UNICAT
CATALYST TECHNOLOGIES, INC.

G. W. Aru, LLC

Integrity · Innovation · Value

Reoptimising the FCCU for OPEX savings using new FCC additive technology

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ERTC 2020 – 17 November 2020

Agenda

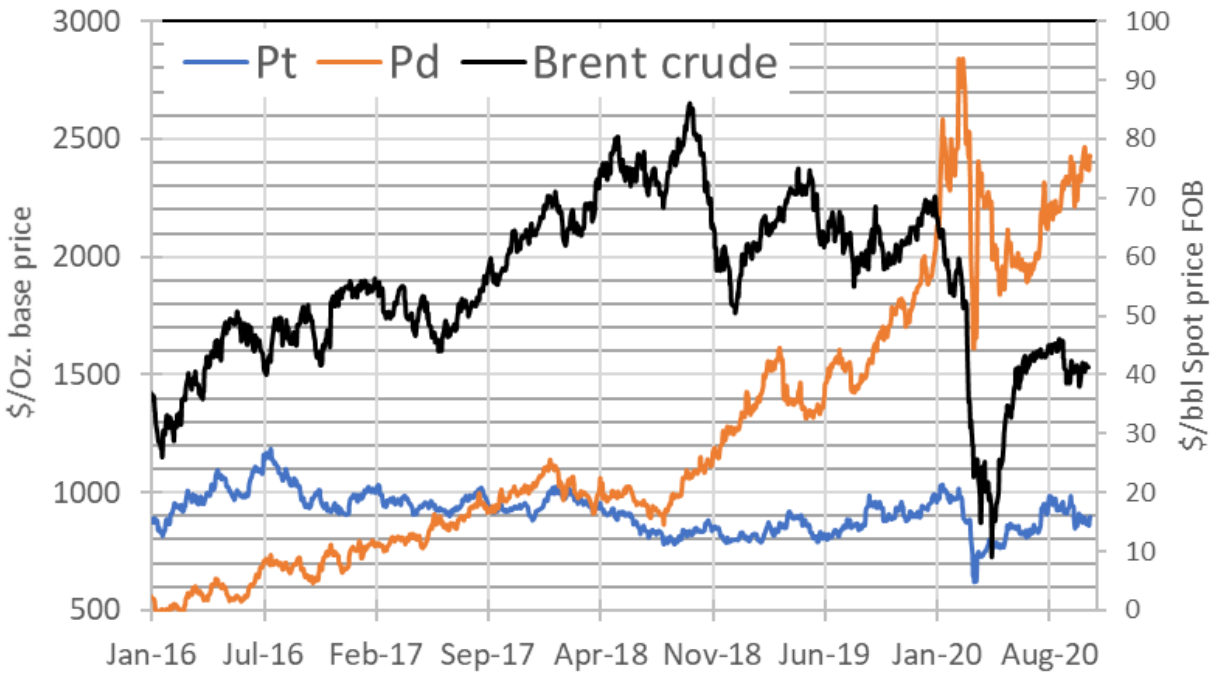
1. Challenges to refiners in 2020
2. New partnership in FCC additives
3. Development of new CO promoter technology
4. Commercial case studies
5. Industry recognition award
6. Conclusions

FCC unit profitability in 2020

- Coronavirus has impacted demand
- FCC run rates almost universally cut
- Sudden shifts in targeted products
- Environmental regulations remain

➢ The need for FCC additives continues

➢ Requirement to make savings – even stronger!



Prices of precious metals and crude oil dropped due to COVID-19. Precious metals have recovered but oil has not re-established to the same level.

Source: http://www.platinum.matthey.com/prices/price-charts ; https://www.eia.gov/dnav/pet/hist/RBRTED.htm

Introducing the companies

G. W. Aru, LLC

Integrity · Innovation · Value

- Founded 2018 by Guido Aru
- US-based company
- Focused on FCC additive technology
- Experienced team in FCC additive industry

Guido Aru – President and CEO

30 years of engineering and commercial experience in aerospace and refining & petrochemical catalyst industries, including managing the $250M Downstream Oil and Gas Business at Johnson Matthey.

www.gwaru.com

UNICAT CATALYST TECHNOLOGIES, INC.

- Co-founded 2000 by Mani Erfan
- Internationally located
- Diverse product line (refinery catalysts & absorbents)
- REACH registered
- European logistics and supply-chain

Mani Erfan – Chief Executive Officer

Co-founder of UNICAT Catalyst Technologies, Inc. and strategic investor in G. W. Aru, LLC. Over 30 years of refining and petrochemical industry experience including with Haldor Topse and Parkans International.

www.unicatcatalyst.com

Building a portfolio – Ultra FCC Additives™

- **Assembled a complete portfolio of FCC additives**
- **Work with Cat Testing Labs, Inc. to verify properties and performance**
  - Understanding chemical composition, structure and physical properties
  - Performance testing using ACE and other means
- **Assisting suppliers to improve manufacturing processes**
  - Materials, spray drying, calcination, etc.
- **Developed new technologies and product improvements**
  - CO promoters
  - SOx additives
  - C4 selective additives
  - Metal traps/Coke reduction

Great FCC Promoter™ (GFP®)	Combustion promoter
GFP®-P2; GFP®-P3; GFP®-P5	Platinum-based
GFP®-PD	Palladium-based
Ultra SOxBuster® (USB™)	SOx reduction additive
Ultra NOxBuster® (UNB™)	NOx reduction additive
Ultra C3Booster® (U3B™)	Propylene booster
Ultra C4Booster® (U4B™)	Butylene booster

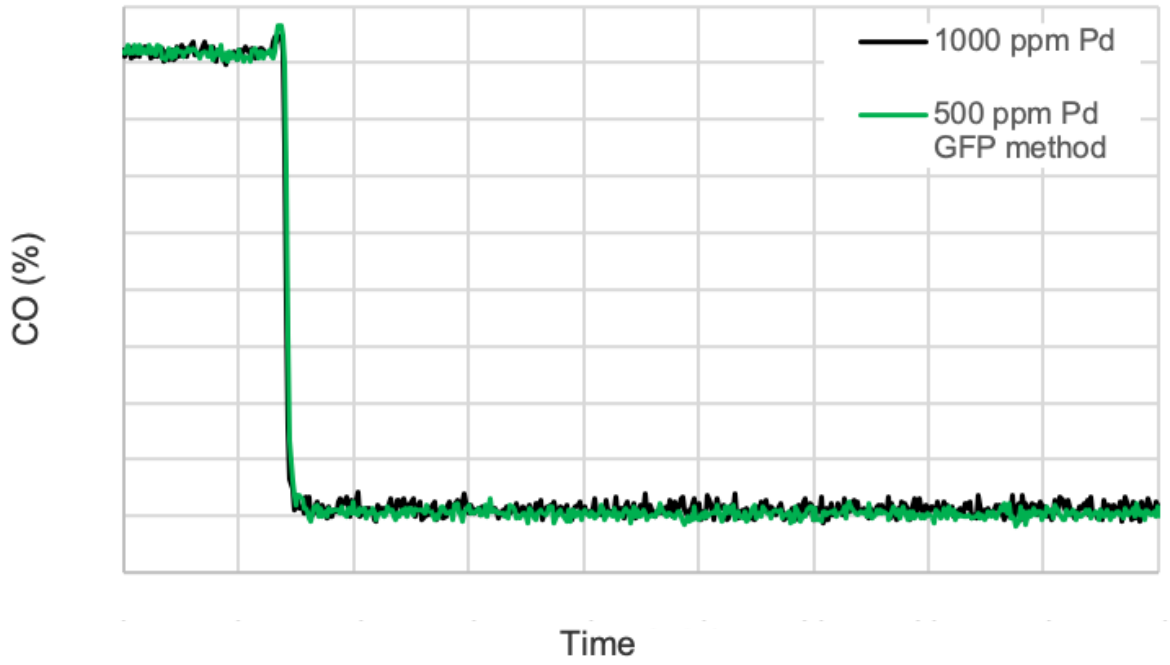
CTL CatTestingLabsInc

CPERI Chemical Process and Energy Resources Institute

Developed technology in part with testing at CPERI that provides comparable activity at lower PGM loading

Development of Great FCC Promoter™ (GFP®)

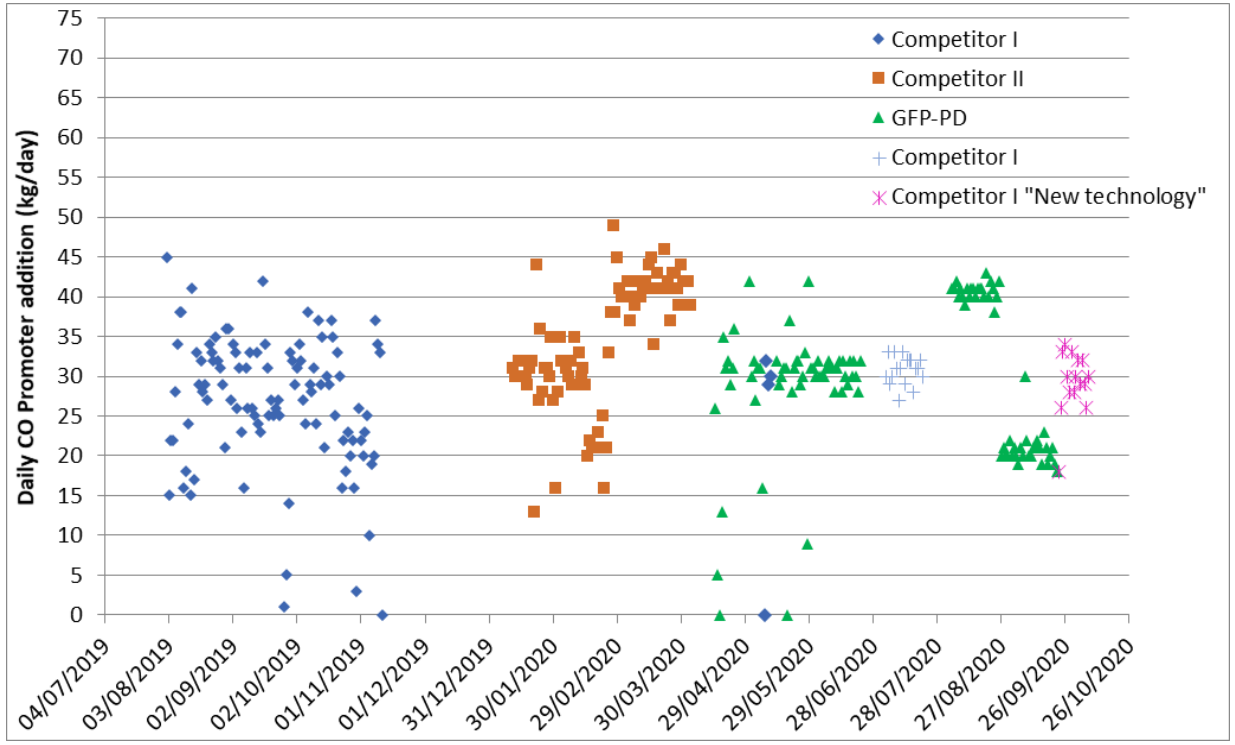
- Platinum-group metals (PGM) catalyse CO to CO_2 in dense bed
- High cost due to PGM prices
- Using our understanding of CO oxidation and deactivation, we designed Great FCC Promoter™
- Example of non-Pt based combustion promoter prepared using new method
  - GFP® method optimises PGM usage for CO promoter activity
  - Patent pending – use, composition of matter and manufacturing methods
- Activity differences not observed when PGM loading reduced by 50%
- Laboratory results validated by commercial case studies



Data collected at CPERI indicated equivalent CO oxidation for ½ Pd content when promoter prepared using GFP method

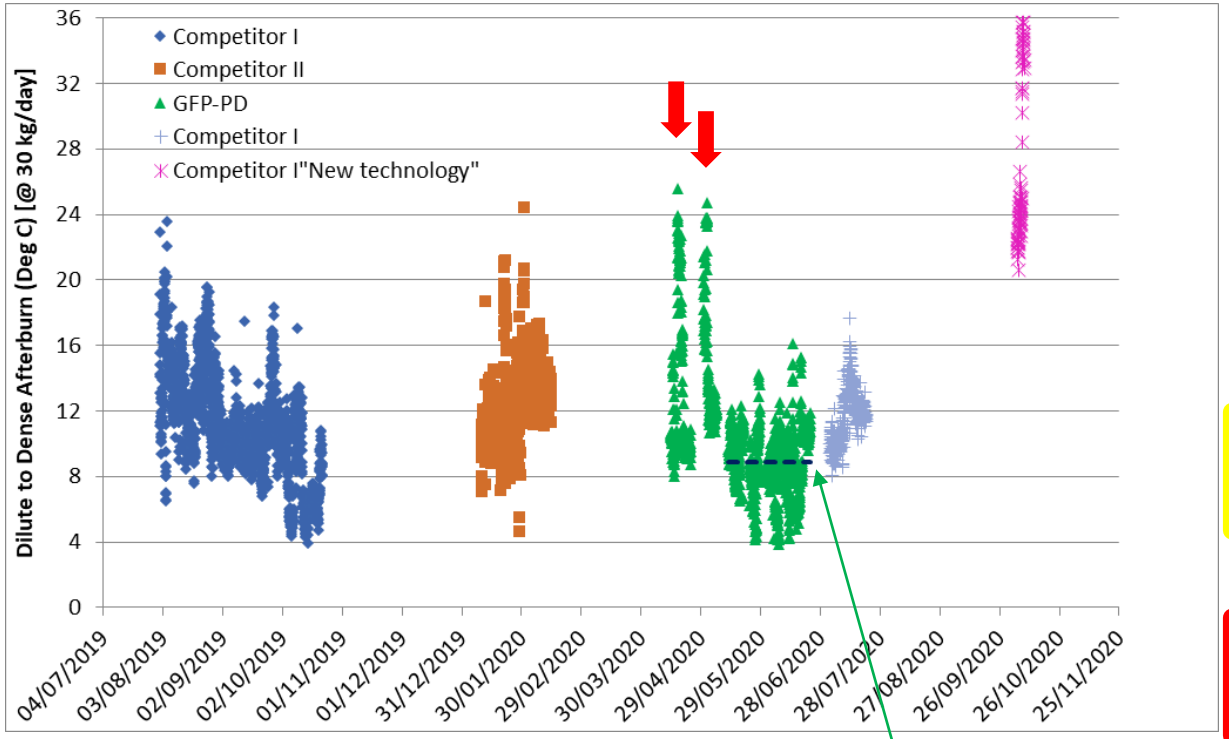
GFP®-PD Case Study 1

- Western Europe FCC unit operated by an oil major
- UOP High Efficiency FCC
- Long-term user of competitor I
- Back-to-back trials conducted with major FCC additives suppliers
  - Competitor I (blue)
  - Competitor II (orange)
  - GFP-PD (green)
  - “New technology” from Competitor I (pink)
- Objective:
  - ➢ Find the most cost-effective CO promoter capable of controlling afterburn, without high NOx emissions
  - ➢ Eliminate copper – on safety and toxicity grounds
- All promoters trialed are palladium-based



Main trial conducted at a fixed promoter addition rate at 30 kg/day for comparison. Other setpoints tested for sensitivity

GFP®-PD Case Study 1



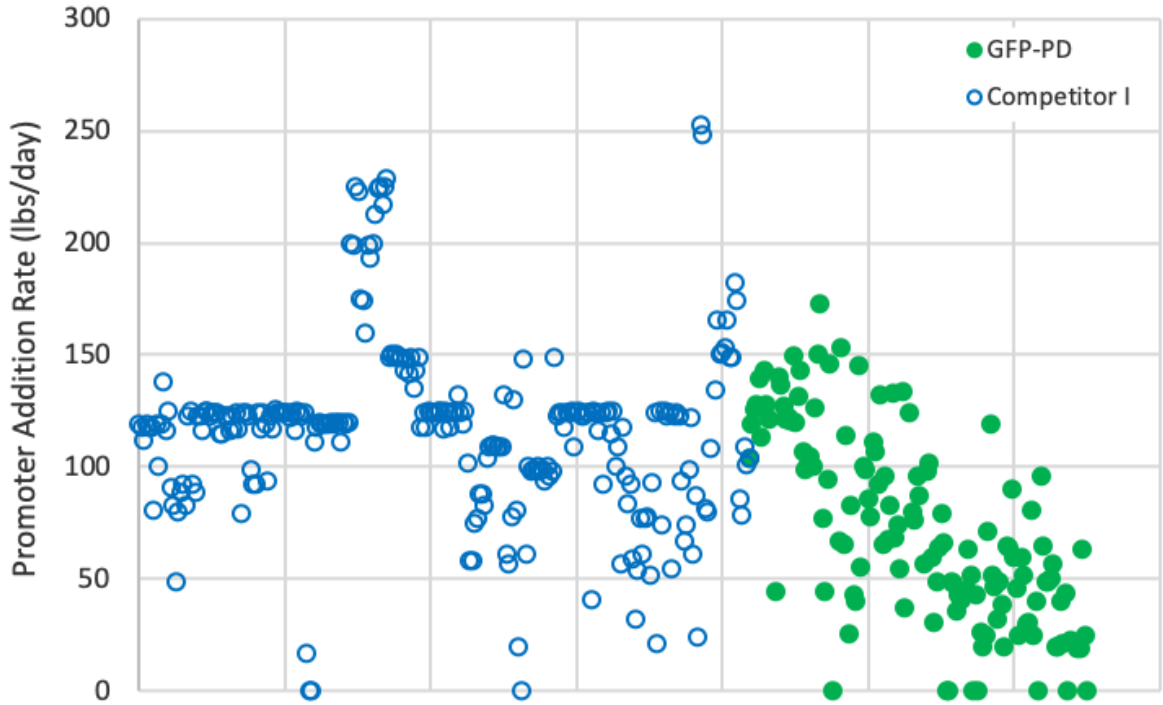
Average values (at 30 kg/day)	Upper regen dense T	Dilute to dense	Cyclone to dense
CO Promoter	°C	°C	°C
Competitor I	733	11.0	4.7
Competitor II	720	12.8	6.1
GFP®-PD	**721**	Lowest **10.4**	Lowest **3.8**
Competitor I	718	11.7	5.2
"New Technology" from Competitor I	722	Highest 27.1	Highest 20.4

- Afterburn lowest with GFP®-PD
  - During stable FCC operation, average of 8.8 °C afterburn
- Various methods of measuring afterburn
  - GFP®-PD lowest in every case

Lowest afterburn despite having lowest PGM content: GFP® improves afterburn control at a lower cost

GFP®-PD Case Study 2

- U.S. Gulf Coast FCC unit
- UOP Side-by-Side FCC
- Long-term user of competitor I
- Back-to-back trial conducted
  - Competitor I (blue)
  - GFP-PD (green)
- Objective:
  - ➢ Maintain constant regenerator flue gas temperature
  - ➢ Tight control of NOx emissions
- Trial period shown ~6-7 weeks
- Both promoters trialed are palladium-based

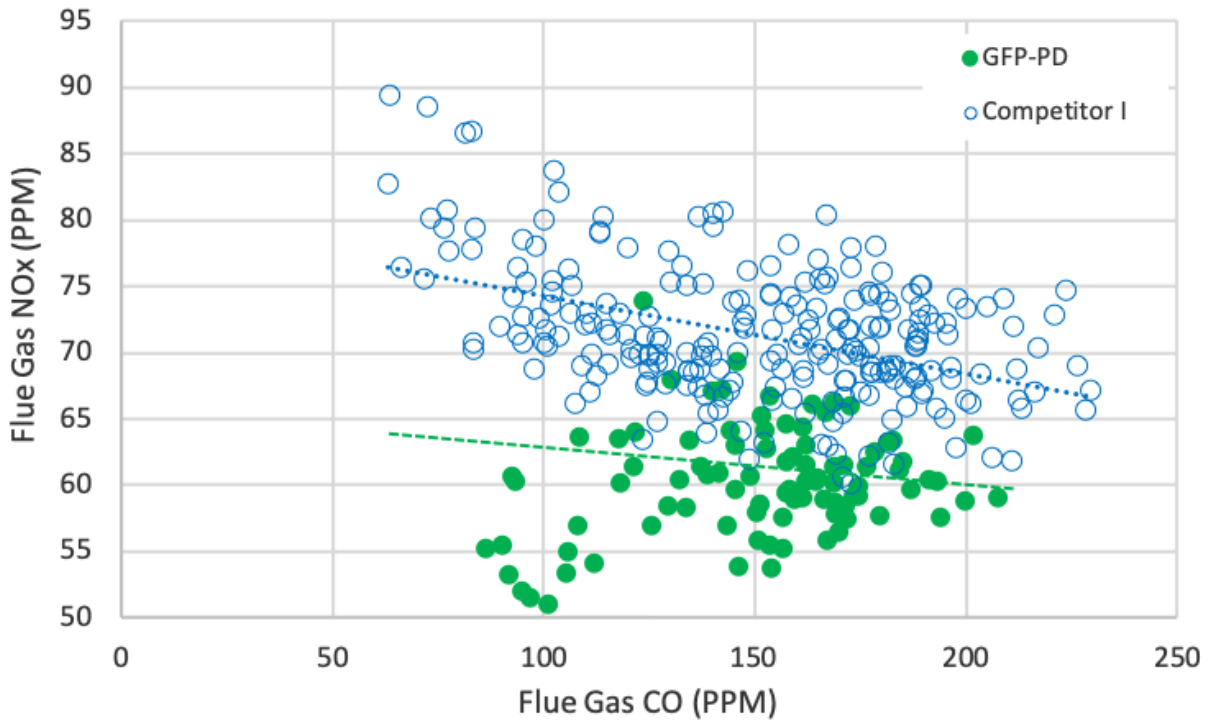


CO promoter addition rate controlled to achieve constant regenerator flue gas temperature

At constant temperature, GFP-PD additions reduced by approximately 40 lbs/day (18 kg/day), based on typical addition rates of 115 lbs/day (52 kg/day) for competitor I

GFP®-PD Case Study 2

- Due to lower PGM required to control afterburn, lower NOx emissions are expected
- Data show a reduction in flue gas NOx during trial
- NOx response this refiner observed with GFP®-PD is extremely beneficial
- Overall, this trial proved profitable for refiner:
  - Lower cost promoter more effective
  - Reduced addition rates
  - Reduced NOx emissions



Reduced NOx emissions at any given CO

Who else has adopted this great technology?

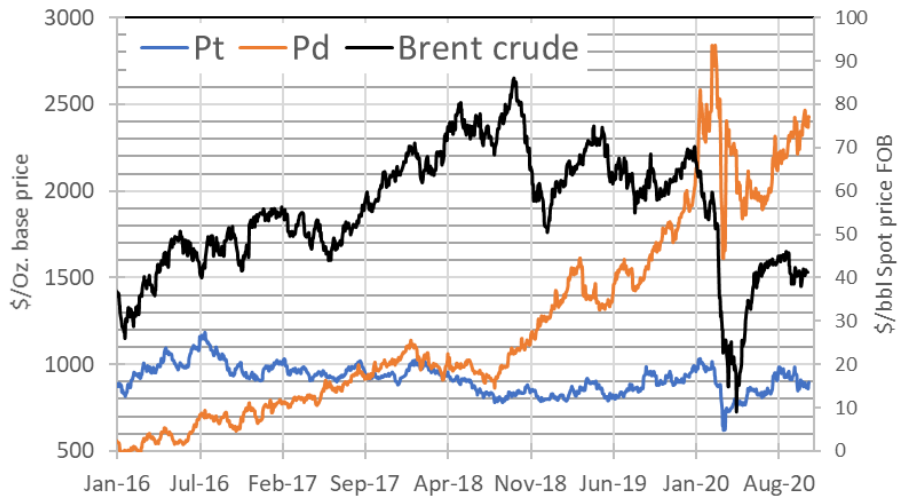
- Technology commercialised for both platinum and non-platinum based promoters
- Proven in over 20 refineries worldwide including Europe, U.S., and Asia

GFP®-PD	GFP®-P2	GFP®-P3	GFP®-P5
15	1	3	3

- Marathon Petroleum Company presented G. W. Aru, LLC with the Innovation Partnership award for GFP® technology as part of their 5th Annual Supplier Recognition Awards 2020

Conclusions – Great FCC Promoter™

- G. W. Aru, LLC & UNICAT have partnered to provide innovative technologies and cost savings to European refiners
- Developed a novel, low precious metal FCC combustion promoter that outperforms traditional CO promoters
  - Lower addition rates to achieve same afterburn control
  - Lower PGM loading yields significant cost savings
  - Lower NOx formation
- Case study data presented here demonstrate afterburn control performance for GFP®-PD. Similar data can be provided for platinum-based GFP®
- Technology adopted globally with more users coming on-stream through 2020



At current PGM prices, users of platinum or palladium-based CO promoters will achieve significant cost savings with GFP® technology

	Q1 2019	Q2 2019	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Current Qtr.
Quarter average Pd price, $/oz	1,441	1,396	1,542	1,805	2,323	2,029	2,190	2,387
$ Pd in 1 kg at 1000 ppm	46.33	44.87	49.58	58.03	74.68	65.23	70.41	76.76

Source: http://www.platinum.matthey.com/prices/price-charts

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