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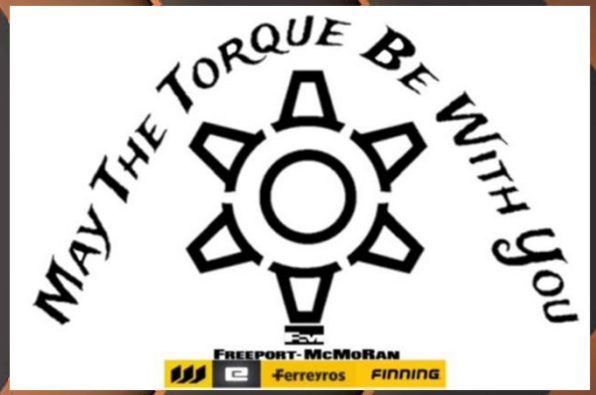
# Component Life Agile Team Overview Presentation

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# Introduction

**Maintenance**

**Intervention**

**Recommendations**

**Sustainability**

**Future Opportunities**

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# Component Life Team Members

**Executive Sponsor:** Cory Stevens

**Stakeholders:** Leeland Boday, Toby Dunn, Steve Pangburn, Mona Ogas, Tim Webb, Karl Reid, Dennis Sorensen

**Product Owner**
Manny Herrera

**Scrum Master**
Cassandra Galvez

**SMEs**
**FMI**: Craig Willis, Luis Montoya, Frank Aguirre, Mitch McInally, Buddy Aguinga
**Empire**: Tyler Dixon

## Scrum Team

OI- David Barnes
OI- Luis Ochoa
Data Science- Mike Bischof
Oil Lab- Colin Cunningham
MOR- Willey Biggs
SIE- Antonio Corral
SIE- Chet Shiflet
BAG-Ted Puleston
CHI- Wayne Toney
TYR- Royce Parra
SAF- Brady Norton
CMX- Shawn Clarno
CMX- Jason Anderson
CV- Diego Malaga
CV- Carlos Arrayan
EIA- Anibaldo Aracena
EIA- Guillermo Vilches
Empire- Trent Reidhead
Empire- Jared Townley
Empire- Jamie Moore
Ferreyros- Jorge Tokashiki
Wagner- Russell Flamm
Wagner- Tim Eldred
Finning- Mario Ananias
Finning- Jorge Selti
CAT- Josh Wirsching

# Caterpillar Component Life Burning Platform and Vision

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**Caterpillar Component life has historically been measured simply utilizing service hours. While this traditional measurement has taken Component life to where it currently is, there has been a pivot toward measuring component life by work. Recently, the same strategy was applied to engines and the results have been promising. Component life can be measured using the same data driven approach. Some examples could be, utilizing travel hours, number of shifts versus service hours will deliver the expected improvement.**

**Component removal and installation is a high-risk task as identified by the fatal risk management (FRM) guidelines. There are seven fatal risks that apply to Component R&I. High risk exposure reduction is estimated to be ~1,900 man-hours per year by measuring final drive removal intervals using travel hours as the measure of life as one example.**

**FCX spends a substantial dollar amount on 793 5 major Components equating to ~$100 MM on 2019 for only components cost. Furthermore, average Component utilization differs between model and site due to different operational and maintenance practices between the sites.**

**Employing a data driven approach to quantify Component life reduces technician exposure and increased safety is the net result. With this knowledge, there is a need to create standardized maintenance best practices and intervention strategies to drive the number of failures down as well as maximize Component life. By implementing this data driven process and optimizing life component it is estimated a potential saving of ~$9.2 MM based on 2020 data.**

**In summary, this project aligns with FCX's overarching 2020 Vision: Focusing on Immediate Value. Utilizing data to make removal decisions rather than traditional methods has been proven to maximize component life. Can we count on your support?**

# Team Objective and Key Results

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## Objective 1: Reduce High Risk Exposure to our employees by extending component life.

**Key Results**

1. Reduce planned man hours required by December 31, 2020.
2. Establish best practices that will aid our current technicians by December 31, 2020.
3. Establish best practices in training future technicians by January 31, 2021.

## Objective 2: Develop metrics to maximize component life at the lowest cost.

**Key Results**

1. Define indicator and target value for Transmission life by November 30, 2020.
2. Define indicator and target value for Torque Converter by November 30, 2020.
3. Define indicator and target value for Final Drives/Differentials by November 30, 2020.

## Objective 3: Standardize component rebuilds performed by dealers.

**Key Results**

1. Review and refine reusability guidelines and customer guidelines for rebuilds by November 30, 2020.
2. Define life of hard parts by November 30, 2020.

# Define Metrics, Targets

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Metrics for different components:

- Differentials – 15,000 Travel Hours
- Final Drives – 15,000 Travel Hours
- Transmissions – 15,000 Travel Hours
- Torque Converters – 1,000,000 gallons of Fuel Burn

- **Differentials/Final Drives/Transmissions**:
  *Travel Hours*: Sum of time where the haul truck's payload status is 'Travel Loaded' or 'Traveling Empty' (data source: PI)

- **Torque Converters**:
  *Fuel Consumption*: Based on the "Engine Fuel Rate"-tag and in 1-second intervals, fuel consumption is aggregated to daily fuel consumption (data source: PI)

# How is Success Measured?

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Success is measured by total travel time achieved rather than failure rate. In other words, as long as the component achieved at least 15K travel hrs. or 1MM gallons for TC, while the component cost remains steady, we are succeeding.

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# Utilizing of Our System of Record is not an Option

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# How do We Build Trust in the System of Record (SAP)?

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**Re-communicate the SAP component tracing process to all sites. Clearly define the process, goals, expectations, benefits, etc.**

The rollout process should be customized for each site while utilizing the feedback collected.

- Focus on Leadership support, training, and sites bandwidth.

All Sites

- Identify a site champion that will lead and be responsible to make the transition from tracking components in Excel spreadsheets to fully utilizing our system of record (SAP)

- Identify a sponsor who will have the overall accountability for this project

- EGST to provide ongoing support to sites
  - Sites are in constant flux thus making ongoing support essential to sustaining this process

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# Forecast and Year over Year Comparisons

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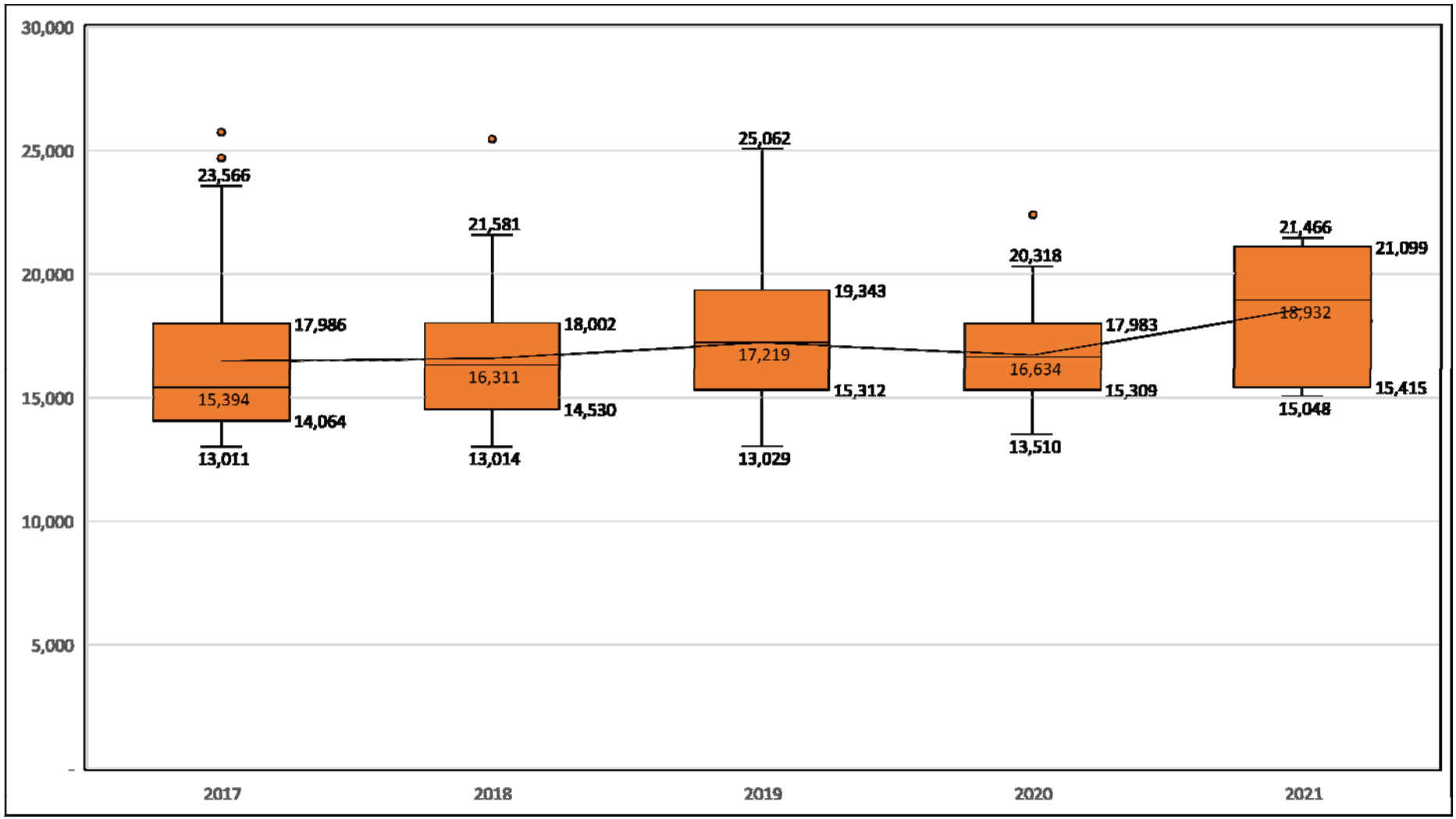
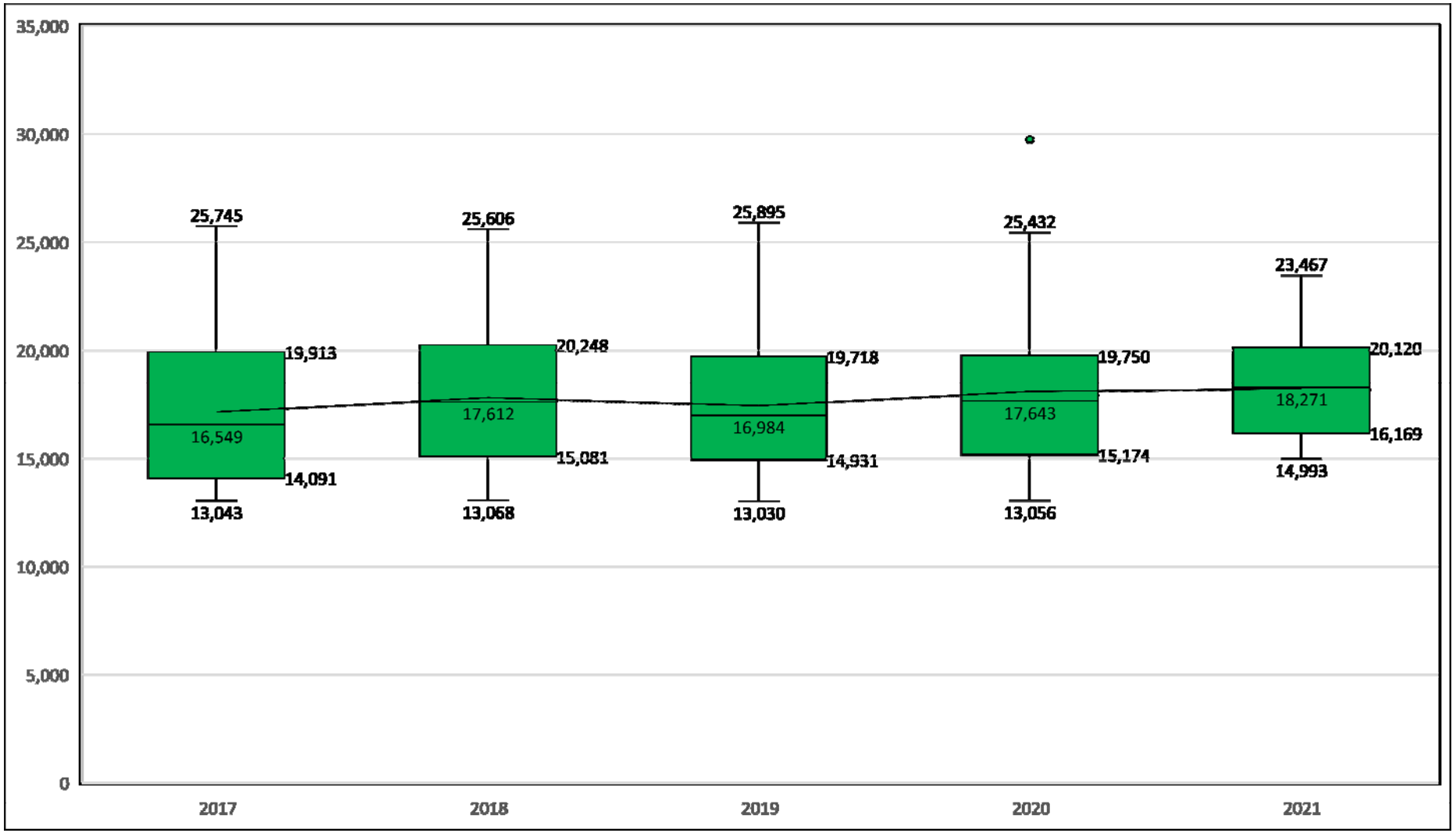
# Differential PCR Hours, by Year – All Sites



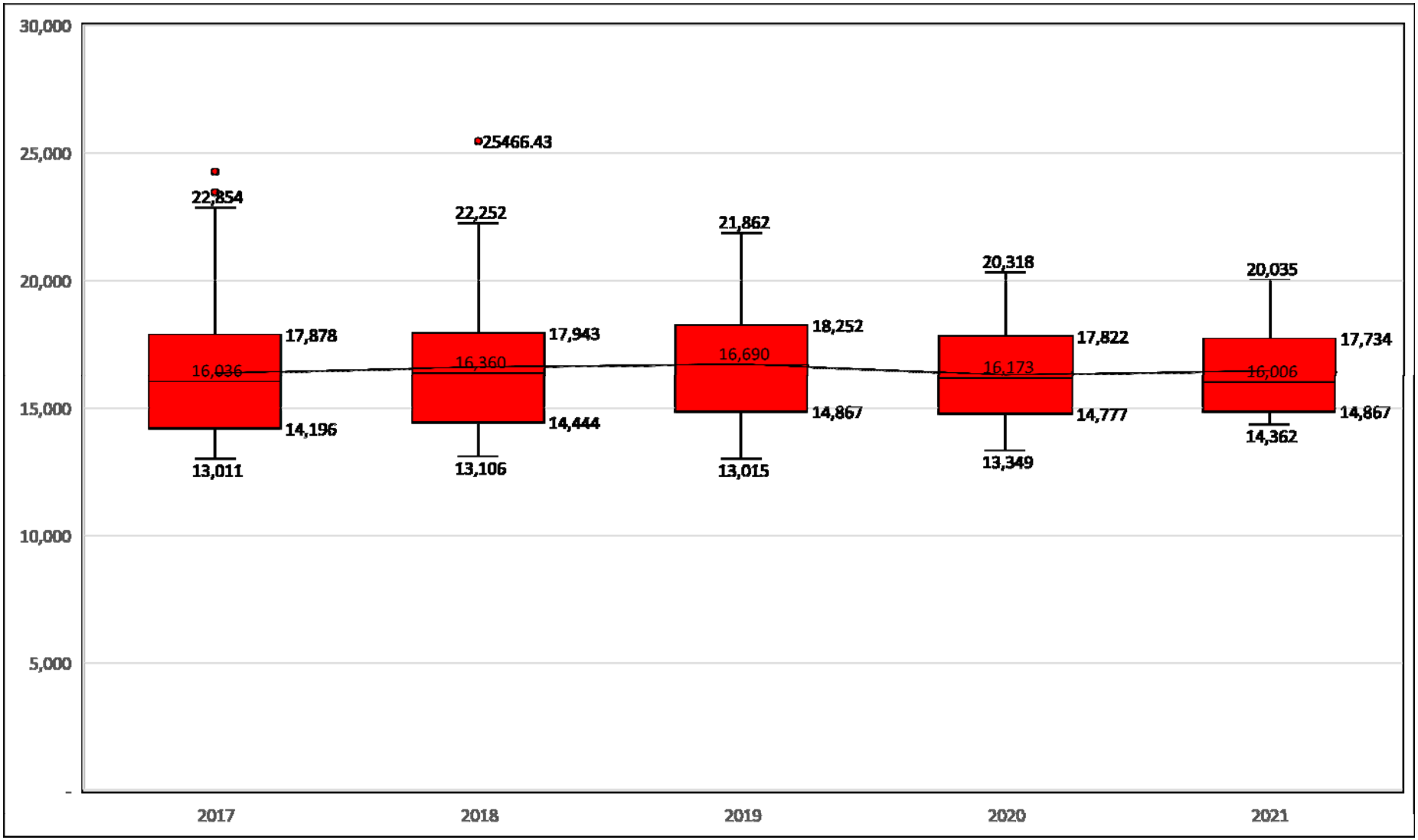

*Data from Master Component Sheet with the addition of 2021 data from Site spreadsheets, component coded PCR, filtered for >13,000 service hours

# Final Drive PCR Hours, By Year – All Sites




*Data from Master Component Sheet with the addition of 2021 data from Site spreadsheets, component coded PCR, filtered for >13,000 service hours

# Transmission PCR Hours, by Year – All Sites




*Data from Master Component Sheet with the addition of 2021 data from Site spreadsheets, component coded PCR, filtered for >13,000 service hours

# Torque Converter Fuel Consumption, by Year – All Sites

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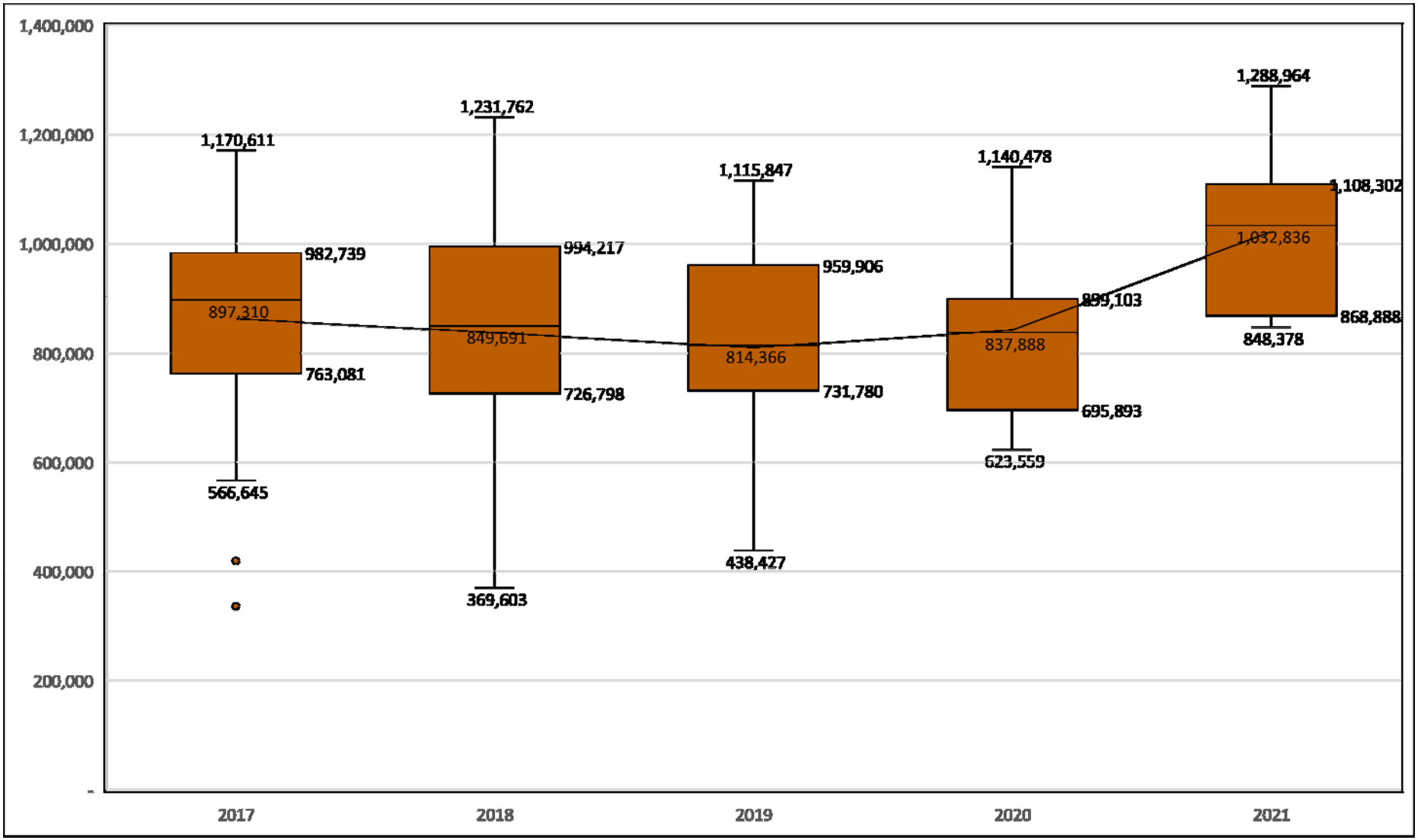


* Data from Master Component Sheet with the addition of 2021 data from Site spreadsheets, component coded PCR, filtered for >350,000 gallons of fuel consumption

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# Cost per Hour Comparisons

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# Cost per Hour Comparison – Differential

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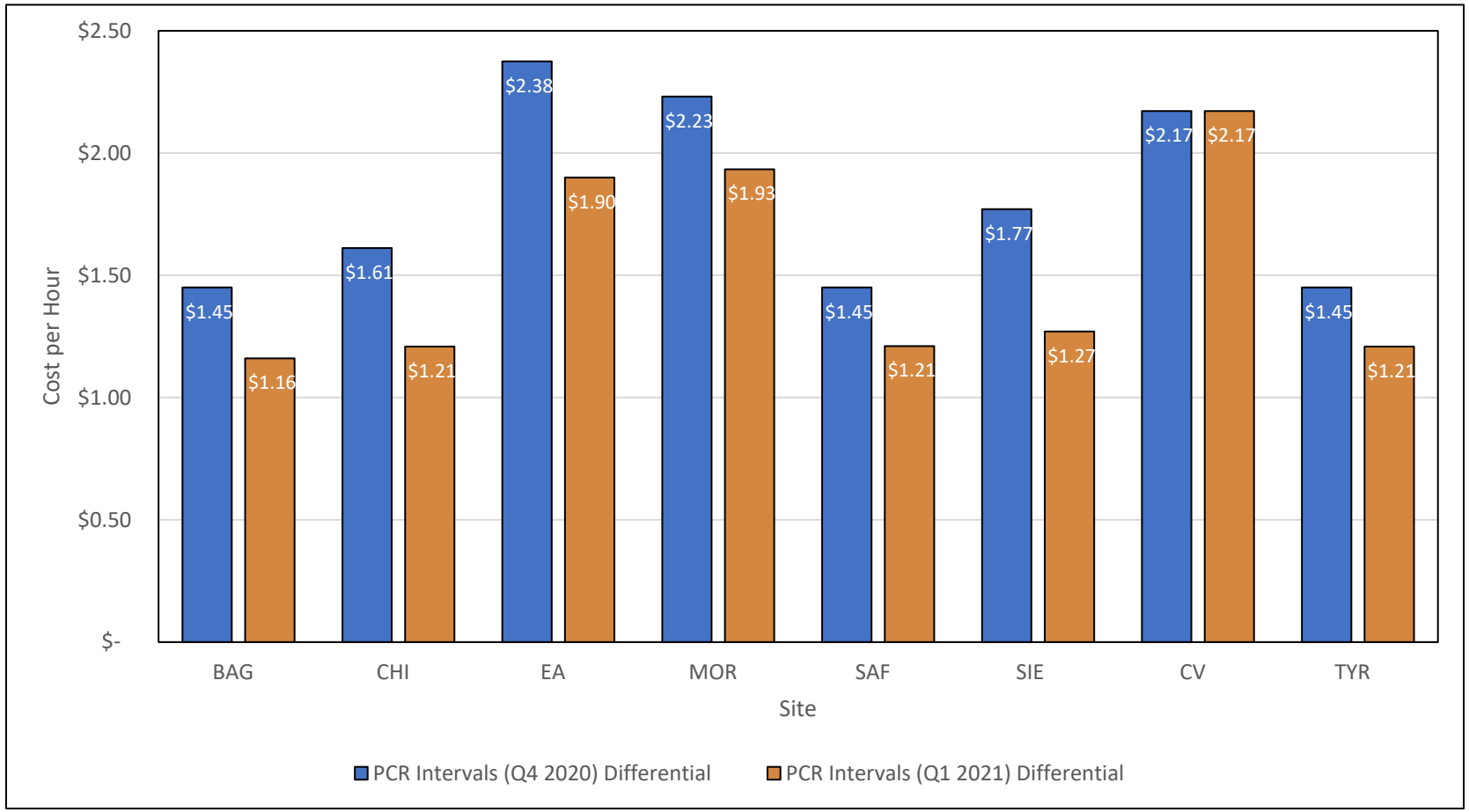
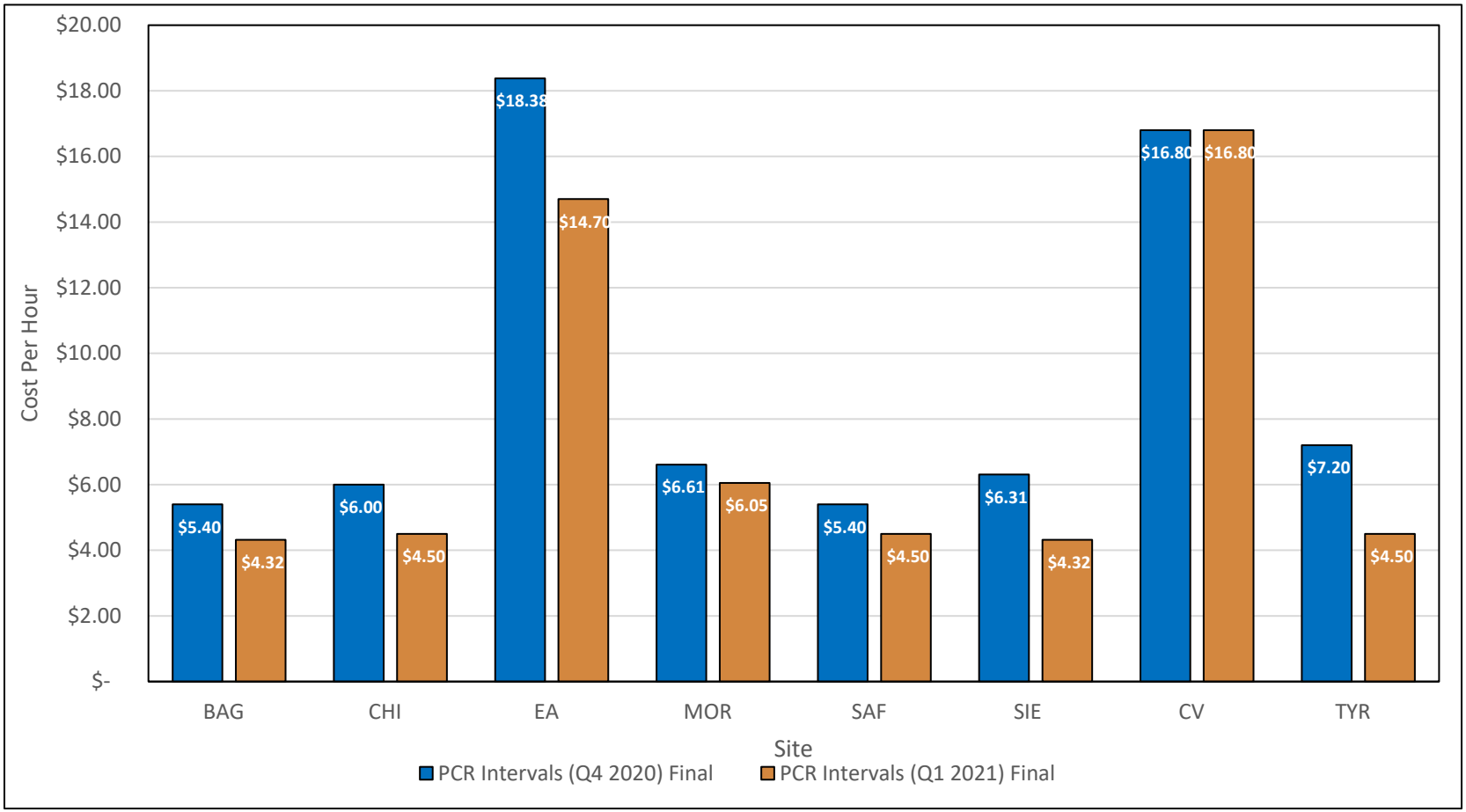


# Cost per Hour Comparison – Final Drive



# Cost per Hour Comparison – Transmission

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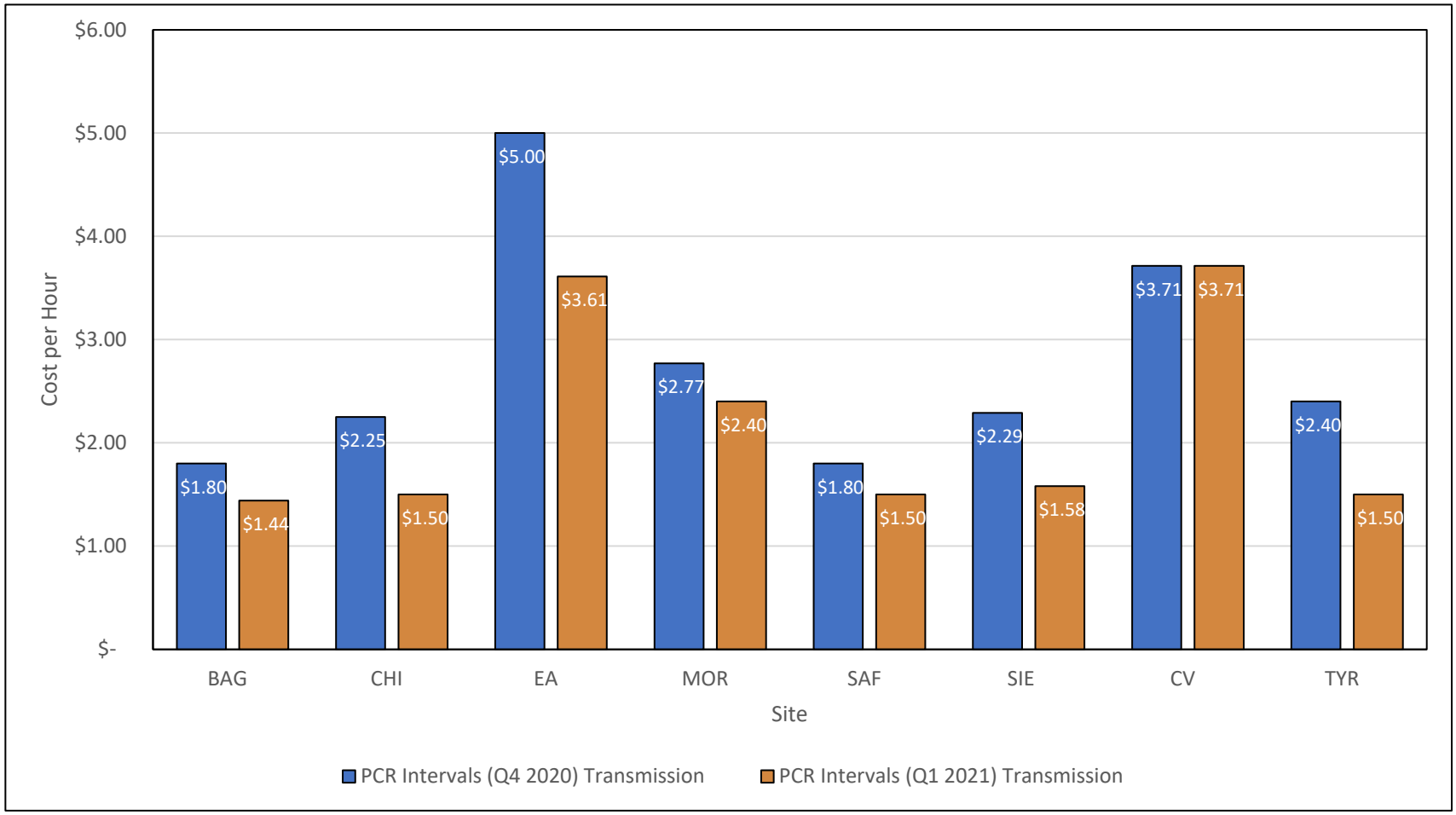

# Cost per Hour Comparison – Torque Converter

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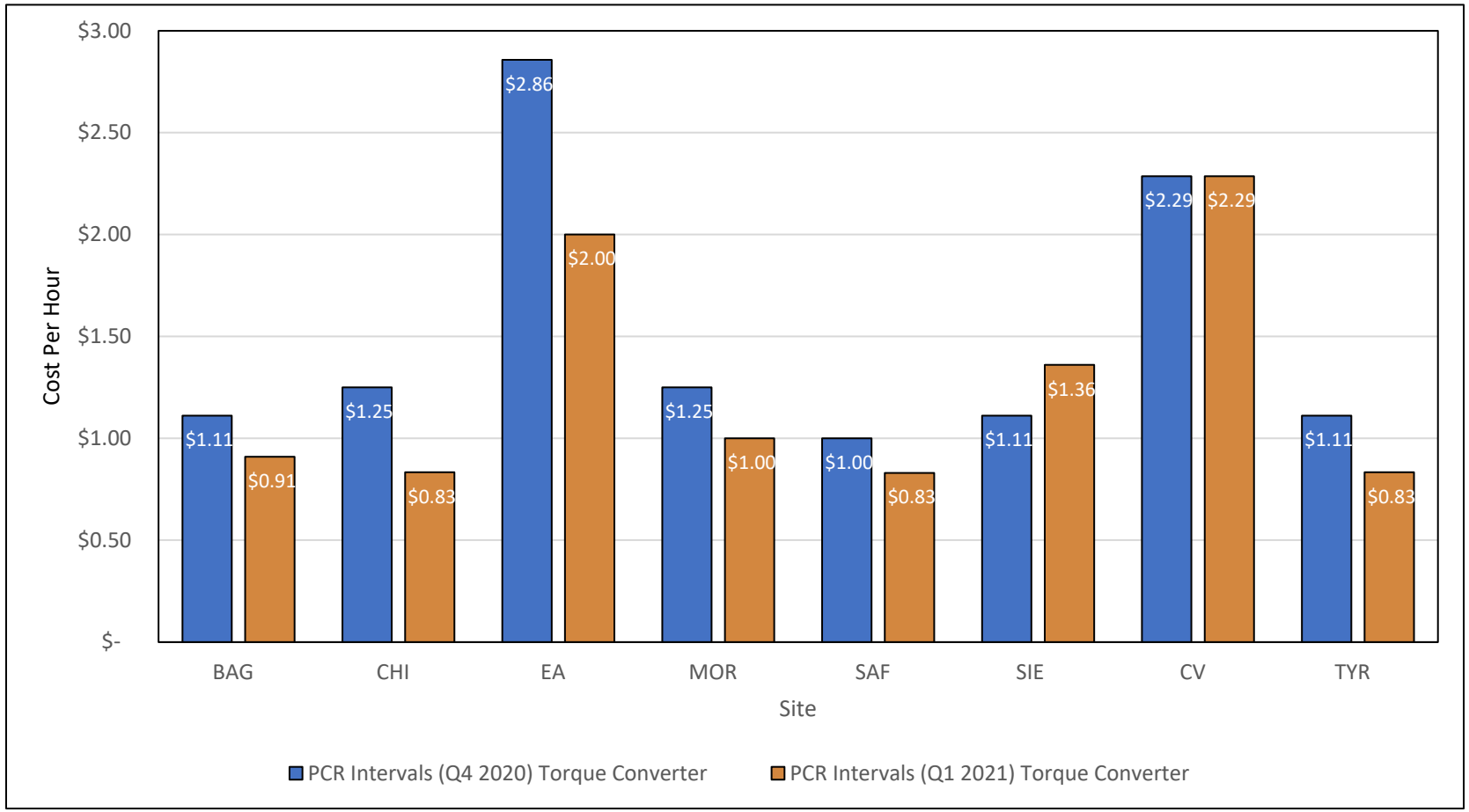

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# Estimated Cost Savings per Year

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# Cost Analysis Detailed Methodology

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- **Calculating Diff/Final/Trans PCR $/Year:**

$$Site\frac{\$}{yr} = 2020\ Site\ Oper.Hrs * \frac{2020\ Site\ PCR\ Interval * Diff, Final, or\ Trans\ Cost}{24000\ hours}$$

- **Calculating Torque Converter PCR $/Year:**

$$Site\frac{\$}{yr} = 2020\ Site\ Oper.Hrs * \frac{2020\ Site\ GPH * Torque\ Converter\ Cost}{1\ MM\ Gal}$$

Assumptions:

Site operating hours = Ready Production hrs + Operational Delay hrs + Shift Change hrs for 2020 (goal is time the truck is running)

Current PCR interval taken from Oct. 2020 FCST

Component cost is estimated at Jan. 2020 average* dealer prices

Gallons/hour for T/C calculation estimated from 2020 MEM fuel burn data

1 MM Gal PCR interval for T/C calculated from 2020 site gal/hr

*SA average after FESA CAP+MER discount is applied

# Forecasted Differential PCR Savings per Year

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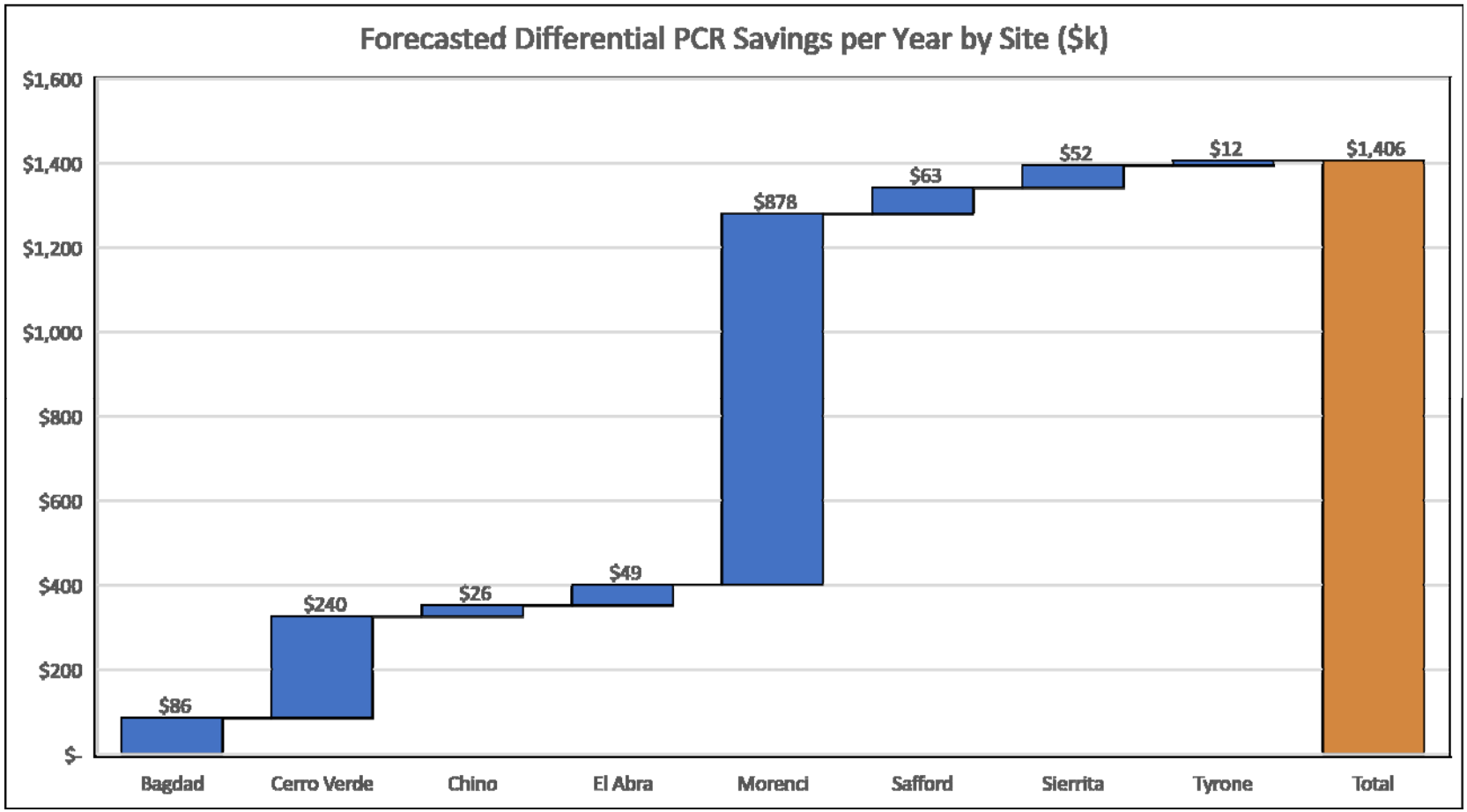
- PCR quantity is based off average number of PCRs needed per year using 2020 operating hours; actual numbers each year may be higher/lower than average
- Total estimated FMA cost savings of $1.4MM/year




*Estimate based on Jan. 2021 average component costs, 2020 operating hours, and Oct. 2020 PCR intervals

# Forecasted Final Drive PCR Savings per Year

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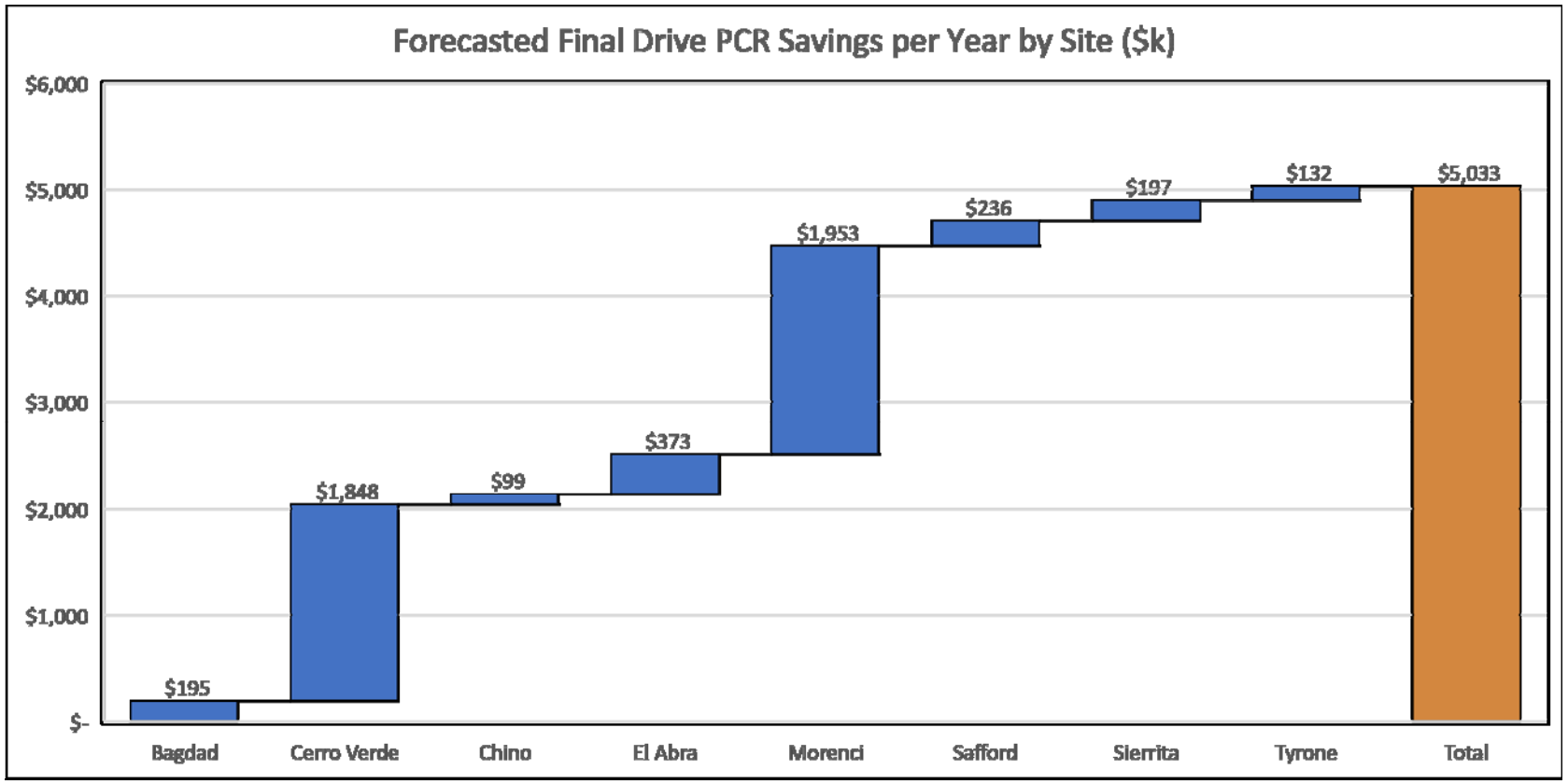
- PCR quantity is based off average number of PCRs needed per year using 2020 operating hours; actual numbers each year may be higher/lower than average
- Total estimated FMA cost savings of $5.03MM/year




*Estimate based on Jan. 2021 average component costs, 2020 operating hours, and Oct. 2020 PCR intervals

# Forecasted Transmission PCR Savings per Year

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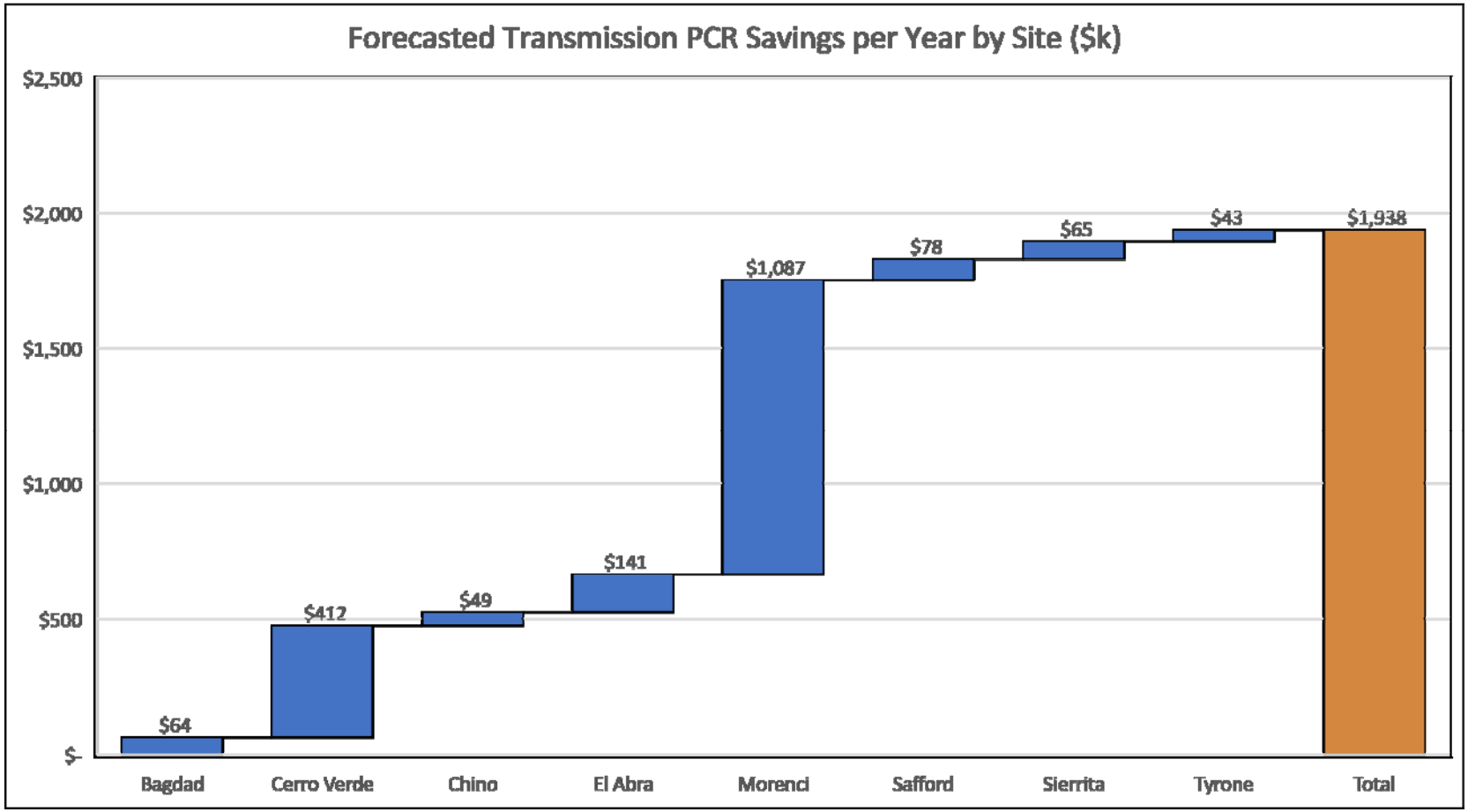
- PCR quantity is based off average number of PCRs needed per year using 2020 operating hours; actual numbers each year may be higher/lower than average
- Total estimated FMA cost savings of $1.9MM/year




*Estimate based on Jan. 2021 average component costs, 2020 operating hours, and Oct. 2020 PCR intervals

# Forecasted Torque Converter PCR Savings per Year

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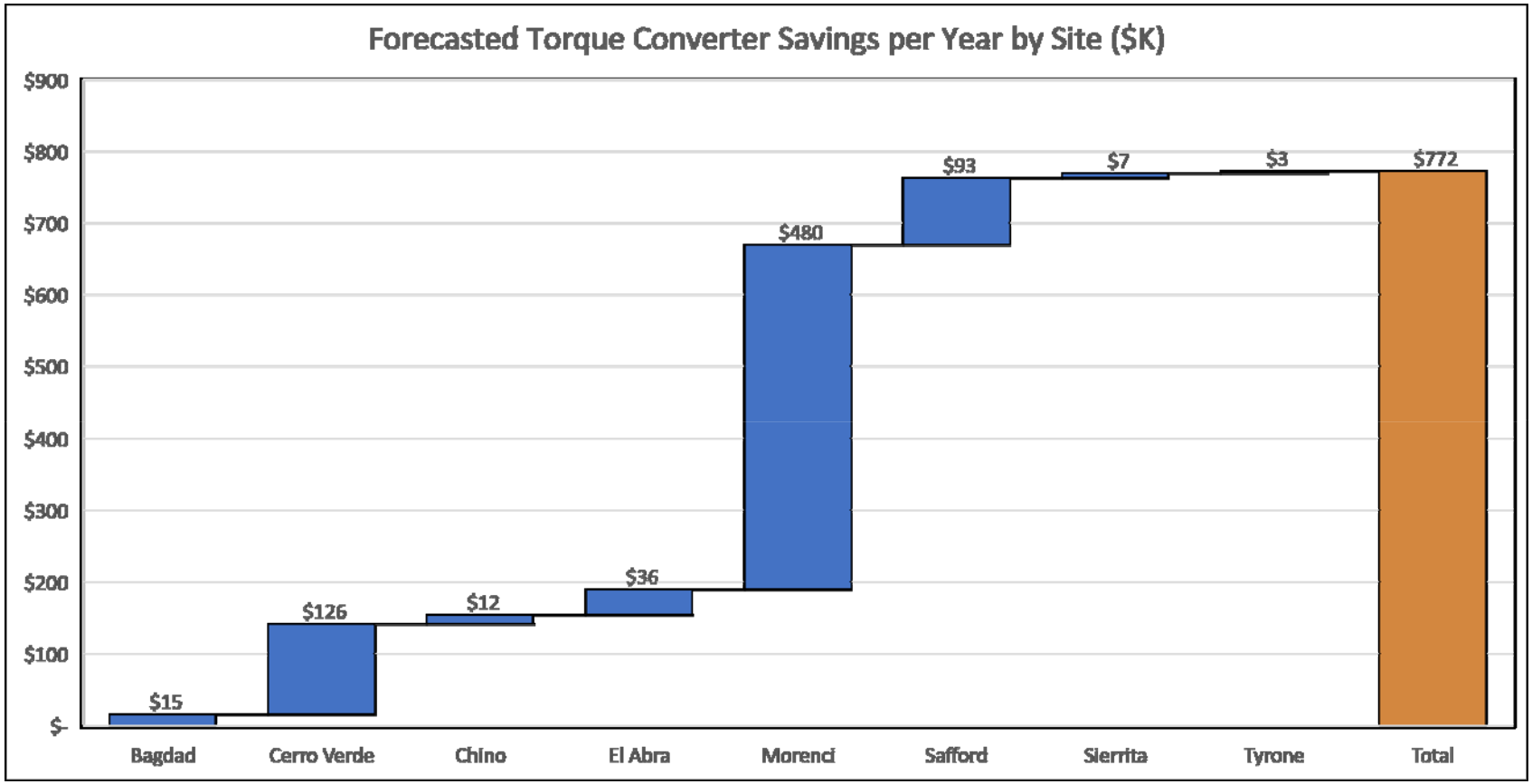
- PCR quantity is based off average number of PCRs needed per year using 2020 operating hours; actual numbers each year may be higher/lower than average
- Total estimated FMA cost savings of $772k/year




*Estimate based on Jan. 2021 average component costs, 2020 operating hours, and Oct. 2020 PCR intervals

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Introduction

# Maintenance

Intervention

Recommendations

Sustainability

Future Opportunities

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# Main PM Maintenance

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- As we did With the Feel the Fuel Burn Agile Team, we:
- Reviewed all components (Transmission, Torque Converter, Differential, Final drive PM activities from all FMI sites
- Consolidated all information and added input from Caterpillar and team SME's
- Provided a list of best practices for PM activities with a supporting document called the PM Book
- PM Book content includes SOP's for 'high-risk' components PM activities determined by SME's as requiring extra focus while performing the job

# Commissioning/Break-in Procedures and Training Guides for Components - 793

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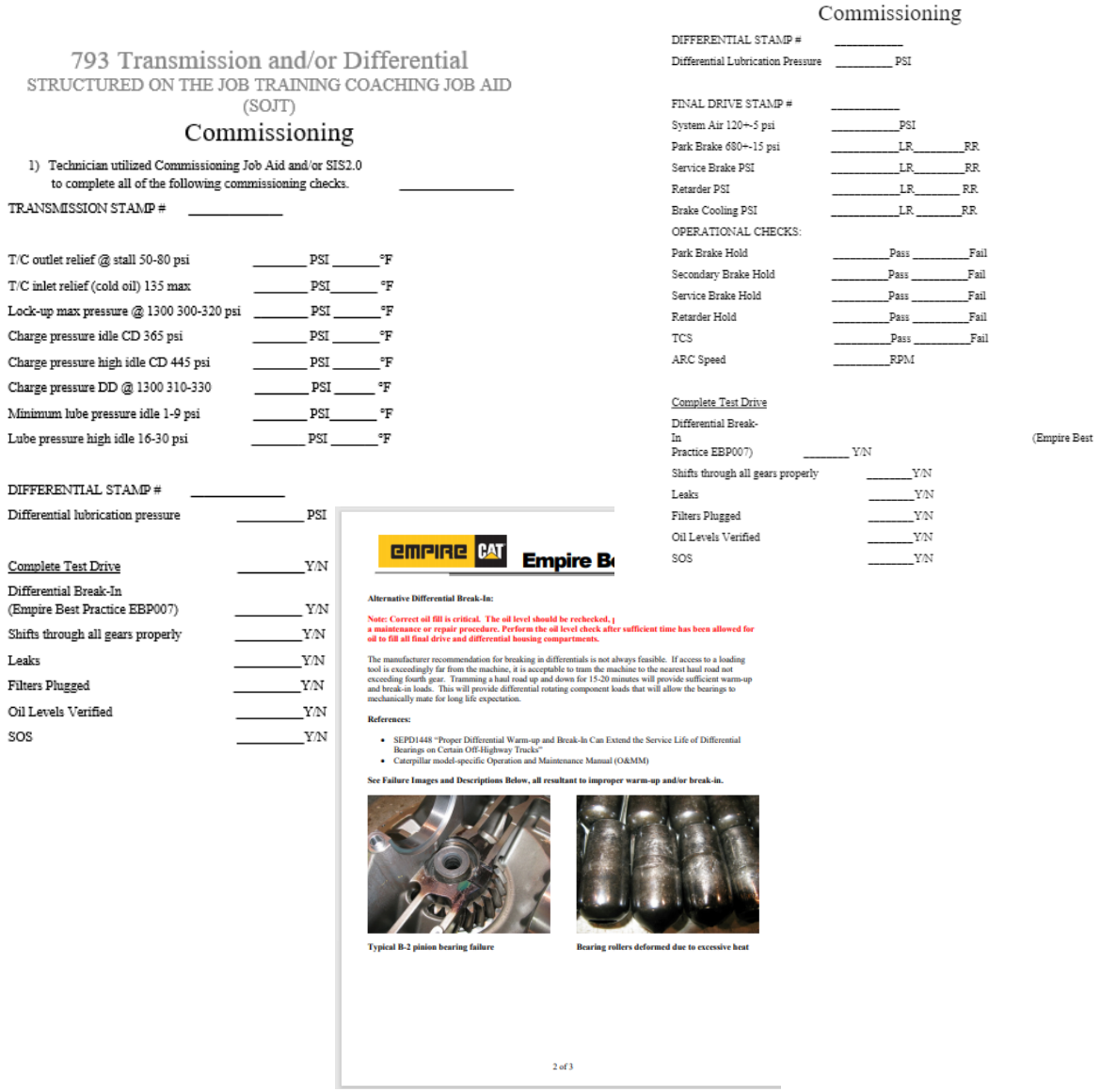
Below are the links to the procedures and training guides to properly commission and break-in the components along with On-the-Job Training for the technicians.

Link to Differential Break In Procedure

Link to Transmission Commissioning Sheet

Link to Final Drive Commissioning Sheet

Link to Torque Converter Commissioning Sheet



793 Transmission and/or Differential
STRUCTURED ON THE JOB TRAINING COACHING JOB AID (SOJT)

Commissioning

1) Technician utilized Commissioning Job Aid and/or SIS2.0 to complete all of the following commissioning checks. _____

TRANSMISSION STAMP # _____

| | | |
|---|---|---|
| T/C outlet relief @ stall 50-80 psi | _____ PSI | _____ °F |
| T/C inlet relief (cold oil) 135 max | _____ PSI | _____ °F |
| Lock-up max pressure @ 1300 300-320 psi | _____ PSI | _____ °F |
| Charge pressure idle CD 365 psi | _____ PSI | _____ °F |
| Charge pressure high idle CD 445 psi | _____ PSI | _____ °F |
| Charge pressure DD @ 1300 310-330 | _____ PSI | _____ °F |
| Minimum lube pressure idle 1-9 psi | _____ PSI | _____ °F |
| Lube pressure high idle 16-30 psi | _____ PSI | _____ °F |

DIFFERENTIAL STAMP # _____
Differential lubrication pressure _____ PSI

| | |
|---|---|
| Complete Test Drive | _____ Y/N |
| Differential Break-In (Empire Best Practice EBP007) | _____ Y/N |
| Shifts through all gears properly | _____ Y/N |
| Leaks | _____ Y/N |
| Filters Plugged | _____ Y/N |
| Oil Levels Verified | _____ Y/N |
| SOS | _____ Y/N |

EMPIRE CAT Empire B

**Alternative Differential Break-In:**

**Note: Correct oil fill is critical. The oil level should be rechecked, a maintenance or repair procedure. Perform the oil level check after sufficient time has been allowed for oil to fill all final drive and differential housing compartments.**

The manufacturer recommendation for breaking in differentials is not always feasible. If access to a loading tool is exceedingly far from the machine, it is acceptable to tram the machine to the nearest haul road not exceeding fourth gear. Tramming a haul road up and down for 15-20 minutes will provide sufficient warm-up and break-in loads. This will provide differential rotating component loads that will allow the bearings to mechanically mate for long life expectation.

**References:**

- SEPD1448 "Proper Differential Warm-up and Break-In Can Extend the Service Life of Differential Bearings on Certain Off-Highway Trucks"
- Caterpillar model-specific Operation and Maintenance Manual (O&MM)

**See Failure Images and Descriptions Below, all resultant to improper warm-up and/or break-in.**

**Typical B-2 pinion bearing failure**

**Bearing rollers deformed due to excessive heat**

2 of 3

Commissioning

DIFFERENTIAL STAMP # _____
Differential Lubrication Pressure _____ PSI

FINAL DRIVE STAMP # _____

| | |
|---|---|
| System Air 120+-5 psi | _____ PSI |
| Park Brake 680+-15 psi | _____ LR _____ RR |
| Service Brake PSI | _____ LR _____ RR |
| Retarder PSI | _____ LR _____ RR |
| Brake Cooling PSI | _____ LR _____ RR |
| OPERATIONAL CHECKS: | |
| Park Brake Hold | _____ Pass _____ Fail |
| Secondary Brake Hold | _____ Pass _____ Fail |
| Service Brake Hold | _____ Pass _____ Fail |
| Retarder Hold | _____ Pass _____ Fail |
| TCS | _____ Pass _____ Fail |
| ARC Speed | _____ RPM |

Complete Test Drive

| | |
|---|---|
| Differential Break-In (Empire Best Practice EBP007) | _____ Y/N |
| Shifts through all gears properly | _____ Y/N |
| Leaks | _____ Y/N |
| Filters Plugged | _____ Y/N |
| Oil Levels Verified | _____ Y/N |
| SOS | _____ Y/N |

# General Oil Best Practices

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## Best Practices:

- Communicate best practices around oil drains and fill-ups
- Communicate best practices around oil sampling.
  - Ø Sample pump
  - Ø Sample port
- ➤ Monthly sampling strategy for bulk oil (hose reels and lube trucks) at the nozzle
- ➤ Formal Lubrication Training for Maintenance Personnel

## Sampling:

- Implement training for oil sample process and the process to input data into LIMS
- Create a site owner for LIMS data entry
- Distribute oil sample alerts to a broader audience
- Train people on the features of the HTHD

# Maintenance Interventions

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- It is crucial that we follow the maintenance best practices.

- Torque Converters, Transmissions, and Differentials there is no beneficial internal component that we can change on site to extend life. (Engines we can change heads, injectors, etc.)

- Final drives also have limited components we can change (first and second reductions) and we recommend not to change.

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Introduction

Maintenance

# Intervention

Recommendations

Sustainability

Future Opportunities

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# Life Models and Predictive Maintenance Models

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# Predictive Models

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For each major HT component, we are building 2 models

- Life Models
  → how much more life is left in the currently-installed component?
- Predictive Maintenance Models
  → are there any warning signs for the health of the currently-installed component?

Current Status by component & model type:

| Component | Life Model | Predictive Maintenance Model |
|---|---|---|
| *Engine* | ***BO Report in HTHD*** | ***BO Report in HTHD*** |
| Transmission | Model Completed | **BO Report in HTHD** |
| Right Final Drives | Model in Development | **BO Report in HTHD** |
| Left Final Drives | Model in Development | **BO Report in HTHD** |
| Torque Converters | *(not started)* | Model in Development |
| Differential | *(not started)* | *(not started)* |

# *Case Study*: MORT527 in September 2020

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MORT527's engine failed ("Engine Day Light") in mid-September 2020. The Engine PM Model alarmed in Red since early April 2020.

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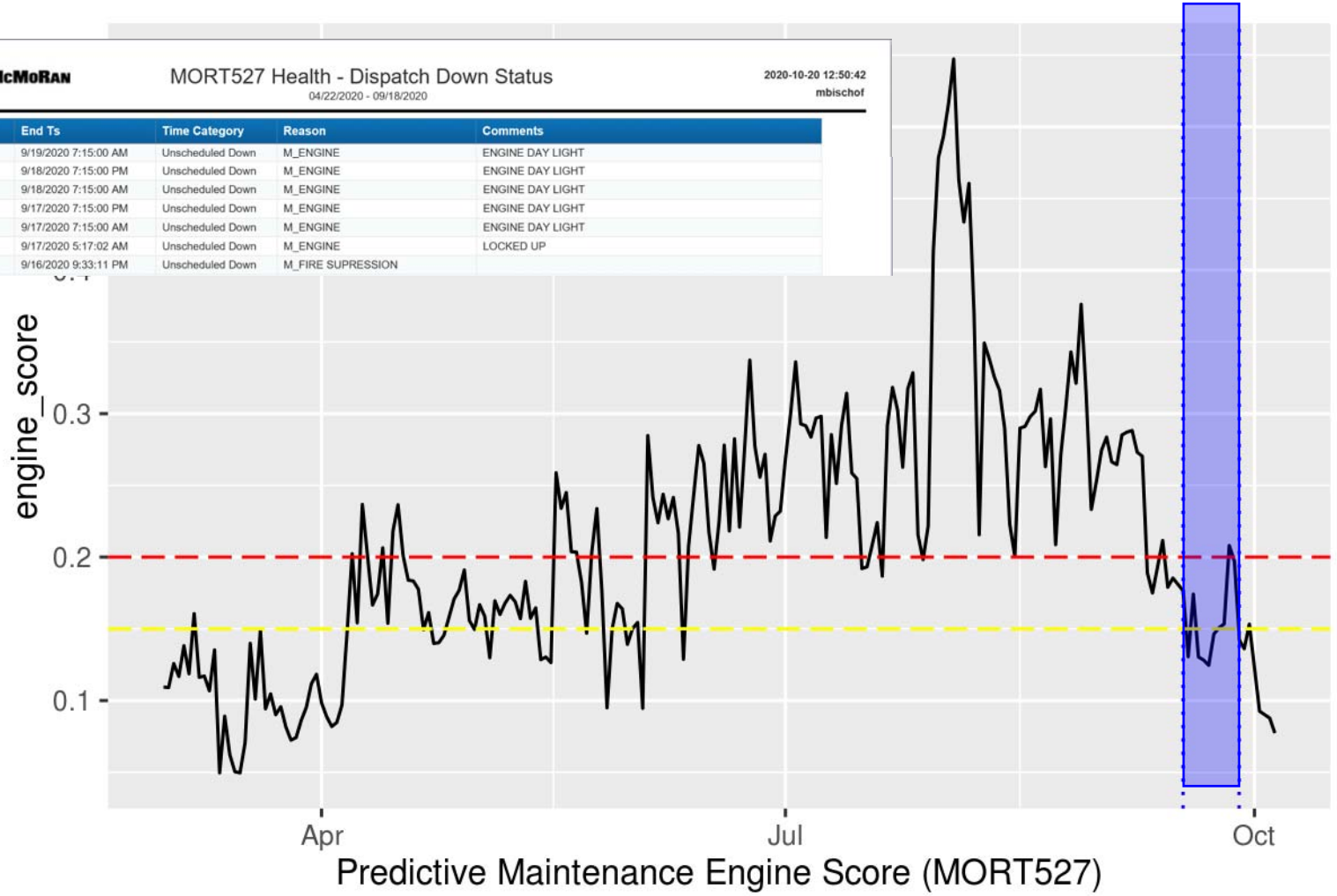
MORT527 Health - Dispatch Down Status

04/22/2020 - 09/18/2020

2020-10-20 12:50:42
mbischof

| Start Ts | End Ts | Time Category | Reason | Comments |
|---|---|---|---|---|
| 9/18/2020 7:15:00 PM | 9/19/2020 7:15:00 AM | Unscheduled Down | M_ENGINE | ENGINE DAY LIGHT |
| 9/18/2020 7:15:00 AM | 9/18/2020 7:15:00 PM | Unscheduled Down | M_ENGINE | ENGINE DAY LIGHT |
| 9/17/2020 7:15:00 PM | 9/18/2020 7:15:00 AM | Unscheduled Down | M_ENGINE | ENGINE DAY LIGHT |
| 9/17/2020 7:15:00 AM | 9/17/2020 7:15:00 PM | Unscheduled Down | M_ENGINE | ENGINE DAY LIGHT |
| 9/17/2020 5:30:43 AM | 9/17/2020 7:15:00 AM | Unscheduled Down | M_ENGINE | ENGINE DAY LIGHT |
| 9/16/2020 9:33:11 PM | 9/17/2020 5:17:02 AM | Unscheduled Down | M_ENGINE | LOCKED UP |
| 9/16/2020 8:46:15 PM | 9/16/2020 9:33:11 PM | Unscheduled Down | M_FIRE SUPRESSION | |



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# Site Reports

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# Feedback Methods – Standard Site Report

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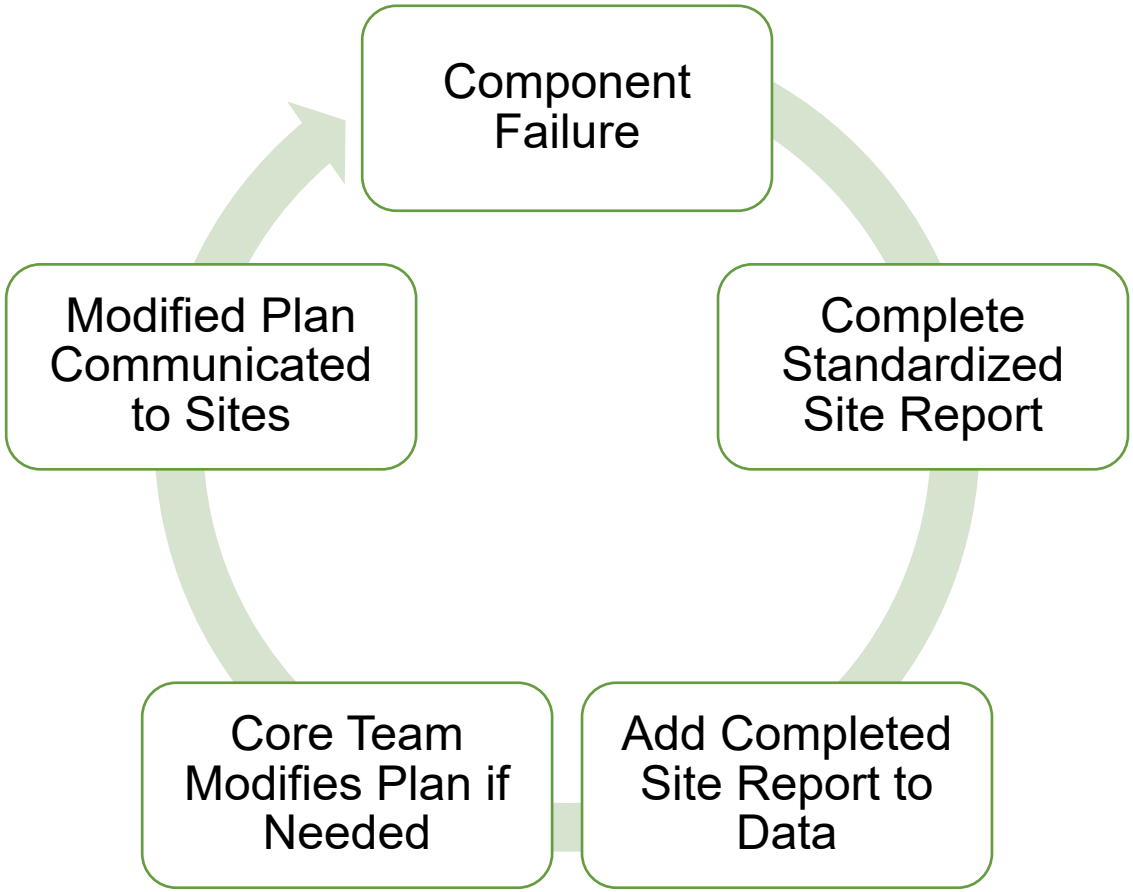
- We must continue to **build and refine** our component life strategy in response to new data
- This process begins with **standardized Site Reports** for failed Powertrain and major components



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Introduction

Maintenance

Intervention

## Recommendations

Sustainability

Future Opportunities

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# Condensed list of Currently Achievable Recommendations

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Below is the finalized list of Component recommendations to be used at all sites going forward in order to Maximize Component Life.

- Extending Component Life to 15000 Travel Hours
  - Extending oil drain intervals based on sample conditions before PM
  - Most up to date Duo Cones in finals and spindles
  - Most up to date Duo Cone install tooling
  - Standardized Ancillary Component PCR replacement list
  - Standardized component Midlife list
  - Extended Life brake disks to be used to maximize brake Life
  - Condition based oil changes from sample data to Extend oil life
    - This helps reduce. Freeport's waste and carbon footprint and potentially save Millions
  - Differential oil cooler installation (Already Happening at TRP but some were missed)

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# Oil Recommendations

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# Oil Data Summary

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Oil samples from past 2 to 4 years analyzed to understand life of oil

Minimal indications of oil degradation at current maximum intervals

## Differential/Final

- PD6000 shows minimal degradation at 5000 hrs. in North America
- 3000 hrs. for Cerro Verde with current oil
- 6000 hrs. for El Abra with current oil

## Transmission

- Current data supports 2500 hrs. for North American sites
- Current data supports 1500 hrs. for Cerro Verde
- Current data supports 2000 hrs. for El Abra

## Spindle

- 2500 hrs. achievable with PD6000 or Power Drive SAE 60 in North America
- No data for El Abra, and only data from 500 hr. samples from Cerro Verde – possibility to extend significantly with testing

# Changing Attitudes Around Changing Oil

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## Condition based oil drain strategy starts here

- Daily evaluation of Oil Sample Reports to identify when to change oil
- Would not require major changes to PM plans.
  - Sample should be taken from 400-500 hours. Plan oil drains from results.
  - Training for sample information to help understand importance

Extending Transmission, Differential, Final, and Spindle oil drain intervals through condition-based changes could potentially save more than $3MM in North America alone.

## Freeport's Carbon Footprint

- Estimated 845k gallon reduction in oil usage over life of components in North America
  - 20MM lbs. reduction in $CO_2$ emissions (based on EIA)

# Cost Savings Summary

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Estimated Potential Cost Savings Breakdown

- Safford – $0 savings (already doing condition-based oil changes)
- Tyrone – $66k
- Bagdad - $114k
- Sierrita – $235k
- Chino – $374k
- Morenci - $2,209k

Example:

| Differential oil extended drain example PD6000 | | | | Average Differential Life 20,000 eng hours |
|---|---|---|---|---|
| Differential PD6000 | 2000hrs | Differential PD6000 | 5000hrs | |
| # Trucks | 149 | # Trucks | 149 | |
| Gallons | 270 | Gallons | 270 | |
| Price/gallon | $8.15 | Price/gallon | $8.15 | |
| Times/comp life | 10 | Times/component | 4 | |
| Oil Cost/yr/truck | $22,005.00 | Oil Cost/yr/truck | $8,802.00 | |
| Oil Cost/fleet/yr | $3,278,745.00 | Oil Cost/fleet/yr | $1,311,498.00 | Difference $1,967,247.00 |

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# Component Recommendations

FREEPORT

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# Extending Component life recommendations condensed list

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- Our team realizes that there have been many updates to the duo cones
- Ensure all sites and dealers are using most updated duo cones and installation tooling
- Standardized list of components to replace at PCR and after Failures to ensure component longevity
- Midlife PCR recommendations for drivelines, roto chambers and slack adjusters
- Entire fleet to use Extended Life brake discs as a direct replacement of standard brake discs to aide in extending final drive life
- All sites ensure that the most updated park brake release adjustment procedure is being followed to make sure park brakes are not dragging
  - Park brake pressures must be adjusted at the Left Rear wheel for proper release pressure. Verify park brake pressure at wheel replaced. (RENR8330) (SENR6343)

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# TRP Recommendations – Differential Oil Coolers

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# Do Our D-Model Fleets Exceed the Limit?

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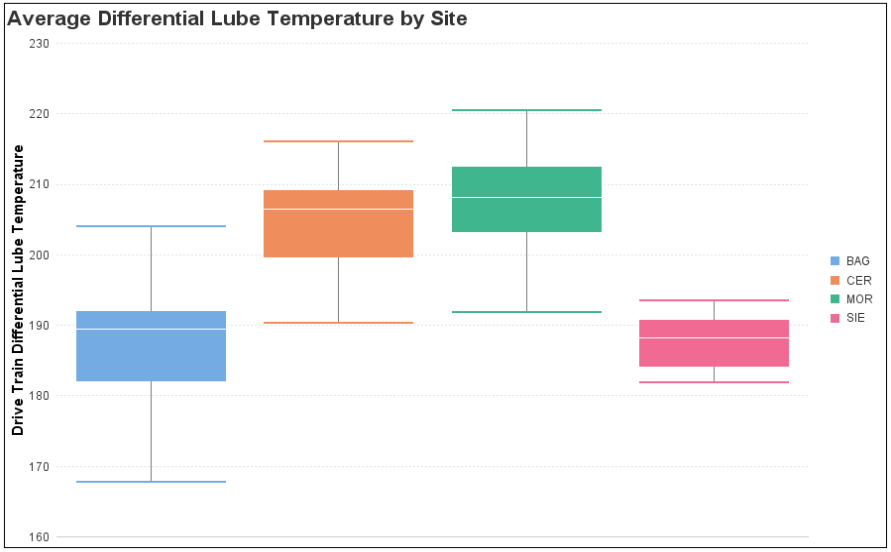
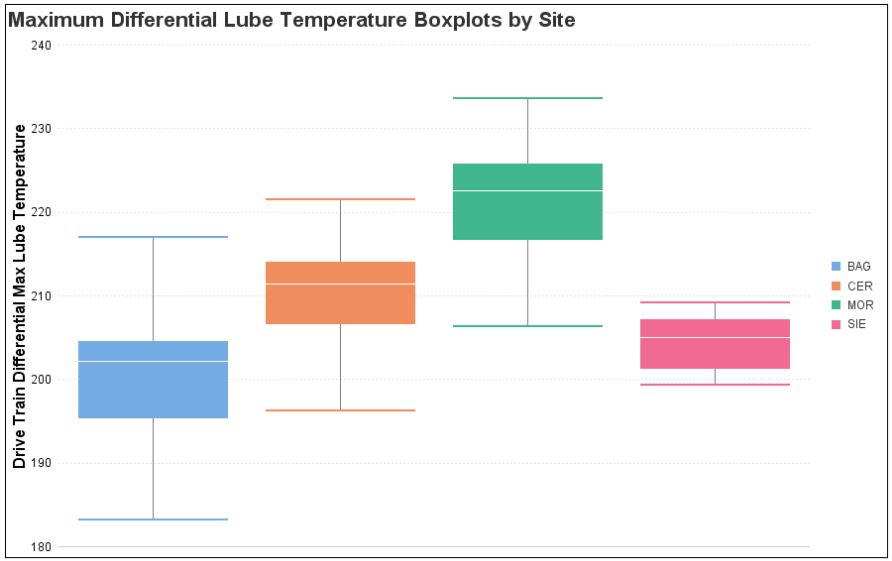
- Boxplot data shows that during the summertime, average oil temperatures consistently exceed the threshold of 194° F consistently in the summertime particularly at sites with flat, high-speed runs (Morenci/CV)

- The exception is Bagdad, who currently have differential oil coolers on all trucks except for T220



# Differential Cooler Recommendations

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- Standardize installation of differential oil cooler package on all D-Model TRPs

- Retrofit machines that have already gone through TRP but did not receive the update

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# H&E Finals

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# H&E Final Drive

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**OVERVIEW**

- H&E Final Drive is mainly a CAT Final Drive with addition of H&E improvements.
- The process and time to R&I the final drive CAT are equal WITH H&E final drive.
- The maintenance practices are equal between CAT and H&E, only have the difference in kidney looping. H&E requires this process for each independent components (final drive RH, Final drive LH and Differential and Differential oil coolers are ineffective.
- Oil samples show that particle counts and wear are similar.
- Bearing, gear and other parts are original CAT**.**
- H&E finals do have a direct impact on isolating failures.
- The pre-load procedure was a block due to H&E policy.
- Recommendation is we continue to use Caterpillar finals.

Links: https://www.h-eparts.com/solutions/mining-solutions/birrana-enhancements-wheel-ends/

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Introduction

Maintenance

Intervention

Recommendations

## Sustainability

Future Opportunities

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# Site Communication/Transition Plan

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## Communicate to Management and Superintendents

- MVP rollout & value
- Feedback system
- Importance of proper maintenance, Best Practices, and intervention

## Frontline Supervisors/Planners

- Value of work
- Use of PM books, commissioning guides and intervention tools
- Implementation of recommendations and Best Practices

## All Truck Shop Techs

- Value and purpose of increased work
- Execute Best Practices
- Positive recognitions

# CL Sustainability Team Charter

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| | |
|---|---|
| **Opportunity** | • Establish a team that meets with **all sites** to monitor, answer questions, and share information between all sites and dealers |
| **Goal** | • Add to the **success** of the Component Life Project at all sites |
| **Objectives** | • Provide a means by which **all sites** can gain and **share information** that will help to extend the life of all CAT Haul Truck components |
| **Expectations** | • Meet via **teleconference bi-monthly** to discuss data combining the FTFB and CL teams |

# Proposed CL Sustainability Team

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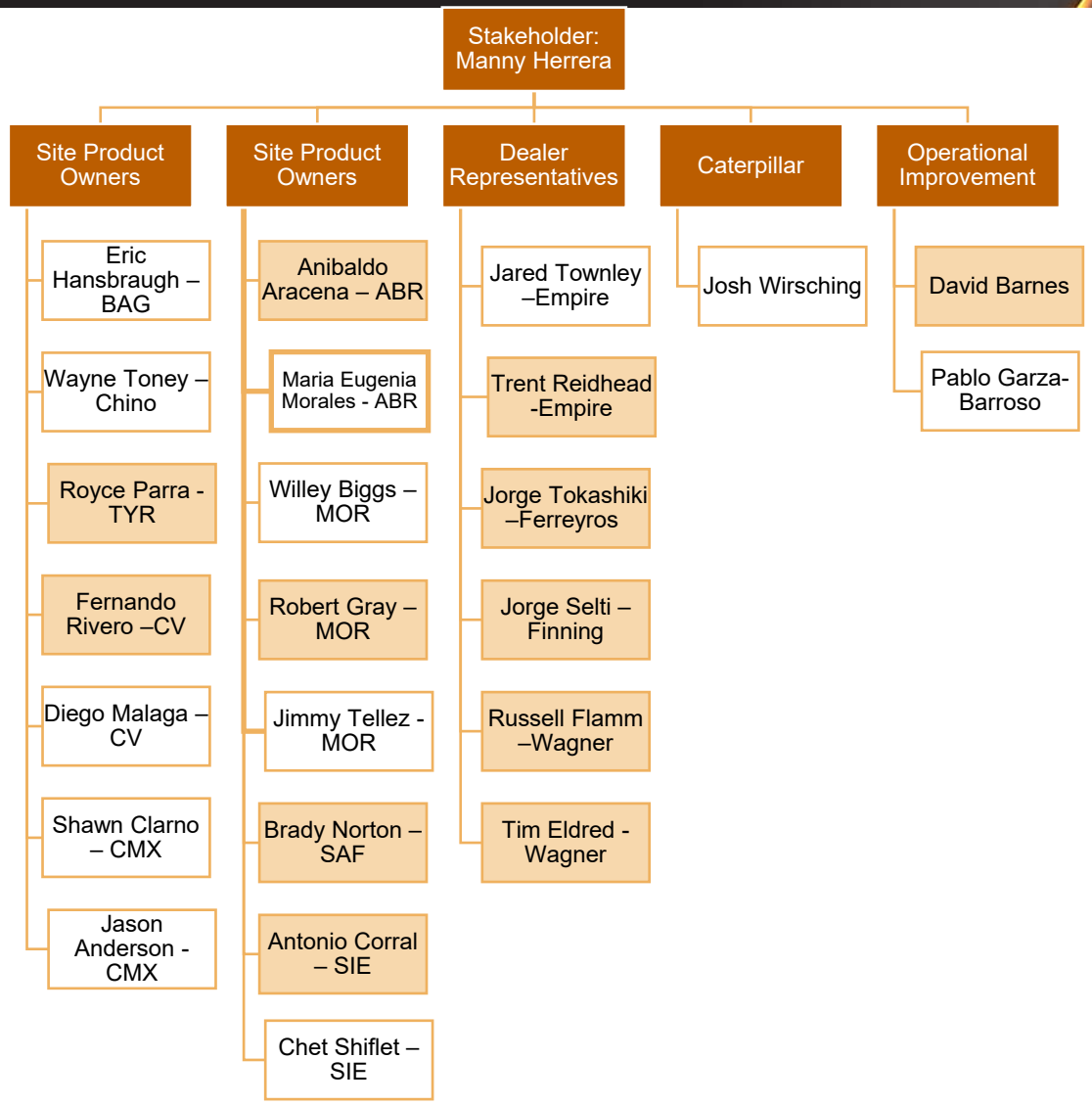


Member of the FTFB sustainability team

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# Tracking Value

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# How do we track Value?

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Utilize Sustainability Dashboard in Power BI to track key metrics across all sites

- Ensure component maintenance costs are maintained
- Track component life at each site in an easy-to-use format
- Ensure component reliability is maintained

Customer feedback is key as we iterate on this report

# Power BI Component Overview
# MVP

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4/19/2021 12:47:35 PM

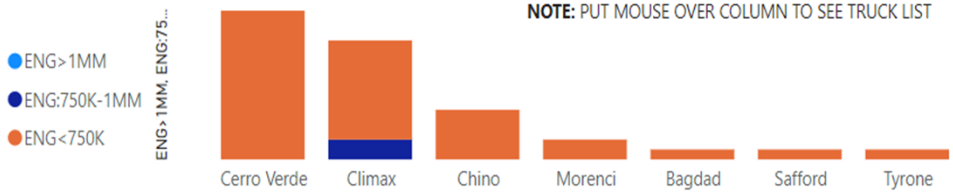
## MAJOR COMPONENTS BY EQUIPMENT

FREEPORT-MCMORAN

NOTE: To make multiple Selection Ctrl + Left button of mouse

| SITE | MODELO | SERIE | TRUCK |
|---|---|---|---|
| Select all | Select... | Sel... | All |
| Bagdad | 730 | | |
| Cerro Verde | 735 | A | STATUS |
| Chino | 740 | B | OP |
| Climax | 769 | | |
| Morenci | 773 | | |
| Safford | 777 | | |
| Tyrone | 789 | | |
| | 793 | | |
| | 930 | | |
| | GR8 | | |

ENGINE
T. CONVER.
TRANSM.
DIFFEREN.
FINAL DRIV.
BED SERV.
SUSPENS.




| | Cerro Verde | Climax | Chino | Morenci | Bagdad | Safford | Tyrone | Total |
|---|---|---|---|---|---|---|---|---|
| ENG>1MM | | | | | | | | |
| ENG:750K-1MM | | 2 | | | | | | 2 |
| ENG<750K | 15 | 10 | 5 | 2 | 1 | 1 | 1 | 35 |
| Count | 15 | 12 | 5 | 2 | 1 | 1 | 1 | 37 |

| | | |
|---|---|---|
| > 1MM Gallons | 665 | < 5 000 hrs |
| 900K - 1 MM Gallons | 23,357 | > 20 000 hrs |

| Site | Truck | Modelo | Serie | Engine Fuel Burn (gal) | Fuel Burn Rate (gal/hrs) | Engine (hrs) | Torque Converter (hrs) | Transmission (hrs) | Differential (hrs) | Final Drive Rigth (hrs) | Final Drive Left (hrs) | Bed Service (hrs) | Suspension FRLT (hrs) | Suspension FRRT(hrs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Climax | HT103 | 789 | A | 906,344 | 48 | 18,689 | 18,689 | 2,743 | 18,689 | 14,579 | 18,689 | 0 | 0 | 0 |
| Climax | HT105 | 789 | A | 769,341 | 60 | 12,805 | 17,324 | 17,324 | 17,324 | 17,080 | 0 | 0 | 0 | 0 |
| Climax | HT106 | 789 | A | 658,462 | 71 | 9,219 | 11,753 | 3,952 | 18,587 | 0 | 323 | 0 | 0 | 0 |
| Climax | HT101 | 789 | B | 636,121 | 81 | 7,890 | 13,676 | 13,652 | 0 | 21,828 | 21,828 | 0 | 0 | 0 |
| Climax | HT102 | 789 | B | 636,121 | 55 | 11,532 | 13,429 | 13,222 | 13,222 | 12,268 | 12,268 | 0 | 0 | 0 |
| Climax | HT107 | 789 | A | 626,983 | 55 | 11,476 | 6,134 | 0 | 0 | 11,476 | 11,476 | 0 | 0 | 0 |
| Climax | HT104 | 789 | A | 615,457 | 53 | 11,537 | 14,209 | 0 | 19,697 | 19,697 | 9,439 | 0 | 0 | 0 |
| Climax | HT109 | 789 | A | 586,183 | 41 | 14,346 | 7,637 | 14,346 | 14,346 | 17,061 | 17,061 | 0 | 0 | 0 |
| Climax | HT108 | 789 | A | 520,009 | 47 | 10,966 | 5,465 | 21,426 | 10,966 | 10,966 | 10,966 | 0 | 0 | 0 |
| Climax | HT110 | 789 | A | 147,239 | 10 | 14,690 | 14,666 | 14,666 | 14,666 | 14,666 | 14,666 | 0 | 0 | 0 |
| Bagdad | BAM00039 | 789 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cerro Verde | 43 | 789 | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cerro Verde | 47 | 789 | A | 0 | 0 | 4,337 | 4,337 | 10,731 | 10,731 | 17,404 | 17,404 | 0 | 26,935 | 26,935 |

# Ranked Components – High to Low MVP

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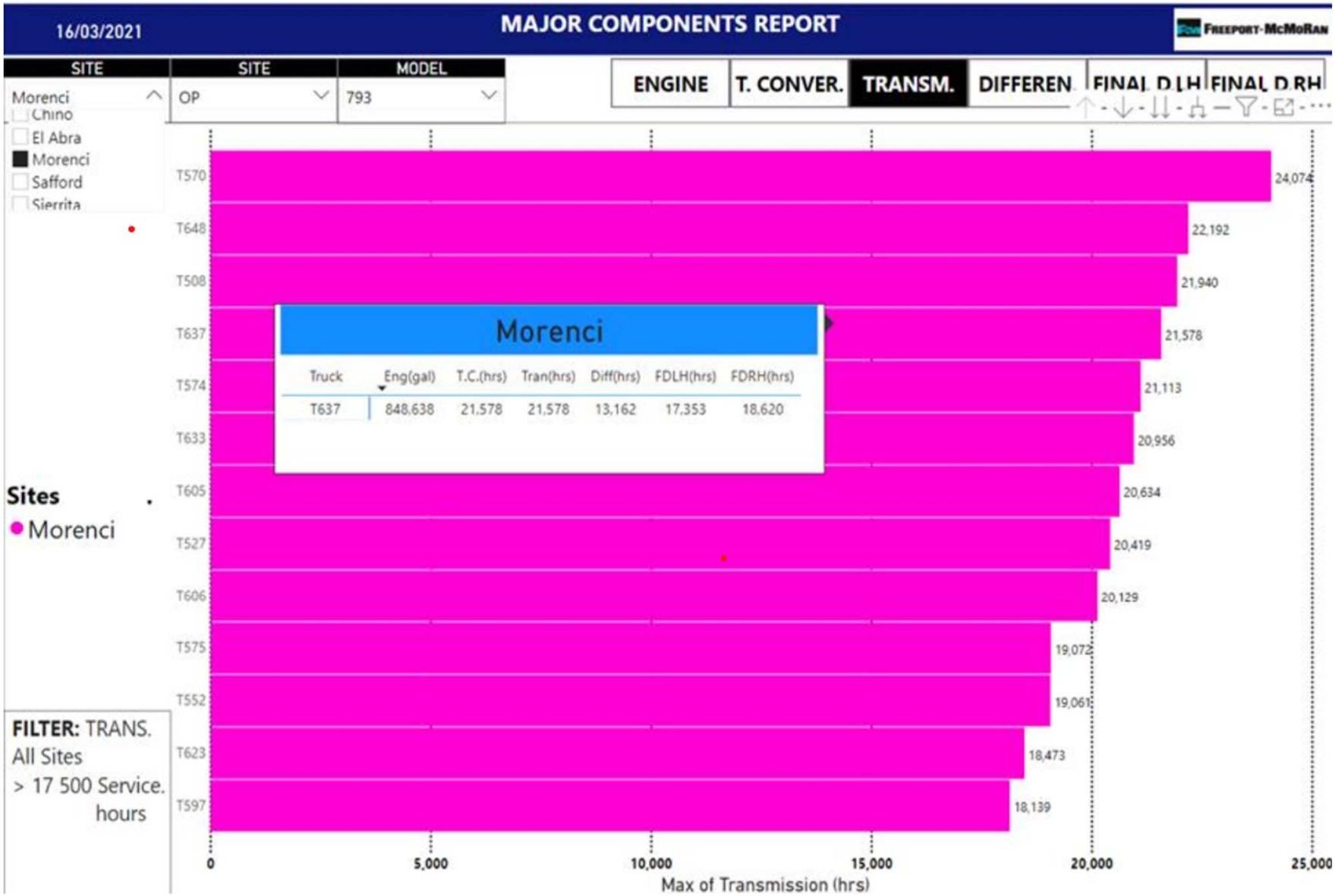
FOREMOST IN COPPER



# Communicating Team Goals to a Broader Audience

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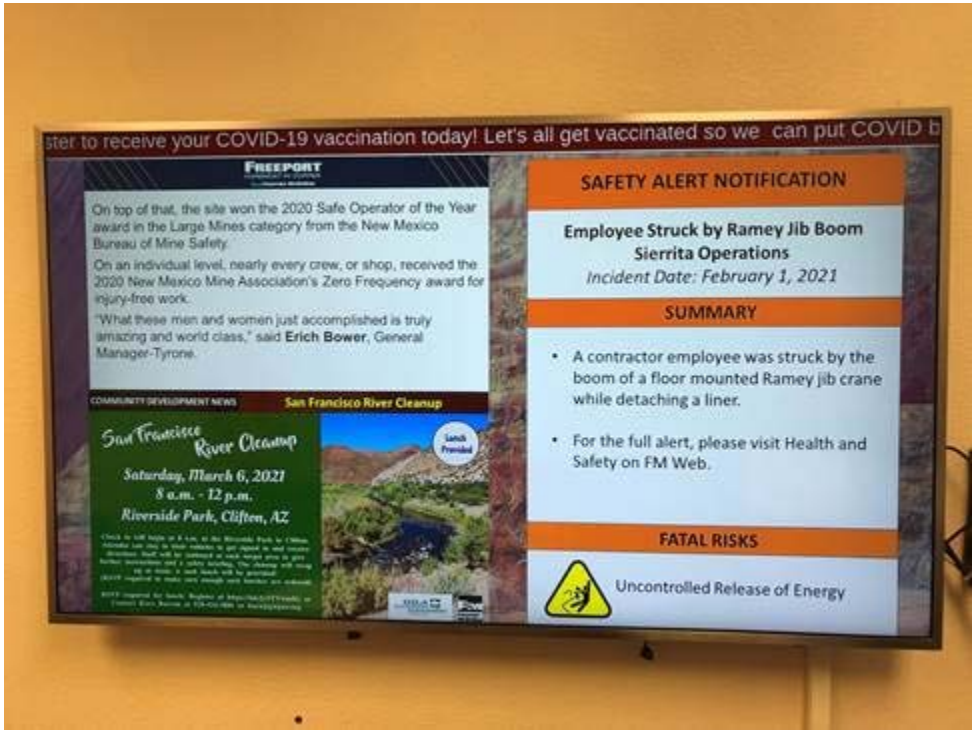
Utilize V-Net Screens onsite to communicate wins, value, and KPIs which will create some excitement and build a bit of friendly competition between sites

Work is underway with the corporate communications team to make this a reality



# Our Ask: Own and Support this for your Site!

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Your buy-in and continued support is critical to meeting our ambitious goal

Please communicate *why* we are making any changes to increase component life – show the value!

Let the core team know any doubts or setbacks so they can be addressed

Each site should form a small team to carry on component life work and communicate back to the Core Team through site Product Owners:

- Site Dealer Representative
- Site Sr. Planner
- Site Supervisor

These efforts and collaboration on each site should tie in with the 1MM gallon fuel burn on engines from the Feel the Fuel Burn team.


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Introduction

Maintenance

Intervention

Recommendations

Sustainability

# Future Opportunities

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# Future Opportunities Overview

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# Things We Found Out Along the Way

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Extensive analyses have generated future opportunities for improving HT reliability and are highlighted below. Details are in the appendix

- Syncon Synthetic differential fluid
- Synthetic differential fluid test in Cerro Verde
- Automated oil sample data entry system (SAP/LIMS interaction)
- B/C model differential oil cooler test
- On-Board kidney looping
- 793C model transmission in 793B model trucks
- Brake cooler improvements
  - Mesabi brake coolers
  - Brake cooler screens
- D-Model Extra-Retarding packages
- Diamond Like Carbon Coated bearing for front and rear wheel groups
  - Currently in some front wheel groups in Chino
- Standardize the use of Wiggins Quick Connect fittings at all sites for all equipment


Link to Future Opportunity details

# MVP Site Rollout (Tentative)

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| | | |
|---|---|---|
| March 24th/ 25th — Morenci | March 26th — Tyrone | March 30th — Safford |
| March 31st — Sierrita | April 5th — Bagdad | April 6th — El Abra |
| April 7th/8th — Cerro Verde | April 13th — Chino | April 20th — Climax |

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# Comments and Questions

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# Appendix

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# Power BI Component Overview MVP

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02/03/2021

NOTE: To make multiple Selection Ctrl + Left button of mouse

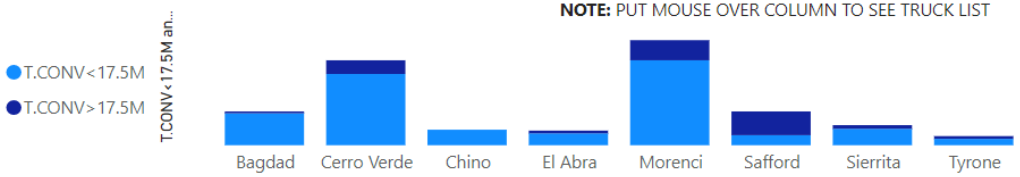
| SITE | MODELO | SERIE | TRUCK |
|---|---|---|---|
| Select all | Select... | Sel... | All |
| Bagdad | 730 | | |
| Cerro Verde | 735 | B | STATUS |
| Chino | 740 | C | OP |
| El Abra | 769 | D | |
| Morenci | 773 | | |
| Safford | 777 | | |
| Sierrita | 789 | | |
| Tyrone | 793 | | |
| | 930 | | |
| | GR8 | | |

ENGINE
T. CONVER.
TRANSM.
DIFFEREN.
FINAL DRIV.
BED SERV.
SUSPENS.

## MAJOR COMPONENTS BY EQUIPMENT

FREEPORT-McMoRan

**NOTE:** PUT MOUSE OVER COLUMN TO SEE TRUCK LIST




| | Bagdad | Cerro Verde | Chino | El Abra | Morenci | Safford | Sierrita | Tyrone | Total |
|---|---|---|---|---|---|---|---|---|---|
| T.CONV<17.5M | 35 | 78 | 17 | 13 | 93 | 11 | 18 | 7 | 272 |
| T.CONV>17.5M | 2 | 15 | | 3 | 22 | 26 | 4 | 3 | 75 |
| Count | 37 | 93 | 17 | 16 | 115 | 37 | 22 | 10 | 347 |

> 1MM Gallons
900M - 1 MM Gallons

665
23,357

< 5 000 hrs
> 20 000 hrs

| Site | Truck | Modelo | Serie | Engine Fuel Burn (gal) | Fuel Burn Rate (gal/hrs) | Engine (hrs) | Torque Converter (hrs) | Transmission (hrs) | Differential (hrs) | Final Drive Rigth (hrs) | Final Drive Left (hrs) | Bed Service (hrs) | Suspension FRLT (hrs) | Suspension FRRT(hrs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Morenci | T626 | 793 | D | 1,085,664 | 52 | 20,692 | 3,743 | 3,743 | 13,209 | 8,531 | 1,748 | 0 | 0 | 0 |
| Cerro Verde | 130 | 793 | D | 1,059,996 | 51 | 20,804 | 24,733 | 9,533 | 14,840 | 17,755 | 21,493 | 16,767 | 18,220 | 13,091 |
| Tyrone | HAL417 | 793 | B | 1,030,368 | 42 | 24,482 | 17,497 | 14,401 | 12,279 | 18,404 | 18,404 | 0 | 0 | 0 |
| Sierrita | 16059 | 793 | D | 1,012,962 | 52 | 19,537 | 19,537 | 9,914 | 9,914 | 13,261 | 14,247 | 0 | 0 | 0 |
| Bagdad | BAM00220 | 793 | D | 1,011,253 | 46 | 21,962 | 665 | 7,726 | 7,726 | 15,339 | 15,339 | 0 | 0 | 0 |
| Tyrone | HAL415 | 793 | B | 1,010,228 | 43 | 23,639 | 23,357 | 11,647 | 19,481 | 17,194 | 17,194 | 0 | 0 | 0 |
| Cerro Verde | 113 | 793 | D | 1,007,355 | 51 | 19,674 | 10,317 | 3,841 | 10,317 | 10,317 | 10,317 | 20,520 | 17,530 | 17,530 |
| Bagdad | BAM00216 | 793 | D | 1,005,561 | 51 | 19,771 | 19,771 | 17,650 | 11,688 | 10,160 | 11,688 | 0 | 0 | 0 |
| Sierrita | 16072 | 793 | D | 969,805 | 46 | 20,873 | 4,328 | 12,074 | 7,421 | 22,662 | 3,271 | 0 | 0 | 0 |
| Morenci | T563 | 793 | B | 963,064 | 46 | 20,852 | 8,765 | 8,896 | 19,247 | 15,889 | 13,632 | 0 | 0 | 0 |
| Sierrita | 16073 | 793 | D | 956,505 | 52 | 18,222 | 18,222 | 3,290 | 13,220 | 13,220 | 7,968 | 0 | 0 | 0 |
| Cerro Verde | 139 | 793 | B | 954,259 | 42 | 22,549 | 8,417 | 13,285 | 20,171 | 19,506 | 9,130 | 0 | 19,818 | 19,818 |
| Cerro Verde | 119 | 793 | D | 948,758 | 49 | 19,182 | 16,272 | 8,447 | 6,982 | 6,982 | 6,982 | 17,958 | 16,416 | 16,416 |
| Morenci | T539 | 793 | B | 939,473 | 45 | 20,864 | 8,110 | 2,425 | 1,714 | 20,468 | 0 | 0 | 0 | 0 |

# Overview of Life Models

FREEPORT
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## Building a Component Life Model

1. Get data on historical components with install and removal dates

2. Calculate their life using the correct life metric
   → *for example*: 4 years of differentials at all sites & calculated travel hours

3. Get data to describe the working conditions during the life of the component
   → *for example*: oil data, excessive idle data & operating conditions for engines

4. Build statistical model predicting component life with these condition variables

5. Solicit SME input to finalize model
   → *for example*: exclude counterintuitive variables

FREEPORT
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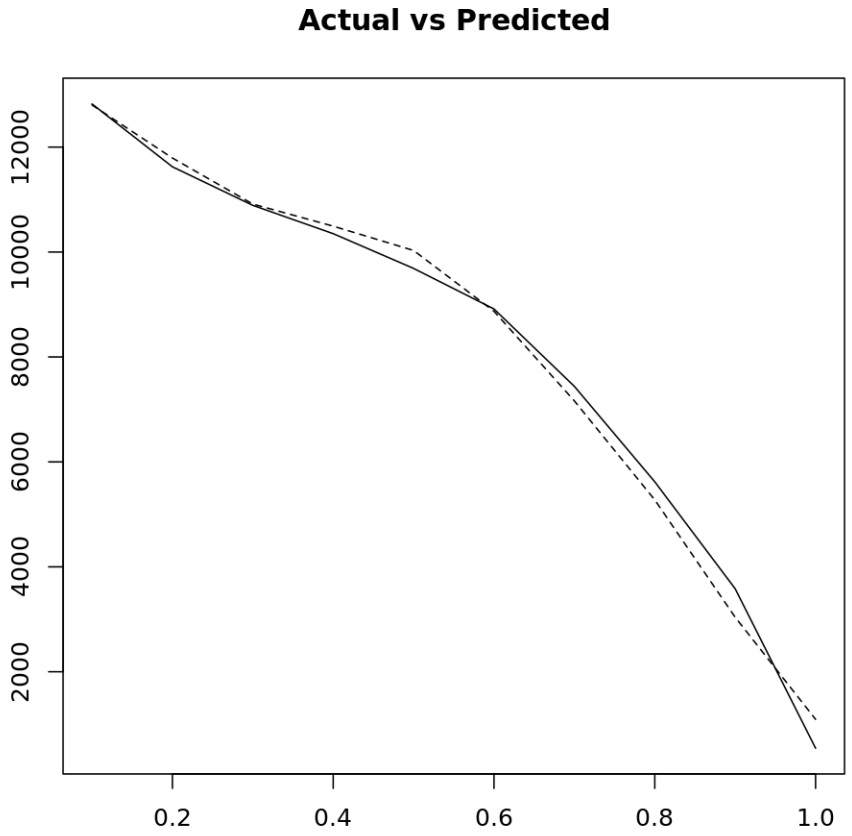
**Model Diagnostics for Component Life Model:**
→ Actual component life closely tracks predicted component life



# Overview of Predictive Maintenance Models

FREEPORT
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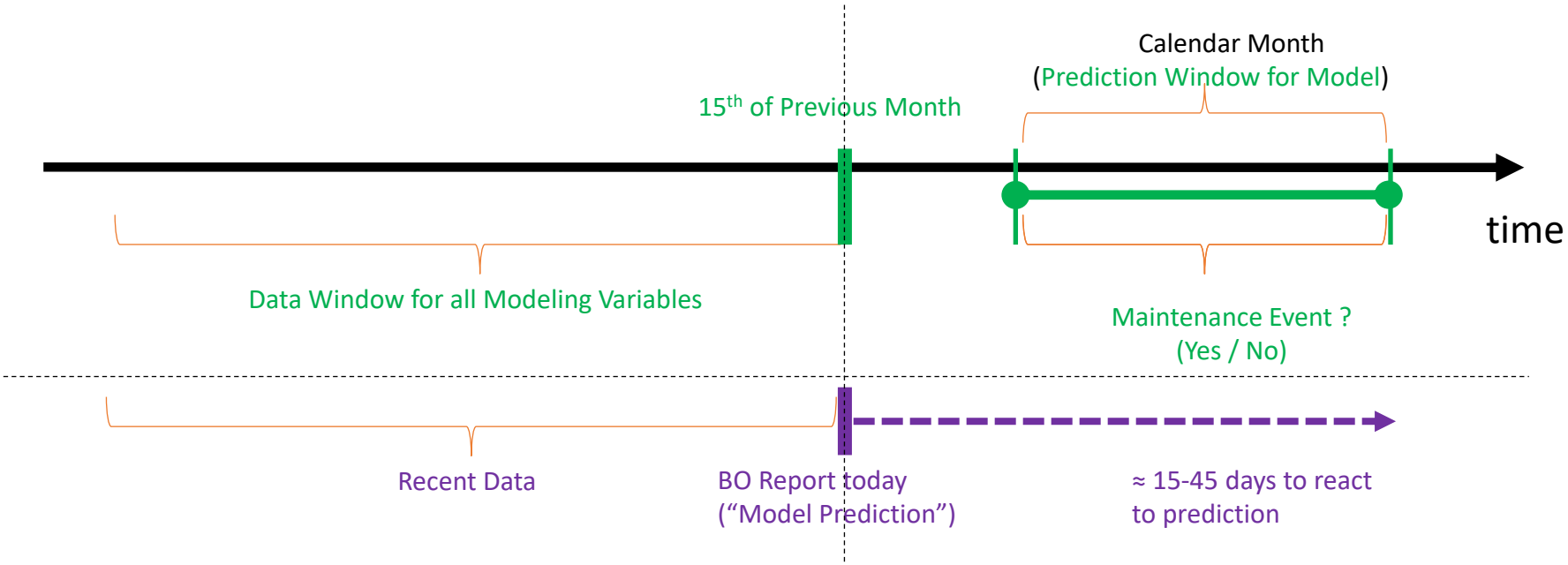
A “performance window” methodology is used to identify these major maintenance events for model building & model usage:

- Model Building
  - For each calendar month, determine whether an event has happened.
  - Attach the dataset of the predictive variables for the 15th of the previous month
- Model Usage (“Predictions”)
  - The predictions will give user 15–45 days to preemptively service the component



# Oil Dialysis / Kidney Loop

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## Current Differential Kidney Loop Intervals

| Site | Interval |
|---|---|
| Bagdad | 500 hours |
| Chino | 460 hours |
| Cerro Verde | 660 hours |
| Climax | N/A |
| El Abra | 350 hours |
| Morenci | 1750 hours or N/A |
| Safford | 500 hours |
| Sierrita | 500 hours |
| Tyrone | 500 hours |

Currently only El Abra kidney loops transmission oil (at 350 hours)

# Current Oil in Components

FREEPORT
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| Site | Hydraulics | Transmission | Front Spindles | Rear Axle (Final Drive and Differential) |
|---|---|---|---|---|
| **Bagdad** | P66 PowerDrive SAE 30 | P66 PowerDrive SAE 30 | P66 PowerDrive 6000 | P66 PowerDrive 6000 |
| **Chino** | P66 PowerDrive SAE 10 | P66 PowerDrive SAE 30 | P66 PowerDrive 6000 | P66 PowerDrive 6000 |
| **Climax** | P66 PowerDrive SAE 10 | P66 PowerDrive SAE 30 | P66 PowerDrive 6000 | P66 PowerDrive 6000 |
| **Morenci** | P66 PowerDrive SAE 30 | P66 PowerDrive SAE 30 | P66 PowerDrive 6000 | P66 PowerDrive 6000 |
| **Safford** | P66 PowerDrive SAE 10 | P66 PowerDrive SAE 30 | P66 PowerDrive SAE 60 | P66 PowerDrive 6000 |
| **Sierrita** | P66 PowerDrive SAE 10 | P66 PowerDrive SAE 30 | P66 PowerDrive 6000 | P66 PowerDrive 6000 |
| **Tyrone** | P66 PowerDrive SAE 10 | P66 PowerDrive SAE 30 | P66 PowerDrive 6000 | P66 PowerDrive 6000 |
| **Cerro Verde** | Shell Spirax S4 CX SAE 10 | Shell Spirax S4 CX SAE 30 | Shell Spirax S5 CFD M SAE 60 | Shell Spirax S5 CFD M SAE 60 |
| **El Abra** | Mobil Mobiltrans HD SAE 10 | Mobil Mobiltrans AST | Mobil Mobilube XFD SAE 50 | Mobil Mobilube XFD SAE 50 |

# Current Oil Change Intervals

FREEPORT
FOREMOST IN COPPER

| Site | Hydraulics | Transmission | Front Spindles | Rear Axle (Final Drive and Differential) |
|---|---|---|---|---|
| **Bagdad** | 3,800 Hours | 2,500 Hours | 2,500 Hours | 3,800 Hours |
| **Chino** | 920 Hours | 920 Hours | 500 Hours | 1848 Hours |
| **Climax** | 1000 Hours | 1000 Hours | 250 Hours | 2000 Hours |
| **Morenci** | 1,600 Hours or SOS Condition | 1,600 Hours or SOS Condition | 1,600 Hours or SOS Condition | 2,000 Hours or SOS Condition |
| **Safford** | 20K Hours PCR or SOS Condition | 20K Hours PCR or SOS Condition | 20K Hours PCR or SOS Condition | 20K Hours PCR or SOS Condition |
| **Sierrita** | 1,000 Hours | 2,000 Hours | 500 Hours | 3,000 Hours |
| **Tyrone** | 1,000 Hours | 1,000 Hours | 500 Hours | 5,000 Hours |
| **Cerro Verde** | 2,600 Hours | 1,300 Hours | 500 Hours | 2,600 Hours |
| **El Abra** | 2,000 Hours | 2,000 Hours | 250/500 Hours | 4,000 Hours |

# Transmission Oil – North America

FREEPORT
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- 5000 Samples Analyzed (2019 and 2020 Oil Samples)
- Team reviewed current oil specifications, sample results and specific factors that determine the oil degradation with the Safford Oil Lab and P66 team
- No indication of Oil Degradation at current max drain interval – 2500 Hours

| Oil Hours | Viscosity 100 | Viscosity 40 | Ca | P | Zn |
|---|---|---|---|---|---|
| 0-500 | 10.85 | 92.08 | 2495 | 871 | 1078 |
| 500-1000 | 10.87 | 92.32 | 2502 | 872 | 1074 |
| 1000-1500 | 10.82 | 91.66 | 2500 | 857 | 1062 |
| 1500-2000 | 10.78 | 91.44 | 2541 | 873 | 1079 |
| 2000+ | 10.80 | 91.47 | 2543 | 875 | 1081 |

# Transmission Oil – Cerro Verde

FREEPORT
FOREMOST IN COPPER

- 1700 Samples Analyzed (2019 and 2020 Oil Samples)
- No indication of Oil Degradation at current max oil hours – 1500 Hours

- **Shell Spirax S4 CX SAE 30:**
  - Meets TO-4 specifications
  - Viscosity at 40C: 93.9 cSt
  - Viscosity at 100 C: 10.9 cSt
  - Viscosity Index: 100
  - Additive Package Element Range
    - Calcium: 3000 to 3600 ppm
    - Phosphorus: 750 to 1000 ppm
    - Zinc: 1000 to 1400 ppm

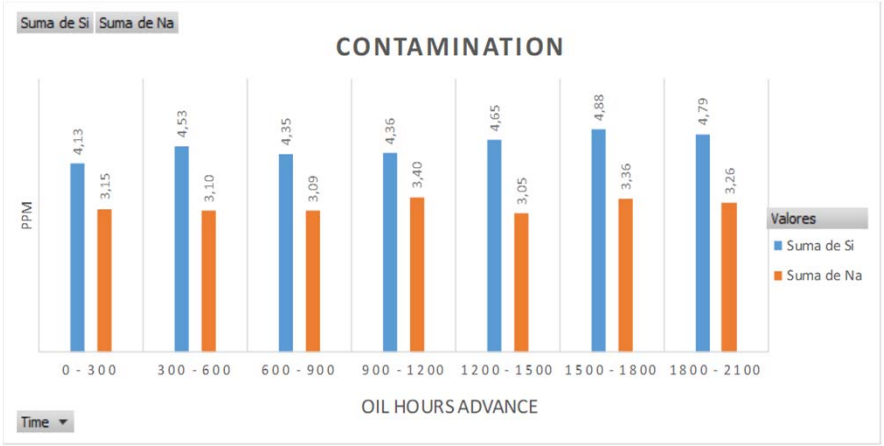
| Oil Hours | Viscosity 100 | Ca | P | Zn |
|---|---|---|---|---|
| 0-500 | 10.87 | 3261.27 | 877.77 | 1249.37 |
| 500-1000 | 10.92 | 3452.07 | 877.23 | 1315.51 |
| 1000-1500 | 10.89 | 3440.49 | 873.61 | 1301.90 |
| 1500+ | 10.89 | 3472.74 | 860.50 | 1321.20 |

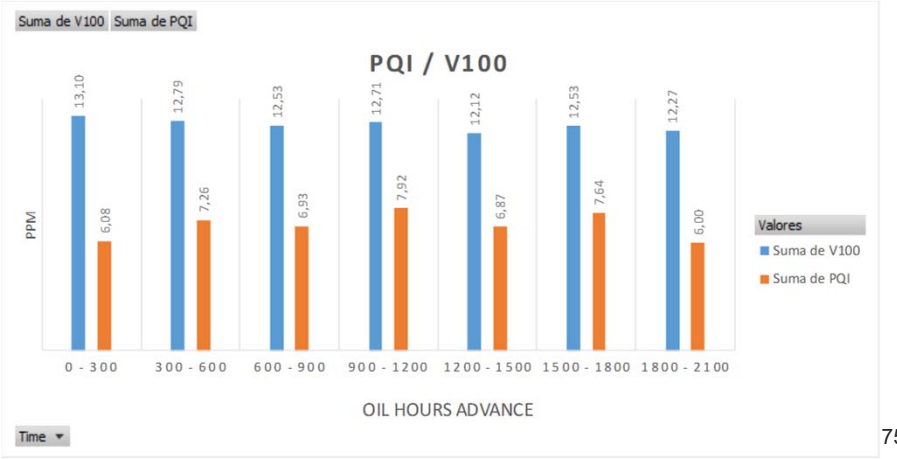
# Transmission Oil – El Abra

FREEPORT
FOREMOST IN COPPER
Team Member

- Type (Mobil Trans AST Multigrade, Meets specifications Caterpillar TO-4M)
- Samples analyzed from 2017 to 2020
- Oil Change 2000 hours or condition
- Oil dialysis / Kidney lube each 350 hours

Analysis.


- Stable wear elements
- Controlled contamination
- Ferrous density with a downward trend
- Viscosity without variations

# Differential Oil – North America

FREEPORT
FOREMOST IN COPPER

## P-66 PowerDrive 6000

- Meets CAT FD-1
- Viscosity at 40C: 344 cSt
- Viscosity at 100 C: 25.8 cSt
- Viscosity Index: 98
- Additive Package Element Range
  - Boron: 70 to 120 ppm
  - Calcium: 200 to 500 ppm
  - Phosphorus: 200 to 500 ppm

5000 hour interval is minimum recommendation with PD6000. Slight oil degradation in samples with increasing hours of runtime, but the viscosity is likely affected by Duo-Cone Leaks. No additive loss.

| Hours | NOx | Oxidation | ISO4 | ISO6 | ISO14 | PQ | TAN | V100 | V40 | B | Ca | Cu | Fe | P | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-500 | 1.17 | 2.28 | 23.36 | 21.09 | 15.84 | 25 | 0.71 | 24.9 | 330.5 | 107 | 385 | 2 | 23 | 343 | 8 |
| 500-1000 | 1.40 | 2.71 | 23.02 | 20.75 | 15.62 | 29 | 0.69 | 24.8 | 328.4 | 102 | 413 | 3 | 26 | 352 | 7 |
| 1000-1500 | 1.62 | 4.05 | 22.98 | 20.71 | 15.47 | 31 | 0.72 | 24.6 | 323.0 | 102 | 440 | 4 | 32 | 359 | 8 |
| 1500-2000 | 1.60 | 4.23 | 22.86 | 20.52 | 15.33 | 34 | 0.76 | 24.6 | 324.3 | 105 | 435 | 3 | 35 | 362 | 7 |
| 2000-2500 | 1.87 | 5.16 | 22.80 | 20.49 | 15.09 | 49 | 0.79 | 24.5 | 322.5 | 102 | 465 | 5 | 40 | 365 | 8 |
| 2500-3000 | 1.79 | 6.01 | 22.88 | 20.35 | 14.68 | 23 | 0.79 | 24.4 | 318.8 | 104 | 460 | 4 | 41 | 366 | 8 |
| 3000-3500 | 1.91 | 5.96 | 22.52 | 20.19 | 14.73 | 40 | 0.81 | 24.4 | 321.6 | 107 | 456 | 4 | 42 | 370 | 8 |
| 3500-4000 | 1.91 | 5.67 | 22.03 | 19.62 | 14.69 | 16 | 0.82 | 24.2 | 317.3 | 108 | 500 | 5 | 41 | 382 | 7 |
| 4000+ | 1.72 | 5.79 | 22.23 | 19.74 | 14.19 | 25 | 0.78 | 23.7 | 308.6 | 102 | 501 | 4 | 42 | 381 | 8 |
| Hours N/A | 1.87 | 4.36 | 23.11 | 20.83 | 15.66 | 32 | 0.83 | 24.7 | 324.7 | 98 | 476 | 4 | 41 | 364 | 11 |

PHILLIPS 66

# Differential Oil – Cerro Verde

FREEPORT
FOREMOST IN COPPER

Shell Spirax S5 CFD M SAE 60

- Meets CAT FD-1
- Viscosity at 100 C: 22.8-25.2 cSt
- Additive Package Element Range
  - Boron: 70 to 120 ppm
  - Calcium: 150 to 500 ppm
  - Phosphorus: 150 to 500 ppm

3000 hour interval is minimum recommendation, with testing to extend it further. Slight oil degradation in samples with increasing hours of runtime. No indication of additive depletion.

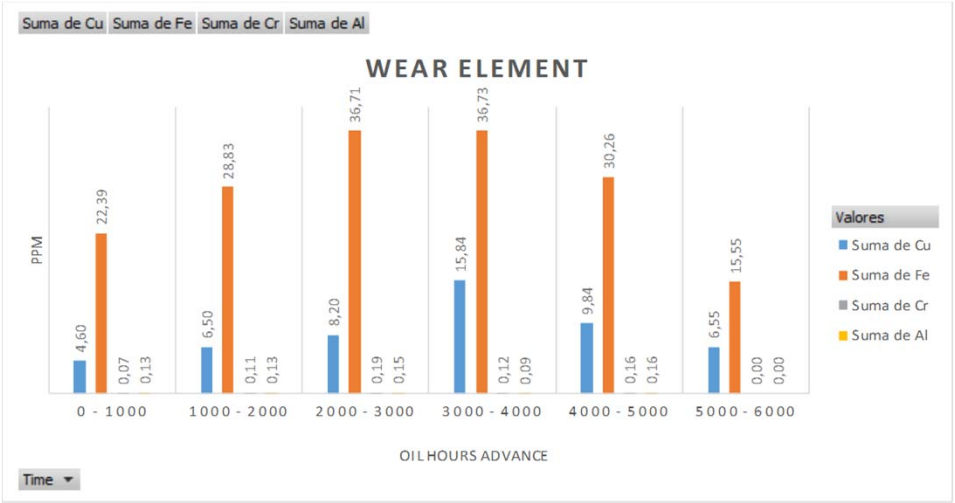
| Hours | Oxidation | ISO4 | ISO6 | ISO14 | PQ | Viscosity 100 | B | Ca | Cu | Fe | P | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-500 | 9.7 | 22.2 | 20.0 | 14.7 | 45 | 22.9 | 84 | 331 | 2 | 20 | 271 | 5 |
| 500-1000 | 10.3 | 22.4 | 20.1 | 14.7 | 32 | 23.8 | 87 | 243 | 2 | 20 | 256 | 5 |
| 1000-1500 | 11.0 | 22.1 | 19.7 | 14.1 | 35 | 23.8 | 86 | 248 | 3 | 23 | 255 | 5 |
| 1500-2000 | 11.2 | 22.4 | 20.2 | 14.6 | 119 | 23.6 | 87 | 258 | 3 | 29 | 256 | 6 |
| 2000-2500 | 11.6 | 22.5 | 20.2 | 14.3 | 30 | 23.6 | 85 | 266 | 3 | 27 | 256 | 5 |
| 2500-3000 | 12.2 | 21.5 | 19.1 | 12.8 | 20 | 23.5 | 85 | 287 | 4 | 29 | 258 | 5 |

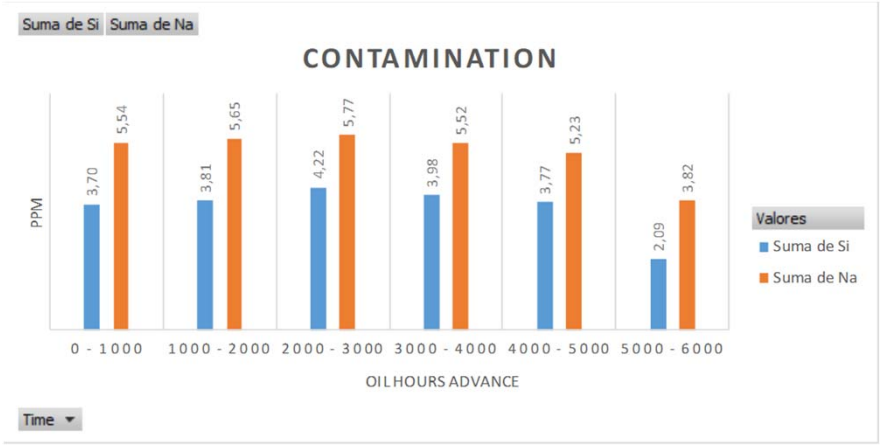
Shell SPIRAX

# Differential Oil – El Abra

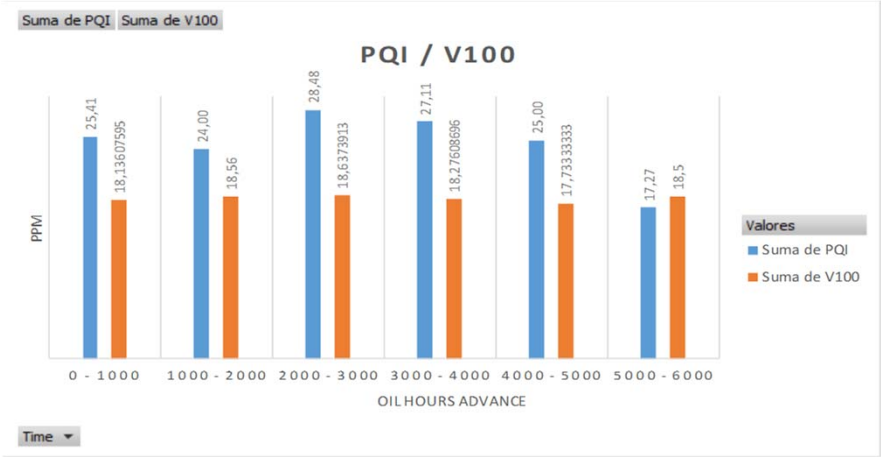
FREEPORT
FOREMOST IN COPPER
Team Member

- Samples analyzed from 2017 to 2020
- Oil Change Currently 6000 hours or condition
- Oil dialysis / Kidney lube each 350 hours




- Stable wear elements
- Controlled contamination
- Ferrous density with a downward trend
- Viscosity without variations



# Spindle Oil Recommendations

FREEPORT
FOREMOST IN COPPER

- Data proves that we can extend spindle oil drain intervals out to 2500hrs in North America

| Oil Hours | NOx | Oxidation | PQ | Viscosity 100 | Viscosity 40 | B | Ca | Fe | Ni | P | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-500 | 0.3 | 0.4 | 17 | 24.7 | 327.2 | 104 | 390 | 19 | 3 | 340 | 19 |
| 500-1000 | 0.8 | 0.6 | 51 | 24.7 | 325.6 | 105 | 424 | 35 | 3 | 357 | 14 |
| 1000-1500 | 0.8 | 0.9 | 81 | 24.5 | 319.6 | 106 | 460 | 74 | 10 | 374 | 18 |
| 1500-2000 | 0.7 | 0.8 | 58 | 24.8 | 327.2 | 110 | 421 | 46 | 4 | 363 | 15 |
| 2000+ | 0.7 | 1.0 | 93 | 24.7 | 324.8 | 107 | 433 | 101 | 6 | 359 | 18 |

| Site | Viscosity Issues | Wear Issues (Fe or PQ) | Contamination (Water or Si) |
|---|---|---|---|
| Bagdad | 6.36% | 10.14% | 1.94% |
| Chino | 28.64% | 5.40% | 2.75% |
| Climax | 4.80% | 6.40% | 0.80% |
| Morenci | 24.15% | 28.66% | 2.68% |
| Safford | 21.25% | 11.92% | 3.13% |
| Sierrita | 4.15% | 1.12% | 0.52% |
| Tyrone | 61.35% | 9.61% | 5.49% |
| NA Overall | 21.75% | 16.61% | 2.61% |

# Is there a difference? The data says there is!

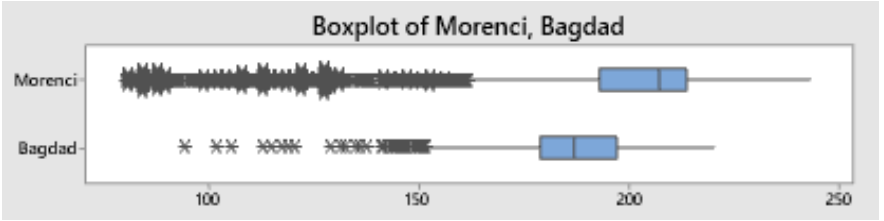
FREEPORT
FOREMOST IN COPPER

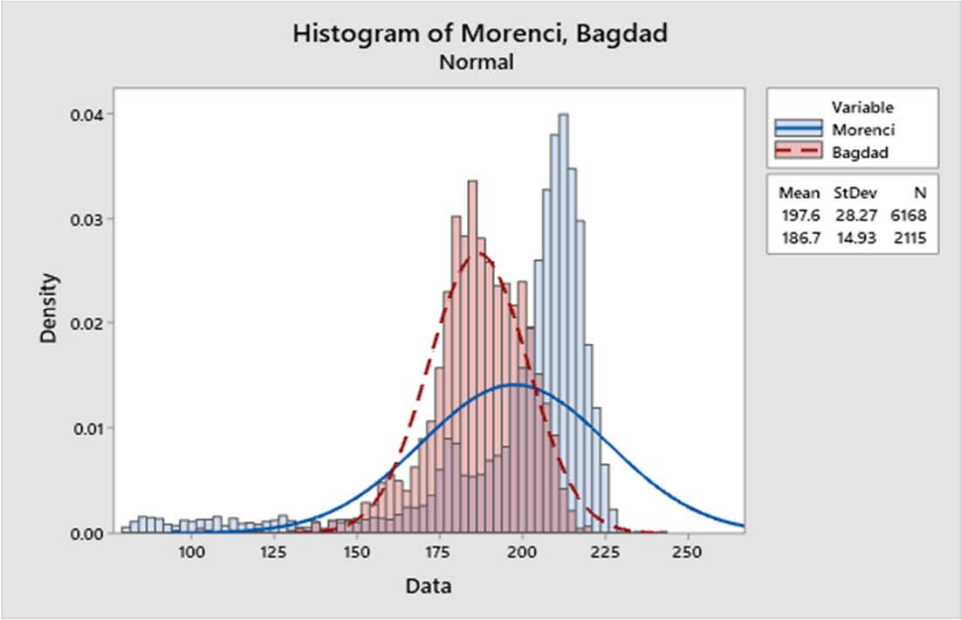
## Descriptive Statistics

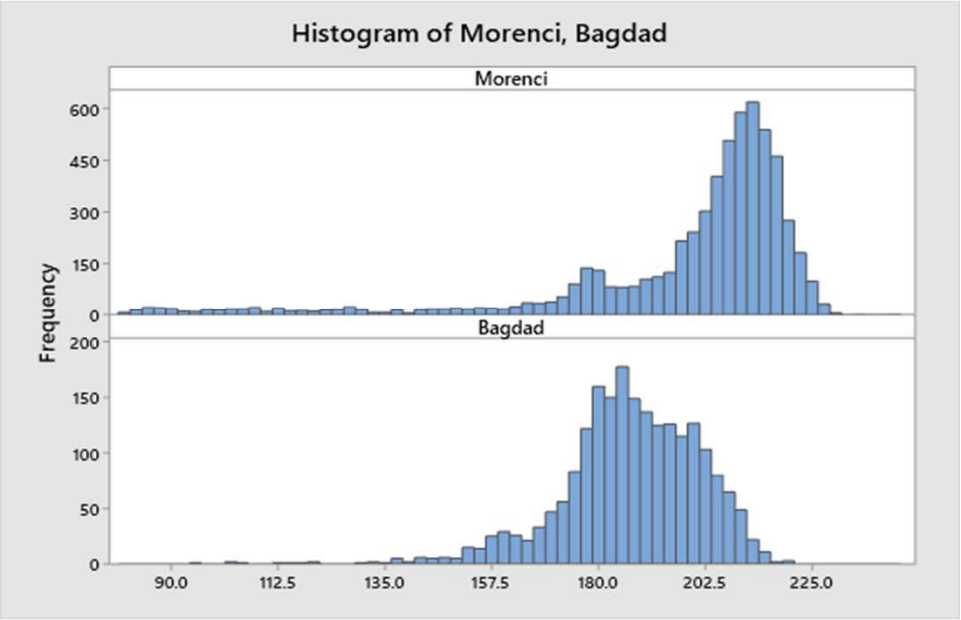
| Sample | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Morenci | 6168 | 197.6 | 28.3 | 0.36 |
| Bagdad | 2115 | 186.7 | 14.9 | 0.32 |

## Estimation for Difference

| Difference | 95% CI for Difference |
|---|---|
| 10.931 | (9.981, 11.882) |



# Without Outliers – BAG vs SIE

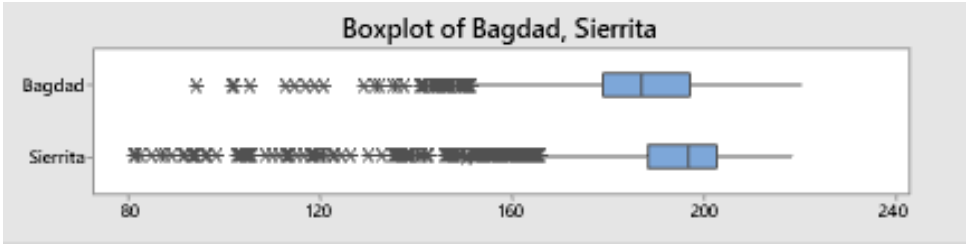
FREEPORT
FOREMOST IN COPPER

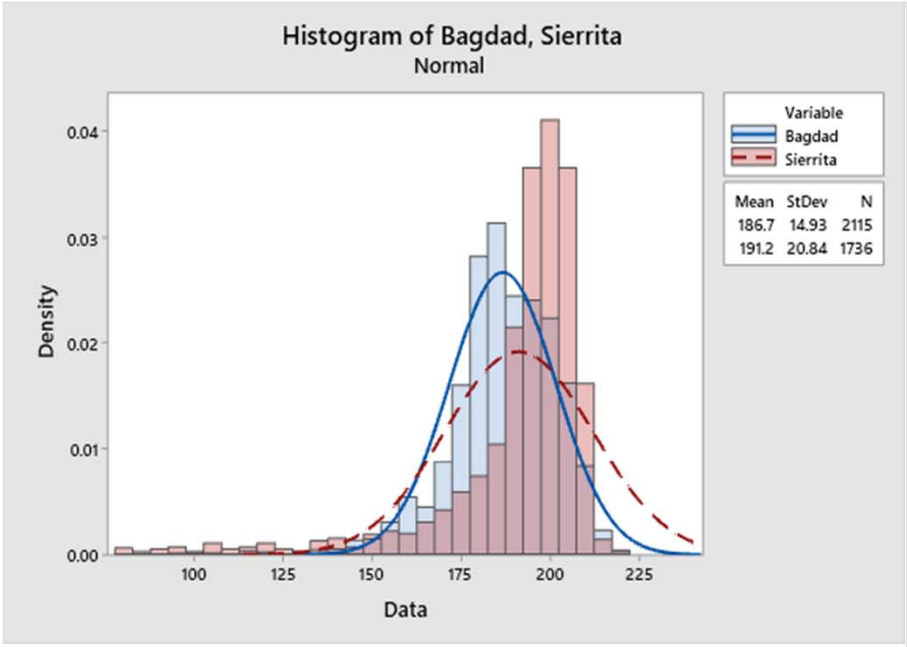
## Descriptive Statistics

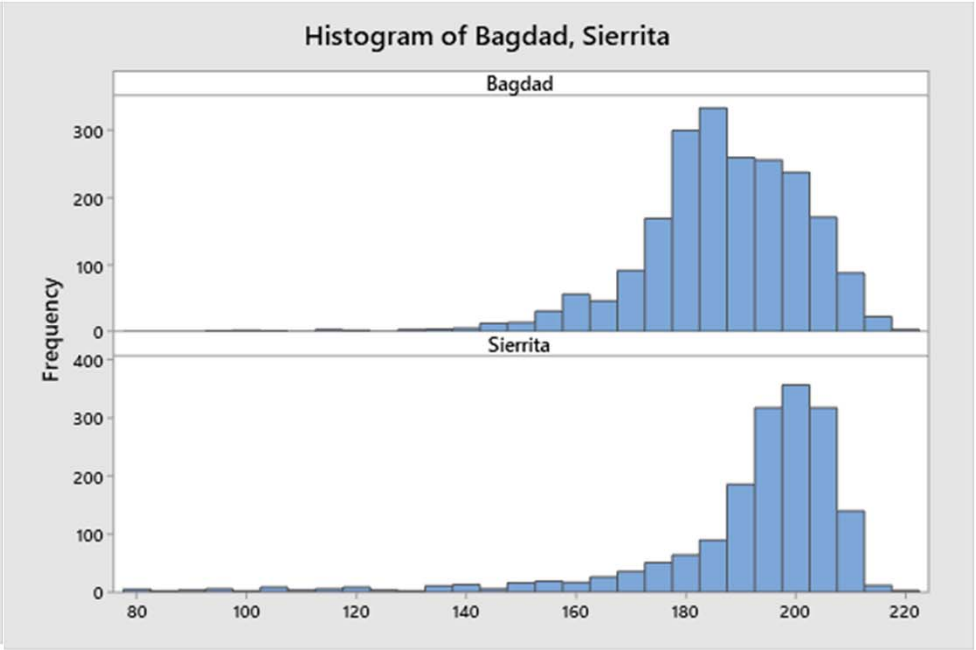
| Sample | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Sierrita | 1736 | 191.2 | 20.8 | 0.50 |
| Bagdad | 2115 | 186.7 | 14.9 | 0.32 |

## Estimation for Difference

| Difference | 95% CI for Difference |
|---|---|
| 4.487 | (3.318, 5.656) |



# Without Outliers – MOR vs SIE

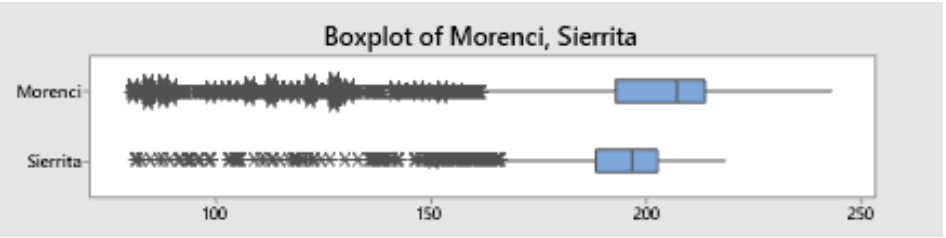
FREEPORT
FOREMOST IN COPPER

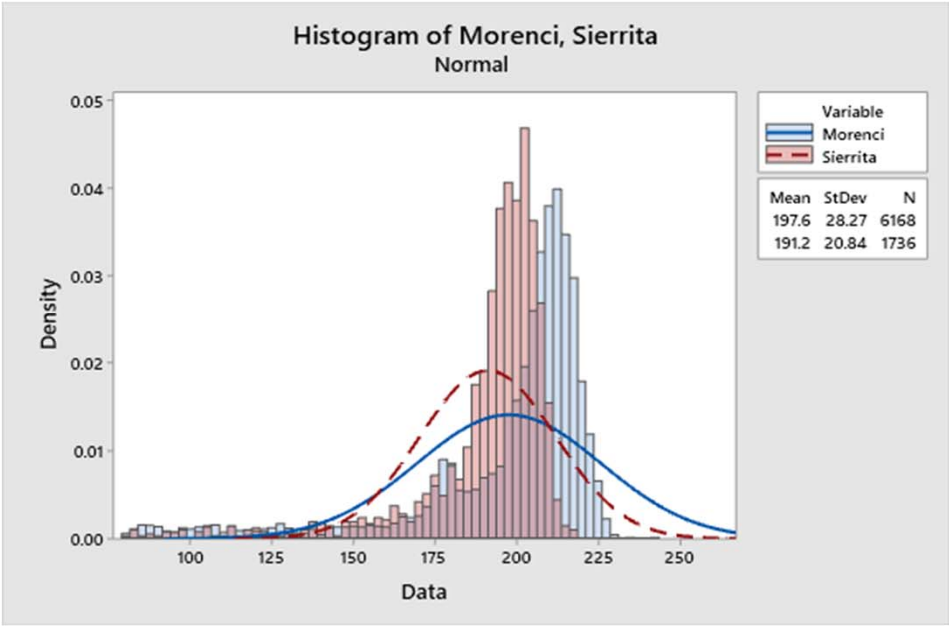
## Descriptive Statistics

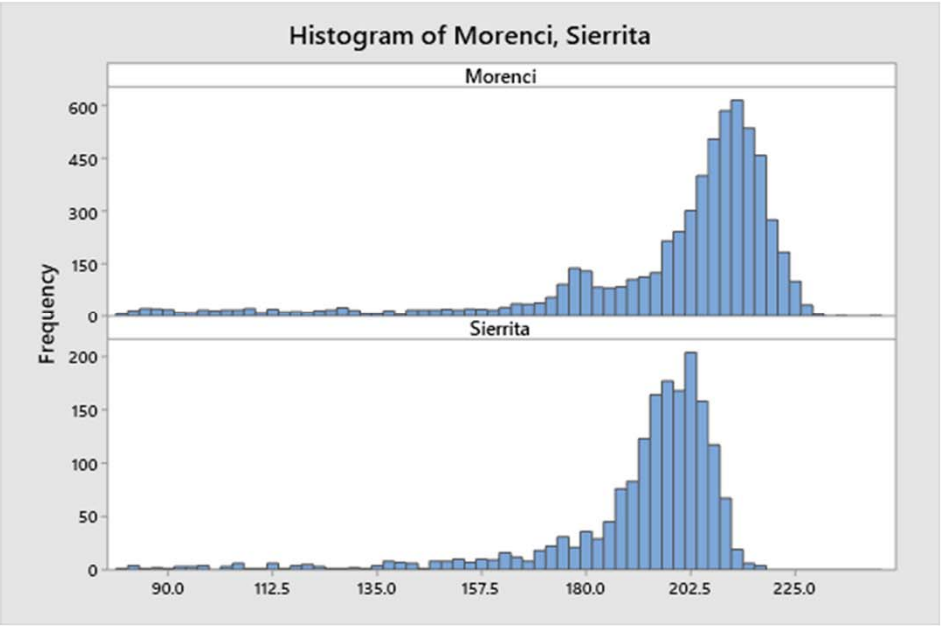
| Sample | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Sierrita | 1736 | 191.2 | 20.8 | 0.50 |
| Morenci | 6168 | 197.6 | 28.3 | 0.36 |

## Estimation for Difference

| Difference | 95% CI for Difference |
|---|---|
| -6.444 | (-7.653, -5.236) |



# CV Vs. Morenci

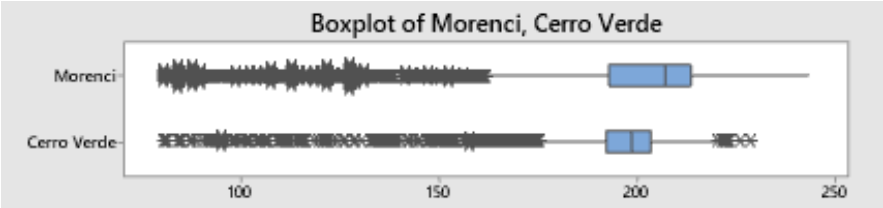
FREEPORT
FOREMOST IN COPPER

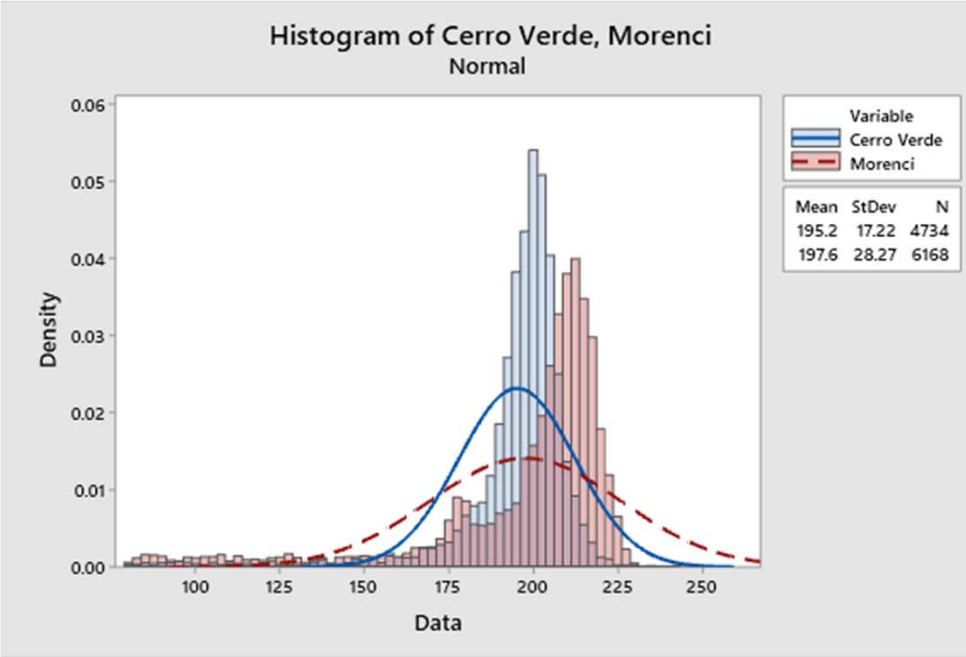
## Descriptive Statistics

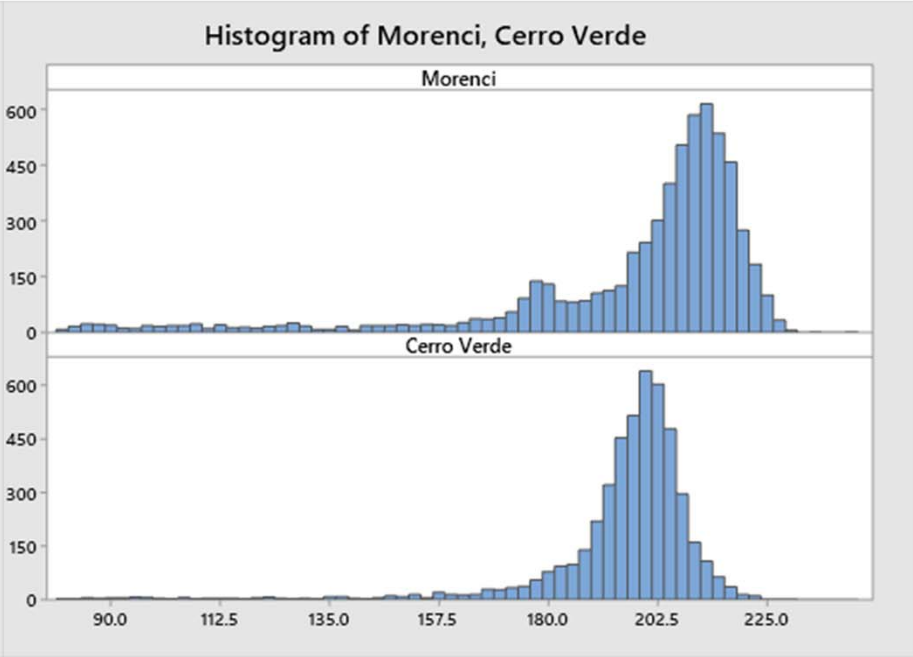
| Sample | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Cerro Verde | 4734 | 195.2 | 17.2 | 0.25 |
| Morenci | 6168 | 197.6 | 28.3 | 0.36 |

## Estimation for Difference

| Difference | Pooled StDev | 95% CI for Difference |
|---|---|---|
| -2.409 | 24.103 | (-3.322, -1.496) |



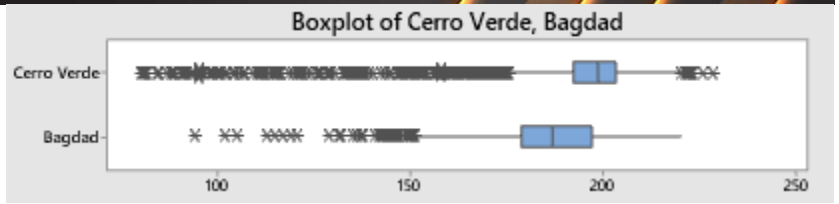



# CV Vs. Bagdad

FREEPORT
FOREMOST IN COPPER

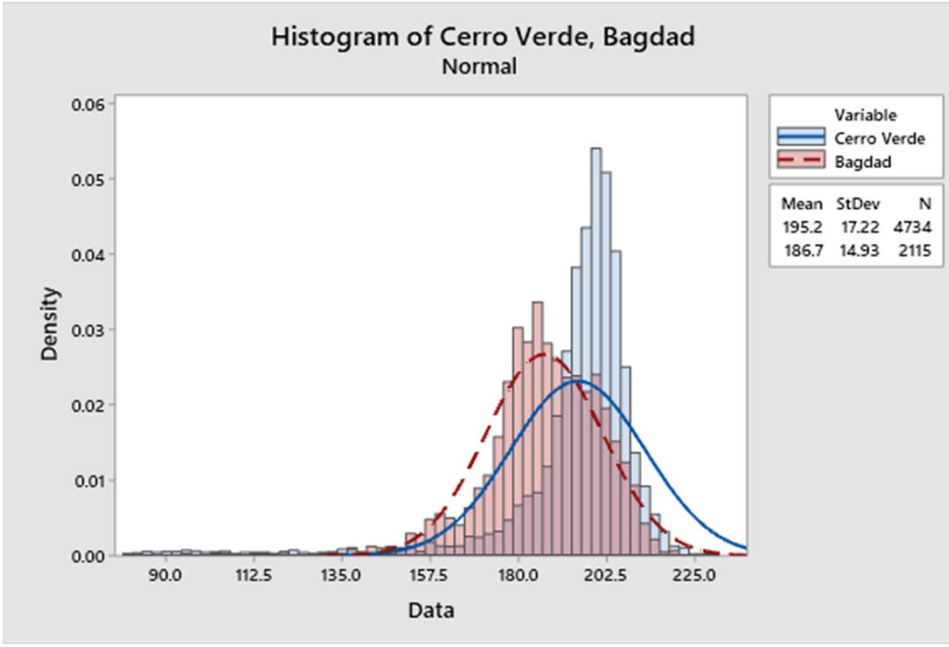
## Descriptive Statistics

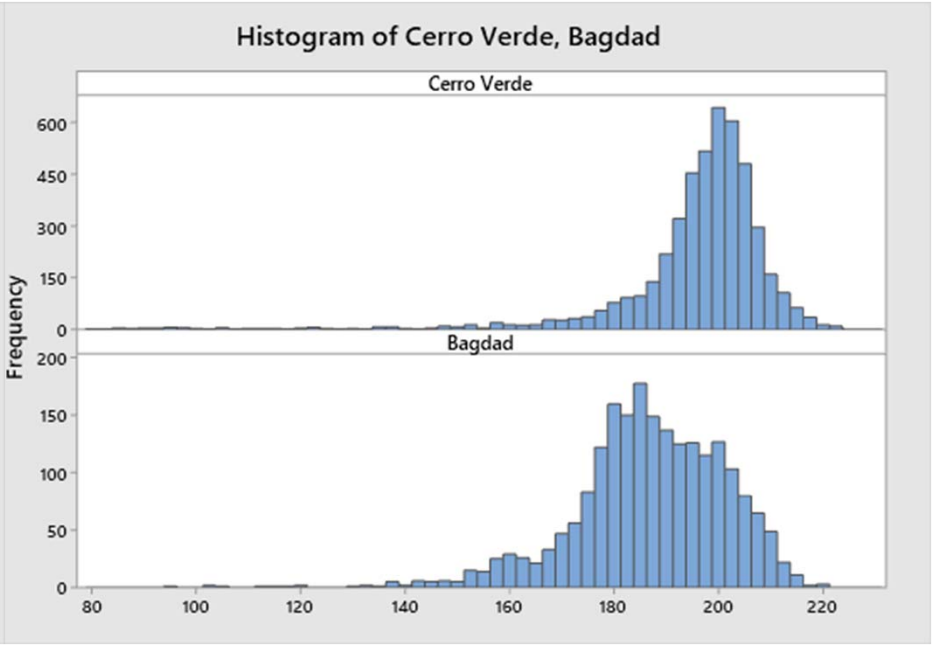
| Sample | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Cerro Verde | 4734 | 195.2 | 17.2 | 0.25 |
| Bagdad | 2115 | 186.7 | 14.9 | 0.32 |




## Estimation for Difference

| Difference | 95% CI for Difference |
|---|---|
| 8.522 | (7.718, 9.326) |



# CV Vs. Sierrita

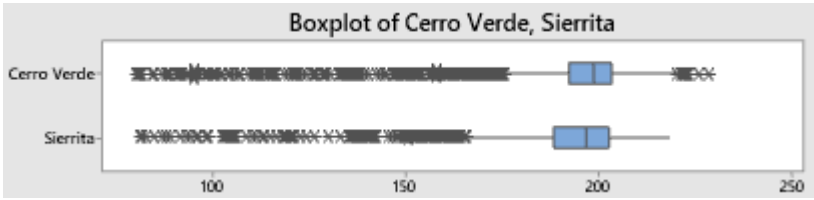
FREEPORT
FOREMOST IN COPPER

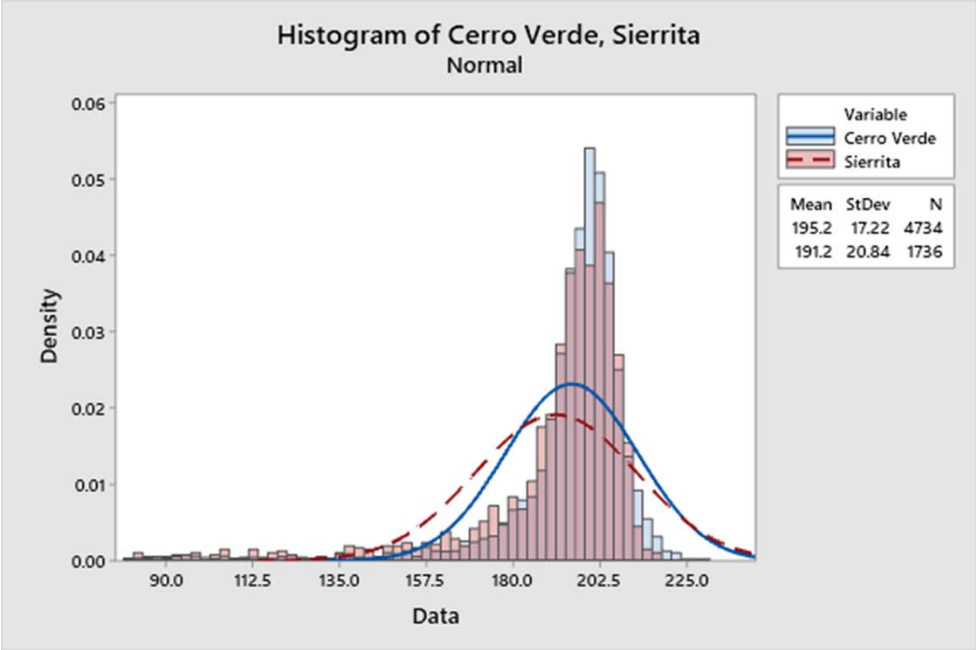
## Descriptive Statistics

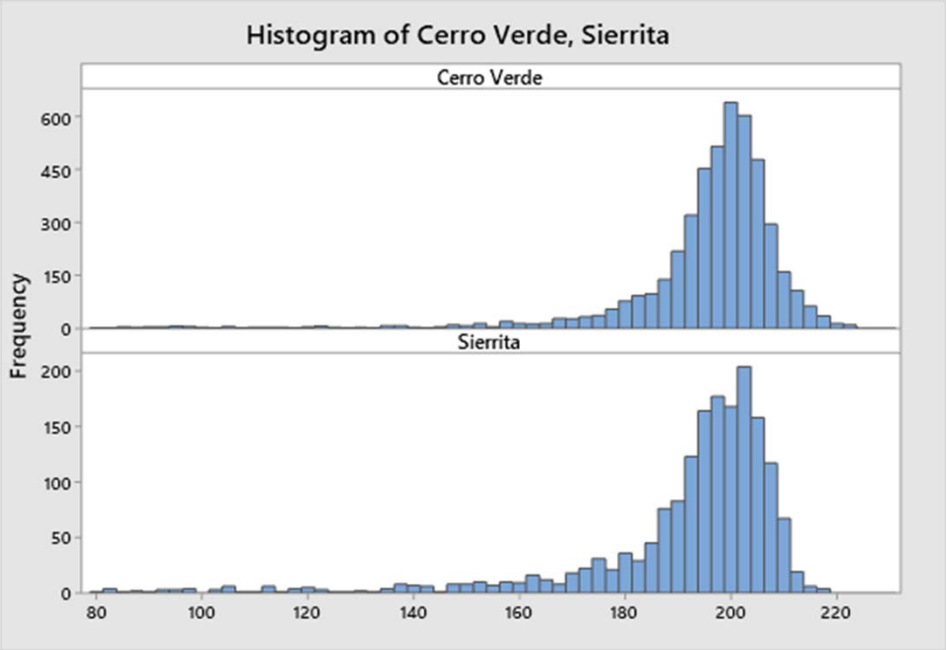
| Sample | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Cerro Verde | 4734 | 195.2 | 17.2 | 0.25 |
| Sierrita | 1736 | 191.2 | 20.8 | 0.50 |

## Estimation for Difference

| Difference | 95% CI for Difference |
|---|---|
| 4.035 | (2.938, 5.132) |



# Duo Cone

FREEPORT
FOREMOST IN COPPER

Following are old duo cone numbers and the most updated duo cones offered.

| | WITH REVERSE FLOW - CURRENT | | WITHOUT REVERSE FLOW | |
|---|---|---|---|---|
| STANDARD | FRONT | | FRONT | |
| | WHEEL GP | 470-8606 | WHEEL GP | 280-2056 |
| | OUTER SEAL | 563-8599 | OUTER SEAL | 563-8599 |
| | INNER SEAL | 421-8985 | INNER SEAL | 421-8974 |
| | REAR | | REAR | |
| | WHEEL GP | 280-2051 | WHEEL GP | 280-2051 |
| | OUTER SEAL | 563-8599 | OUTER SEAL | 563-8599 |
| | INNER SEAL | 423-2091 | INNER | |
| XLP | FRONT | | FRONT | |
| | WHEEL GP | 280-2057 | WHEE | |
| | OUTER SEAL | 423-2089 | OUTE | |
| | INNER SEAL | 423-2091 | INNER | |
| | REAR | | REAR | |
| | WHEEL GP | 280-2052 | WHEE | |
| | OUTER SEAL | 423-2089 | OUTE | |
| | INNER SEAL | 423-2091 | INNER | |

| Old Seal | Replaced With Seal |
|---|---|
| 378-0592 | 423-2089 |
| 314-4130 | 563-8599 |
| 365-4922 | 423-2091 |

Summarize recommendations and move this slide to the Appendix- Wayne

# Physical and Chemical QC tests

FREEPORT
FOREMOST IN COPPER

| | CAT FDAO-SYN | SYNCON FD-1 |
|---|---|---|
| KV @ 40 $^0$C, cSt | 318.4 | 311.8 |
| KV @ 100 $^0$C, cSt | 33.0 | 36.8 |
| VI | 145 | 167 |
| SG | 0.8578 | 0.8855 |
| Cu Corrosion, 150 $^0$C, 3hrs | 1B | 1A |
| BV @ -20 $^0$C, cP | 29226 | 23915 |
| BV @ -30 $^0$C, cP | 104709 | 86017 |
| Flash Point $^0$C, COC | 258 | 274 |
| Sulfated Ash | 0.1 | 0.1 |
| Pour Point, $^0$C | -47 | -40 |
| Foam, Opt. A | | |
| Foam, Seq I | 0/0 | 0/0 |
| Foam, Seq II | 120/0 | 0/0 |
| Foam, Seq III | 0/0 | 0/0 |
| HTHS, 150 $^0$C, cP | 8.32 | 9.55 |
| TBN | 1.73 | 2.20 |
| Color, D1500 | 0.90 | 1.00 |

| ICP, ppm | CAT FDAO-SYN | Syncon FD-1 |
|---|---|---|
| B | 97.5 | 105.2 |
| Ca | 272.1 | 312.1 |
| P | 313.7 | 342.4 |
| Si | 1.3 | 1.7 |
| Zn | 0.1 | 1.6 |

Syncon Final Drive advantages:

- Higher Kinematic Viscosity @ 100°C for better high temp performance
- Higher Absolute Viscosity (HTHS @ 150°C)
- Lower Brookfield Viscosity at -20, -30°C for better low temp performance
- Better foam control

Provided by P66 – Competitive Benchmarking

# Oxidation Tests

FREEPORT
FOREMOST IN COPPER

| | ASTM Methods | CAT FDAO-SYN | Syncon FD-1 |
|---|---|---|---|
| RPVOT, min | D 2272 | 991.5 | 1038.0 |
| PDSC, 190 $^0$C, min | D 6186 | 67.9 | 181.1 |

**RPVOT (Rotating Pressure Vessel Oxidation Test):**
**Testing conditions:** 150 $^0$C; 90 psi; in the presence of water and copper catalyst coil
**Conclusion:** SYNCON Final Drive has slightly better performance versus CAT FDAO-SYN

**PDSC (Pressure Differential Scanning Calorimetry):**
**Testing conditions:** 500 psi, 190 $^0$C; measures oxidation induction time (OIT)
**Conclusion**: SYNCON Final Drive has significantly better performance than CAT FDAO-SYN

# Friction and Wear Tests

FREEPORT
FOREMOST IN COPPER

## 1. HFRR (High Frequency Reciprocating Rig; ASTM D6079)

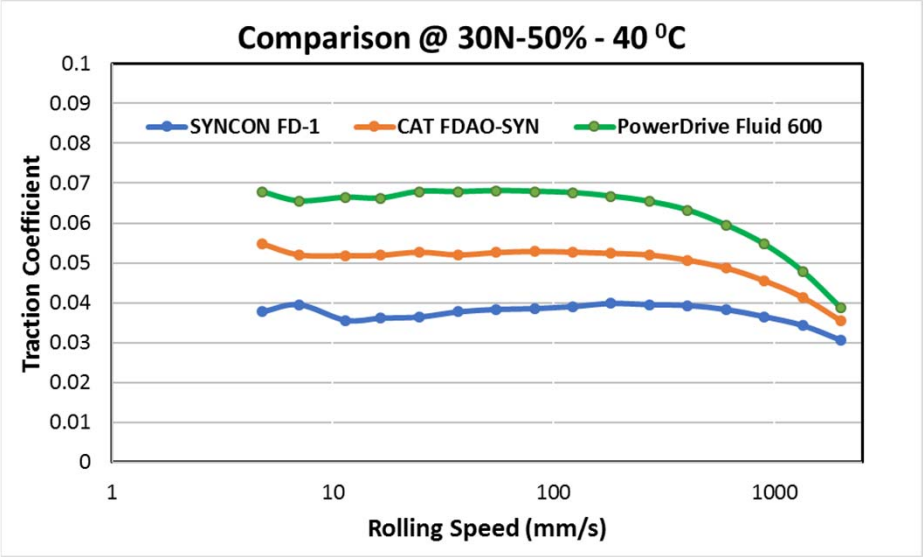
| HFRR test | CAT FDAO-SYN | Syncon FD-1 | PowerDrive Fluid 6000 |
|---|---|---|---|
| Friction Coefficient | | | |
| 40 $^0$C | 0.101 | 0.093 | 0.097 |
| 60 $^0$C | 0.119 | 0.116 | 0.102 |
| 80 $^0$C | 0.13 | 0.138 | 0.117 |
| 100 $^0$C | 0.131 | 0.138 | 0.136 |
| 120 $^0$C | 0.126 | 0.134 | 0.129 |
| 140 $^0$C | 0.115 | 0.139 | 0.138 |
| | | | |
| Wear Scar Width, mm | 0.30 | 0.29 | 0.26 |

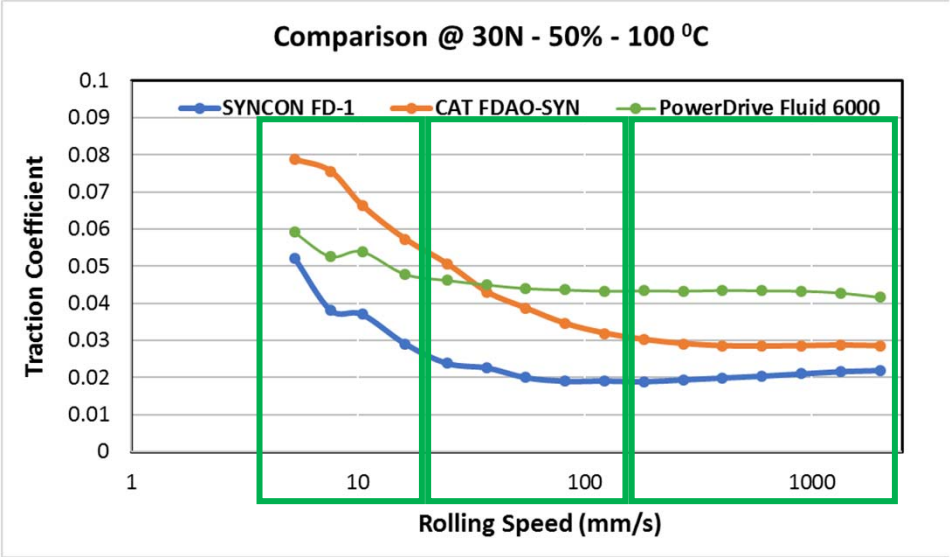
## 2. Four Ball Wear Test (ASTM D4172)

| Four Ball Wear test | CAT FDAO-SYN | Syncon FD-1 | PowerDrive Fluid 6000 |
|---|---|---|---|
| Wear Scar Diameter, mm | 0.35 | 0.34 | 0.35 |

**Conclusions:** The basic friction and wear properties of these fluids are very similar (all use the same additive system)

# MTM Stribeck Curve




Pulling away from the shovel

Loaded on uphill grade

Loaded on level ground

SYNCON Final Drive has the lowest friction coefficient at the testing conditions

- Should result in lower component temperatures and improved fuel efficiency

Provided by P66 – Competitive Benchmarking

# Viscosity Comparison

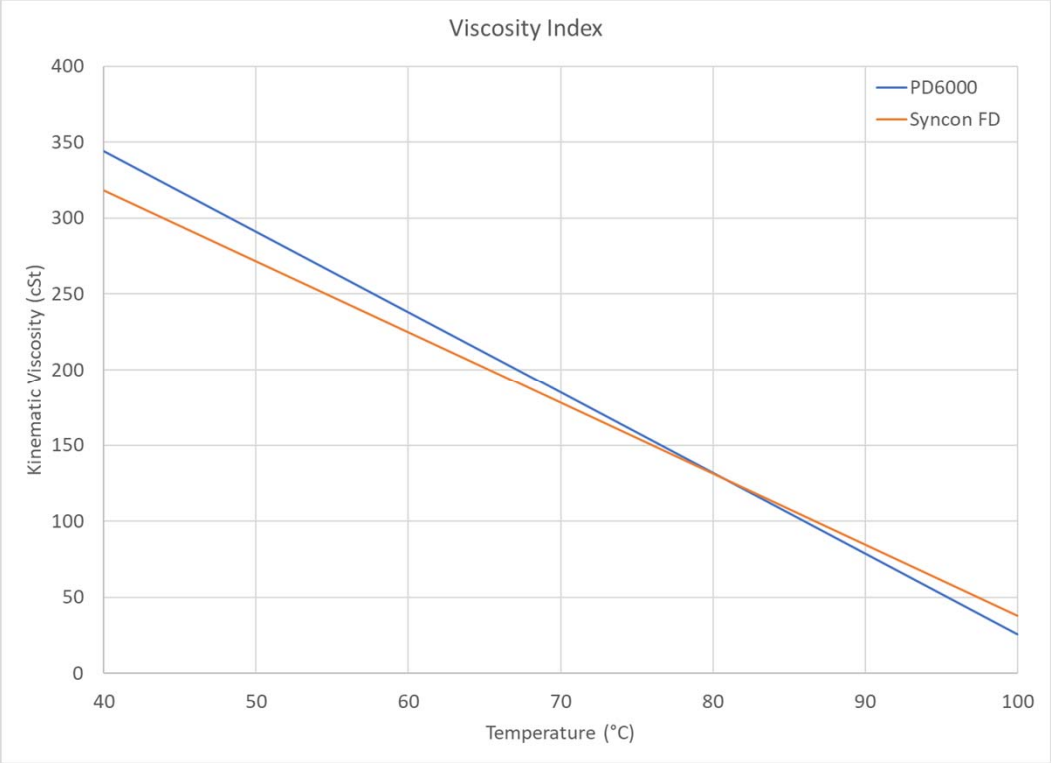
FREEPORT
FOREMOST IN COPPER

## Viscosity Index

- Syncon Final Drive – 170
- PD6000 – 98

## Viscosity

- Syncon Final Drive
  - 318 cSt @ 40C
  - 38 cSt @ 100C
- PD6000
  - 344 cSt @ 40C
  - 25.8 cSt @ 100C



# Background and Test Plan

FREEPORT
FOREMOST IN COPPER

- Syncon Final Drive Oil in Sierrita Haul Truck 16064 Differential and Final Drives
  - Test Started on or about January 15, 2019 (still ongoing)
- Components involved in testing are two (2) wheel group assemblies built in the Empire CRC facility, with all F model gears, and a Torrington bearing differential.
- The differential housing prepared to ensure a clean start and painted with a suitable paint, bright white in color.
- Oil Samples and Magnetic Plugs taken every 250 hours (Standard Oil Tests)
- P66 to perform RULER testing at 750 hour intervals
- Same kidney loop schedule as other trucks – 500 hrs (dedicated kidney loop for Syncon FD)
- Compare to a truck with PD6000 rebuilt at same time (16057)

# Testing Details/Comments

FREEPORT
FOREMOST IN COPPER

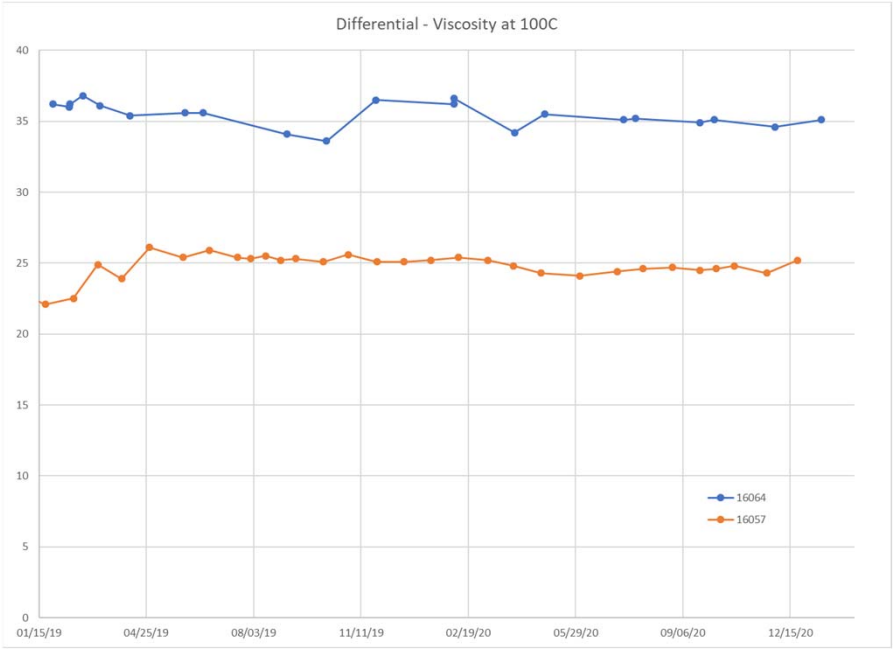
- Incorrect magnetic plugs used initially (too long, not OEM, rare earth)
  - Metallurgical analysis indicated debris was not bearing or gear wear
  - 2/12/19 inspection indicated no damage to component
- Duo Cone Seal Leaks
  - Minor leak in Right Final (slight viscosity loss) inspected on 5/31/19
    - Truck continued to operate, topped off with more oil (~30 gal)
  - More substantial leak in Left Final (continual viscosity loss)
    - Forced repair and replacement of oil on 10/30/19 (with 5923 hours on oil)
    - Inspection showed component in excellent condition

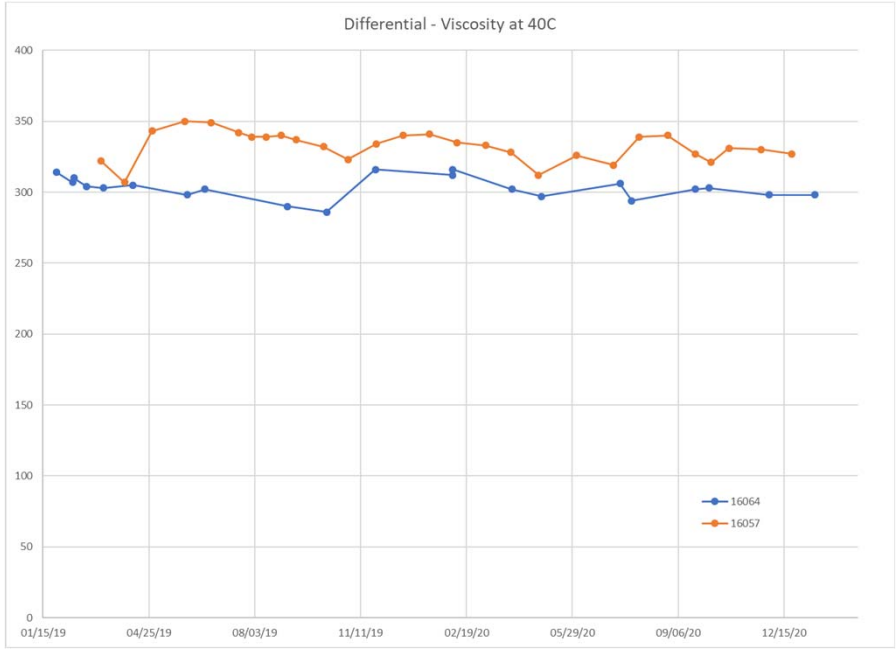
# Results

FREEPORT
FOREMOST IN COPPER

- Currently 14,655 hours on components (as of 1/26/2021)
- RULER Results
  - Syncon Final Drive
    - 3664 hours – 90% (taken 7/15/2019)
    - 5498 hours – 90% (taken 10/10/2019)
    - 6059 hours – 97% (taken 9/9/2020 from 2nd batch of oil)
    - 7414 hours – 88% (taken 11/17/20 from 2nd batch of oil)
  - Powerdrive 6000
    - 2100 Hours – 79%

# Viscosity


Differential - Viscosity at 100C
40
35
30
25
20
15
10
5
0
01/15/19
04/25/19
08/03/19
11/11/19
02/19/20
05/29/20
09/06/20
12/15/20
16064
16057


Differential - Viscosity at 40C
400
350
300
250
200
150
100
50
0
01/15/19
04/25/19
08/03/19
11/11/19
02/19/20
05/29/20
09/06/20
12/15/20
16064
16057

# Wear and ISO

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Better PQ results (lower wear generation)

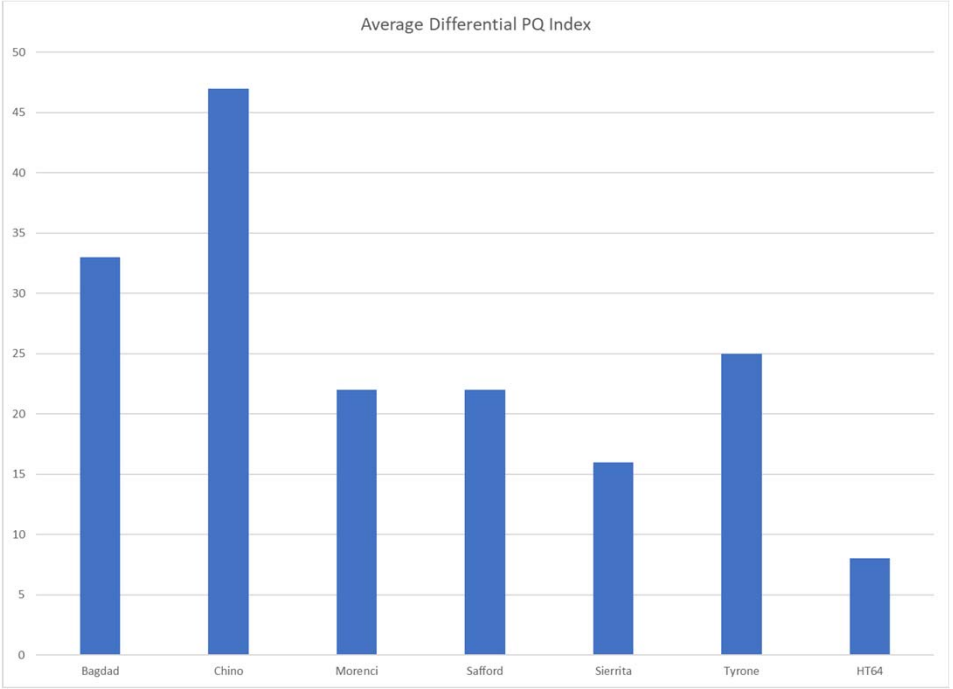
- 8 average for HT64
- 16 average for Sierrita fleet

Comparable Iron wear

- 33 ppm average for Sierrita fleet
- 35 ppm for HT64

Better ISO Code results to rest of fleet

- HT64 – 21.5/19.3/15 average
- Sierrita fleet – 22.5/20/15 average



# Differential Oil Temperature Sierrita D Models

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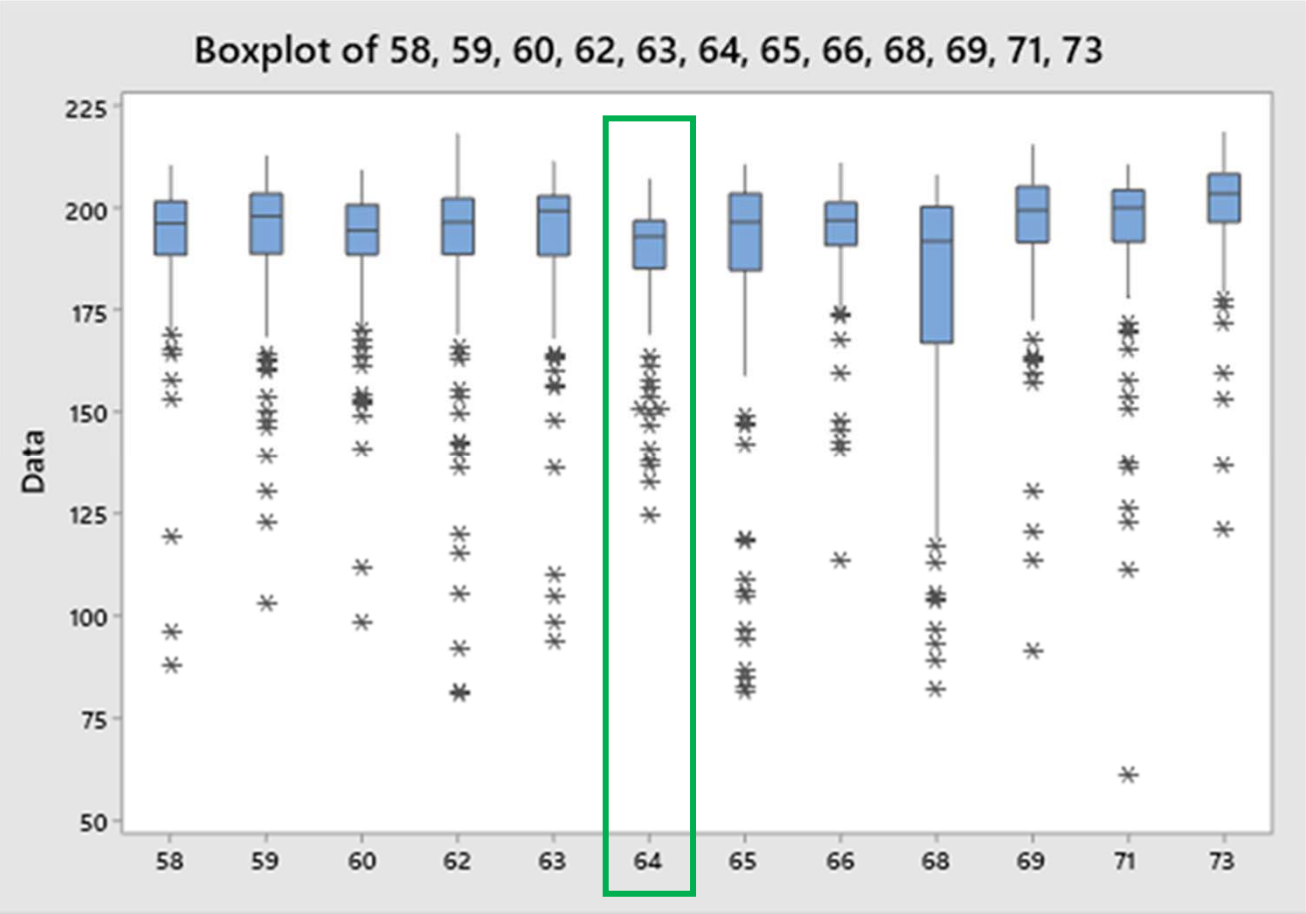


HT64 Differential Oil Temperature running 5°F cooler in Summer 2020 (on average) compared to rest of 793Ds in Sierrita

# Syncon FD1 Costs

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| | PD6000 Oil Volume (2019) | Cost (at 2021Q2 price) |
|---|---|---|
| Tyrone | 5697 | $ 50,931.18 |
| Morenci | 135942 | $ 1,215,321.48 |
| Chino | 41512 | $ 371,117.28 |
| Sierrita | 19345 | $ 172,944.30 |
| Bagdad | 31894 | $ 285,132.36 |
| Safford | 9500 | $ 84,930.00 |
| Climax | 9900 | $ 88,506.00 |
| Total | 253790 | $ 2,268,882.60 |

| Average Interval | Syncon FD Yearly Cost | PD6000 Yearly Cost | Yearly Volume of Oil |
|---|---|---|---|
| 2000 | $ 5,883,671.52 | $ 2,537,386.56 | 283824 |
| 3000 | $ 3,922,447.68 | $ 1,691,591.04 | 189216 |
| 4000 | $ 2,941,835.76 | $ 1,268,693.28 | 141912 |
| 5000 | $ 2,353,468.61 | $ 1,014,954.62 | 113530 |
| 6000 | $ 1,961,223.84 | $ 845,795.52 | 94608 |
| 7000 | $ 1,681,049.01 | | 81093 |
| 8000 | $ 1,470,917.88 | | 70956 |
| 9000 | $ 1,307,482.56 | | 63072 |
| 10000 | $ 1,176,734.30 | | 56765 |

# Comparison – Caterpillar Recommended Cleanliness Targets Vs. Actual Average ISO Counts

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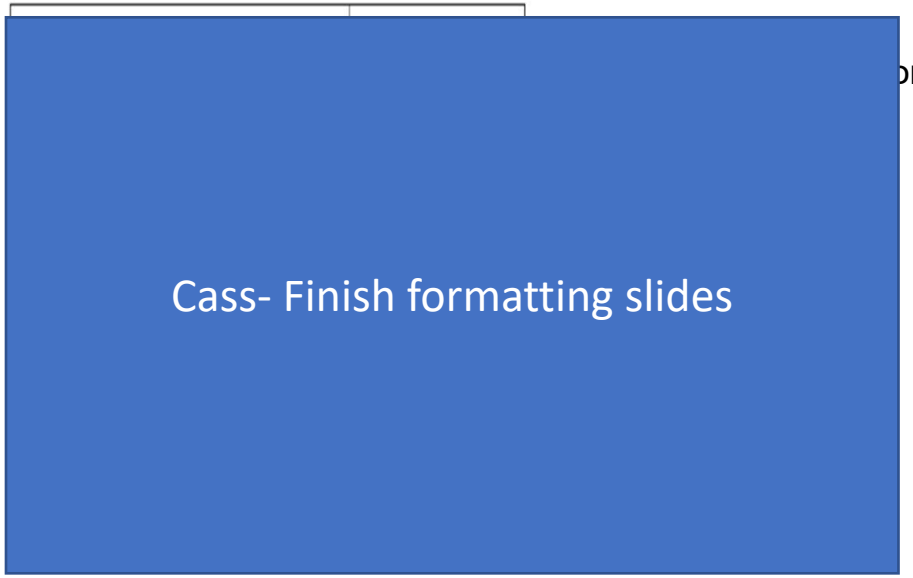
David Barnes

FOR CATERPILLAR MACHINES OPERATING IN THE FIELD




- Chino
- El Abra
- Safford
- Climax

## Average Transmission Oil ISO Count (2020)

| Site | ISO4 | ISO6 | ISO14 | K/L? |
|---|---|---|---|---|
| Bagdad | 20 | 18 | 14 | No |
| Cerro Verde | 20 | 18 | 13 | No |
| Chino | 20 | 18 | 14 | No |
| Climax | 19 | 18 | 14 | No |
| El Abra | 20 | 16 | 12 | Yes |
| Morenci | 22 | 21 | 17 | No |
| Safford | 19 | 18 | 14 | No |
| Sierrita | 20 | 19 | 15 | No |
| Tyrone | 22 | 20 | 16 | No |

**Are there best practices used at these sites that can help Morenci, Sierrita, & Tyrone achieve CAT standards for oil cleanliness?**

# Total Forecasted Components Q4 2020 vs. CL Forecast

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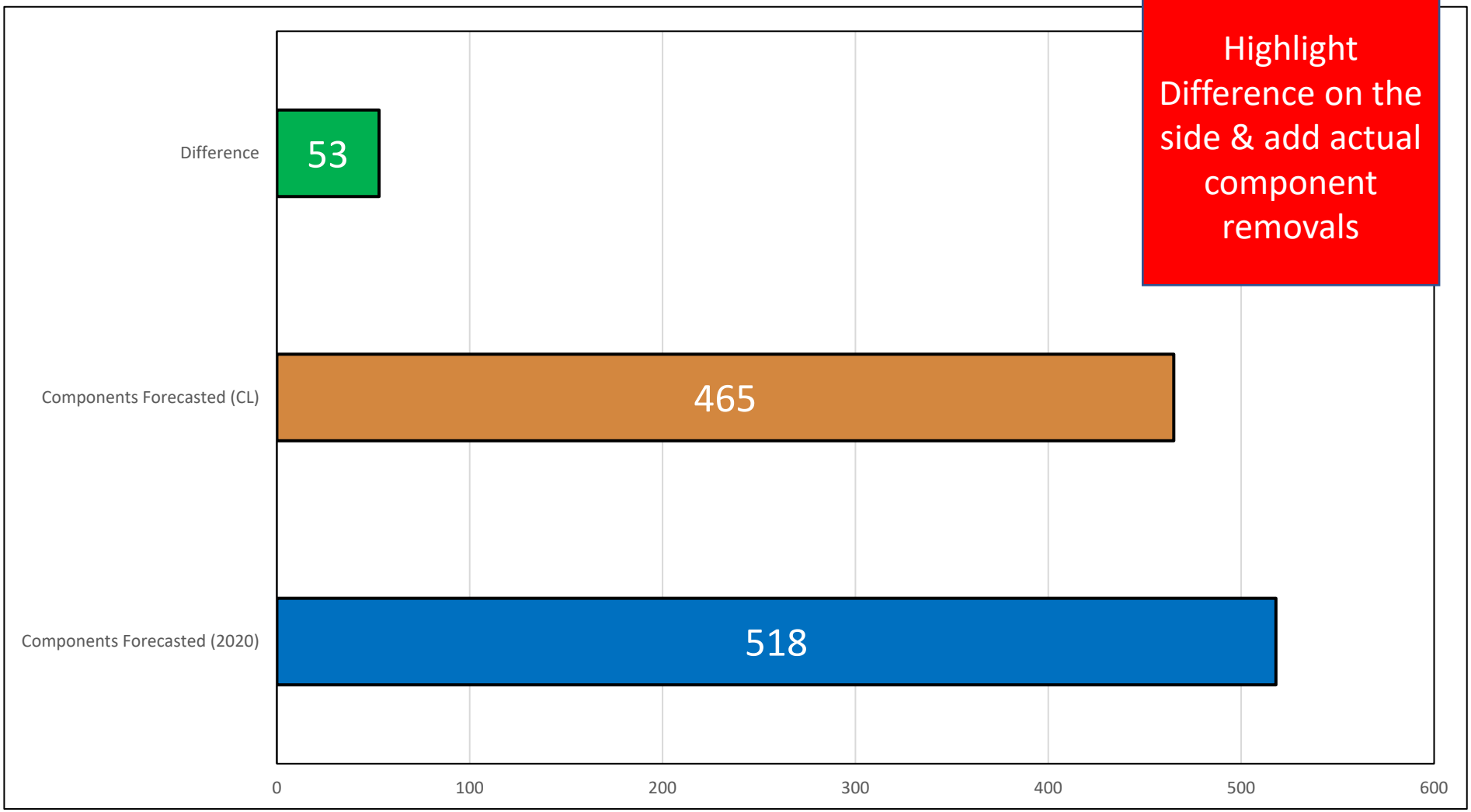


Highlight Difference on the side & add actual component removals

# Total Forecasted Downtime to Replace Components – Q4 2020 vs. CL Forecast

FREEPORT
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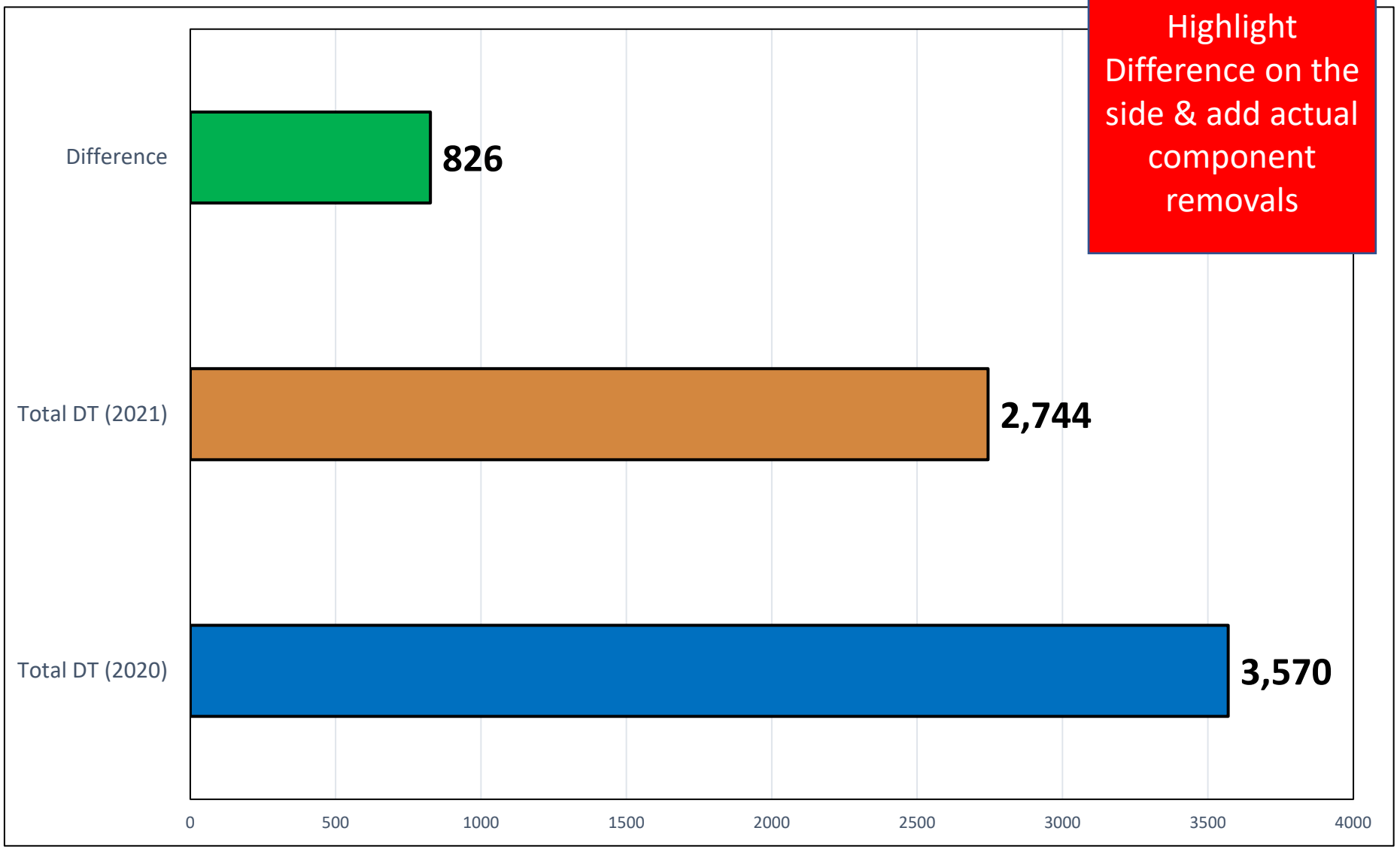

# Total Forecasted Man Hours to Replace Components – Q4 vs. CL Forecast

FREEPORT
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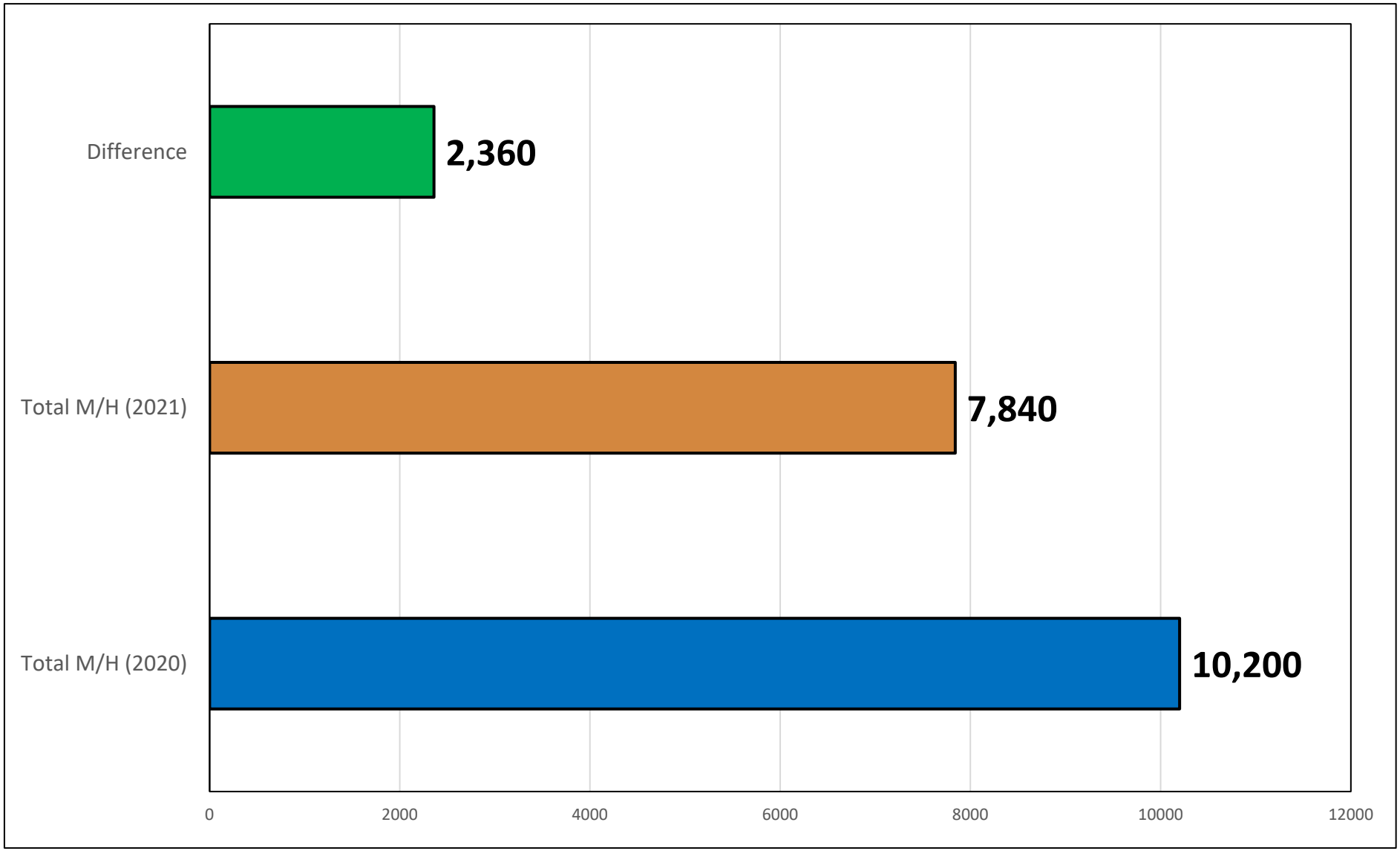

# Total Forecasted Cost Deferrals Forecast

Q4 vs. CL

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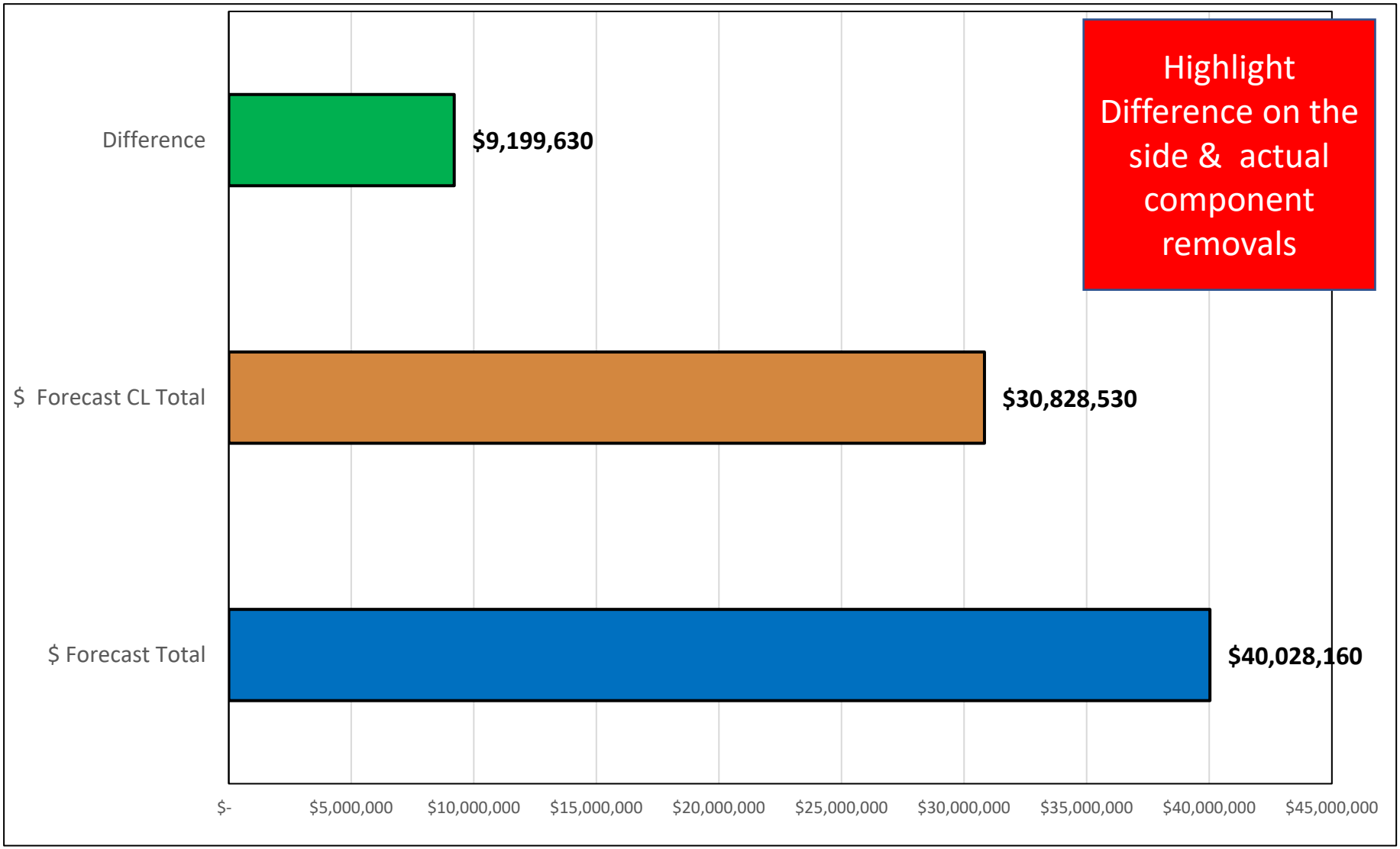

# Ranked Components – High to Low

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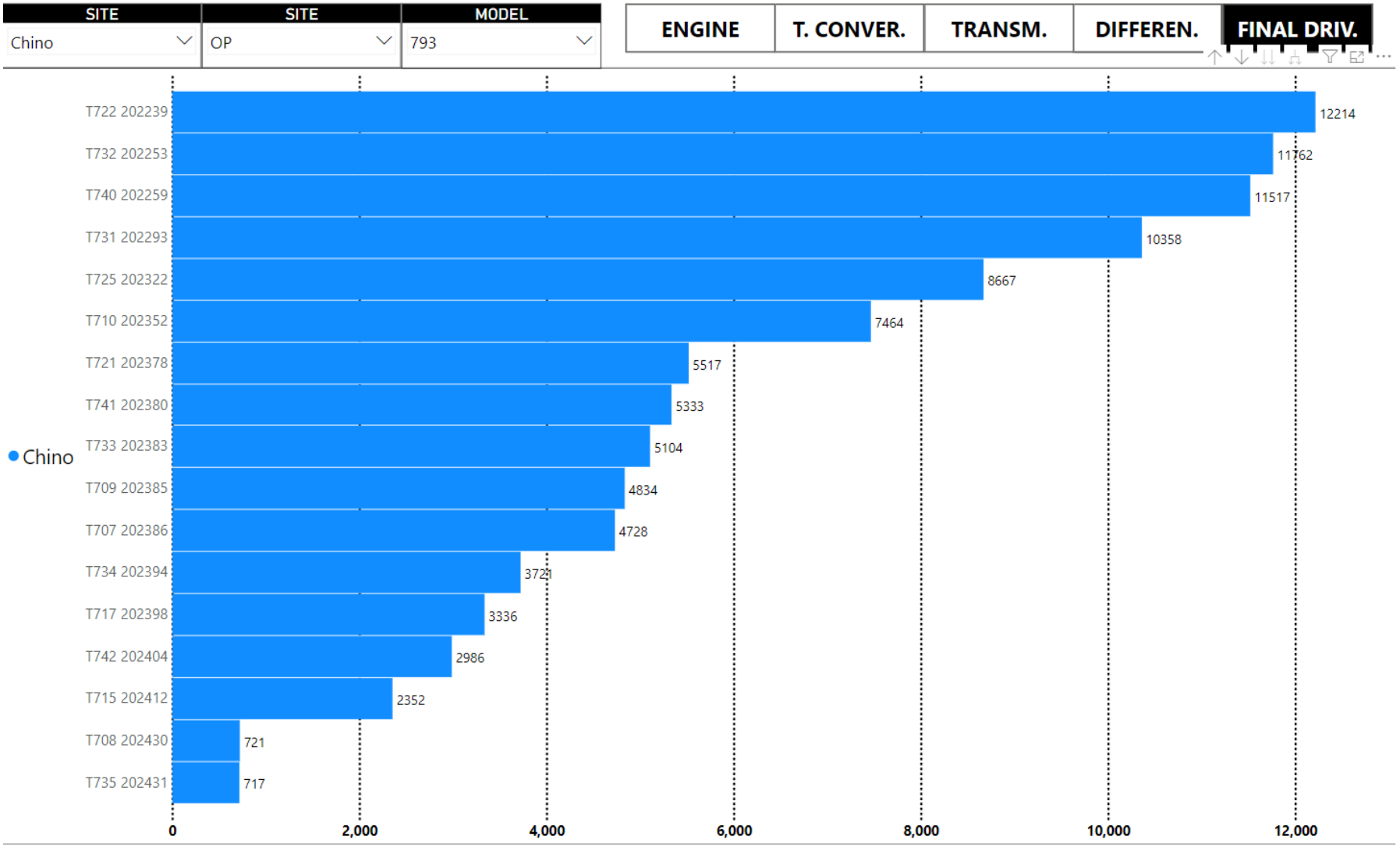

# Syncon FD-1 Test Summary

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Tested on Sierrita HT64 since Jan 15, 2019 (close to 16k hours on components)

- ~10,000 hours on Oil (changed once due to duo cone leak)

Syncon Final Drive is a better oil for CAT 793 Final Drives and Differentials

- Longer Oil Life (3x Oil Life)
- Lower wear generation (PQ average half of fleet)
- Better Viscosity Index
- Better oil performance at high and low temperatures
- Slight decrease in component operating temperature (5 F in Summer)

- Cost: 2.3x cost of PD6000 ($20.73/gal vs $8.94/gal)

Challenges

- Duo Cone Seal Leaks
  - Leaks that can affect viscosity need to be addressed promptly
- Cannot replace all 60w oil at sites
  - Cannot be used in "Wet Brakes" (same as PD6000)

# Future Opportunities for Syncon FD-1

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We are asking for a site or two to volunteer switching entire fleet to Syncon for a large scale, long term test.

- Site Tank Conversion from PD6000 to Syncon
- Portable tanks needed for drain and re-fill

Syncon FD-1 for Spindles

- Syncon FD-1 Spindle test on 5 trucks in Sierrita

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# Potential Brake Solutions

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# Brake Coolers

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- Caterpillar brake coolers are a weak link in the brake cooling system that introduce cross contamination into many systems not just the brakes
- Brake coolers are a component life limiting factor. Once coolant is introduced into the brake discs, brake failures usually occur within a short period of time unless extreme measures are taken
  - Drain all fluids, affected compartments cleaned, the addition of water inhibiting additives, and flushing oil after running for a period
  - This is expensive and labor intensive. (See downtime analysis)
- Transmissions and engine oil coolers are susceptible to contamination as well. Is there an opportunity to test a better solution in these applications?

# Mesabi Brake Coolers - Financial Analysis & Pros/Cons

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## Pros:

1. Proven solution – Mesabi coolers have been in operation for over 32K hours in Morenci. ROI has been realized
2. Mesabi coolers have features that are proven to prevent the excessive downtime and cost associated with brake cooler failures
3. Mesabi coolers have the potential to run until failure and then simply replace a tube driving cost down due to the sight glass utilized to identify failure. An electronic alarming option is available, at additional cost
4. Potential to setup a PX plan with a much lower future cost profile (only replacing tubes that have failed or do not meet re-use, rather than replacing a complete bundle)

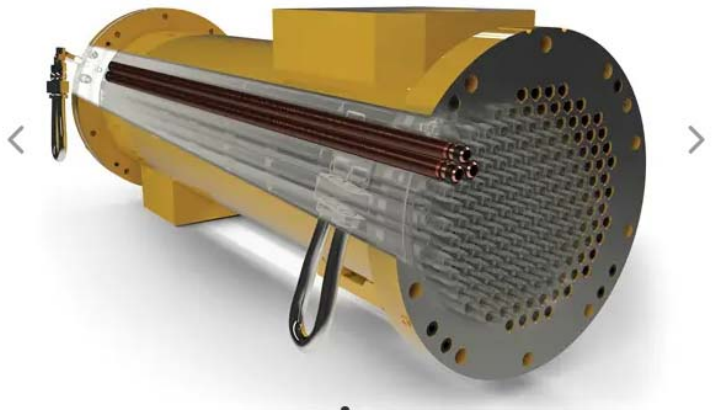
## Cons:

1. High initial implementation cost
2. Loss of core credit for CAT coolers

| Description | Cost | Qty Per Truck | Cost Per Truck | B –Model Fleet Size | B-Model Fleet Cost | Number of Lives required for ROI |
|---|---|---|---|---|---|---|
| Core As - Cooler Caterpillar PN 20R7386 | $ 3,325 | 5 | $ 16,625 | 182 | $ 605,150 | |
| Mesabi System Protector - PN 111589 - Empire | $ 7,542 | 5 | $ 37,711 | 182 | $ 1,372,680 | 2.27 |

| Typical cost of a single cooler failure | |
|---|---|
| Cooler cores | $ 16,625 |
| Ancillary components | $ 6,600 |
| Avg . Downtime (hrs.) | 120 |
| Cost/hr | $ 300 |
| Total | $ 59,225[1] |

[1] Total cost includes only 5 brake coolers and ancillary components. Does not reflect brake replacement when brakes are damaged due to coolant contamination nor the cost of cleanout (oil)



L & M System Protector Video on Vimeo

# Brake Cooler Screen – Financial Analysis & Pros/Cons

FREEPORT
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## Pros:

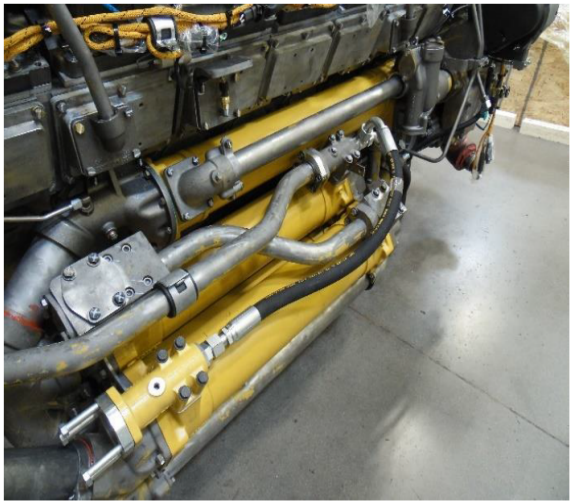
1. Much lower implementation cost
2. Should provide large particle protection to the rear brake coolers
3. Proven solution on 777 machines

## Cons:

1. No serviceability. The screens are in a position that will only allow service when an engine is out of chassis
2. Hose routing for this configuration is difficult. Installing this screen makes the routing and serviceability of this hose worse than the original. Hose must be custom-clocked in each machine to make sure that it clears the coolant tube. Potential contamination entry point if this hose rubs on the tube
3. Unproven on 793 machines in Morenci. Screens only installed on a few trucks with the earliest install in July 2020

| QTY | Part Number | Description | Cost | SubTotal |
|---|---|---|---|---|
| 1 | 104-7658 | Housing / Elbow | $ 189.41 | $ 189.41 |
| 1 | 6F-8146 | Seal | $ 3.76 | $ 3.76 |
| 1 | 224-3895 | Screen | $ 281.63 | $ 281.63 |
| 1 | 6K-6307 | Seal | $ 1.93 | $ 1.93 |
| 1 | 9S-4182 | Plug | $ 7.50 | $ 7.50 |
| 1 | 214-7566 | Seal | $ 3.04 | $ 3.04 |
| 4 | 8T-0279 | Bolt | $ 2.36 | $ 9.44 |
| 8 | 8T-4223 | Washer | $ 0.63 | $ 5.04 |
| 2 | 1P-4582 | Flange | $ 15.18 | $ 30.36 |
| 4 | 032-3180 | Bolt | $ 4.53 | $ 18.12 |
| 1 | 8X-4613SCREENHOSE | Hose | $ 211.71 | $ 211.71 |
| | | | GrandTotal | $ 761.94 |

| B-Model Fleet Size | Cost | Total |
|---|---|---|
| 182 | $ 761.94 | $ 138,673.08 |



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# On-Board Kidney Loop

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# On-Board Filtration Recommendation

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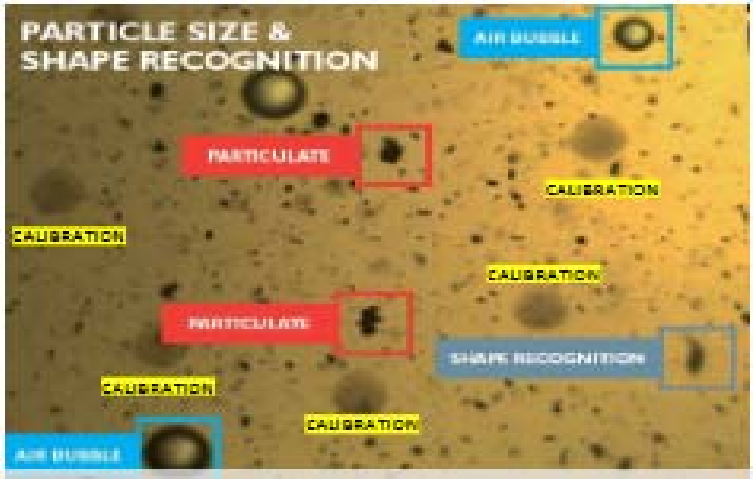
Based on the information gathered we know that keeping the oil cleaner will help extend life on the component but in order to quantify the impact or to have better data to be able to make a full recommendation the team is proposing the following;

- Perform an onboard filtration test by installing the CC Jensen system on two trucks (B or C models)
- Run these 2 trucks for 6 months and compare oil sample analysis with other trucks that do not have onboard filtration system
- If moving forward with this idea, the team will define a more structured test plan

This will allow us to measure the effectiveness of the system and how the oil condition can be maintained in order to make a further recommendation




filter's hydraulic pump supplied the necessary pressure and oil volume for the Counter to operate.

*In this case the inspection port cover was replaces with the dip tube. There were no sampling connections near the replacement inspection cover.*

*Sampling for this version was done on the Minimess ports that are built into the CCJensen system. This made a much simpler to operate and cleaner installation.*

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# Other Opportunities

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# Other Future Opportunities

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Consider synthetic differential oil test in Cerro Verde (similar cost profile to Syncon FD-1)

B/C Model differential oil cooler test

- Install system on 5 trucks in Morenci
- Compare temperature data between these 5 trucks and the rest of the fleet to determine statistical significance

Develop an automated oil sample data entry system (SAP/LIMS interaction)

Test of Diamond-Like Carbon (DLC) Coated Bearings (for wheel bearings)

- Currently in front wheel groups at Chino.

Investigate/Discuss 793C transmissions in 793B model trucks.

Wiggins quick connect fitting for draining and filling oils (Engine & T\C) for contamination control.

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# D-Model Extra-Retarding Brake Packages

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# Extra Retarding Package

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- The Extra Retarding package has been proven to reduce downhill braking temperatures.
- This package is an upgrade that can be done to any truck with the XLWS MA2 or MA4 brake stations.
- It is quite costly however the long-term Component Life will benefit.
- We are investigating parts availability and TRP installation possibilities that would stretch out the costs and the install will be included in TRP down time instead of shop down time.

# Results

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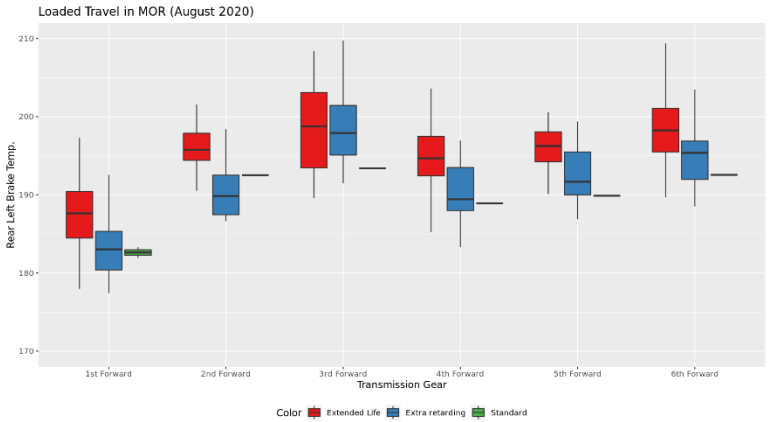
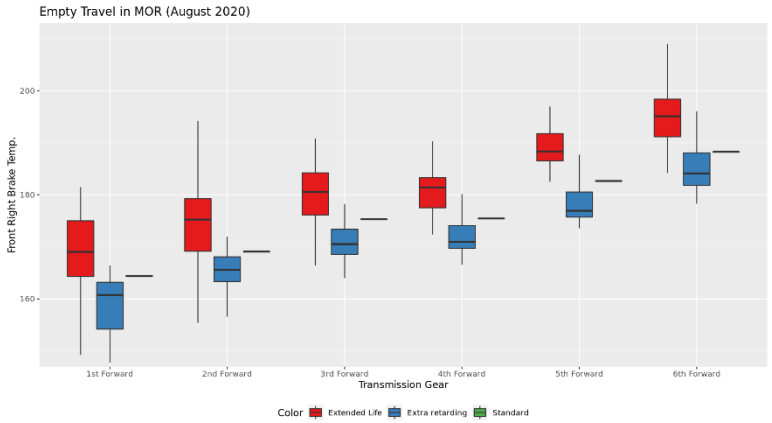
- The results show (statistically) significant differences between the “extended life” (MA-4) and the “extra retarding” (MA-2) approaches, with the latter showing lower brake temperatures.

- Loaded & Empty Travel has interesting patterns (by gear) that are consistent by brake location – see images.

## Loaded Travel




## Empty Travel



# Different Brake Packages in FCX D-Model Fleet

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| Morenci | Bagdad | Sierrita | Cerro Verde |
|---|---|---|---|
| MA1 - 2 | MA4 - 16 | MA4 - 13 | MA1 - 22 |
| MA2 - 36 | | | MA4 - 18 |
| MA4 - 18 | | | |

# Cost to Convert from MA4 to MA2

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## Notes

- Only available for D-Model trucks
- The cost analysis only represents the cost for conversion from MA4 (extended-life) brake package to MA2 (extra-retarding) brake package, MA2 package includes extended-life brakes
- This cost analysis includes parts only, no labor

| MA4 to MA2 Conversion | |
|---|---|
| # Trucks | 73 |
| Price | $ 24,633.40 |
| Total for fleet conversion | $ 1,798,238.20 |

Link to parts and pricing for MA4 (Extended-life) to MA2 (Extra-retarding) conversion

# Conversion from MA1 (Standard) to MA2 (Extra Retarding)

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## Notes

Only available for D-Model trucks

MA1 to MA2 conversion requires all of the previously mentioned parts plus *NEW* Extended-life front wheels group, *NEW* Extended-life final drives, steering linkage, hydraulic arrangements, & axles

This cost analysis includes parts only, no labor

| MA1 to MA2 Conversion | |
|---|---|
| # Trucks | 24 |
| Price | $ 925,811.66 |
| Total for fleet conversion | $ 22,219,479.84 |

Link to parts and pricing for MA1 (Standard) to MA2 (Extra-retarding) conversion

# If We Knew Then What We Know Now

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**As we move into the future, we should consider a data-driven approach to new equipment purchases**

- An opportunity was identified for better utilization of trucks that are equipped with the extra-retarding brake package during the component life project
- There are 36 trucks with the extra retarding brake package that are currently in service in Morenci
- These trucks have the capability of travelling downhill loaded in 3$^{rd}$ gear and downhill empty in 6$^{th}$ gear without overheating the brakes
- Morenci does not train to use 3$^{rd}$ gear downhill loaded nor 6$^{th}$ gear downhill empty, due to the mixed fleets that exist at that site
- The extra retarding package and corresponding speed gained could be better leveraged at a site like Safford or Chino that have extended downhill loaded runs
- Having a fleet of extra retarding D-Model machines that achieve higher speeds would reduce the quantity of trucks required at either of these sites thereby driving down cost per hour

# Duo Cone

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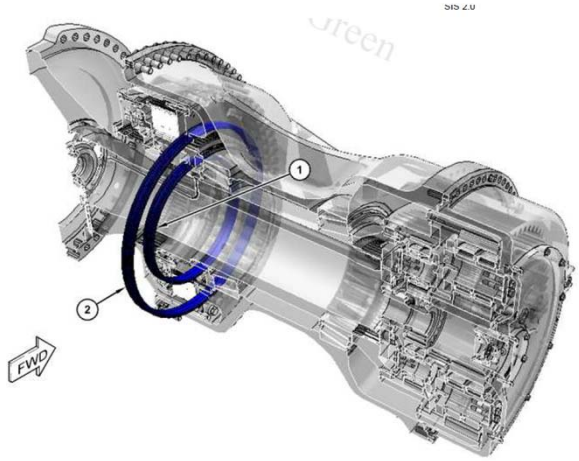
- Team realizes that there have been many updates to the duo cones.
- Ensure all sites and dealers are using most updated duo cones.

793 STD Brake

| New Part Number | Part Name | Former Part Number |
|---|---|---|
| 423-2091 | Duo-Cone Seal Gp | 365-4922 |
| 563-8599 | Duo-Cone Seal Gp | 314-4130 |




793 XLWS

| New Part Number | Part Name | Former Part Number |
|---|---|---|
| 423-2091 | Duo-Cone Seal Gp | 365-4922 |
| 423-2089 | Duo-Cone Seal Gp | 378-0592 |

# Duo Cone Tooling

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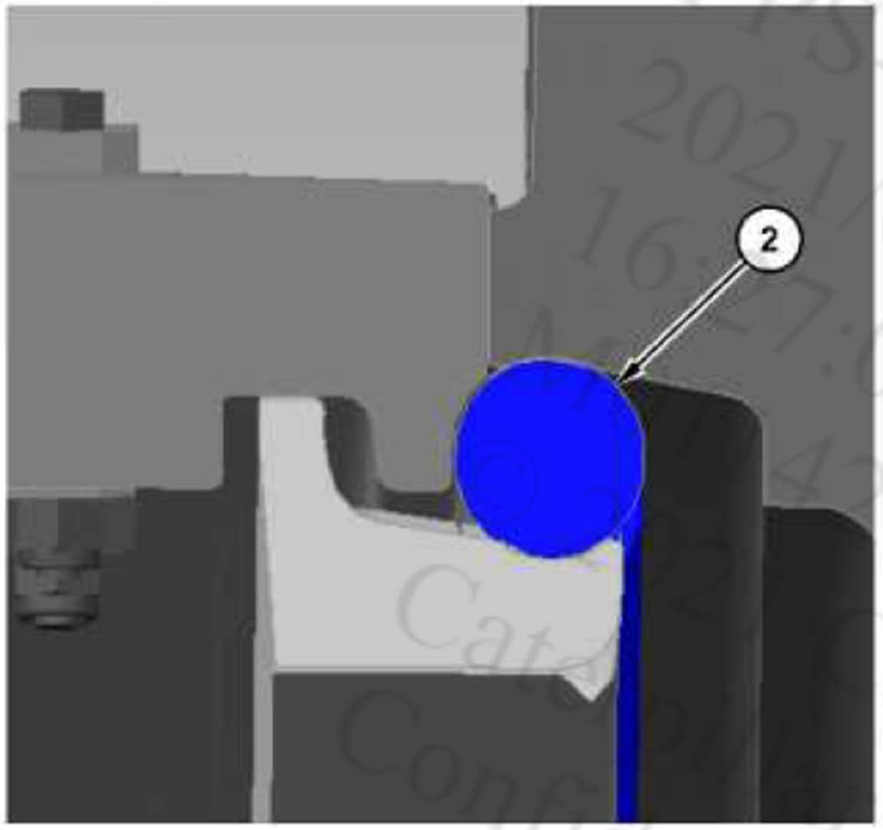
## Tooling Required

A new installer will be required to install each Duo-Cones as shown

| Installer Part Number | Seal Part Number |
|---|---|
| **423-9901** Seal Installer As | **423-2091** Duo-Cone Seal Gp |
| **423-9903** Seal Installer As | **563-8599** Duo-Cone Seal Gp |

- There will be a gap between the installer and seal face
- The new design pushes off the rubber toric rather than the seal face reducing debris between installer and seal face.



# Recommendation: Ancillary Component Changes With Major Component Replacement

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David Barnes

| Component | Differential | Transmission | Torque Convertor | Final Drives/Brake | Front Suspension/Brake |
|---|---|---|---|---|---|
| **Parts Replaced or Task required** | Reseal differential lube valve | Transmission oil pump | Torque convertor pump | Reseal differential lube valve | Front brake actuators (rotochambers) |
| | Thermostats | Powertrain cooler | Front main driveline spider and bolts | Thermostats | Front slack adjuster |
| | Differential harness | Cab to transmission harness | Torque Converter hoses | RE 6 Valve, Rear brake actuators (rotochambers) | Hydraulic system cleanout if brake had a disc, cooler or hard part failure. |
| | Differential lube pump & Motor (D-Model) | Hose kit | All filters | Rear slack adjuster | |
| | | Rear main driveline spider and bolts | Hydraulic system cleanout if 793b | Axle shaft | |
| | | Hydraulic system cleanout if the transmission had a clutch, cooler, or hard part failure | | Brake hoses | |
| | | If cross contamination is suspected check hydraulic tank system and filters. | | Hydraulic system cleanout if the brake had a disc, cooler, or hard part failure | |

# Mid-Life Recommendations

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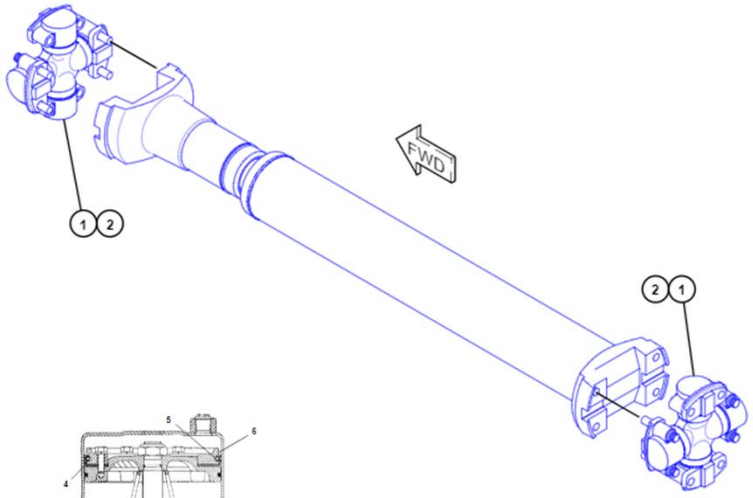
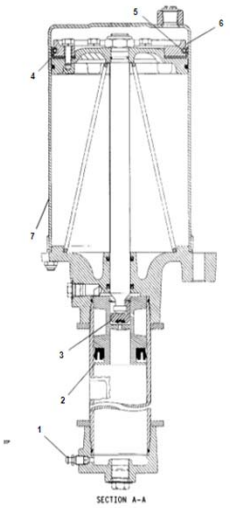
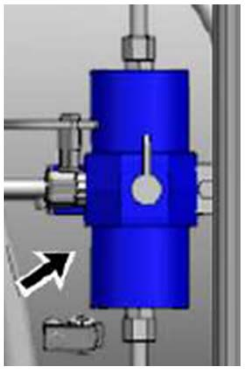
Staying in alignment with Feel the Fuel Burn mid-life recommendations.

- The main drive line spiders need to be replaced with new hardware using the D model spider (313-1923)
- Change the brake roto chambers and slack adjustors.
  - Improved Slack Adjuster Service Magazine



# Recommendation: Extended Life Brake Discs

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- This is a comparison of extended life brake discs vs standard brake discs

- In B and C model trucks, extended Life brake discs are a direct replacement for standard brake discs

Note: Most of our fleets are already using extended life discs in the rear brake. In order to extend brake life, we should utilize extended life discs in all brake configurations

| 793A,B Rear Brake Groups | | | | |
|---|---|---|---|---|
| Rear Brakes | | | | |
| * | 8X-0241 | Std brake group all 3SJ & 1HL | $28,715 | 226-2826 XL discs add $2,009 each brake |
| Front Brakes | | | | |
| * | 8X-0222 | Std brake group all 3SJ & 1HL | $34,837 | Add 190-3532 XL discs add $1,714 each brake |
| | 334-5020 | XL brake group 1HL ^ only | $37,589 | Difference of $2,752 each brake |

| 793C ATY Brake Disc Analysis | | | |
|---|---|---|---|
| Front brakes | | | |
| Extended Life friction disc | 190-3532 | $470.29/ea x 10 = $4,702.90 | Difference of $(1,713.20) per suspension for Extended Life brake discs |
| Standard Life friction disc | 7T-2815 | $298.97/ea x 10 = $2,989.70 | |
| Rear brakes | | | |
| Extended Life friction disc | 226-2826 | $436.78/ea x 15 = $6551.70 | Difference of $(2,008.20) per final drive for Extended Life brake discs |
| Standard Life friction disc | 198-1137 | $302.90/ea x 15 = $4,543.50 | |

# Extending Brake Life Overview

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Brake failures are one of the life limiting factors of the final drive assembly.

- Brake cooler, duo-cone, and ancillary brake components are common failure modes.
- Contamination is often a root cause for both brake cooler and duo-cone failure.
- Brake actuator, RE-6 valves, and slack adjusters often fail, causing brake overstrokes or individual brake application problems.
- The newest park brake pressure checks procedures are not implemented at all sites, causing low park brake release pressure which in turn can cause the brake to drag increasing wear, heat and premature failure.
  - Park brake pressures must be adjusted at the Left Rear wheel for proper release pressure. Verify park brake pressure at wheel replaced. (RENR8330) (SENR6343)