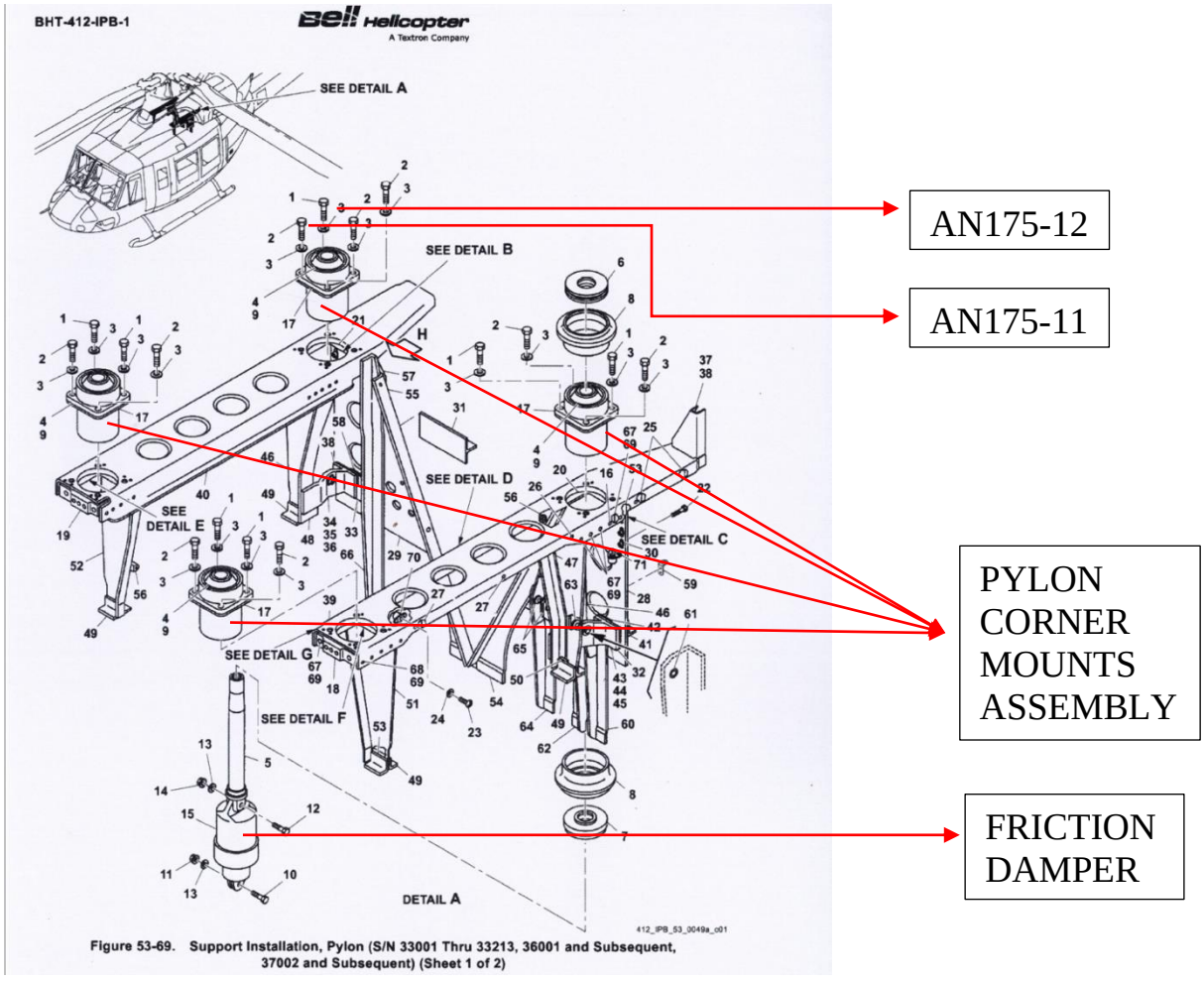


Figure 19: Pylon Corner Mount and Friction Damper depicting the Two Different bolts

In both LH and RH forward mounts, the bolts in the left/fwd corner and right/aft corner were found swapped. Such incorrect installation can result in insufficient clamping in the locations where a longer bolt was used. It is reported by the manufacturer, that this has been observed in at least one other field incident involving excessive vertical vibrations.

It is to be noted that the approved maintenance program of the organization or the maintenance manual of the manufacturer does not indicate any inspection on these mounts specifically. However, the maintenance manual calls for a visual inspection of the mounts for unserviceable condition before installation of the transmission when it is removed for inspection after every 3000 hours of operation.

1.16.2 Pylon Friction Dampers

The friction dampers were sent out to the OEM to perform their Acceptance Test Procedure, which is a test performed on every damper before it is shipped. The OEM had reported that both dampers met the Acceptance Test Procedure requirements. The physical inspection of the dampers did not show any visual defects. The ATP test was also repeated at Bell followed by characterization testing.

The friction dampers were characterized to investigate the sensitivity of damping force to steady displacement, oscillatory displacement, and excitation frequency. Testing showed that the damper provided no significant change in the damping force in the case of steady displacement, whereas it had shown a considerable amount of increase in the damping force when the magnitude of oscillatory displacement and the oscillatory frequency was increased.

It was concluded that visual inspection and testing found the rod end bearings were in good condition. The characterization testing concluded that there was no degradation of damper performance found under high amplitude oscillatory motion.

1.17 Organizational and Management Information:

M/s Heligo Charters Private Limited is a Non-Scheduled Operations Permit Holder which conducts both onshore and offshore operations using rotary wing helicopters. The fleet of the organization consists of 11 Helicopters of different types. The main base for operations and maintenance is situated in Juhu Aerodrome in Mumbai, Maharashtra.

1.18 Additional Information

1.18.1 Operation Safety Notice from Manufacturer

The Manufacturer of the helicopter had published an Operation Safety Notice number 412-18-43 dated 19th December 2018 titled "LARGE FORWARD CYCLIC DISPLACEMENT INDUCING ONE – PER – REV VIBRATION ON THE GROUND", which details situations where the pilot reported a rapid build-up of one-per-rev vertical vibration associated with a large steady-state forward cyclic displacement in combination with collective input while at 100/103 percent RPM with any part of the skid gear in contact with the ground.

The purpose of this OSN was to inform operators that should a rapid build-up of excessive one-per-rev vertical vibration level be experienced, the amount of forward cyclic input shall immediately be reduced and, if necessary, the collective and rotor RPM shall also be reduced to exit the vibration mode described.

1.18.2 Information received from the statements of the crew and Organization personnel.

- The instructor who was operating the helicopter along with other crew from 25.02.2019, had stated that no event regarding vibrations was either recorded or reported by him or any other crew members, before the incident.
- The instructor stated that the helicopter had a technical snag with the autopilot system and the same was discussed with the pilot flying before

conducting the flight. The pilot flying had denied knowledge of the error in the autopilot system, even though it was evident from the CVR recordings that the pilot flying acknowledged the error when the instructor had informed him.

- The instructor also stated that the snag was present in the autopilot system ever since the helicopter was released for service from a major inspection completed on 24.02.2019 and clarified that the Chief Engineer of the organization had briefed that the snag would be rectified on receipt of spares. With regards to the same the chief engineer had submitted that the aircraft was not released with an active snag on the autopilot system and the column of the techlog in which the snag was recorded was cleared by the AME.
- The instructor stated that the snag had no effect on the safety of operations and hence the same was not recorded in the techlog book.
- During the interviews, it was submitted that the crew of the organization did not have any knowledge of the Operation Safety Notice issued by the manufacturer as mentioned in 1.18.1.

1.19 Useful or Effective Investigation Techniques

None

2 ANALYSIS

2.1 Engineering & Maintenance Aspects

2.1.1 Scheduled Maintenance Inspections and Tasks

The helicopter had undergone a 300 hour inspection on 15.02.2019 and was released for service on 24.02.2019, i.e., 17 days before the incident, during which several components were removed and serviced. The completed schedules were perused, and the replaced components were physically reviewed. However, no abnormality was found within the scope of the 300 hrs maintenance inspection carried out.

The Main Rotor Mast assembly was replaced on the helicopter with a new assembly while the helicopter was undergoing the 300hrs scheduled inspection as it was due for an overhaul. The removal and installation of the assembly were carried out by the Chief Engineer of the organization. The perusal of the worksheets revealed no abnormality.

The scheduled maintenance tasks and inspections carried out are not considered contributory factors to the incident.

2.1.2 Unscheduled Maintenance Tasks

During the system checks of the incident flight, an error in the AUTOTRIM was encountered by the crew. The pilot monitoring informs the pilot flying about the defect in the autopilot system and the pilot flying also acknowledges the same.

After the 300hrs scheduled maintenance inspection was completed and released for service, the Pilot monitoring of the incident flight was the first pilot to operate the helicopter from Mumbai to a different station. In his statement, tt was stated that the snag on the autopilot system was present from the first day of operation out of Mumbai and the same was not reported in the techlog book as the snag was perceived as one without any effect on the safety of operations. It was also stated that the Chief Engineer of the organization briefed that the snag would be rectified as soon as the spares were received by the organization, however the same could not be established.

The troubleshooting and rectification action carried out for the autopilot system snags entered in the techlog book on 14.02.2019, was not according to the manufacturer's maintenance manual. The details of rectification of the snag on the certificate of release and worksheets were also found to have been added at a later stage as shown in Figures 6 & 7.

All the above circumstantial evidence indicates that non-standard practices concerning recording & rectification of defects were followed in the organization as opposed to what is recommended by the manufacturer and required by the CAR.

The auto trim snag in the autopilot system encountered by the crew during the system checks of the incident flight is not considered a contributory factor in the incident, however, the non-standard practices of the organization concerning recording & rectification of defects are a matter of non-compliance of CAR.

2.1.3 Transmission Mount Assembly

The Corner mounts and the friction dampers of the helicopter were suspected to be the cause of the vertical vibrations and they were sent to the Manufacturer for testing. During the testing, their performance was found to be satisfactory, and the testing did not show any excessive degradation of either the pylon corner mounts or the friction dampers.

However, before the testing was initiated, during the visual inspection, it was found that the mounting locations of the bolts were swapped in both the forward mounts. The manufacturer has confirmed that the installation of longer bolts in the wrong locations can lead to insufficient clamping force and cause vertical vibrations. The manufacturer had also confirmed that this has been observed in at least one other field occurrence involving excessive vertical vibrations.

The worksheets of removal and installation of the Main Rotor Mast Assembly did not reveal any task or action performed on the pylon corner mounts or its bolts. As per the records available with the operator, these pylon corner mounts were installed on the helicopter in January 2017 at the operator's facility by a rated and qualified engineer and the bolts would probably have been swapped at that time. The incorrect mounting of the bolts in this case is a probable cause of the incident.

2.2 Operational Aspects

The CVR when co-related with the DFDR with regards to the pilot inputs to the collective, reveals that before the instructor took over the controls, the pilot flying gave a small input on the collective, wherein he could sense the vibrations and expressed his doubts about the controls being centred, Whereas he didn't

speak about the vibrations to the pilot monitoring at which point he had presumed that the vibrations were also felt by the instructor.

The pilot monitoring gave a call out and took over the controls. After the controls were taken over, two small inputs were given to the collective lever, during which the vertical acceleration showed significant changes. After these movements, a large input to the collective was given and the helicopter was lifted into a hover, suspecting ground resonance. After the helicopter was lifted into hover the intensity of the vibrations increased and the helicopter had become uncontrollable. During these vibrations, an oscillatory input to the collective, the pedals, and the cyclic was found recorded on the DFDR data. These inputs by the pilot are suspected to be involuntary and were effects of the ongoing vibrations in the helicopter.

The Operation Safety Notice issued by the manufacturer also indicated that should a rapid build-up of excessive one-per-rev vertical vibration level be experienced, the amount of forward cyclic input shall immediately be reduced and, if necessary, the collective and rotor RPM shall also be reduced to exit the vertical vibration. During the investigation, it was found that the crew was unaware of this notice indicating an inefficient information dissemination system in the organization.

Both the pilots with extensive flying experience were found to have acted on their instincts whereas a discussion on the cause of the abnormal vibrations coming up with input on collective, could have convinced the crew to abort the sortie. Inadequate communication and lack of knowledge of the OSN are considered contributory factors to the incident.

3 CONCLUSION

3.1 Findings

i. For the incident flight, the loading of the helicopter was as per the standards and the CG was found to be within limits.

ii. The worksheets and CRS documents of removal and installation of the Main Rotor Mast Assembly did not reveal any anomaly.

iii. The Pilot flying had denied the presence of any error or snag in the DAFCS system in his statement. However, it is found in the CVR recordings indicate pilot flying had complete knowledge of the same.

iv. The defect in the autopilot system was not entered in the Pilot Defect report by any of the crew of the organization.

v. The incident flight was operated with a snag on the autopilot system of the helicopter. The snag of the autopilot system is found not a contributory factor to the cause of the incident.

vi. During testing of Pylon Corner Mounts, it was found that in both LH and RH forward mounts, the bolts in the left/fwd corner and right/aft corner were found swapped. The bolts might likely have been swapped during their installation on the helicopter at the operator's facility by a rated and qualified engineer in January 2017.

vii. No excessive degradation on the Pylon Corner mounts and the friction dampers of the helicopter was found during testing.

viii. The manufacturer has confirmed that installation of longer bolts in the wrong locations can lead to insufficient clamping force which in this case had caused the vertical vibrations. The manufacturer had also confirmed that this has been observed in at least one other field occurrence involving excessive vertical vibrations.

ix. The manufacturer released an Operations Safety Notice in December 2018 titled "LARGE FORWARD CYCLIC DISPLACEMENT INDUCING ONE – PER – REV VIBRATION ON THE GROUND". The crew of the incident flight did not have any knowledge of this Operations Safety Notice indicating an improper system of dissemination of information in the organization.

x. After the helicopter was lifted off the ground into a hover, an oscillatory input to the collective lever, the pedals, and the cyclic was found recorded on the DFDR data. These inputs by the pilot are suspected to be involuntary and were the effects of ongoing vibrations in the helicopter. These involuntary inputs led to an increasing magnitude of vertical vibrations.

xi. Both pilots with extensive flying experience were found to have acted on their instincts.

xii. After the landing, as the pilot monitoring tried to switch off the engines by toggling the fuel cutoff switches, he accidentally switched both the engine governors from automatic to manual mode and immediately back to auto, due to which the helicopter suffered Main rotor over speed and over temperature in No.1 engine.

xiii. The manufacturer introduced a new and special inspection regime for the transmission mount assembly and friction damper assembly inspection regime in the maintenance manual under Revision 29 dated 28 Feb 2020.

3.2 Probable Cause

Bolts mounted at incorrect locations while installing the pylon corner mounts are found to be a probable cause of the incident. Inadequate communication between the crew and lack of knowledge of the Operational Safety Notice are considered contributory factors to the incident.

4 SAFETY RECOMMENDATIONS

i. The procedure concerning the dissemination of information received or published by the manufacturer or any other approved source of importance to the safety and operations of the organization needs to be enhanced.

ii. The requirement of reporting snags in the Pilot Defect Report section of the techlog book needs to be re-iterated in the organization.

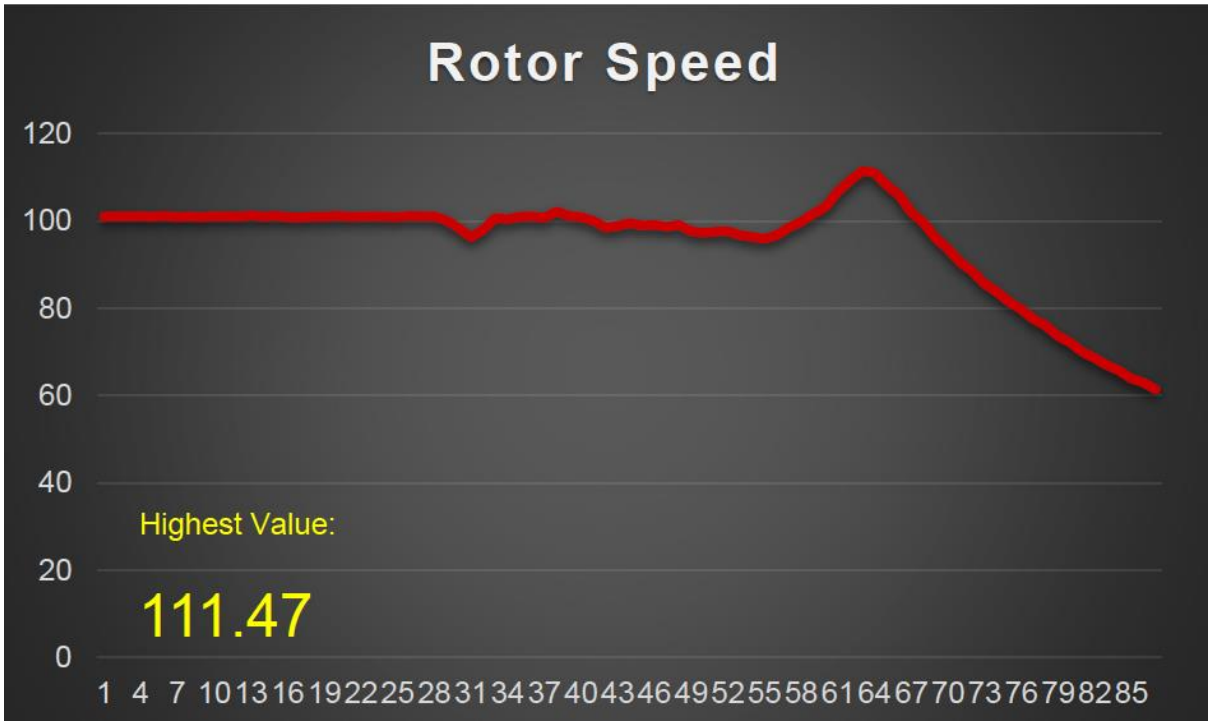
Rohith Mitai

Digitally signed by Rohith Mitai
Reason: I am the author of this document

Rohith Mitai

Investigator–In–Charge

Annexure A


Rotor Speed
120
100
80
60
40
20
0
Highest Value:
111.47
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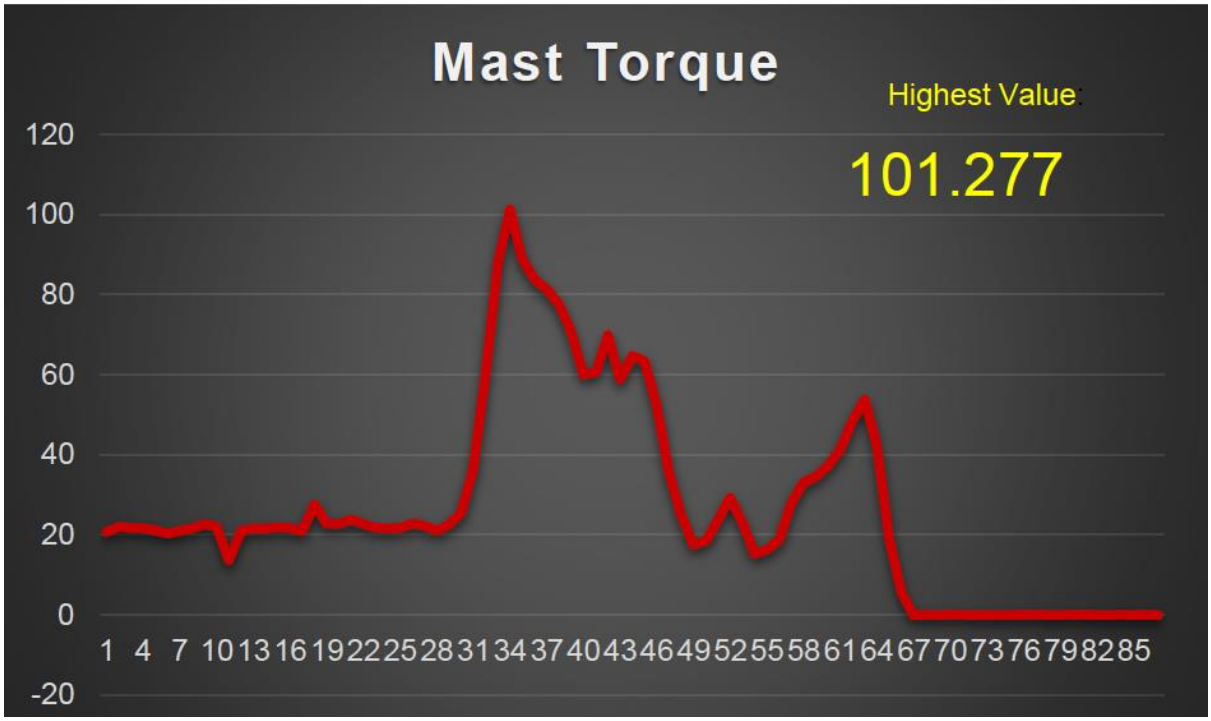
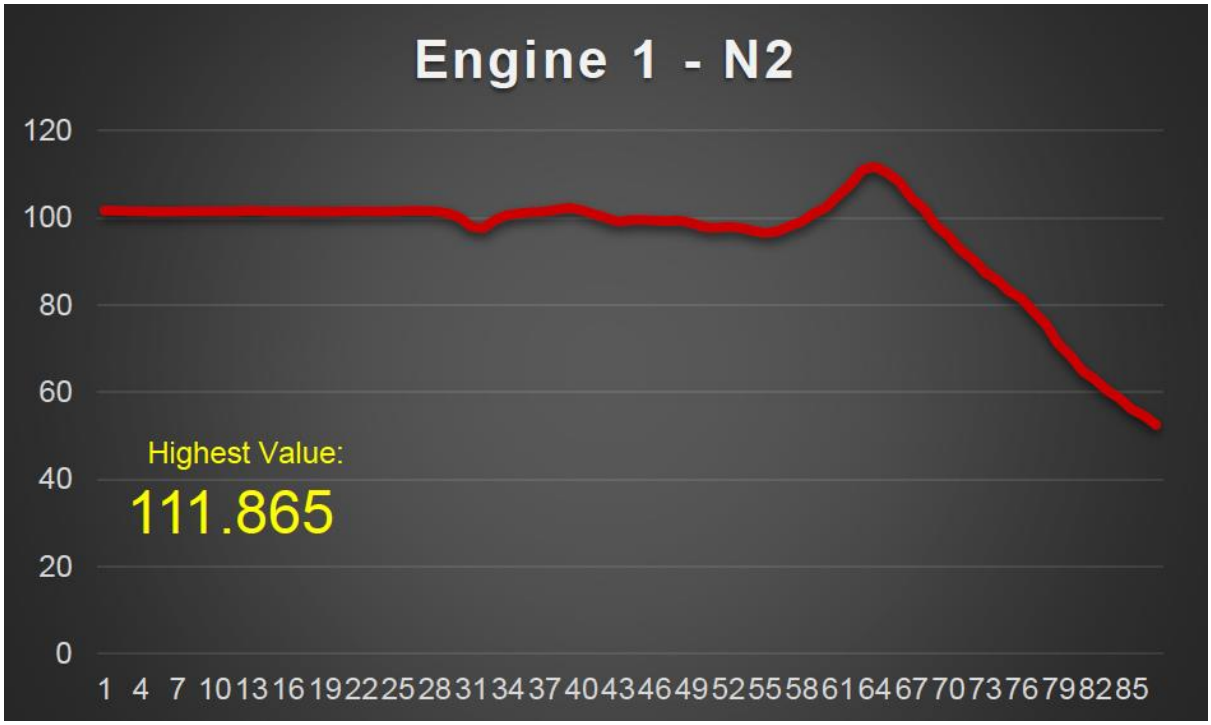

Mast Torque
Highest Value:
101.277
120
100
80
60
40
20
0
-20
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85


Engine 1 - N2
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80
60
40
20
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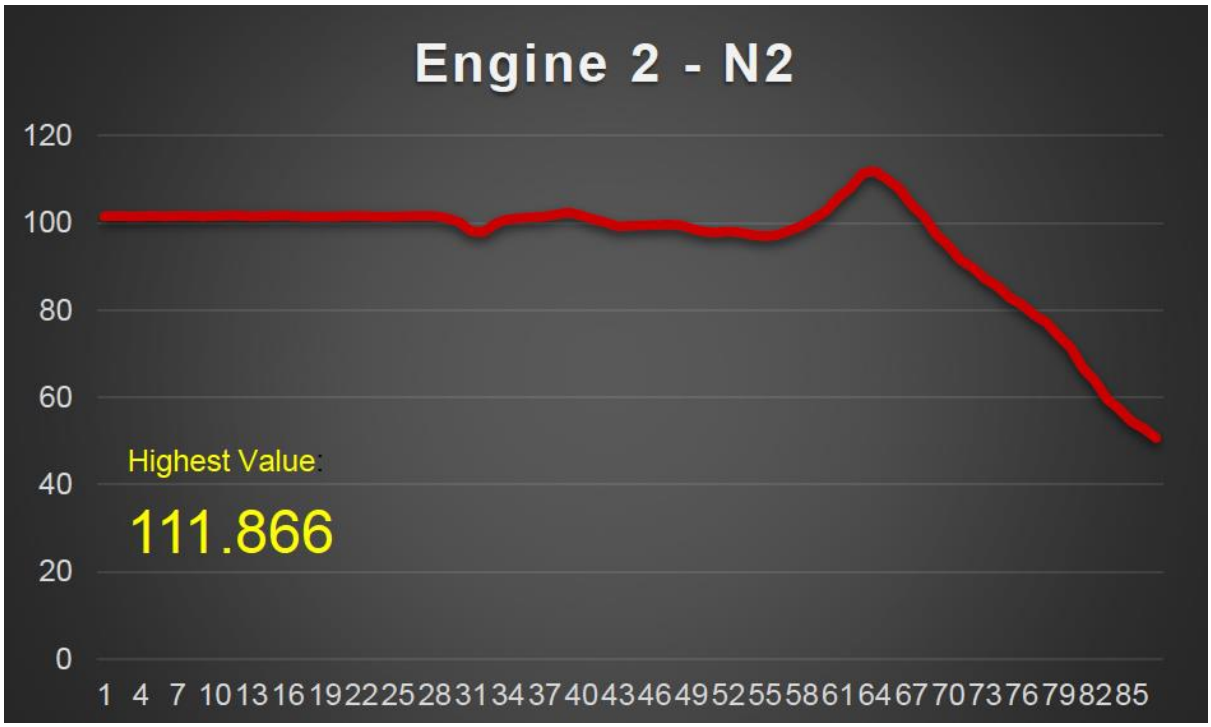
Engine 2 - N2
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100
80
60
40
20
0
Highest Value:
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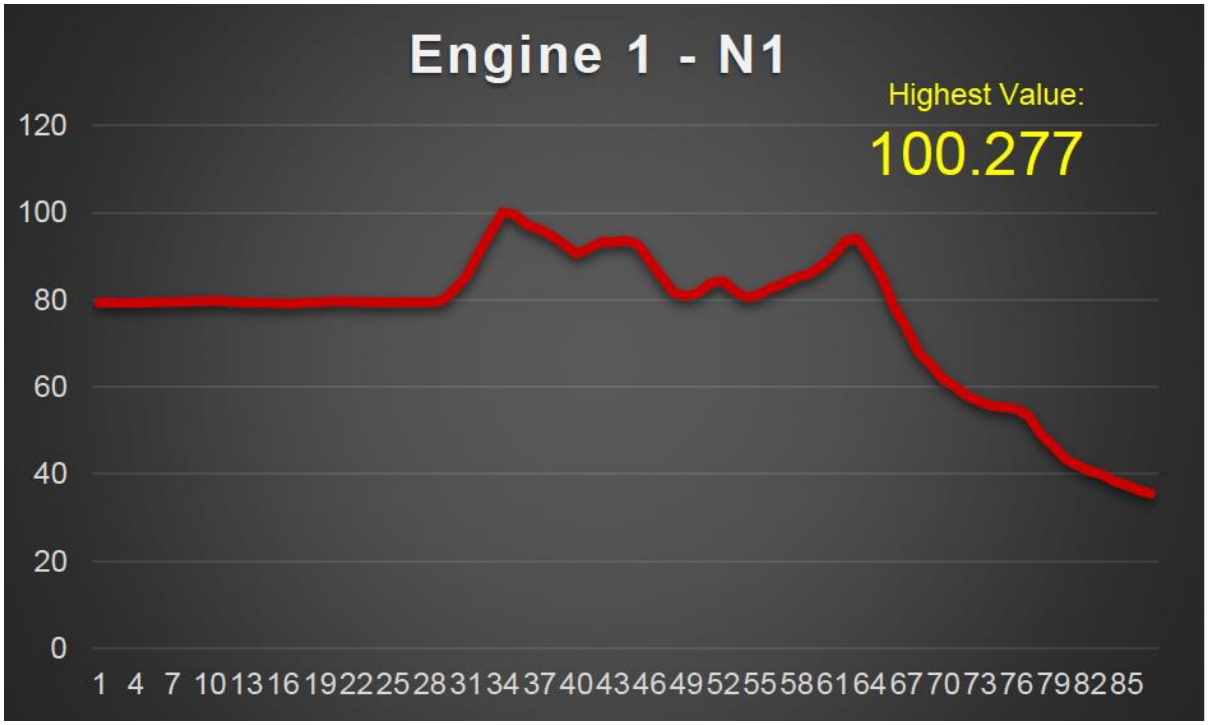
Engine 1 - N1
Highest Value:
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100
80
60
40
20
0
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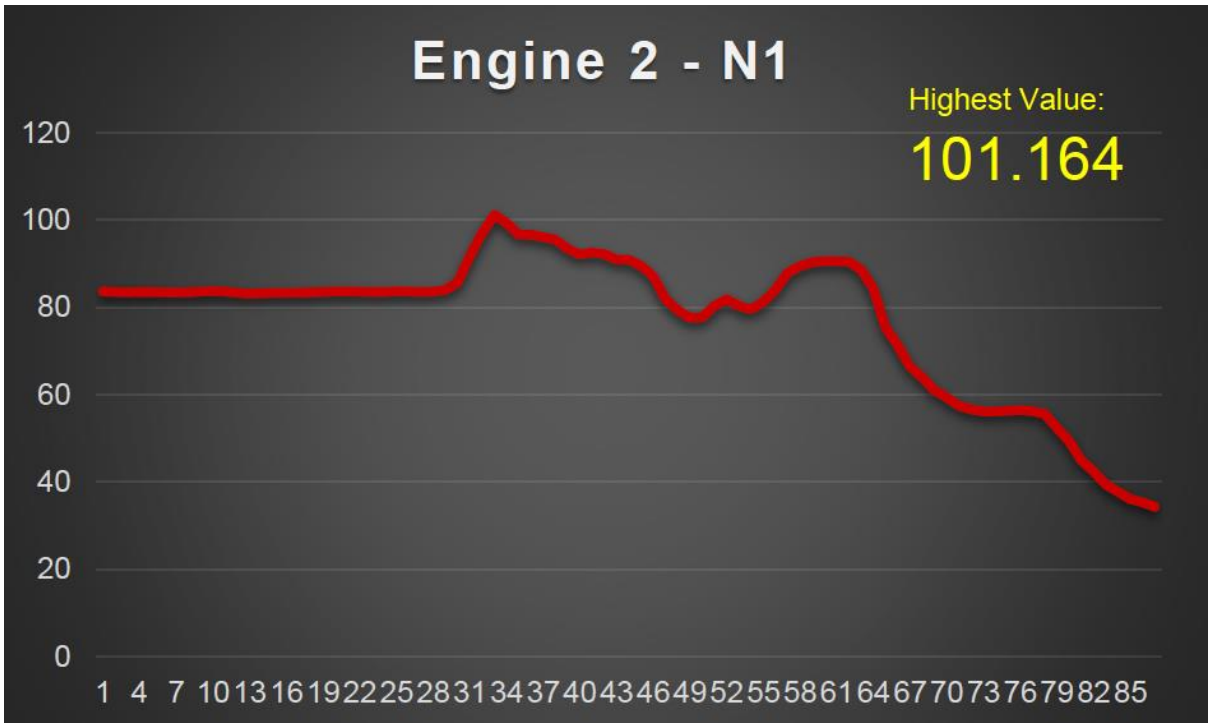
Engine 2 - N1
Highest Value:
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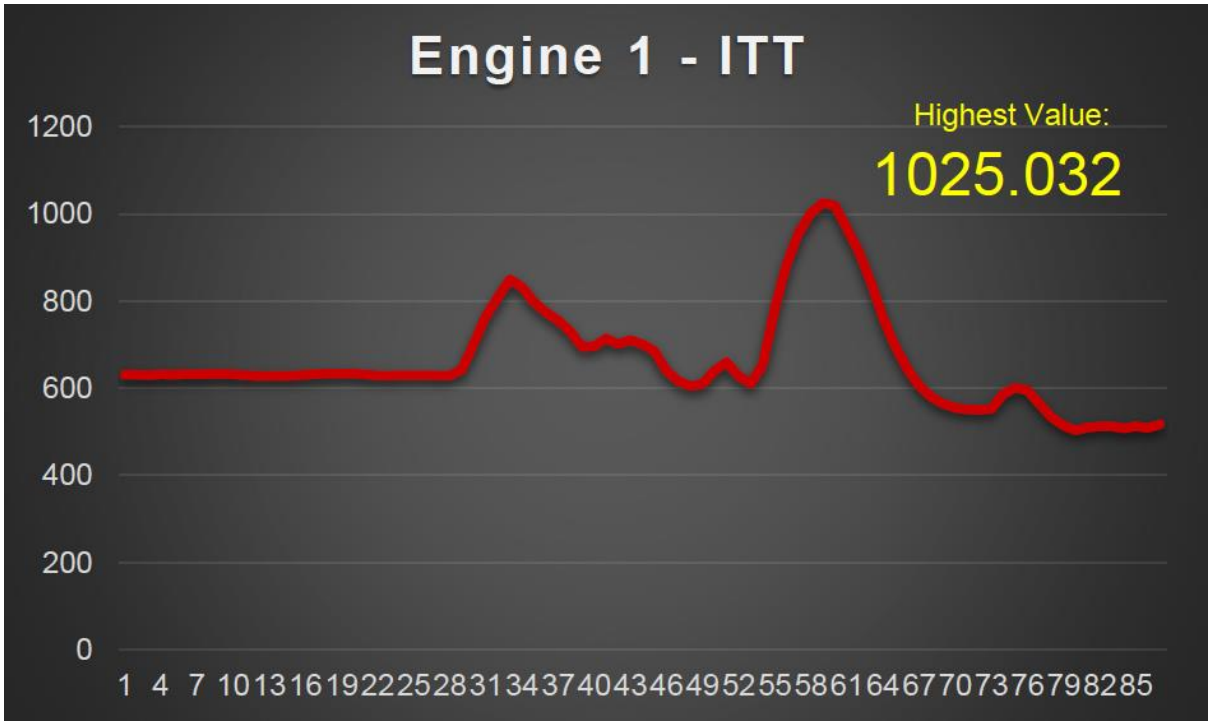
Engine 1 - ITT
Highest Value:
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1000
800
600
400
200
0
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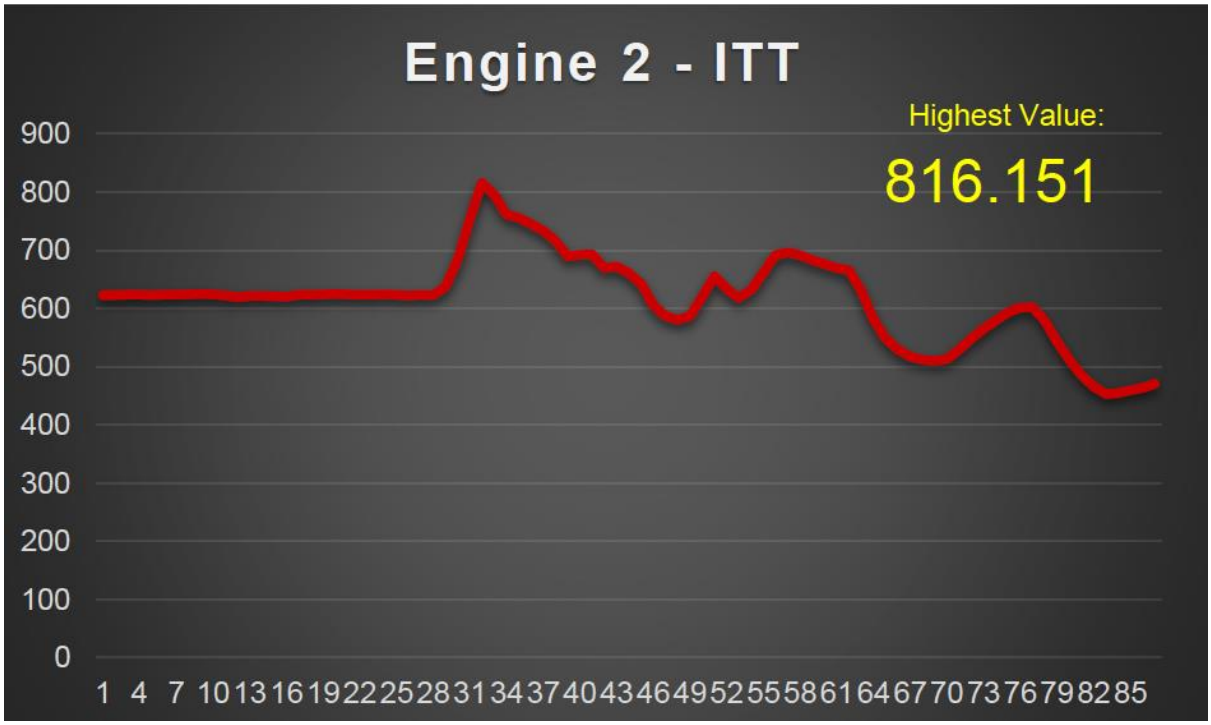
Engine 2 - ITT
Highest Value:
816.151
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700
600
500
400
300
200
100
0
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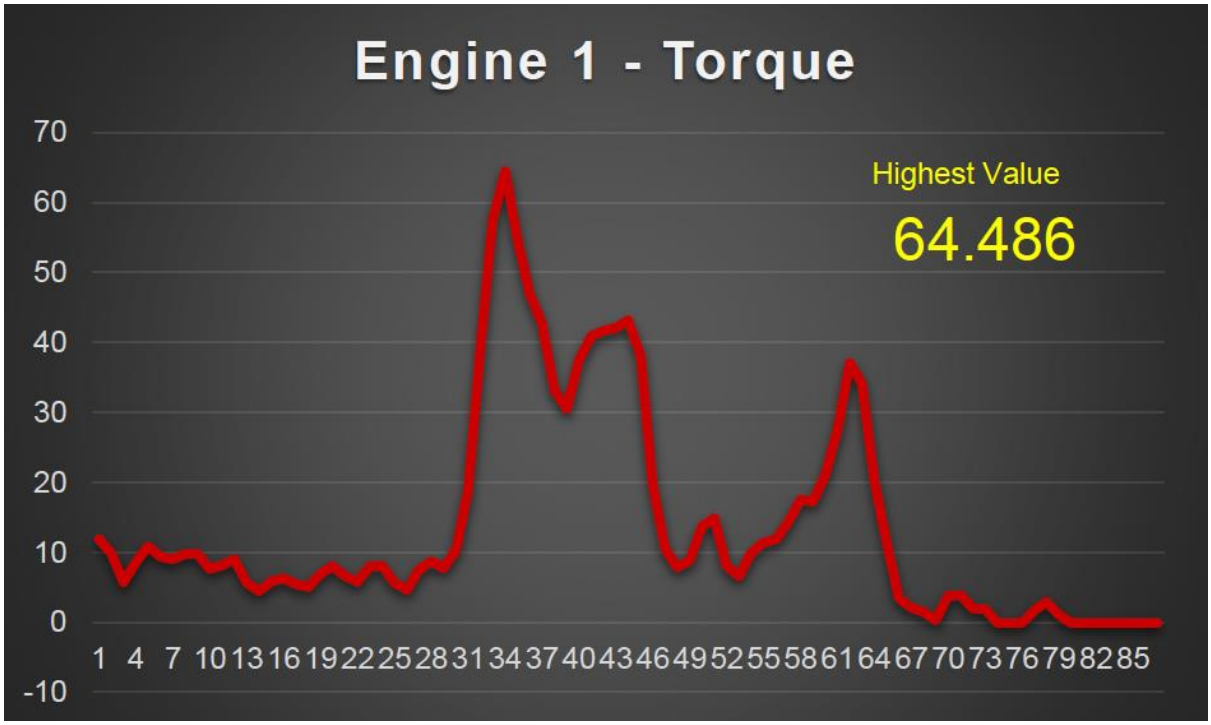
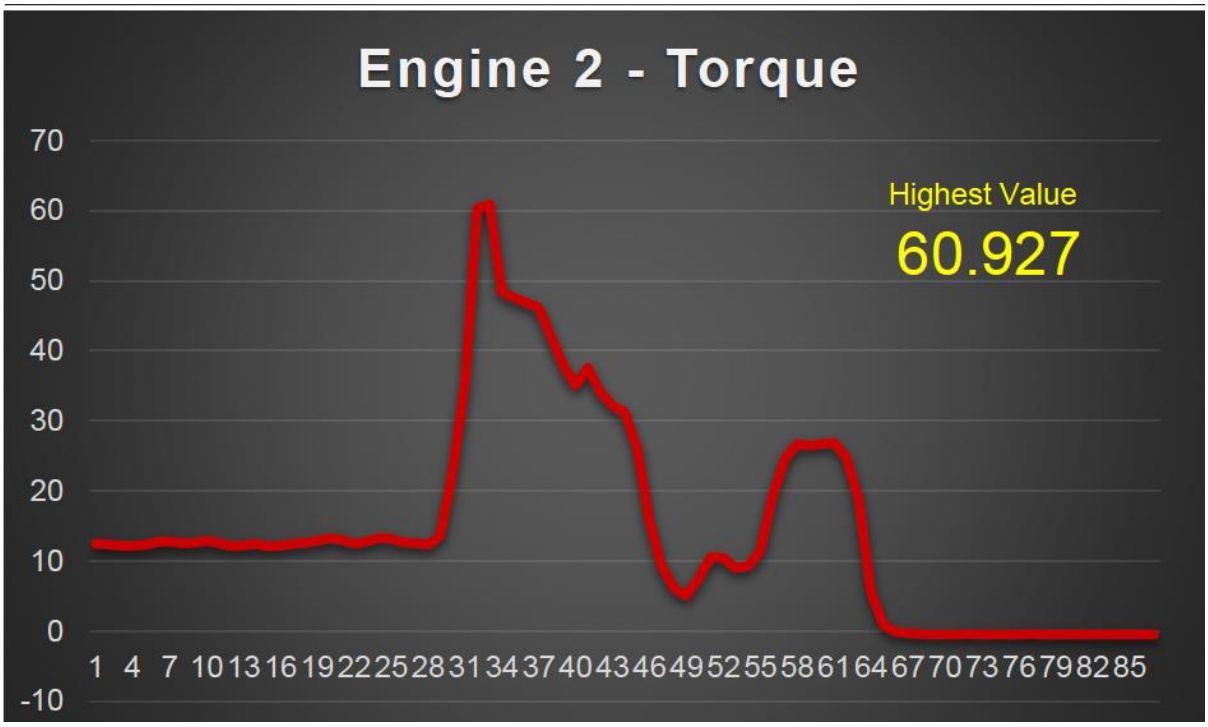

Engine 1 - Torque
70
60
50
40
30
20
10
0
-10
Highest Value
64.486
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85


Engine 2 - Torque
70
60
50
40
30
20
10
0
-10
Highest Value
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1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85