Catalyzed-assisted Manufacture of Olefins (CAMOL):

Realizing Novel Operational Benefits from Furnace Coil Surfaces

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Catalyzed-assisted Manufacture of Olefins (CAMOL)

1. Background
2. Technology Objectives
3. Laboratory-scale Test Results
4. Pilot-scale Test Results
5. Commercial-scale Test Results
6. Conclusions and Future Work

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Catalyzed-assisted Manufacture of Olefins (CAMOL)

- Quantiam Technologies Inc.
- NOVA Chemicals Corporation
- NOVA Research & Technology Corporation (NRTC)
- Sustainable Development Technology Canada (SDTC)
- Industry Canada - Technology Partnerships Canada (TPC)

NOVA Chemicals, Joffre, Alberta – World Scale Ethylene and Polyethylene Site

			SDTC & TPC Investments		
Phase - I Proof of Concept	Phase - II Development	Phase - III Prototyping	Phase - IV Trial Mfg.	Phase - V Demonstration	Commercialization
Completed (private sector only)			2005/06	2007/08	2009

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CAMOL Technology Objectives

Primary Benefits Targeted

1. Coke-free performance through:

- surface inertness to filamentous (catalytic) coke
- surface catalyzed gasification of amorphous (pyrolytic) coke

2. Thermal stability of overall coating, >1100°C (>2012°F)

- with thermal stability of outermost surface, minimum of 100-150°C (212-302°F) > chromia (as reference)

3. Resistance to broad range of materials degradation processes

- carburization
- internal oxidation
- sulfidation
- other forms of corrosion

Overall, targeted 21 chemical, physical and thermo-mechanical properties to achieve commercial viability

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CAMOL Coatings Advanced for Olefins Furnaces

Coating System	Coating Catalytic Properties	Primary Feedstocks	Targeted Maximum Temperatures
CAMOL **LCG**	• **Low**-level **c**atalytic **g**asification • High-level surface coverage	• Ethane/Propane • Butane • Light Naphthas (?)	>1100°C (>2012°F)
CAMOL **HCG**	• **High**-level **c**atalytic **g**asification • Low-level surface coverage	• Butane • Naphthas	
To Be Determined	• Low-temperature catalytic gasification efficacy • Low-Medium levels surface coverage	• TLE surfaces operating at lower temperatures	400-700°C (752-1292°F)

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Laboratory-scale Results Achieved

Of 21 chemical, physical and thermo-mechanical properties targeted – success realized on most fronts; some optimizations to complete by end-of-2008

Surface Properties for a Low-coking Environment	
Inertness to filamentous coking	High
Gasification of amorphous coke • Low-catalytic Gasification coating (LCG) • High-catalytic Gasification coating (HCG)	Tunable Low gasifier High gasifier

Resistance to Materials Degradation	
Carburization Resistance	High
Internal Oxidation Resistance	High
Sulfur Resistance (to 500 ppm; higher levels to complete)	High
Hot Erosion Resistance	Med-High

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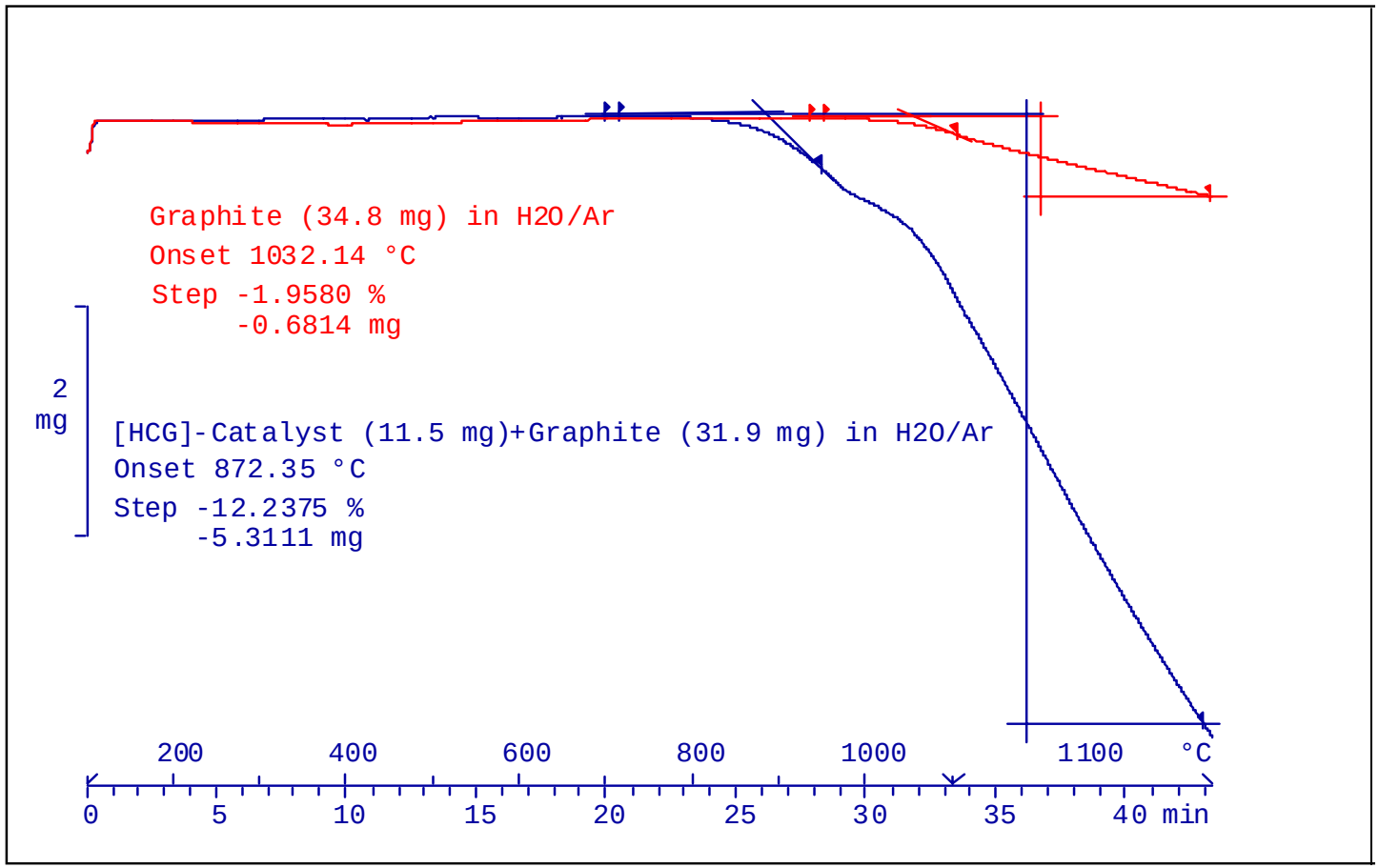
TGA Screening of Catalysts for Carbon Gasification:

Catalyst used in CAMOL HCG Coating – Low Oxidizing Potential



: METTLER

METTLER TOLEDO STAR^{e} System

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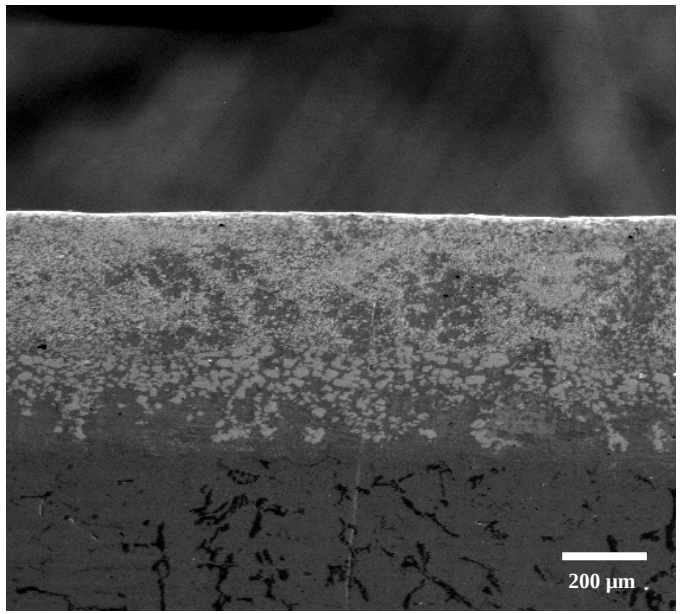
CAMOL Low-catalytic Gasification (LCG) Coating Microstructure



SEM micrograph of LCG coating – cross-sectional view

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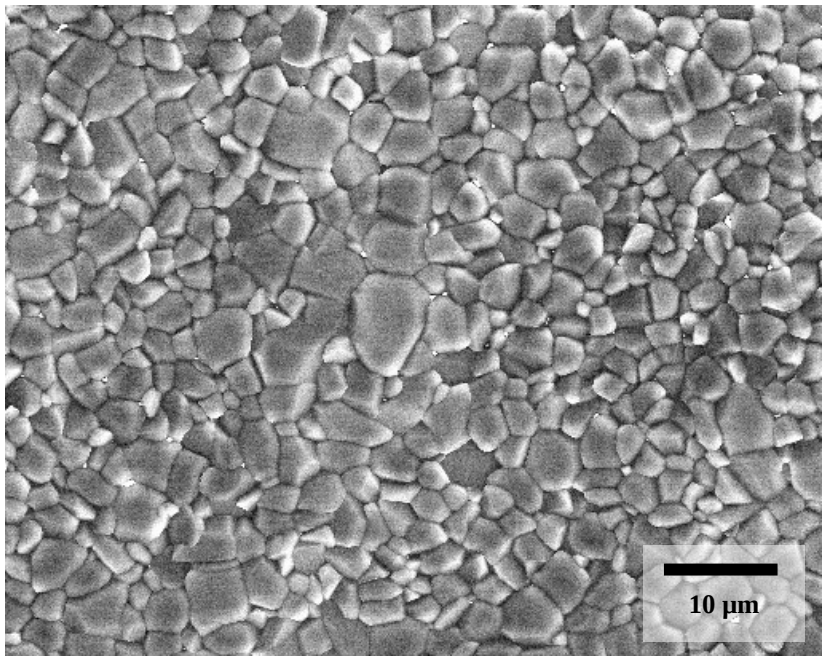
CAMOL Low-catalytic Gasification (LCG) Coating Surface



SEM micrograph of LCG surface – topview

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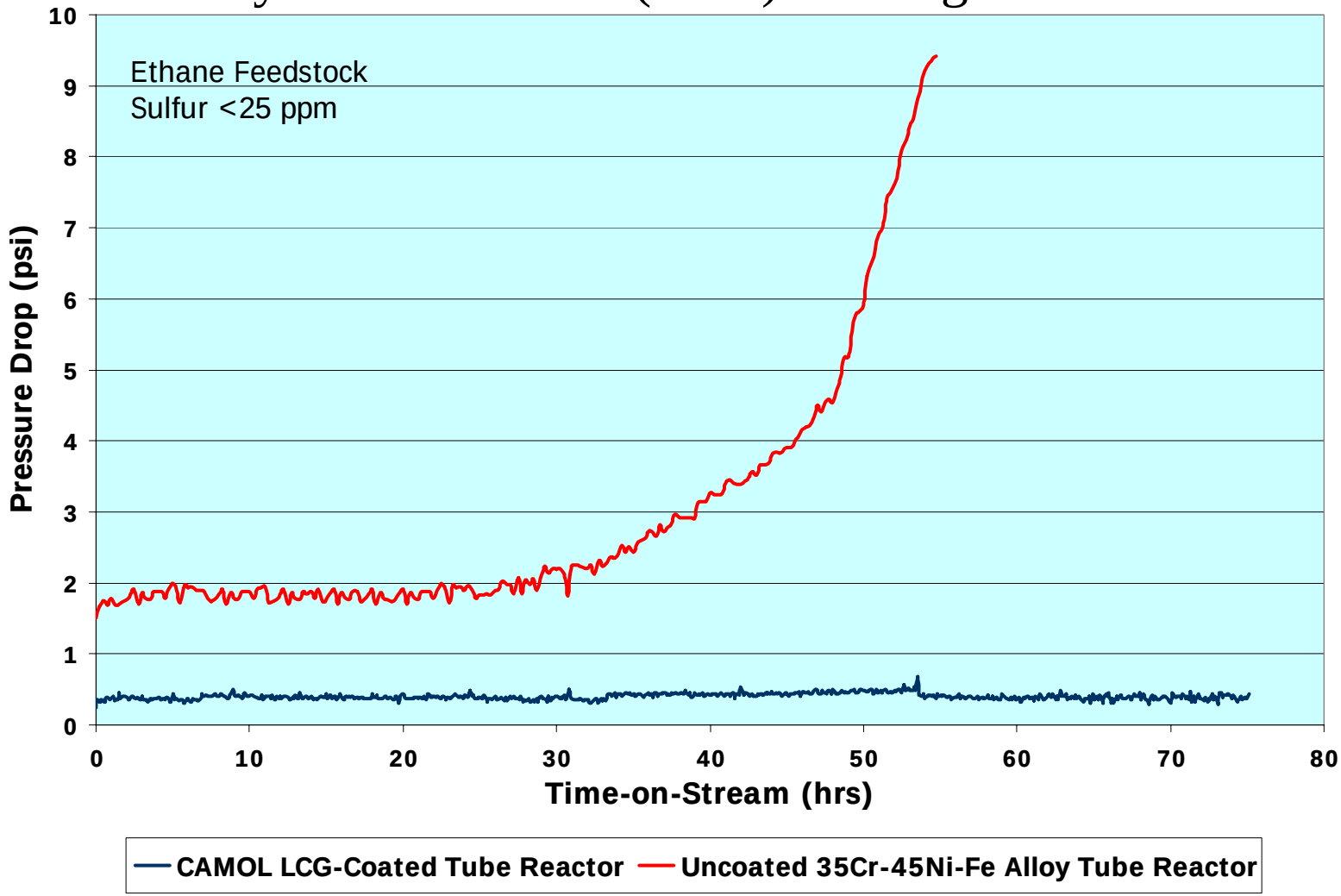
Pilot-scale Pyrolysis Results

- Commercial-scale tube reactors, consisting of both Reference and CAMOL-coated reactors
- Ethane and butane feedstocks to-date; standard cracking conditions
- Sulfur from 0 to 100 ppm
- Testing provides assessment of coking rates and product slate information
- Autopsy, generally undertaken after final end-of-run (without decoking); assess changes to coating/surface and downstream coking

Pilot-scale Pyrolysis Testing of CAMOL

Low-catalytic Gasification (LCG) Coating on Tube Reactor



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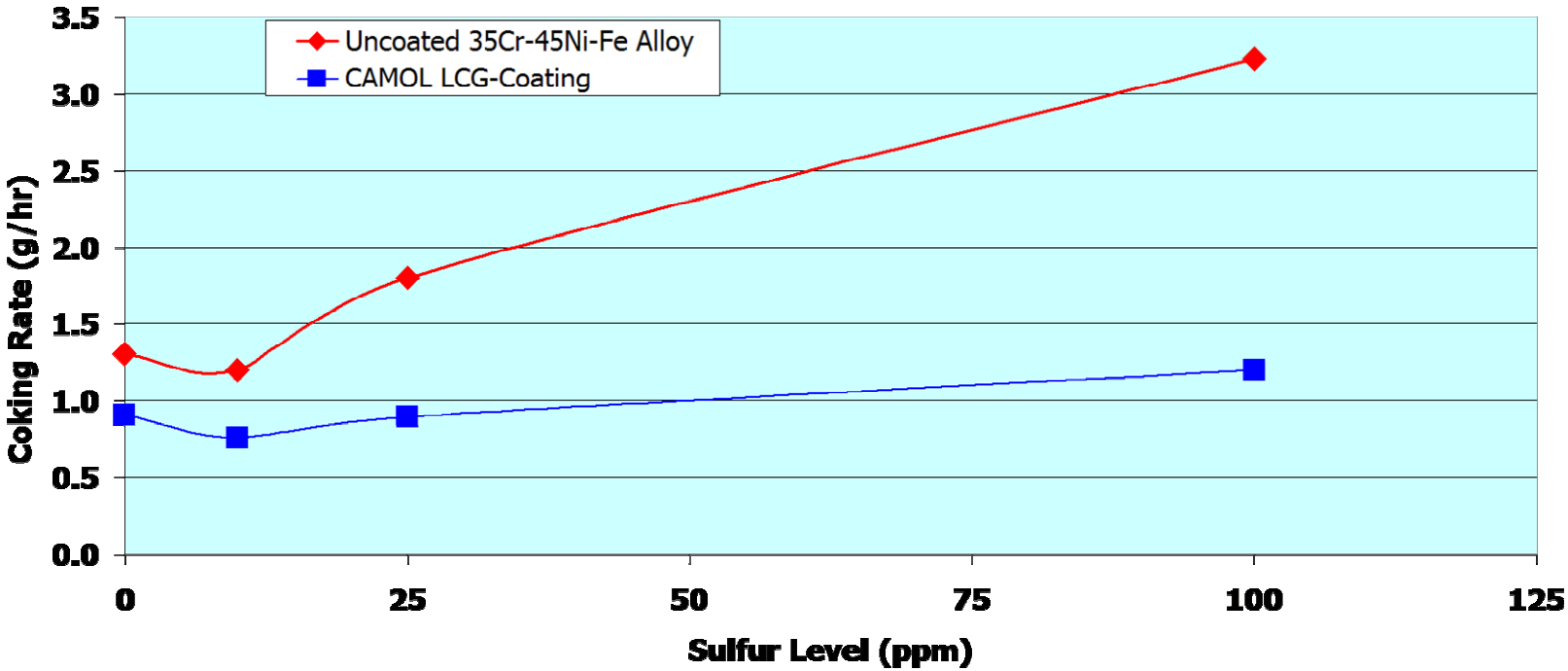
Sulfur Impact:

Coking-rate within Pilot Pyrolysis Circuit vs Sulfur Level

Ethane Cracking; 65% Conversion; 0.3:1 S:H ratio



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Pilot-scale Pyrolysis Testing
Downstream Coking Assessment

(a) Exit of CAMOL LCG-coated Reactor (no S – ethane run)

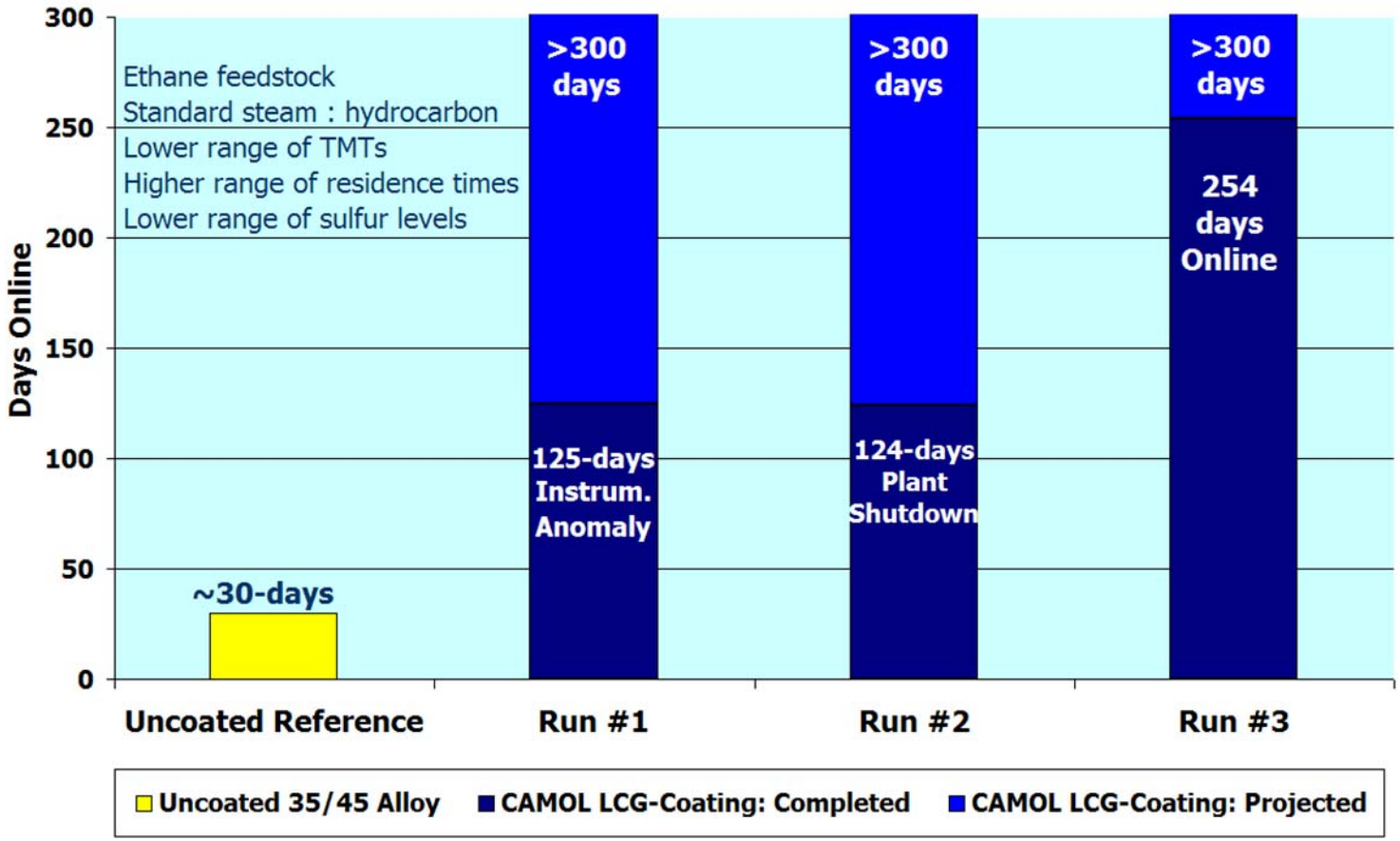
(b) Exit of Uncoated 35Cr-45Ni-Fe Reactor (no S – ethane run)

Commercial-scale Field Trials

1. **Smaller-scale Field trials**
   - coated tubes, fittings, ancillary equipment
   - commenced in 2005 primarily for longevity testing
   - remove for inspection and analysis, opportunistically
2. **Larger-scale Field Trials**
   - installation of coated furnace coils in radiant sections; sufficient fractions to enable assessment of process performance
   - Trial-(1) Joffre, AB: LCG coating/ethane; installed July 2006
   - Trial-(2) Joffre, AB: LCG+HCG coatings/ethane; installed Mar 2008
   - Trial-(3) Corunna, ON: LCG+HCG coatings / propane-naphtha; installed Mar 2008
   - Add'l trials being developed with other petrochemical producers and into other furnace designs/operating environments/feedstocks

Commercial Furnace Trial with CAMOL Catalyst Coating

Low-catalytic Gasification (LCG) Coating in Furnace only – no TLE Coverage



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Conclusions and Future Work

1. Novel catalyst coatings successfully developed, engineered for extreme operating conditions and carbon gasification (~21 properties); compositions and operating regimes possible, being mapped for range of furnaces and feedstocks.
2. Novel cost-effective coating mfg. technology developed for broad range of tube and fitting geometries.
3. Non (low) coking environment on surfaces successfully demonstrated at laboratory, pilot, and commercial-furnace scale; opportunity for catalytic impact on process.
4. Carbon gasification successfully realized to an engineerable (tunable) level of catalytic efficacy; maintained cap on CO and CO_2.
5. Laboratory-scale mapping of operational latitude well advanced and being expanded beyond “normal” limits of pyrolysis operation.
6. Fields Trials: 1st furnace operating well since 2006; 2nd and 3rd trials installed in March 2008; add’l trials being advanced with other producers; expanding furnace designs, operating environments and feedstocks.
7. Coatings adaptable to broad range of High Temperature Alloys and being expanded.

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