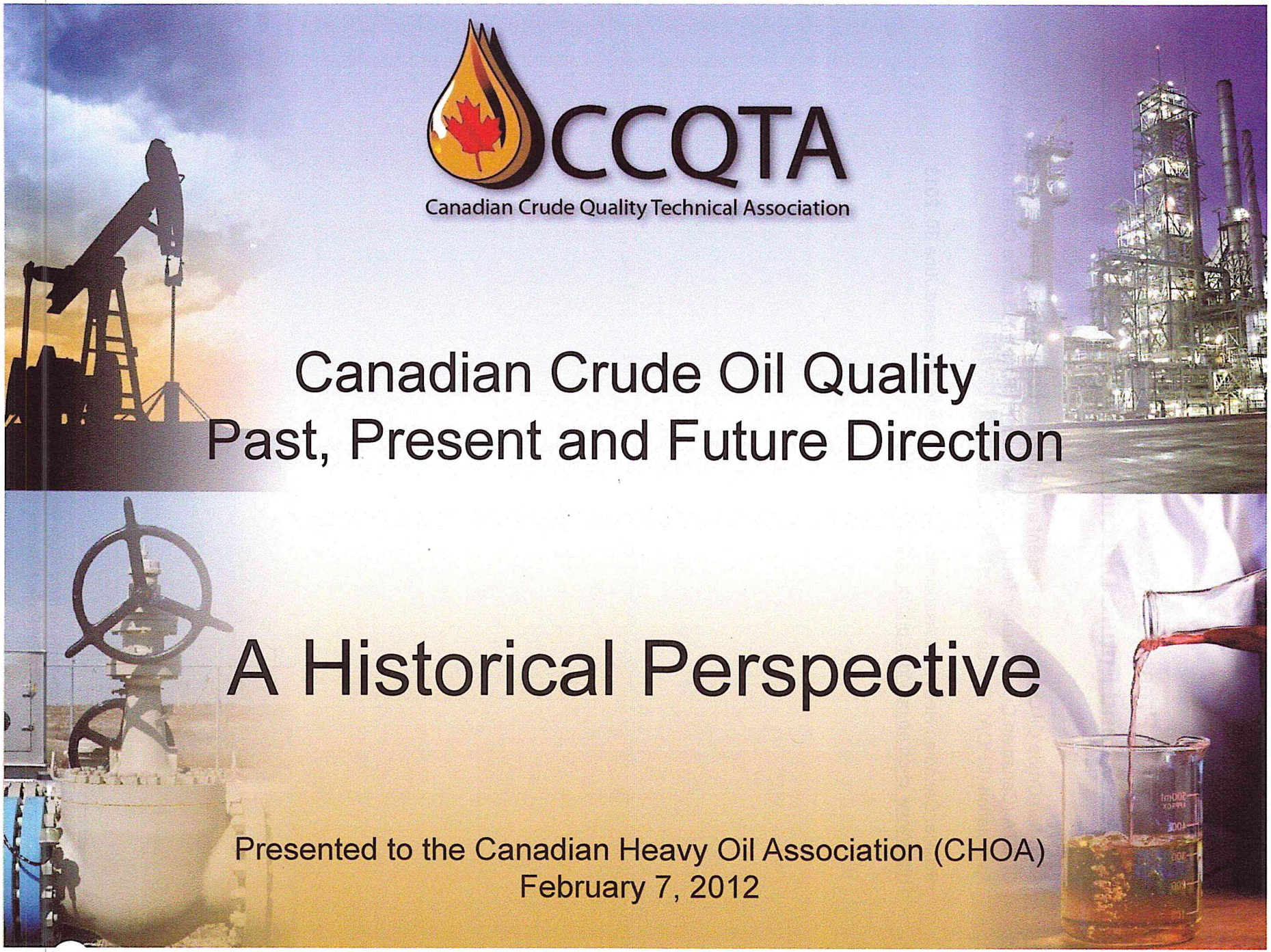
APPENDIX

I. CCQTA Presentation: Canadian Crude Oil Quality: Past, Present and Future Direction

Canadian Crude Oil Quality Past, Present and Future Direction: A Historical Perspective, CCQTA (Canadian Crude Quality Technical Association), Presented to the Canadian Heavy Oil Association (CHOA), February 7, 2012 (40 pages)

Source: Canadian Heavy Oil Association (CHOA) Website: Accessed June 30, 2013
http://www.choa.ab.ca/index.php/ci_id/9210/la_id/1/


CCQTA
Canadian Crude Quality Technical Association
Canadian Crude Oil Quality
Past, Present and Future Direction
A Historical Perspective
Presented to the Canadian Heavy Oil Association (CHOA)
February 7, 2012

Overview

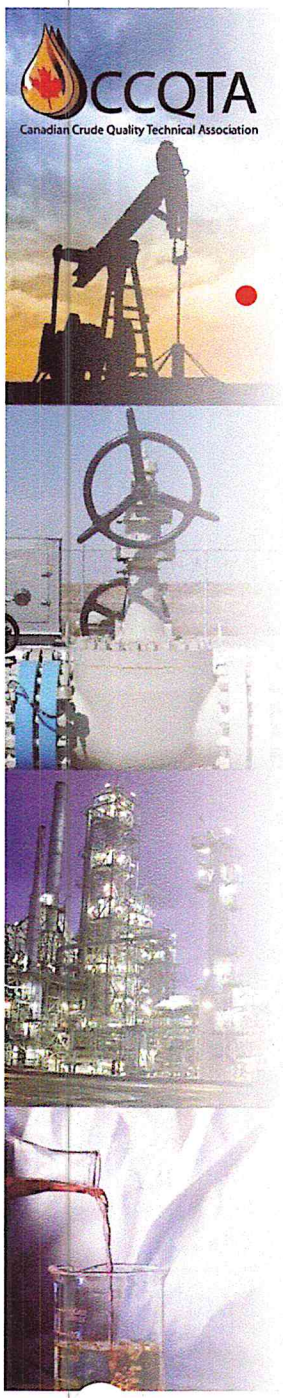
- Introduction to the CCQTA
  - *Very short infomercial*
- What is Crude Quality, and why should I care?
- Where do I sit in the value chain
  - *Producer/upgrader, transportation or refinery*
- What are the Key considerations for crude quality
  - *What has changed over the last 40 years?*
- What does the future look like?

CCQTA

- Canadian Crude Quality Technical Association
- Founded in 1996, the CCQTA is a registered not-for-profit Association in Alberta formed to:
  - *Facilitate the resolution of common crude oil quality issues through collaborative research*
  - *Develop and run "industry research projects"*
  - *Improve industry knowledge and awareness of crude oil quality*
- 59 member companies, 7 active projects
  - →TAN, Condensate Quality, Contaminant Monitoring, Heavy Oil Stability/Compatibility, H2S in Crude, Phosphorus, Bitumen Processability
- For more information, visit: **www.ccqta.com**

Crude Oil Quality

- Broad Measure:
  - *Quality is:*
    - →the degree to which a product (or service)
      - *meets the expectations (and needs) of the <u>end user</u>*
- The <u>end user</u> of crude oil may be:
  - *Production facility*
  - *Pipeline/transportation system*
  - *Refinery/upgrader customer*
- Crude oil quality starts with the oil in the reservoir, and changes with each handling step along the way to "finished products"

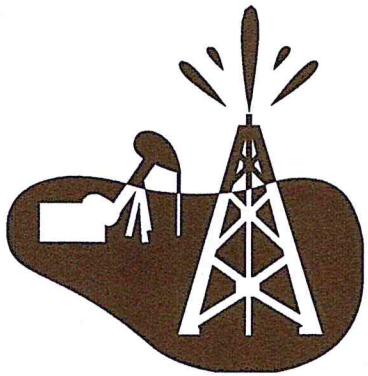


What Does Quality Mean?

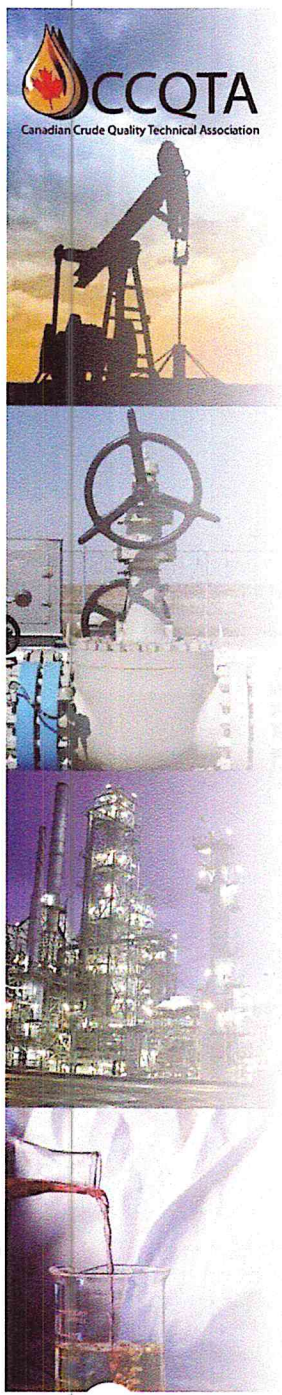
- Depends on where you are..
  - *For a SAGD producer*
    - →Get this material in the pipeline and out to my customers
      - *Meeting pipeline specifications*
  - *For a pipeline company*
    - → I have rules that you must meet to allow this in the pipeline
      - *Related to pumping, transport and pipeline integrity*
    - → Make every effort to deliver material "in good condition"
  - *For a refinery customer*
    - → I need to know what molecules will be delivered
    - → How can I convert these into saleable products?
    - → I need to be in compliance with my operating permits

Where Are You?

- SAGD production facility
  - →Need to satisfy pipeline specifications



- *Key pipeline specifications*
  - → API Gravity (density) @ 15C
    - *940 kg/m3 (19 API)*
  - → Viscosity (at the reference pipe temperature)
    - *Max 350 cSt*
  - → Bottoms Sediment and Water (BS&W)
    - *Max 0.5 lv%*
  - →Maximum Reid Vapour Pressure (RVP)
    - *Butane in crude*
  - → No organic chlorides
  - → No olefins
  - → No physical or chemical characteristics that may render crude oil "not readily transportable"



Quality Measures - Cushing

- Quality Testing requirements the NYMEX and CME (Chicago Mercantile Exchange) – West Texas Intermediate (WTI)

Parameter	Test Method	Comment
API gravity	ASTM D287	Density
Sulphur	ASTM D4249	Contamination
Vapour Pressure	ASTM D5191	Butane in crude
Viscosity	ASTM D445	Pipeline pumping
Pour Point	ASTM D97	Wax

- Recommended NYMEX additional quality parameters

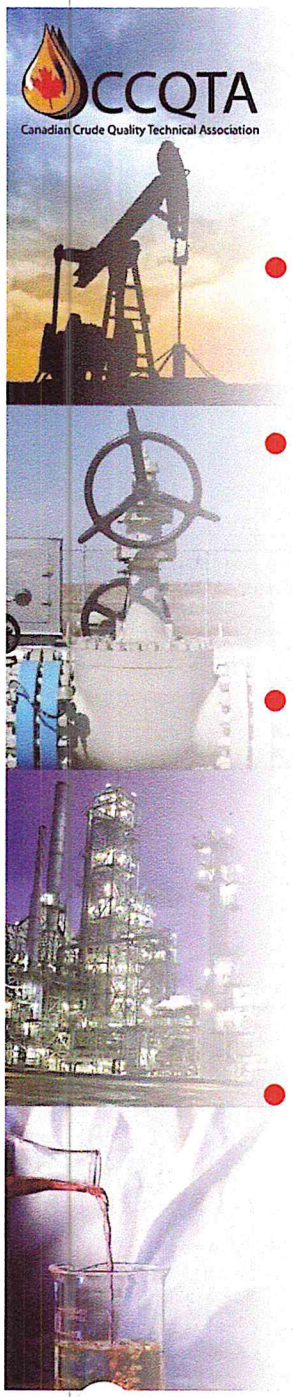
Parameter	Test Method	Comment
Acid Number	ASTM D664	TAN number
Distillation	ASTM D7169	Hydrocarbon
Metals	ASTM D5708	Ni, V and Fe
MCR	ASTM 4350	Microcarbon residue

CCQTA
Canadian Crude Quality Technical Association

Refining Crude Oil

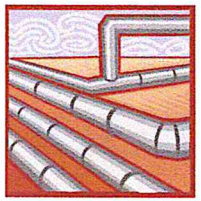
- Need more than sulphur and gravity to determine the "acceptability" of crude oil in a refinery.
- The hydrocarbon make-up and contaminants determine the attractiveness of a particular crude oil type
- Refinery has computer models (LP) representing the refinery hardware capabilities and constraints
  - *Used to determine the fit/value of crude oil*
    - →Recognizes price/quality of crude oil
    - →Looking for and "optimal" crude slate to meet the refinery production requirements… at low cost or max profit

- The best crude is the "cheapest" crude?
  - *If you can handle the hydrocarbon and contaminants*



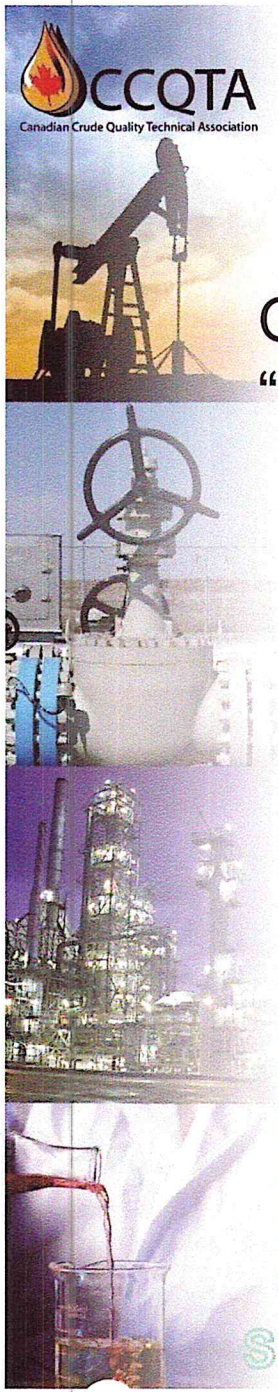
Refining Crude Oil

- A crude assay is like the "fingerprints" of the oil
  - *Think "DNA"*
- Traditionally, crude sold on "as-is" basis with "typical" assay (but no guarantees)
  - *Minimum API gravity, sulphur content, and BS&W*
- A good crude assay is:
  - *Expensive and potentially problematic*
  - *Necessary for comprehensive crude oil evaluation*
    - →Provides details on the hydrocarbon (and contaminant) make-up used for performance predictions
- A produced barrel and a delivered barrel can be different



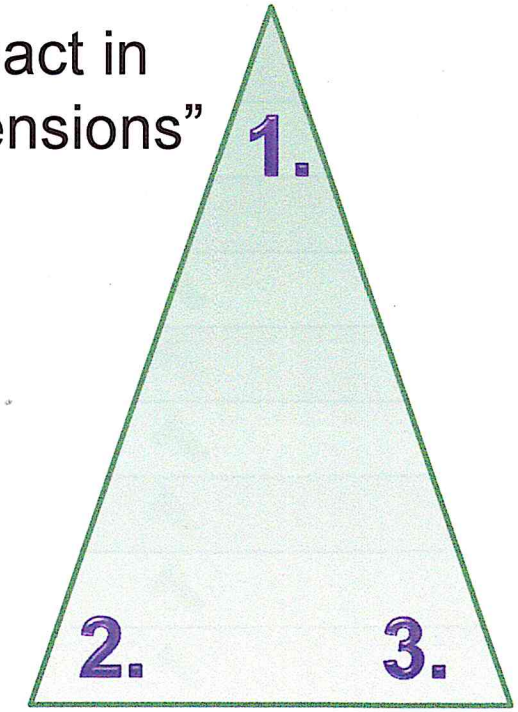
What to Measure - Hierarchy

Property	Must Have	Better	Best
API Gravity (density)	✓		
Sulphur	✓		
TAN	✓		
MCR whole crude	✓		
MCR residue	✓		
Light ends analysis	✓		
Distillation	✓		
Metals – NI, V, FE	✓		
Salt		✓	
Sediment		✓	
RVP, Pour Point, Nitrogen, viscosity		✓	
Arsenic and Mercury			✓
Se, Cu, Na, Mg			✓
Asphaltenes and Mercaptan Sulphur			✓



Crude Quality in a Refinery

Quality impact in "three dimensions"



Presence

Just being there can be a problem
- Toxins
- Banned material

Mercury

Quantity

The amount of material exceeds tolerable levels

Sulphur, Benzene

Variability

The variability of a material in crude may exceed plant process capabilities

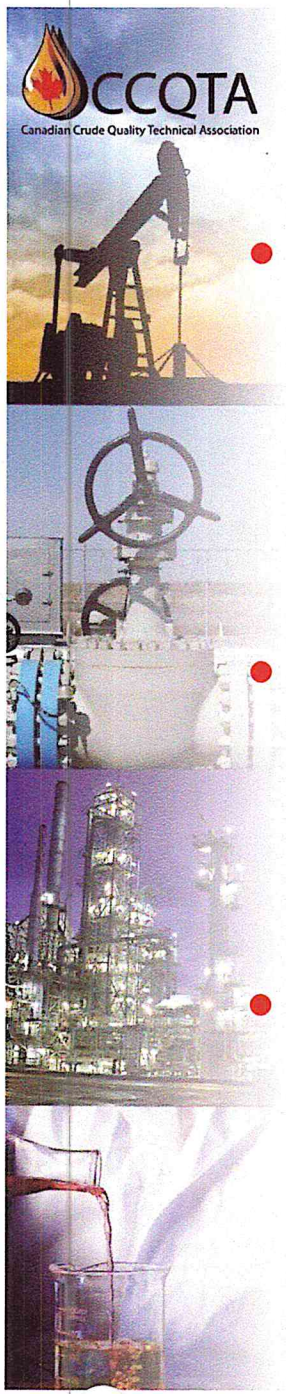
Salt, Sediment

"No surprises"

Hydrocarbon Portion

- What can effect hydrocarbon change?
  - *Reservoir performance over time*
  - *Pipeline batching*
    - →Mixing of heads and tails
  - *Diluent type and origin*
  - *Handling upon receipt*
    - →Heel contamination from tankage

- Ideally, the barrel delivered "to" the pipe will look the same when it is received by the customer at the "end" of the pipeline
  - *Distance and handling can alter this outcome*



Contamination

- Non-hydrocarbon contamination
  - *Salt, sediment and metals (in the oil)*
  - *Oil treatment chemicals*
  - *Well stimulation chemicals*
  - *Pipeline additives*
- Specific environmental considerations
  - *Mercury, selenium, arsenic*
  - *Others:*

    →Copper, titanium, manganese, sodium, silicon
- Surprises are never good

  →Mercury, phosphorous, silicon

Historical Perspective
Crude Oil Quality

What was crude quality like in the 60's & 70's??

Historical Overview

- Produced crude
  - *Light sweet crude oil was the norm*
  - *BS&W and sulphur were the key contaminants of interest*
- Refineries produced gasoline, diesel, jet, fuel oil and asphalt
  - *Simpler operation*
    - → most plants were not running at capacity
  - *Most product streams were virgin (straight run)*
  - *Annual plant shutdowns for cleaning/maintenance*
  - *Desalting for corrosion control*
    - → key contaminant focus

Historical Quality Parameters

- BS&W (Bottoms Sediment and Water)
  - *used as for volumetric accounting of non hydrocarbon portion*
    - →Reported on a % basis
    - →More useful to the pipeline industry
- API gravity
  - *was a useful tool for establishing value to a refiner based on a estimate of yields of various products*
- Sulphur content
  - *used to estimate the sulphur levels of products*

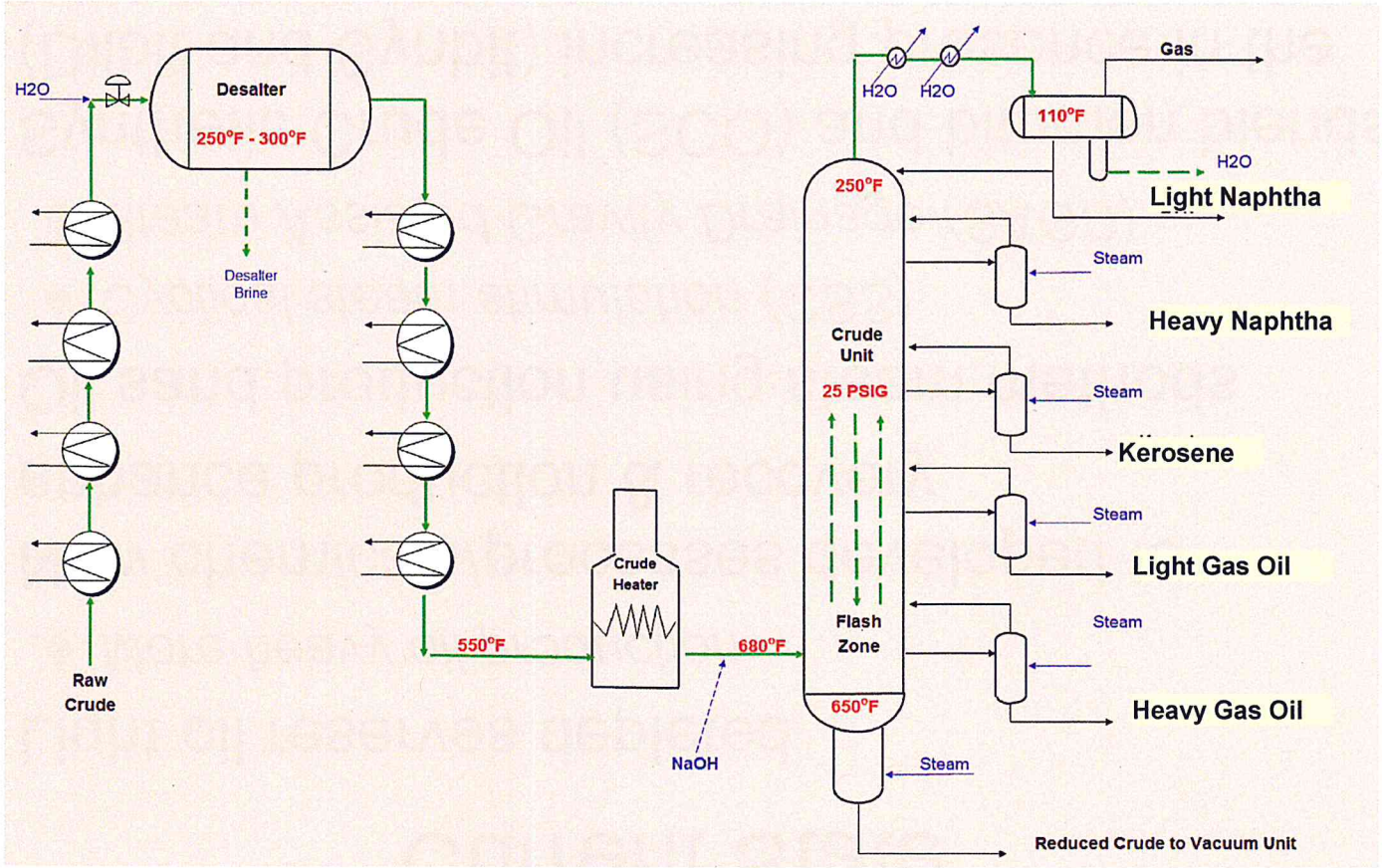
Life was much simpler then…..

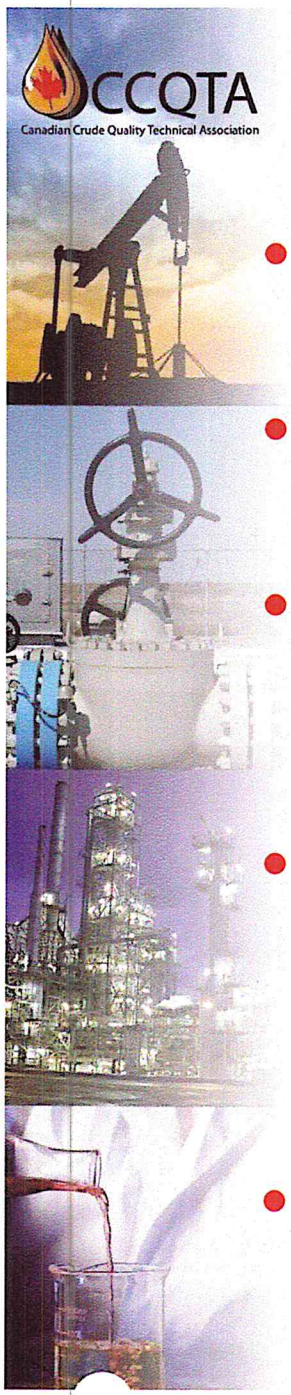
Historical Quality Management

- The refining industry relied on:
  - *Assays to estimate product yields and qualities.*
    - →Crude oil separated into fractions by boiling range
      - *tested for a selection of quality measures*
  - *Desalters for contaminant removal (salt & water)*
    - →Water content in crude impacts crude tower operation
      - *Costs of heating water in the crude furnace*
      - *Fear of tower damage from steam surges*
    - →Salt in crude leads to crude tower overhead corrosion
      - *Salt usually found in produced water within crude*

Simplified Crude Unit Operation

Crude Unit is the first processing step in the refinery





Current State

- Light oil reserves depleted
  - *More heavy oil production*
- New chemicals/processes developed to enhance production & recovery
- Oil sand production using steam methods
  - *Cyclical steam stimulation (CSS)*
  - *Steam Assisted Gravity Drainage (SAGD)*
- Synthetic Crude Oil (SCO) and bitumen blends (Dilbit and Synbit) increasing presence in the marketplace
  - *Bitumen derived*
- Tighter environmental controls
  - *Air, water, land*

Market Changes

- Crude oil demand increases
  - *Price volatility with high crude oil prices*
- Heavy oil can now be produced economically
  - *Wide adoption of SAGD technology*
  - *Low cost natural gas*
    - → lower quality/heavier crude oil in the market
- Increased risk
  - *Introduction of non-traditional materials into the crude pool*
- More crude choices
  - *Greater variability in crude supply requires more work to optimize crude selection*
    - → needing data and improved selection methods

Pipeline Changes

- More pipelines built to handle production
  - *greater mix of products being transported*
- Increased volumes of interface mix
  - *increases the potential for product quality impact*
- More concerns/issues associated with tank heels
  - *As distances and complexity increases*
- Increased volumes of trucked-in production
  - *Including oil from waste oil treatment facilities*

More complexity in the delivery systems impacts ultimate quality of delivered crude oil…….

Refinery Changes

- Fewer Refineries
  - *Individual plant throughput increases*
    - →less flexibility
      - *Running at close to 100% of capacity*
- Feedstock gets heavier
  - *More conversion plants*
    - →thermal cracking (coking) & catalytic upgrading of heavier fraction
      - *processing more ""bottom of the barrel"*
  - *Yield and product quality implications*
    - →Processing heavier, more contaminated feedstocks

Refinery Changes

- Run Lengths increased
  - *No longer shutdown every year to clean*
  - *Target 4 to 6 year run lengths*
- Environmental Pressure
  - *Low sulphur fuel production*
  - *Tighter specifications on air emissions*
    - →Stack emissions (SOX and NOX), GHG's
  - *Implication for waste disposal and water treatment*
    - →By-products and effluent
  - *Carbon footprint and carbon intensity*
    - →Well to wheels measures

Refineries have to work harder to stay in business

Finished Product Changes

- Driven by fuel efficient engine requirements
  - *Tighter performance specifications on*
    - → gasoline, diesel, jet fuel, etc.
  - *Less tolerance for contaminants*
- Low Sulphur Products everywhere…..
  - *Low sulphur gasoline, ULSD, Low sulphur heavy fuel oil in the works*
  - *Requires additional hydrotreating processing to reduce sulphur content*
    - →Additional cost and complexity

Oil sands derived feedstocks have unique processing challenges due to the nature of the chemistry of highly condensed aromatics.

Production vs Refining

- **Production Direction**
  - → *Heavier feed*
  - → *More entrained contaminants*
  - → *More additives used in production*
  - → *More complex product mix in pipelines*
  - → *Greater risk for introduction of foreign material*

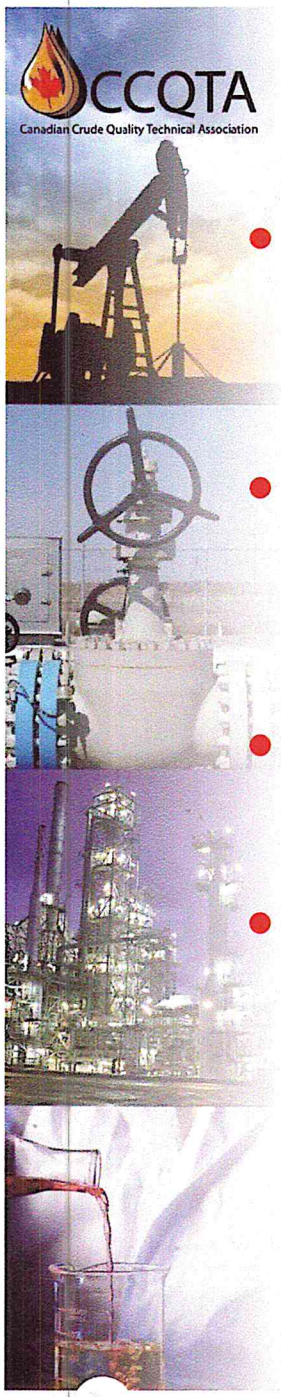
- **Refinery Direction**
  - → *Higher throughputs*
  - → *Longer run lengths*
  - → *More complex/sensitive units*
  - → *Tighter product specifications*
  - → *More environmental pressure*

Feedstock Quality vs Refinery Quality capabilities are being pushed in different directions

Present Day Crude Oil Quality

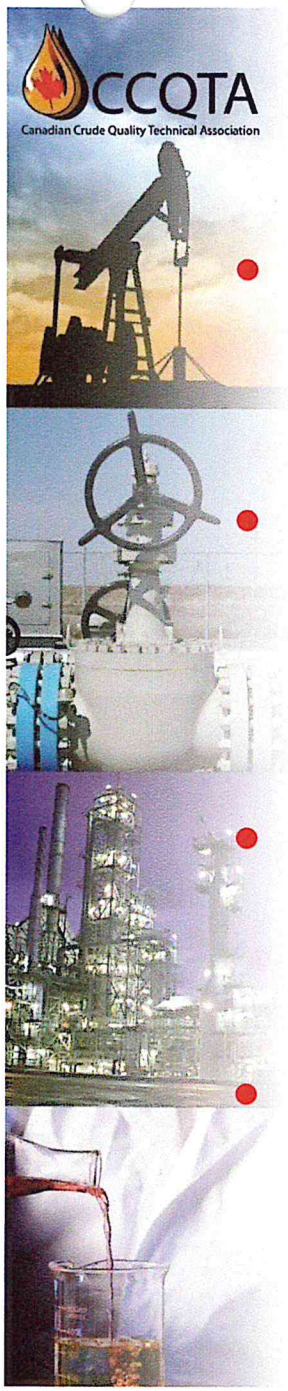
What is being done to "deal" with Crude Quality?

Industry Crude Quality Initiatives



Refinery Based

- Improved documentation/sharing of plant incidents
  - *What went wrong and why*
    - →Learning from experience
- Increased/improved monitoring of feedstock quality
  - *Procedures, testing methods providing key data*
- Better understanding of contaminant quality issues
  - *What they are and how to deal with them successfully*
- Active participation in industry based quality projects
  - *Targeted collaborative research for deal with industry wide problems*

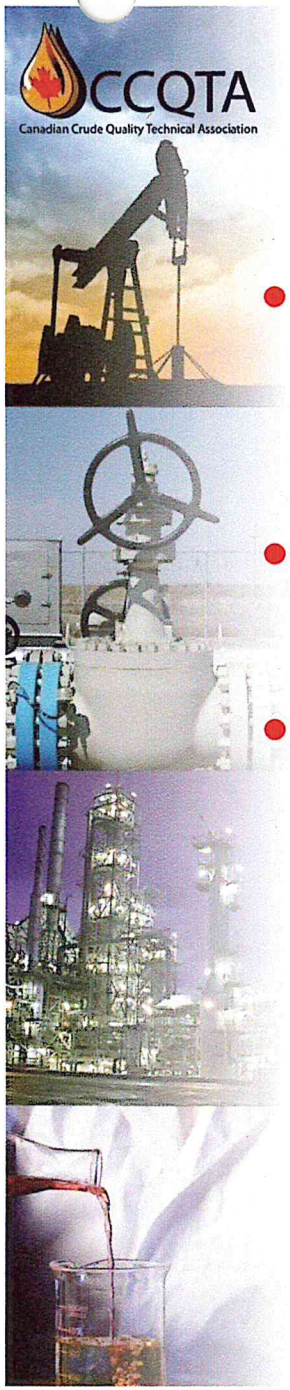


Producer Based

- Canadian Association of Petroleum Producers
  - *CAPP incentive tolling agreement*
    - →Recognition of good crude quality management practices
- Crude quality information widely available
  - *Batch by batch testing and reporting of crude quality information*
    - →www.Crudemonitor.ca
- Introduction of new specifications for more product classes
  - *sweet/sour crudes, high/low TAN crudes*
- Tightening of diluent stream specifications
  - *Redwater condensate quality (CRW)*
    - →The diluent in Dilbit

Pipeline Based

- Stricter guidelines for new/intermittent product addition to the pipeline system
- More/tighter monitoring of key product specifications
  - *Gravity (density), viscosity, olefins*
- Adoption of improved on-line monitoring technologies
  - *Real time information on contaminant levels*
- Interface management protocols
  - *Procedures to minimize pipeline interface material*
- Managing tank heels/cleaning procedures
  - *Minimizing contamination risk*

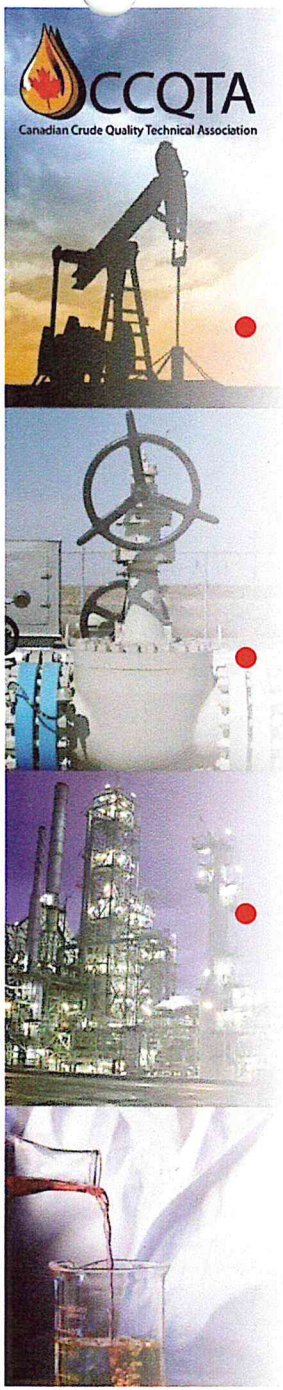


Service Industry Based

- More additive supplier involvement in multi sector quality discussions
  - *Phosphorus, fluorocarbons, etc.*
- More information exchange between the service sector and other oil industry sectors
- Continuous improvements and regulation within the waste oil treatment industry

Improved Analytical Services

- Continuous improvements in instrument capabilities
  - *Better machines with lower detection limits of specific contaminants*
  - *Development of new on-line instrumentation technologies*
    - →NMR, X-Ray
- Laboratory services
  - *Bring analytical capabilities closer to the "action"*
    - →Production facilities, pipeline, and refinery
  - *Consistency in laboratory practices*
    - →Test method standardization and laboratory certification



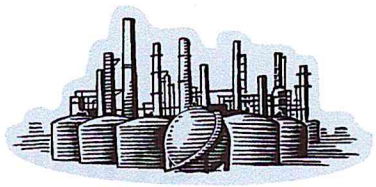
Industry Associations

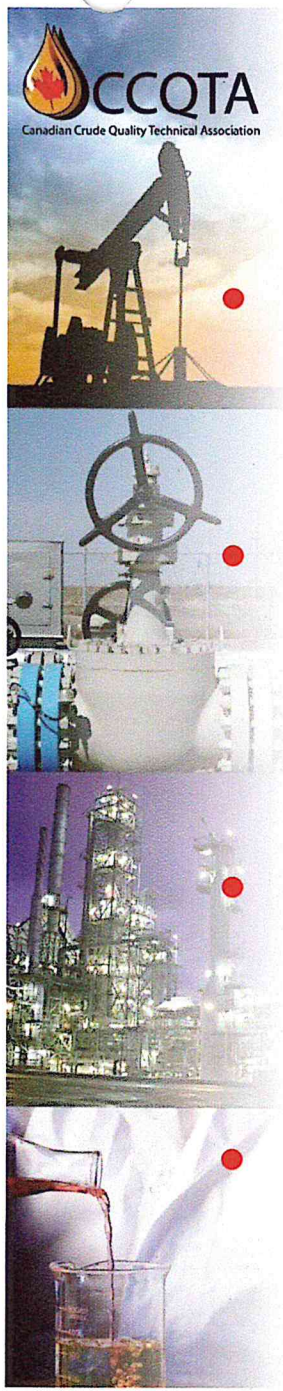
- Collaborative research/testing efforts for a technical focus
  - *Pooled resources*
    - →Results oriented
- Canadian Crude Quality Technical Association (CCQTA)
  - *formed 1996*
- US based Crude Oil Quality Association (COQA)
  - *formed in RCOQ in 1994*

Crude Oil Quality

Knowledge Breeds Understanding

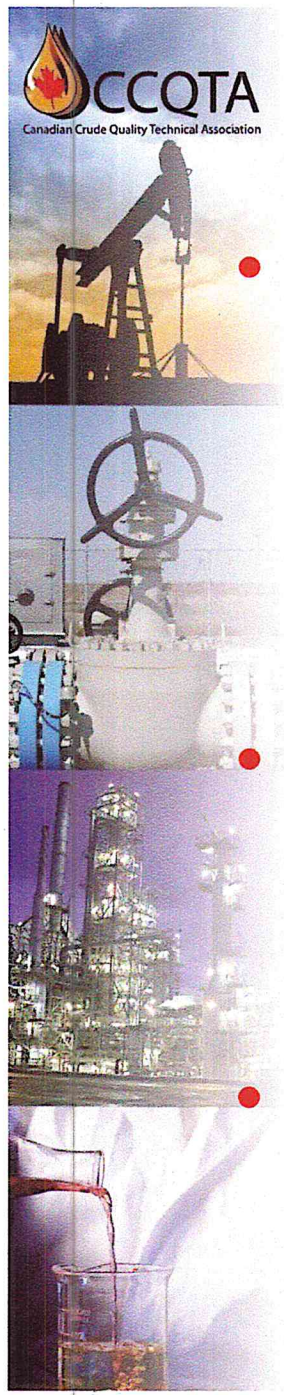
Future Crude Quality Initiatives





Industry Initiatives

- Better understanding of the technical drivers that underpin successful crude oil production/processing
- Communication/education
  - *Providing a factual basis for crude quality in context*
    - →for environmental challenges
- Dispelling "myths"
  - *What, exactly, is "dirty oil"?*
- Application to Production, Transportation and Refining sectors



Producer Based

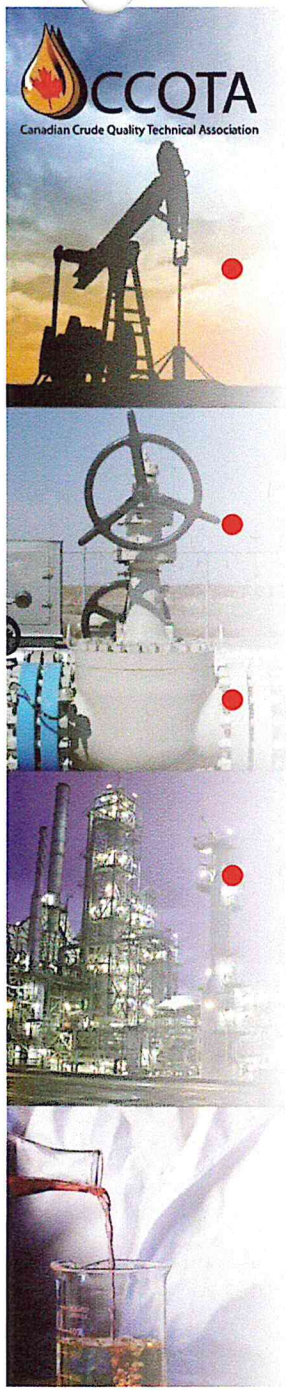
- Improved understanding of the implication of production/treating/handling methods on product desirability
  - *Producer → pipeline → refinery customer relationship*
  - *Better data for crude assessment/valuation work*
    - → good data improves decision quality
- Do we need different key crude quality specifications?
  - *More than API gravity, sulphur and BS&W?*
  - *Greater awareness of banned/restricted materials*
- Controllable contaminants
  - *Clean/dry bitumen…..?*

Pipeline Based

- Greater efforts to control product quality
  - *Larger batch sizes*
  - *Tighter product specifications*
  - *More product segregation*
- Quality monitoring of streams
  - *More product quality testing of incoming streams*
  - *Use of on line instrumentation, real-time information*
  - *Batch tracking*

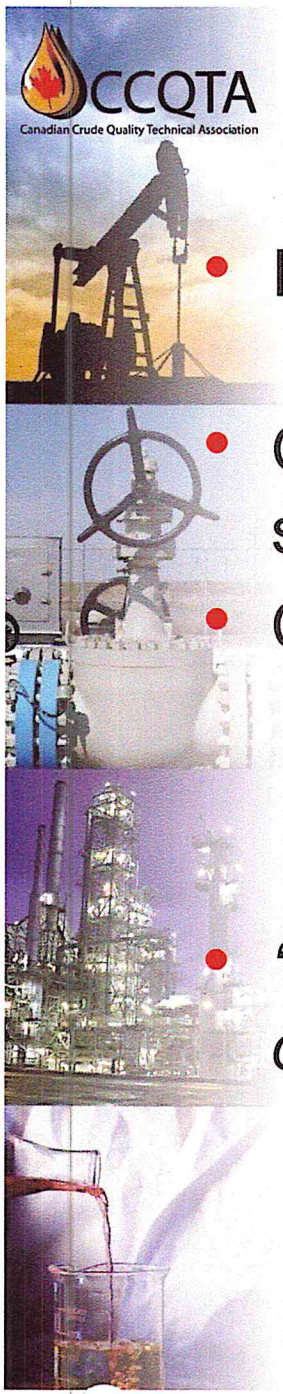
Refining Industry

- Improved understanding/documentation of crude quality impacts on refinery operation
- Better monitoring of feedstock quality
  - *Use of on-line instrumentation to track crude properties and contaminants*
  - *Incorporation of real time data into process control*
- Valuation of crude quality
  - *Provide incentives for the production and delivery of consistent quality crudes.*
- Environmental compliance considerations
  - *Trace contaminants*



Building Understanding

- Improved discussion with industry sector members of quality impact of products, applications and processes
- More disclosure of information on product/application chemistries to industry
- Greater role in the monitoring and management of product quality in all sectors
- Role of key associations
  - *Canadian Association of Petroleum Producers*



Getting the Facts Right

- Improved/standardized testing methods
  - *Analytical service providers*
- Greater role in product quality testing for all sectors
- Continuous improvements in analytical testing
  - *Faster turnover time*
  - *Lower detection limits*
  - *Development of more at-line/on-line instruments*
- *"With good crude quality information, better decisions can be made"*

Conclusions

- Increased awareness of the implications of crude quality benefits all industry sectors
  - *Across all industry sectors*
- "I need the right information to make good decisions…."
  - *Know the molecules and avoid "surprises"*
  - *A good crude assay is a good starting point*
  - *Anticipating future quality changes based on new crude oil sources and production techniques.*
    - →The heavier the crude, the higher the level of contamination
- Industry collaboration solving common technical problems has wide reaching benefits