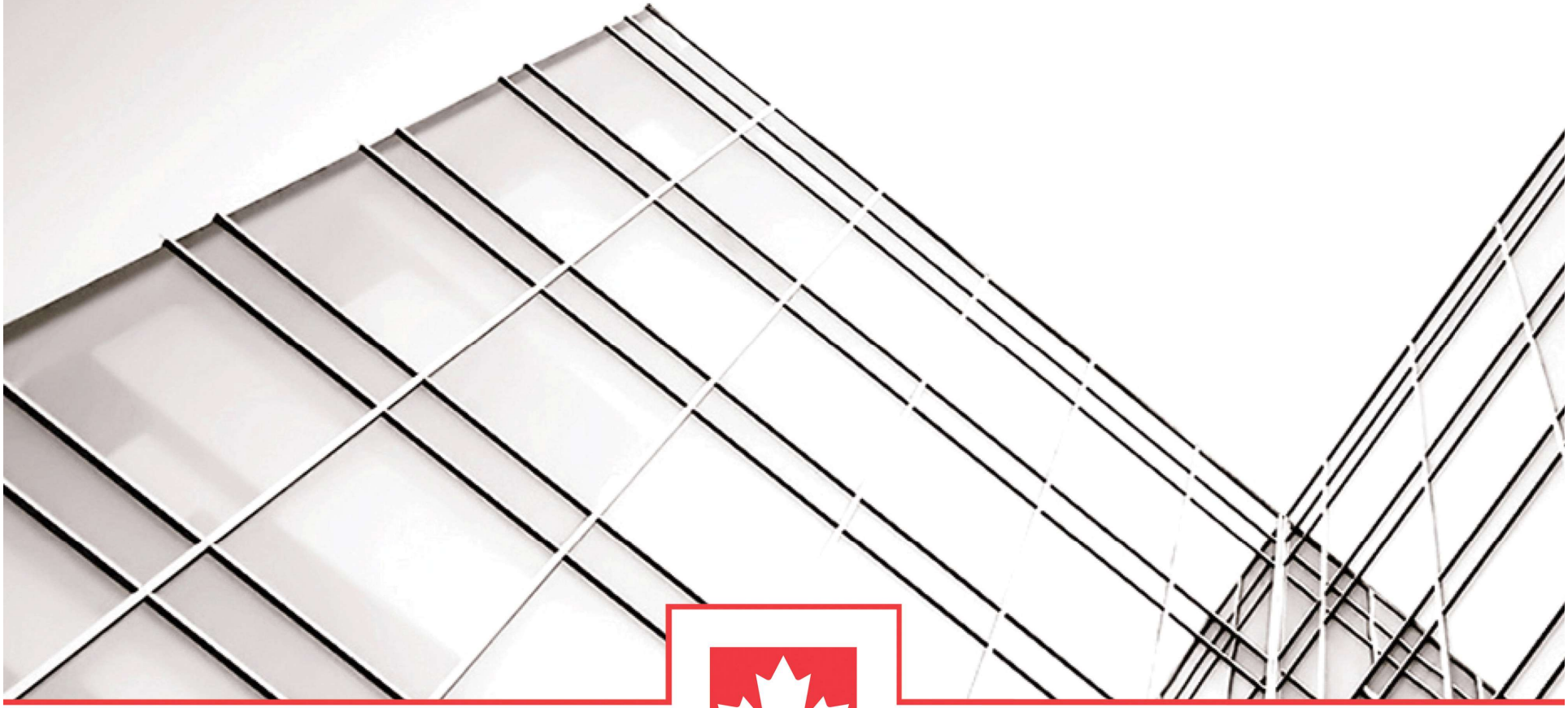
2019 Tech Talk – Fall 2018 Dewax Outage to Clean DWO Recovery Exchangers



PETRO-CANADA

Beyond today's standards.™

June 2019

Agenda

- Dewax Unit Overview
- Oil Recovery
- Fall 2018 Operation vs Design
- Inspection History
- Outage Recommendation
- Outage Findings
- Post Outage Performance

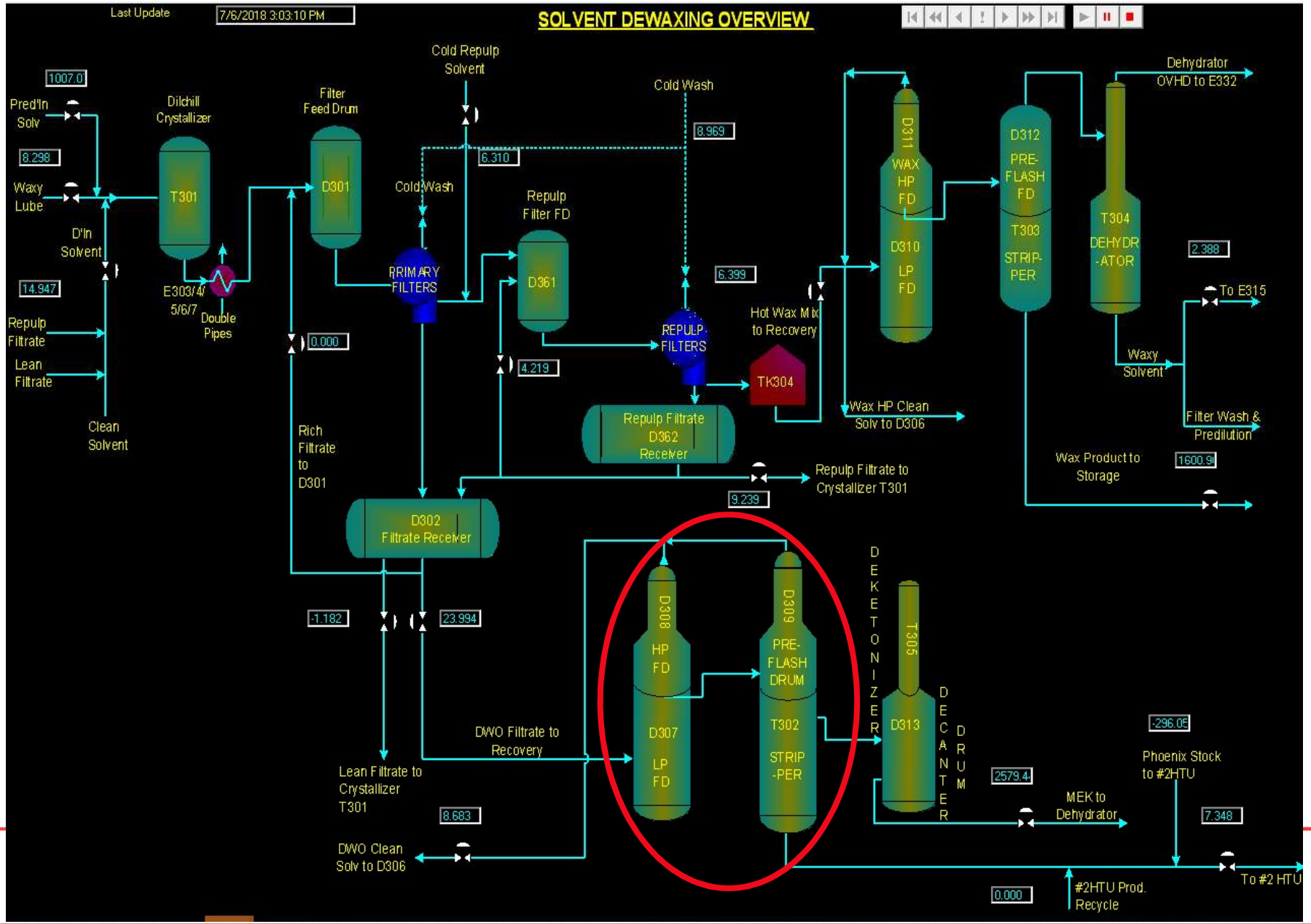
Dewax Unit Overview

- Unit Feed: Waxy products produced in #1 HTU from VGO
- Process Five Stocks: W60L, W100L, W200M, W350L, W650M
- The Dewax processes one stock at a time, pulling the waxy feed from tankage.
    - *Note: we do not process anything directly off #1 HTU*

- Equipment Overview:
    - *1 Dillchill crystallizer, 5 double pipes*
    - *6 filters (4 primary and 2 repulp OR 3 into 3)*
    - *2 compressors (refrigeration compressor & blowgas compressor)*
    - *Propylene Refrigerant, MEK & Toluene Solvents*
    - *Largest steam user on site*

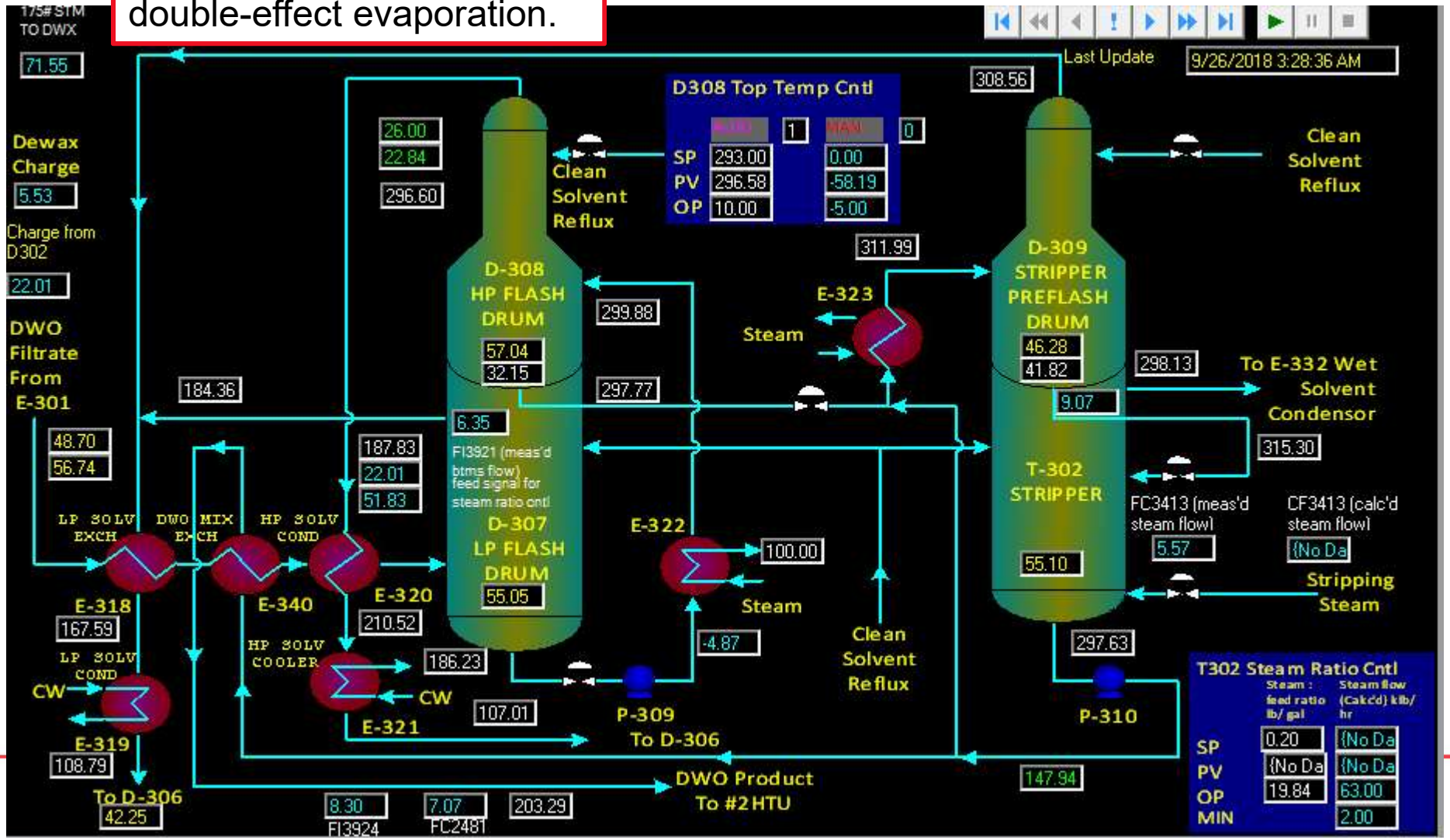
PETRO-CANADA

Dewax Unit Overview



Oil Recovery – 2018 Operation

Purpose: Remove solvent from dewaxed oil through double-effect evaporation.



Design vs. Fall 2018 Operation

	Fall 2018 Operating	Design
Flowrate	22.0 kBPD	30 kBPD
D307 (LP Flash Drum) Operating Temp	188F	212F
D308 (HP Flash Drum) Operating Temp	300F – 310F	350F
T302 (Stripper) Bottoms Temp	295 – 305F	336F

The oil recovery is was our limitation on all stocks as **T302 bottoms temperature must be maintained hot enough to remove all the solvent.**

- Historical (early 2000s) guideline was 320F on T302 bottoms.
- Over time, this has been relaxed to 300F
  - Operating close to Alarm (290F) and Trip (275F), which are there to prevent an exothermic reaction in #2HTU reactor
  - Recent testing (Sept.) shows up to 200 ppmw toluene in oil to #2 HTU

PETRO-CANADA

Impact on Dewax Charge

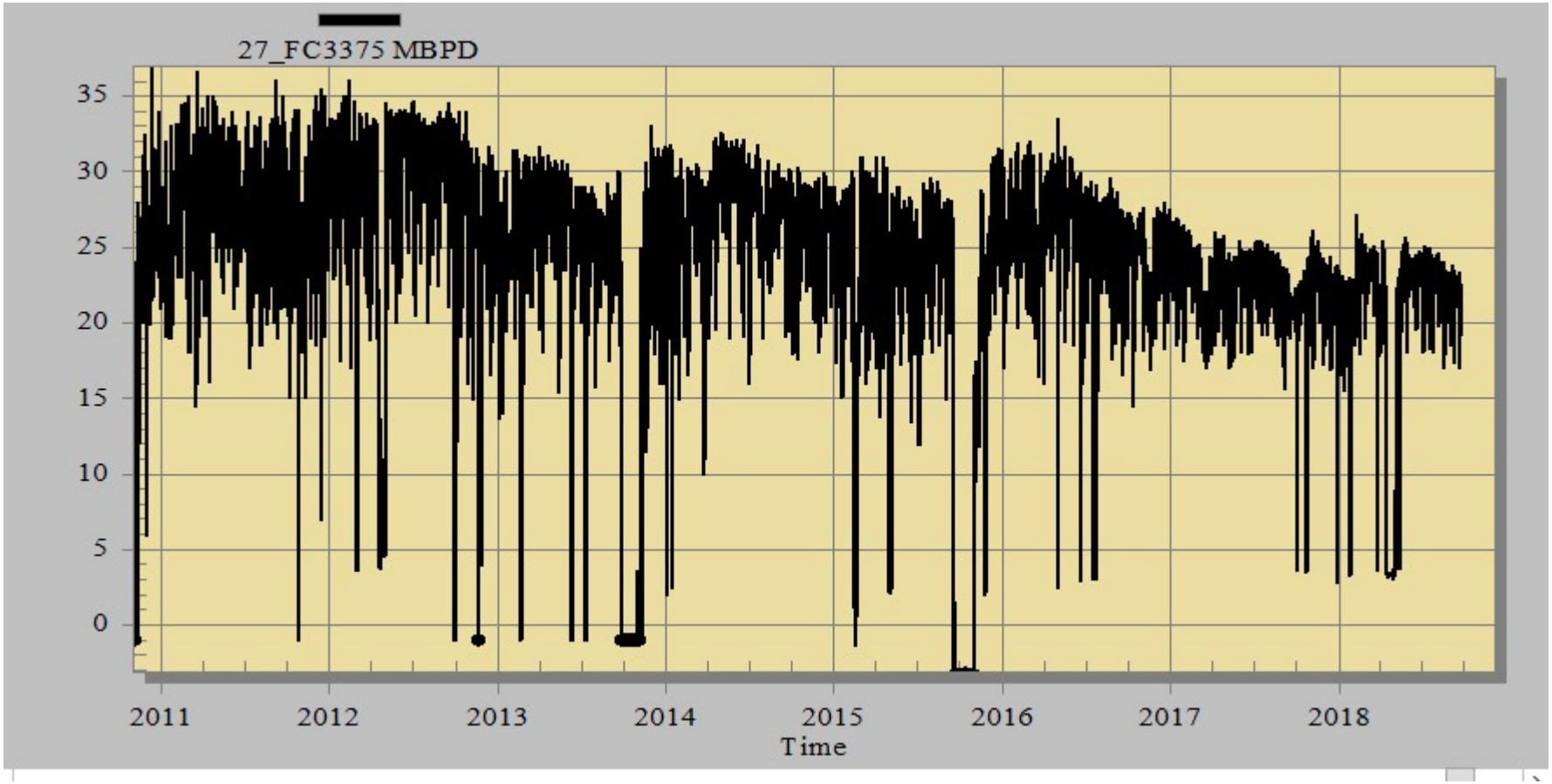
Stock	Historic	Sept. 2018 Avg *
W60	6.2	6.2+
W100	8.7	8.0
W200	8.7	7.5
W350	7.0	6.1
W650	6.2	5.5

* Limited by Dewax Oil Recovery

PETRO-CANADA

Historical Operation

- **Flow Rate to Oil Recovery – 2011 to 2018**

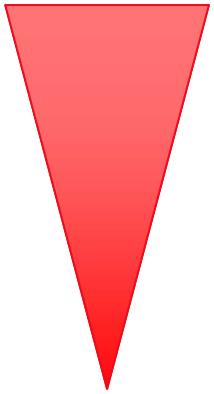


PETRO-CANADA

U Value Calculations

	U value * (% of design)	Design duty (MMBTU/hr)
E322	48%	37.3
E318	63%	19.7
E323	~40%	1.75
E320	85%	23.9
E340	69%	6.2

Cleaning priority



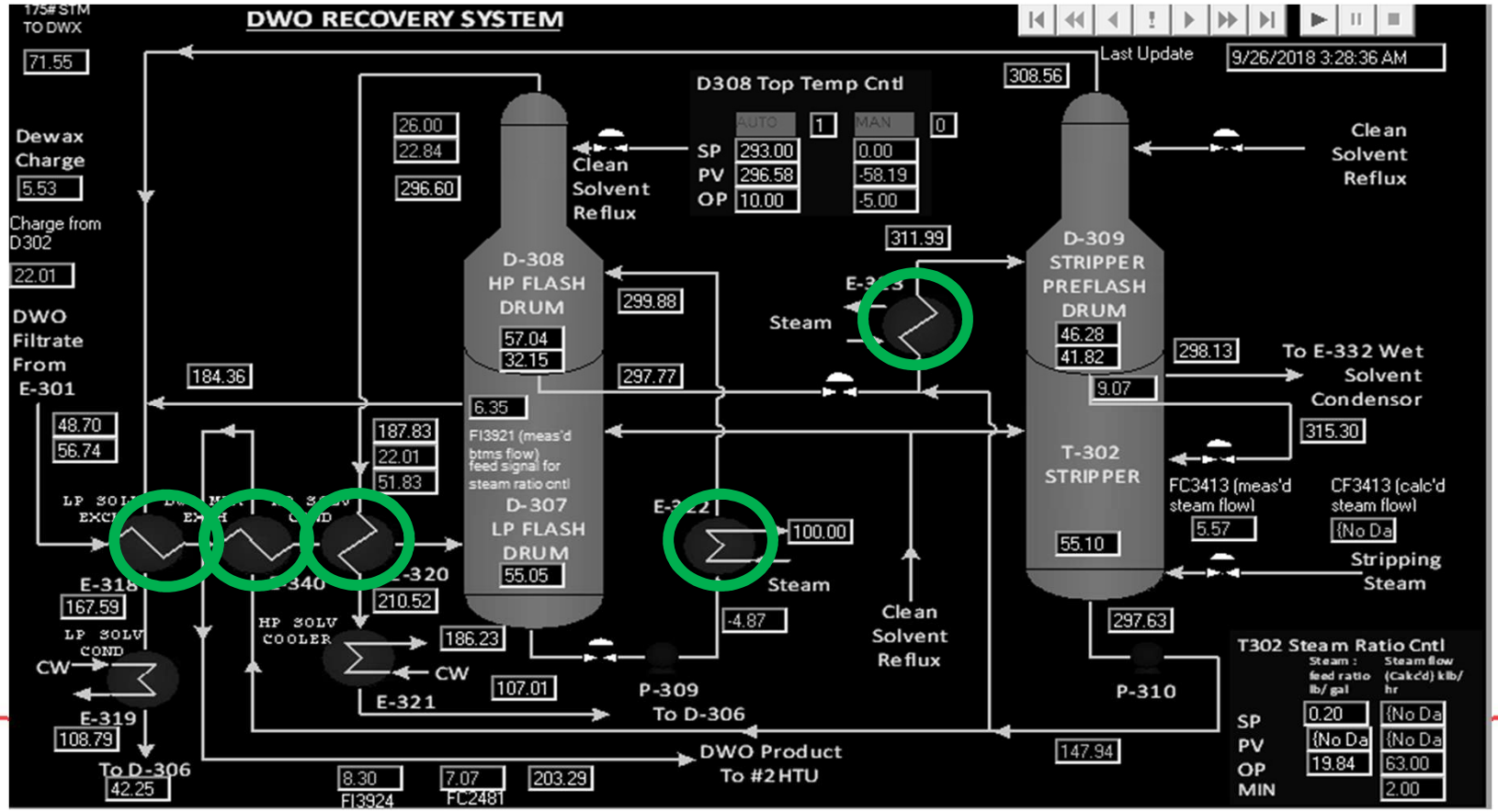
***Completed by C. Pai based on June 2017 data & validated by RefOpt**

Highlights from Inspection Records

- **E322 – history of shell side fouling, varying success with cleaning methods**
  - 2005 – Shell ID had thin black oily product coating all surfaces. Half an inch of watery black sludge. Tube ODs have thin black oily coating. Tube ID's quite clean.
  - 1996 – Tube side was removed – minimal fouling found. Suspected shell side fouling so the Shell side was steamed with 50# steam. Higher rates on start up.
  - 1987 – Shell side lightly fouled with black, metallic scale.
  - 1983 – Mini S/D to clean bundle, flushed with cutter stock. HP water wash in 1984
  - 1981 – Tube ODs covered with friable black magnetic scale. Report mentions exchanger fouling, and only moderate success back-flushing bundle with cycle oil. Again in 1982.
- **E318 – scale, not cleaned since 1995**
  - Tube OD thin hard scale (1991), Bucket of black magnetic scale in channel (1981)
- **E320 – light oily film/fouling**
  - Tubes cleaned (1995), Shell thin oily film (1991), Tubes fairly clean (1984), Tubes lightly fouled, cleaned in place (1981)
- **E340 – oily film, difficult to clean**
  - 2015 – Thin oily film. External deposit on Tube ID, HP water wash unable to clean.
  - Shell ID light oily film (1991), Tubes light oily deposit, HP water wash (1984)
- **E323 – moderate fouling with oily sludge, difficult to clean**
  - last cleaned 2009, Tube IDs moderately fouled with product sludge (1995)

Tech Services Recommendation

- **12-day Dewax Outage to Clean the 5 Exchangers in the Oil Recovery**
  - Dewax on circulation (front end & wax recovery), Shut down C301
  - De-inventory D307, D308, D309
- **Cost estimate ~$900k for pulling bundles and cleaning**



Possible Outage Timing

Window	Pros	Cons/Risks	Mitigations
Nov. 2018	• Alleviate pin on Dewax charge rates	• Challenge building inventory for 12 day outage • Short time to plan and execute cleaning & other work	• 90% allocation on liftings for Oct. & Nov. to maintain 8 DFS Vs. 2 DFS with no allocation • Inject purchased material to the #2 HTU (6-7 days)
March 2019	• Adequate time to plan customer impacts and plan work	• Continue to run at reduced Dewax rates • Possibility of further reductions to charge rates due to fouling. • Produce 120Kbbls less Vs. Nov. outage (assuming 3% reduction in charge rates)= 21 Dewax days • Produce 50Kbbls less Vs. Nov. outage (assuming no reduction is charge rates) = 9 Dewax days	• Additional 600 purchases • Reduction in HT100/200 marginal sales • CDW BOM switches
July 2019	• Align with boiler outage – 12 days without reduced Dewax charge • More time plan customer impacts and plan work	• Excessive fouling causing min Dewax charge rates and inability to build inventory for outage. • Produce 170 kbbls less Vs. Nov. outage (assuming 3% reduction in charge rates) = 31 Dewax days • Restarting Dewax on one boiler	

Cost Comparison for the 3 options

Window	MTCE Cost	Lost Production Cost	Total Cost
Nov. 2018	• $900 k	• 5 days of lost production (12 outage days – 7 injection days) at ~$200K per day = $1M	• $1.9M
March 2019	• $900 k	• 5 days of lost production (12 outage days – 7 injection days) at ~$200K per day = $1M • Best case – loose 9 Dewax day due to limited charge at $200K/day = $1.8M • Worst Case – Loose 21 Dewax days due to limited charge at $200K/day = $4.2 M	• Best Case = $3.7 M • Worst case = $6.1 M
July 2019	• $900 k	• 5 days of lost production (12 outage days – 7 injection days) at ~$200K per day = $1M • Worst Case – Loose 31 Dewax days due to limited charge at $200K/day = $6.2 M	• Worst case = $8.1 M

PETRO-CANADA

Outage Findings

- **Thin black film on the process side of all exchangers**
- **E322 Shell Side (Process) Fouling**

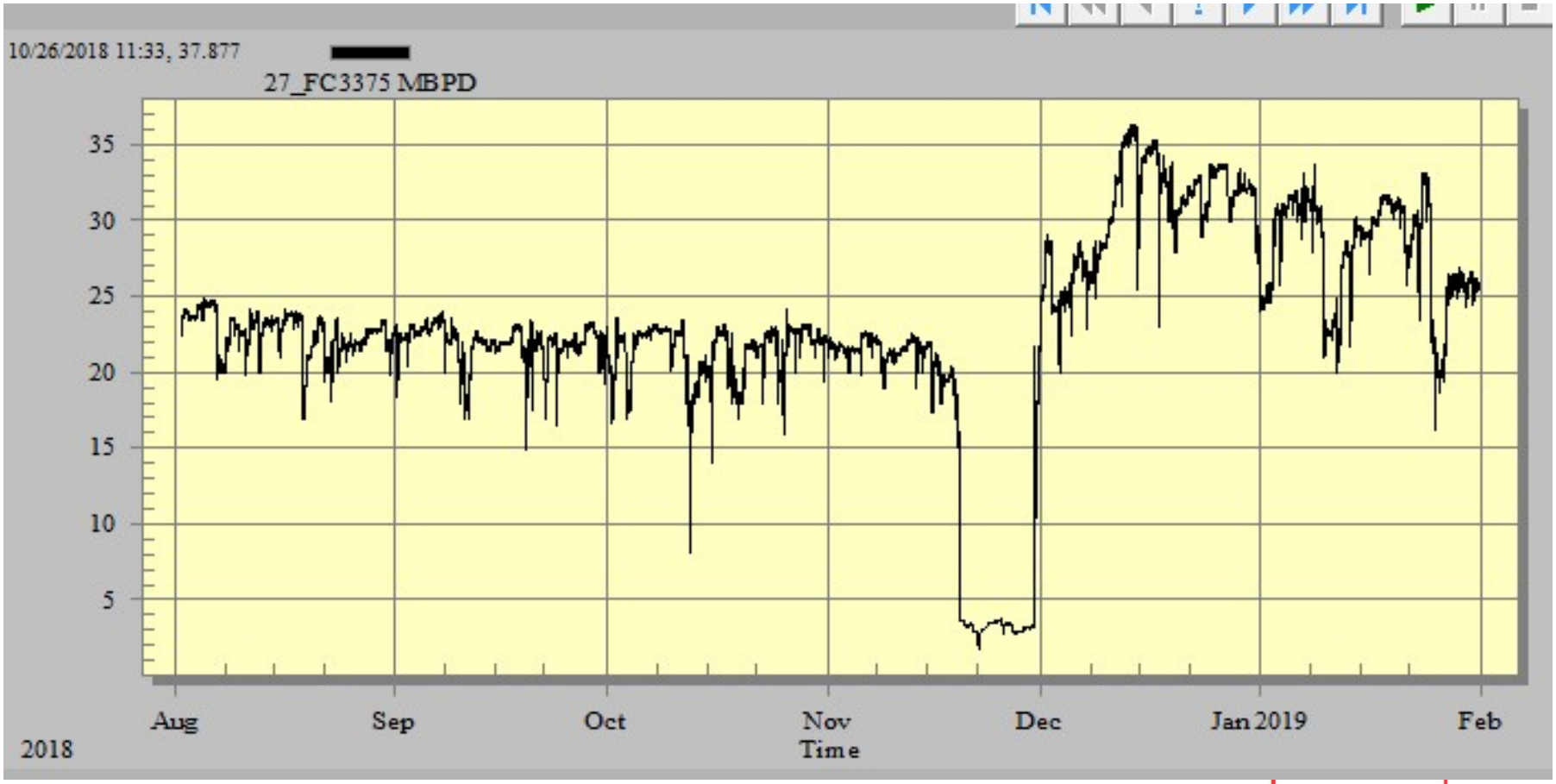
Outage Findings

- **E318 Tube Side**

- **E340 Tube Side**

Post Outage Operation

- **Flow Rate to Oil Recovery – Pre and Post 2018 Outage**



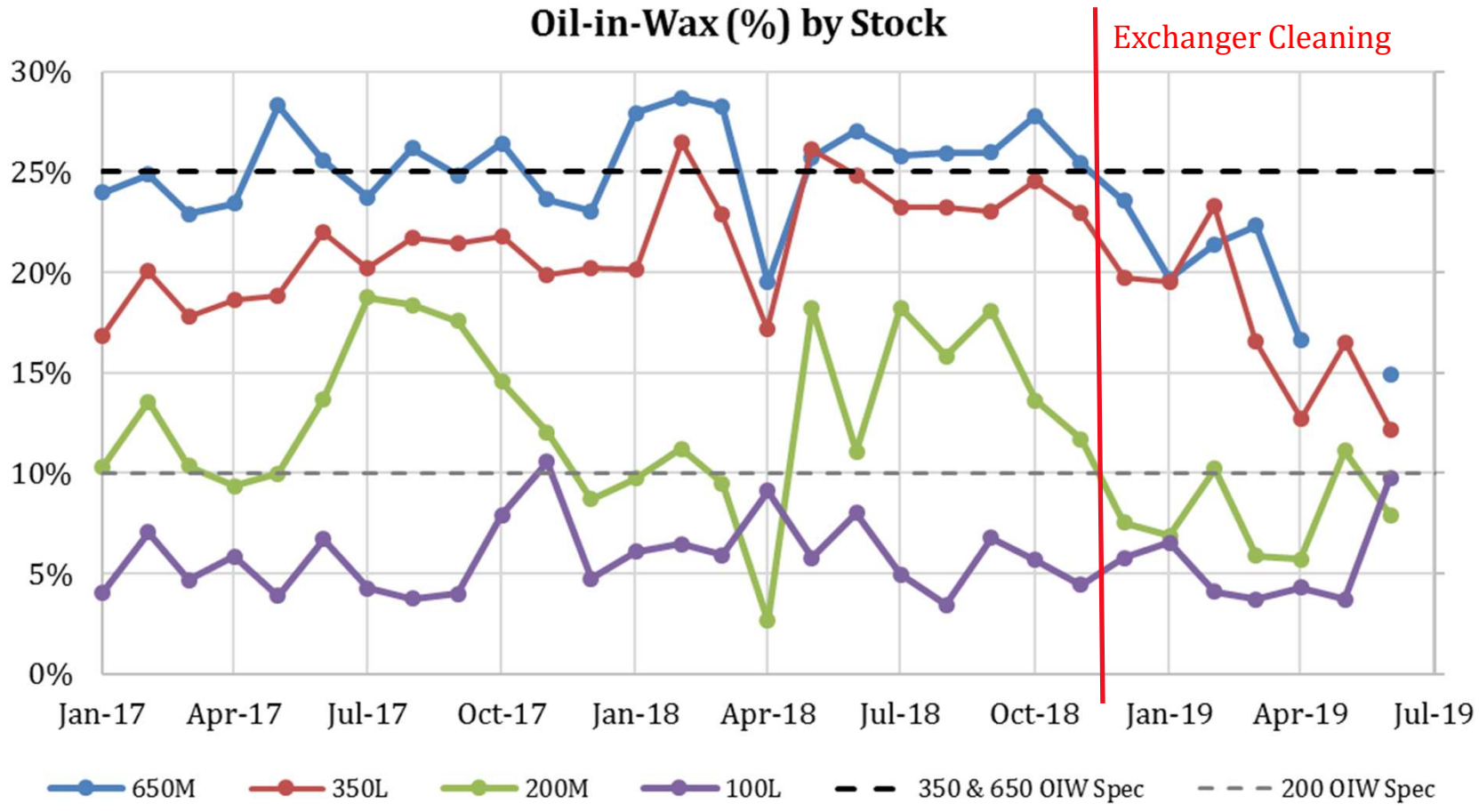
Impact on Dewax Charge

Stock	Historic	Sept. 2018 Avg *	Dec. 2018 Avg
W60	6.2	6.2+	7.5
W100	8.7	8.0	8.9
W200	8.7	7.5	8.8
W350	7.0	6.1	7.1
W650	6.2	5.5	6.2

** Limited by Dewax Oil Recovery*

PETRO-CANADA

Improvement in Wax Quality



Beyond today's standards.™