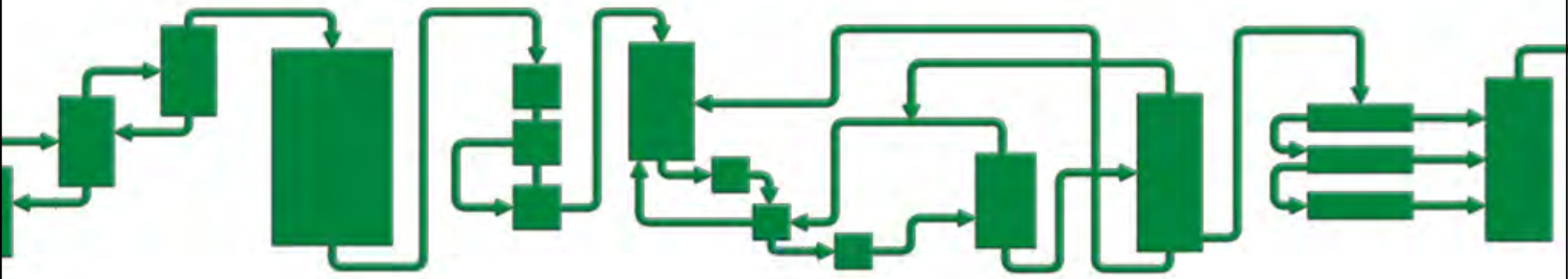

REFCOMM
RIO DE JANEIRO
29 Sept – 3 Oct 2014

CatCracking.com

Developments in Catalyst Handling For FCC & RFCC Units

Johnson Matthey Process Technologies

Oct 2014

JM
Johnson Matthey
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FCC Catalyst Handling – At the Core of the FCC

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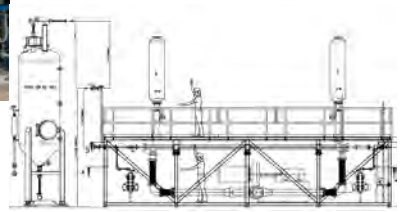
Catalyst

1. Receiving into Refinery

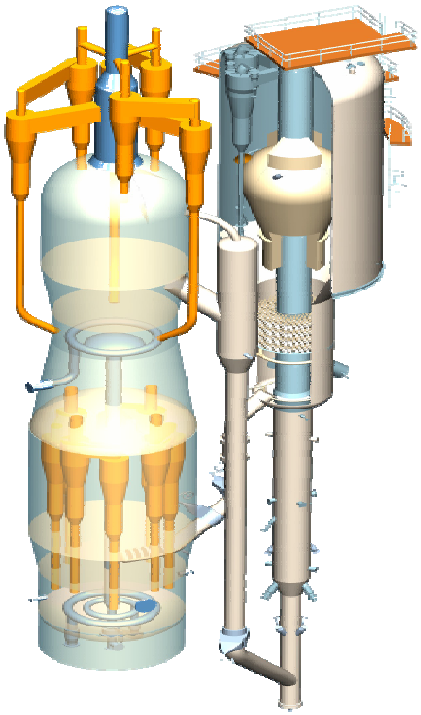
2. Maintaining onsite inventory

3. Adding to FCC



7. Withdrawing from FCC

8. Shipping & Disposal



Additives

4. Receiving into Refinery

5. Maintaining onsite inventory

6. Adding to FCC

1. Receiving Catalyst into the Refinery

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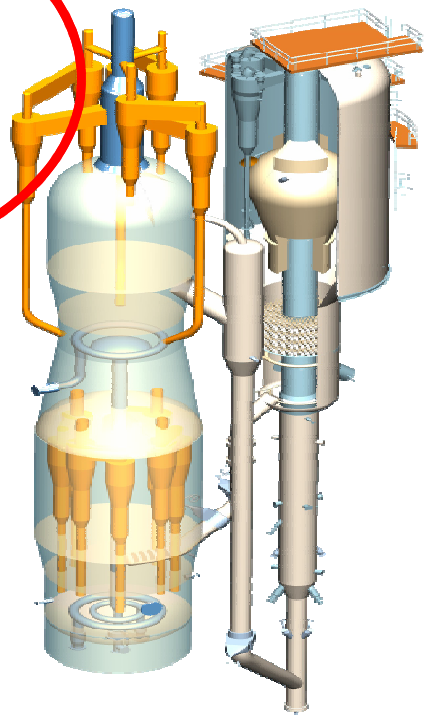
Catalyst

1. Receiving Catalyst into the Refinery



Receiving Catalyst Into The Refinery

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Process Technologies

- This is a simple operation for refiners who receive catalyst in PD Trucks or rail cars
  - Trucks/Cars unloaded directly into hopper

- For refiners who receive catalyst in lined Sea Containers, specialised tilting and unloading facilities are required
  - Fixed tilting platforms have been used, but these take up a lot of plot space

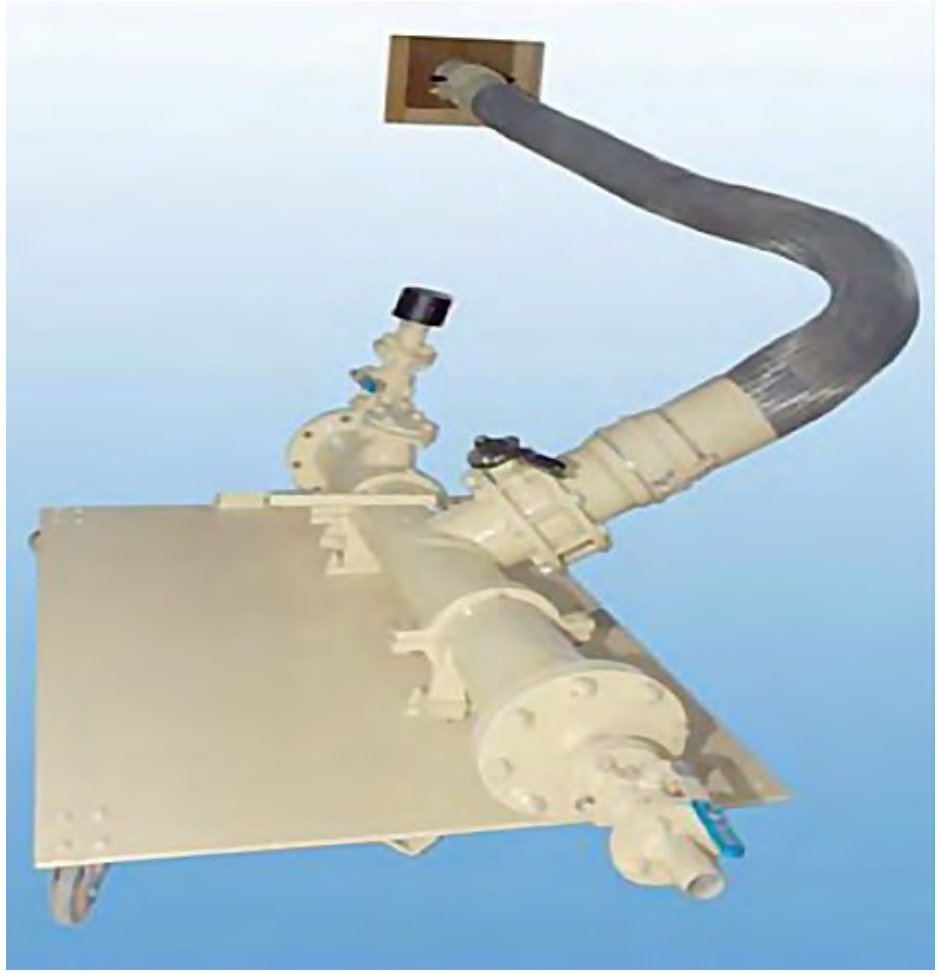
- Preferred solution is to use a tractor with built in tilting device
  - Allows use of standard trailer chassis
  - Tractor can be used for regular service, as well as container unloading

Solutions: Sea Container Unloading

Johnson Matthey
Process Technologies

- Liner Cutter Manifold (LCM) allows sea container liner to be cut safely, with no catalyst losses

- Catalyst Transfer Manifold (CTM) allows container to be unloaded in 30mins or less
- Using this well designed equipment:
  - Maintains clean environment
  - Minimizes operator catalyst exposure



Solutions: Dual Bag Unloading System

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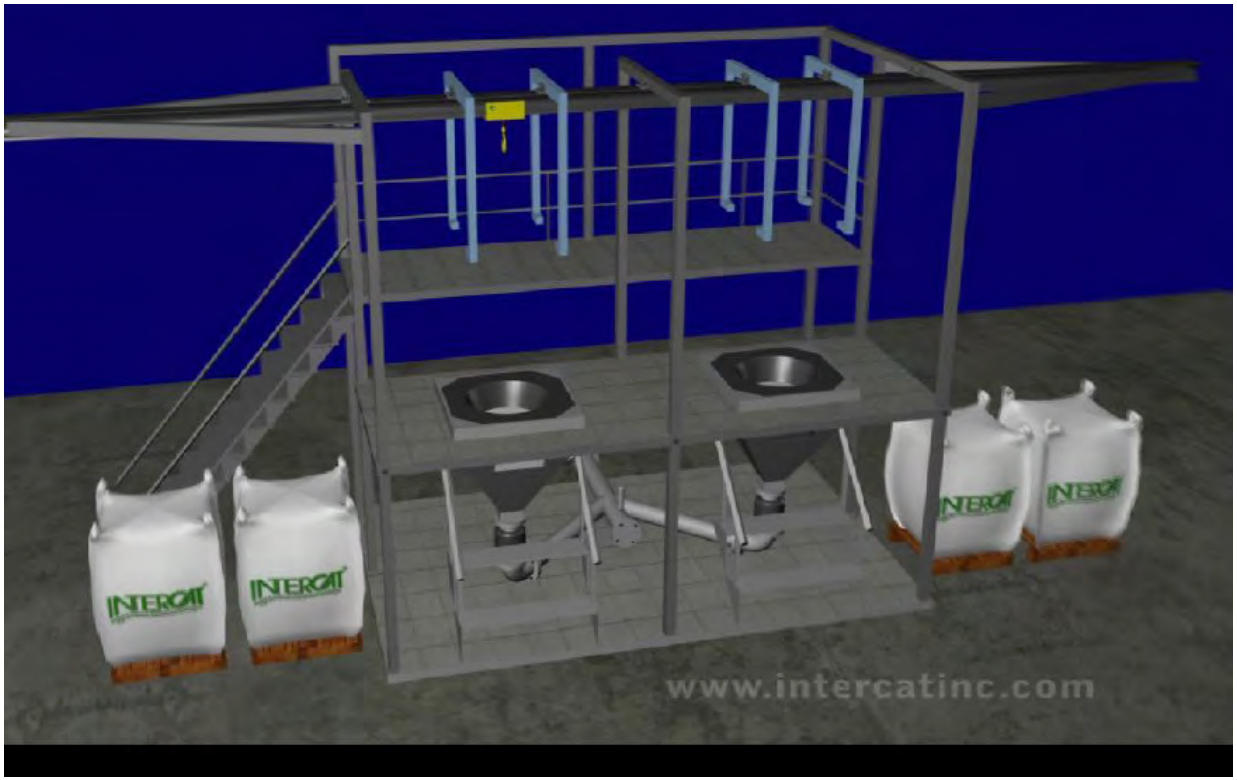
Process Technologies

- Some locations still receive catalyst in supersacks
  - Without correct facilities can be hard to manage, with high catalyst wastage
- Dual bag unloading system allows one bag to be unloaded while the other is being replaced
- Maximizes operator efficiency
- Reduces catalyst handling losses
- Unload 10t of catalyst in <1hr
- Maintains clean environment
- Minimizes operator catalyst exposure



Using the Correct Equipment Saves Money

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Process Technologies

- Basis: 50,000 BPD RFCC, 10 ton/day fresh catalyst, catalyst cost of $3,000/ton ($10.95million per year)
- What are the catalyst losses with conventional catalyst handling systems?
  - Conventional manual unloading facilities
  - Venting using cyclone on catalyst hopper
- Typical fresh catalyst handling losses
  - Big bags 0.1% - 1kg per bag, 10kg/day
  - Sea containers 0.05% - 10kg per container, 5kg/day
  - Vent losses 0.1-0.25%,10-25kg/day
  - Plus miscellaneous spillage
- Typical total losses 20-50kg/day, **($22,000 - $55,000 per year)**

2. Maintaining Adequate Onsite Catalyst Inventory

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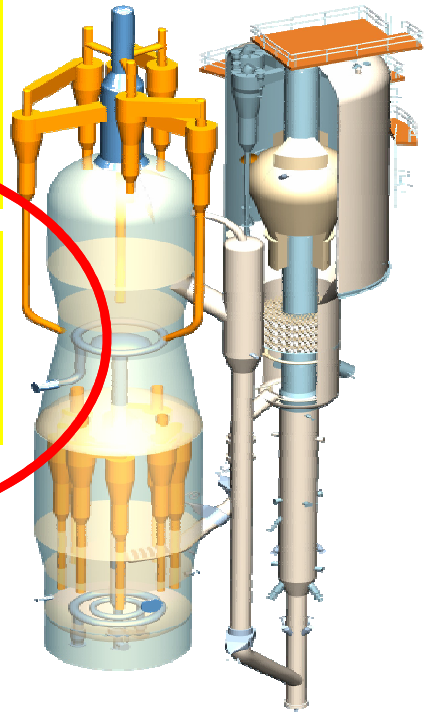
Process Technologies

1. Receiving Catalyst into the Refinery

2. Maintaining onsite inventory



Onsite Catalyst Storage Capacity

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- When revamping an FCC, catalyst addition rates often increase
- Existing catalyst storage hoppers may no longer provide adequate buffer storage
- Especially a concern at remote refineries, or locations with unreliable shipping

Solution:
Extra Storage Capacity – The Pig

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Process Technologies

The Pig

- Up to 85 Tons Capacity
- Compatible with Tilter Truck
- Pneumatic truck able to fill or empty pig as needed
- Pigs can provide significant strategic onsite storage

3. Adding Catalyst to the FCC or RFCC Unit

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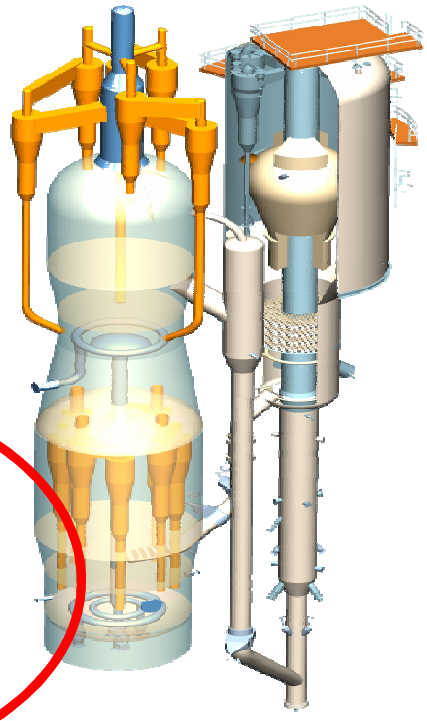
Process Technologies

1. Receiving Catalyst into the Refinery

2. Maintaining onsite

3. Adding to FCC



Solution: Reliable & Accurate Catalyst Addition Systems

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Process Technologies

- INTERCAT$_{JM}$ Catalyst Addition Systems well established as “State of the Art”
- Over 300 systems installed worldwide
  - Reliable, accurate, low maintenance
  - Long term support
- System of choice on most new build FCC & RFCC units

Fresh Catalyst Addition System Designs

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- Numerous design options are available

Conventional autoreload addition systems typically 5-10 ton capacity

Where extra storage is required, large capacity addition systems can have up to 120 ton capacity

Advanced Design Features

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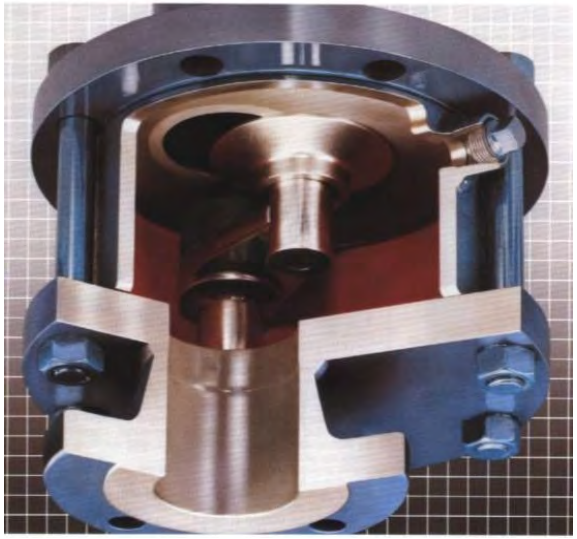
- Sintered Metal filter for zero catalyst losses
- Robust Self Cleaning Design
  - Eliminates the need for unreliable & complex bag house
- Allows vent stream to go straight to atmosphere



- Everlasting Valve for catalyst flow control
- Extremely reliable in fresh catalyst service
- Maintenance frequency > 5 years (valve cycling every 10 - 20 minutes)
- Now standard equipment on all INTERCAT$_{JM}$ Addition Systems

Loader Precision Economics - Example

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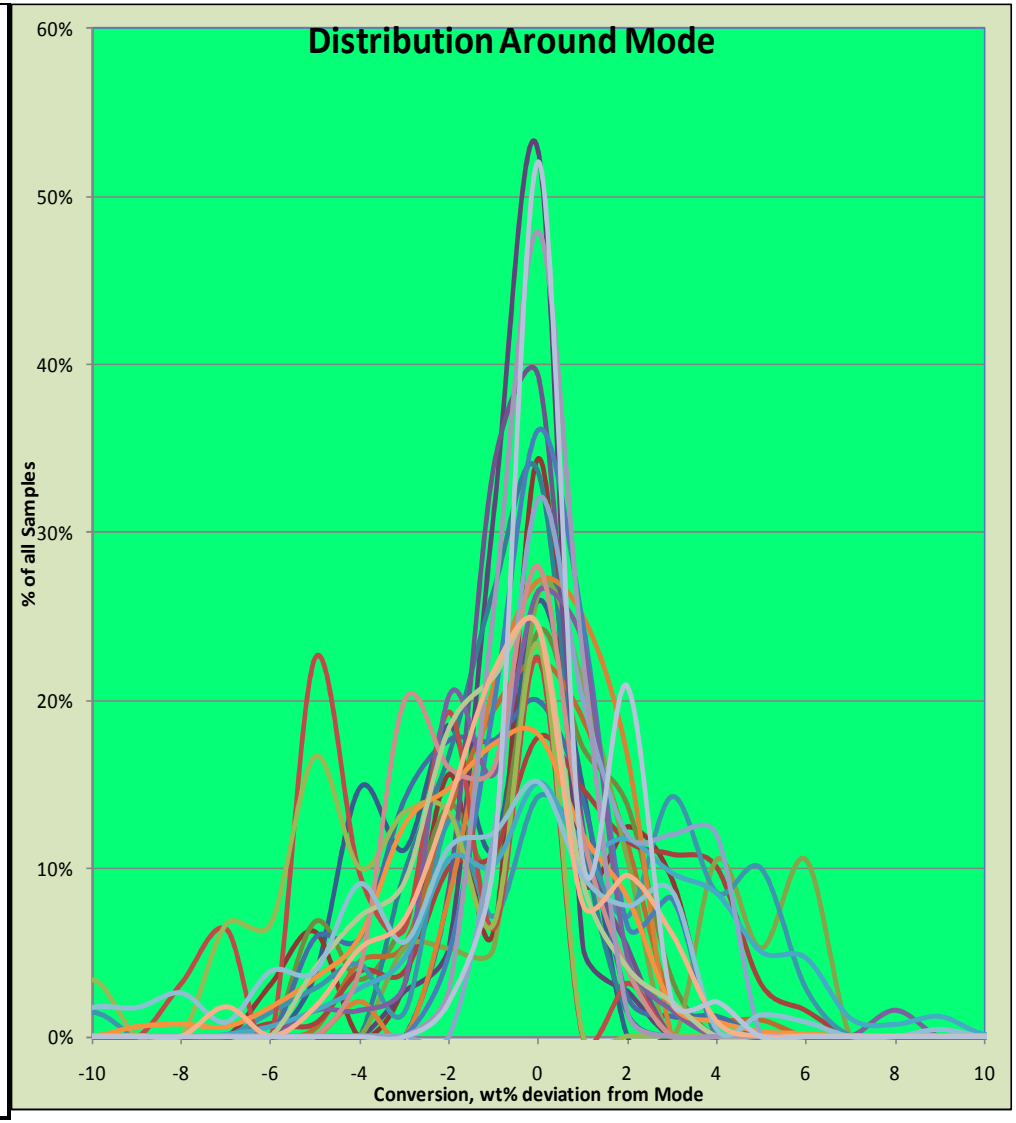
Sample of Refinery Ecat Conversions

		Average MAT	Mode (Target)	Std Deviation from Mode	% within +/-1
	Refinery A	71.6	73	1.83	52%
	Refinery B	67.7	68	2.27	50%
	Refinery C	72.5	73	2.11	52%
	Refinery D	70.5	70	1.18	73%
	Refinery E	70.3	71	1.20	72%
	Refinery F	68.7	69	1.80	61%
	Refinery G	68.8	70	1.92	52%
	Refinery H	65.7	65	2.46	43%
	Refinery I	61.4	60	2.55	53%
	Refinery J	75.7	76	0.99	86%
	Refinery K	64.8	64	3.19	33%
	Refinery L	71.1	71	1.35	73%
	Refinery M	68.3	68	1.25	80%
	Refinery N	71.2	74	2.51	29%
	Refinery O	70.8	74	2.60	30%
	Refinery P	69.7	70	1.85	66%
	Refinery Q	62.1	61	2.98	37%
	Refinery R	70.8	72	2.76	47%
	Refinery S	68.2	67	1.60	64%
	Refinery T	72.0	73	1.59	56%
	Refinery U	71.9	73	1.78	55%
	Refinery W1	76.6	77	0.89	89%
	Refinery W2	76.9	77	0.81	96%
	Refinery Y1	69.4	71	3.96	37%
	Refinery Y2	72.4	73	2.11	54%
	Tight control	62.6	62.7	0.90	71%
Averages	**Average Control**	70.2	70.8	1.71	60%
	Loose Control	68.1	68.6	2.68	42%



Loader Precision Economics

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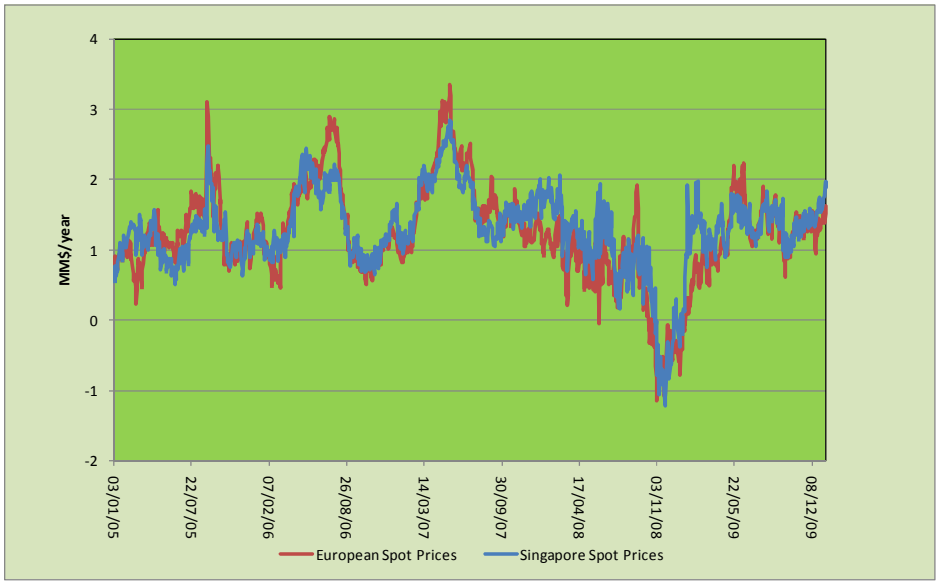
Simple model

- 50,000 barrel/day RFCC unit
- Industry average 2% MAT std deviation from target
  - Best in class achieve 1% MAT std deviation from target
- Typical performance improvement of 1% possible
  - Valued as 0.5%wt conversion
  - Worth $1 Million per year

  (Offers increased flexibility which can be used for feed rate or other improvements as economics dictate)

Product	Yield Delta wt%	Price assumptions
Dry Gas	0.02	1.2 times Fuel Oil
LPG	0.06	Propane
Gasoline	0.37	Regular unleaded gasoline at 0.75sg
LCO	-0.32	Diesel/Gas Oil at 0.925sg
CLO	-0.18	Fuel Oil at 1.08sg
Coke	0.05	0.5 Times Fuel Oil
Total	0.00	



4-5. Receiving & Maintaining Additive Inventory

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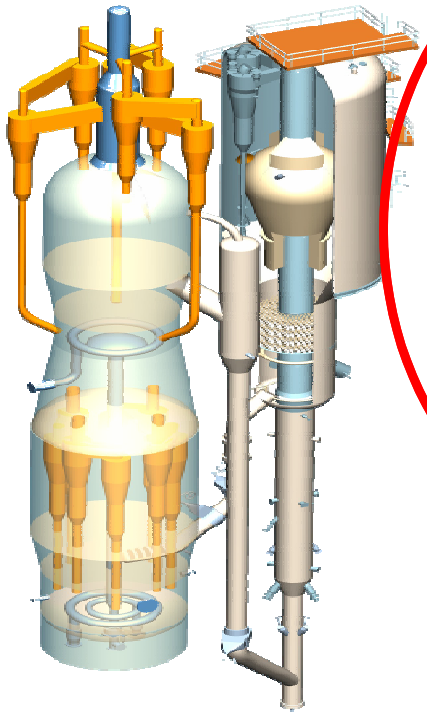
Process Technologies

1. Receiving Catalyst into the Refinery

2. Maintaining onsite

3. Adding to FCC



Additives

4. Receiving into Refinery

5. Maintaining onsite inventory

FCC Additives – Receiving into Refinery

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Process Technologies

- Tote bins commonly used for FCC additives in Europe & USA

- This solution not so practical for large users, or for refiners in remote locations

Solution: Large Additive Users

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Process Technologies

- Introducing “Herman’s Hoppers” - 15 ton portable transport silos.
- Silo is transported and placed into position by a specially designed truck.
  - Similar to systems used in cement industry
- Safe, practical solution for medium to large additive consumers .
- Also offers solution for catalyst change-out, flushing ECat or fines injection
- Already in use in UK and Germany, and now in North America

Solution:
Dual Bag Unloading System

Johnson Matthey
Process Technologies

- For overseas additives users receiving additives in supersacks
- Bag unloading systems allow additives to be unloaded with minimum losses

- Single or dual unloaders available
- Dual system maximises operator efficiency
- Reduced catalyst handling losses
- Unload 10t of catalyst in <1hr
- Maintains clean environment
- Minimises operator catalyst exposure

6. Adding Additives to the FCC

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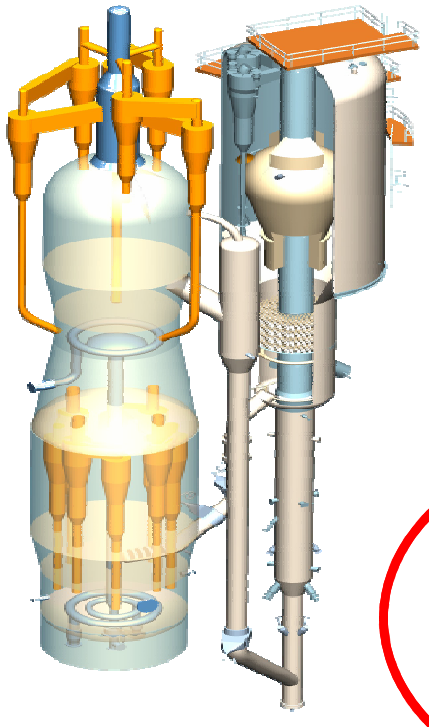
Process Technologies

1. Receiving Catalyst into the Refinery

2. Maintaining onsite

3. Adding to FCC



4. Receiving into

5. Maintaining onsite

6. Adding to FCC

Solution:
Multi-Additive Addition Systems

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Process Technologies

- It is becoming commonplace for refiners to want to add several additives to the FCC at the same time
- Up until recently, each catalyst needed its own addition system
  - Multiple installation locations required (plot space)
  - Multiple utility requirements & process tie ins
- Some locations have restricted plot place, restricted air availability, or a limited budget for installation
- Johnson Matthey therefore offers two choices for multi-additive use:
  - Multi-Compartment (MC-3) Addition System
  - Multi-Source (MSCAS) Addition System

Multi-Compartment Addition System

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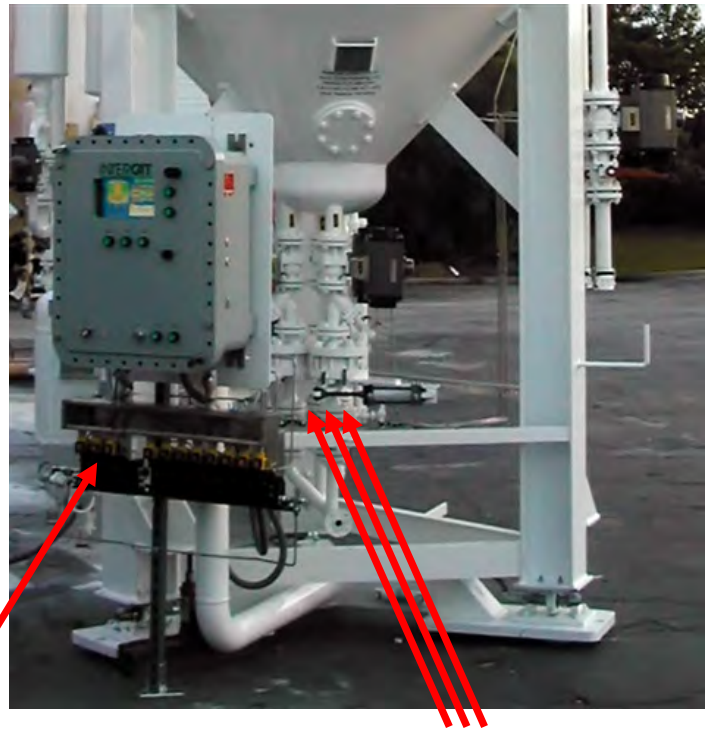
Main Vessel Contains Three Compartments - 2 x 1 ton, 1 x 2 ton



IMS-MC Controller

Three Outlet Lines, Each with it's own Everlasting Valve

Multi-Source (MSCAS) Addition System

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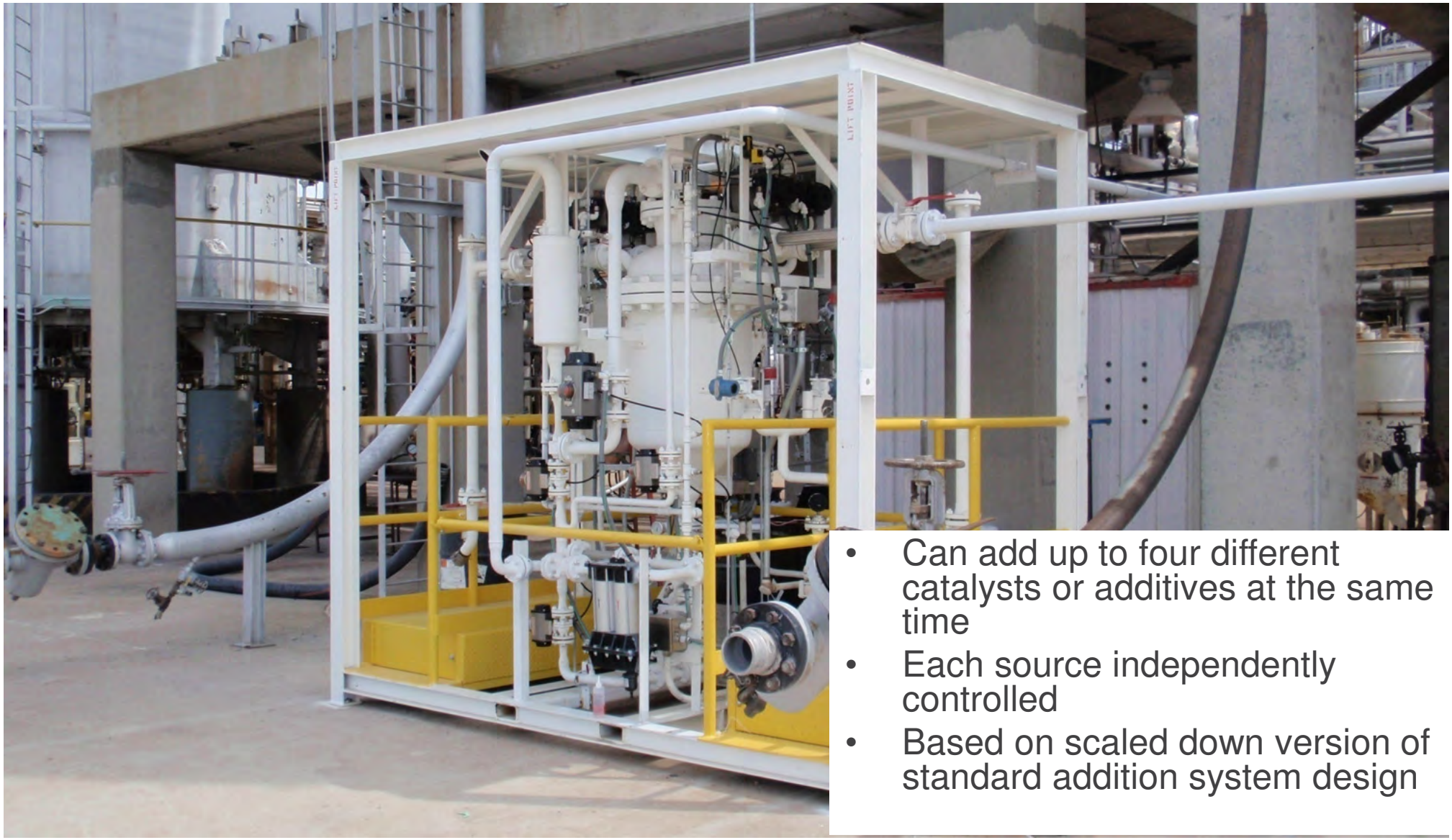

- Can add up to four different catalysts or additives at the same time
- Each source independently controlled
- Based on scaled down version of standard addition system design

7. Withdrawing Catalyst from the FCC

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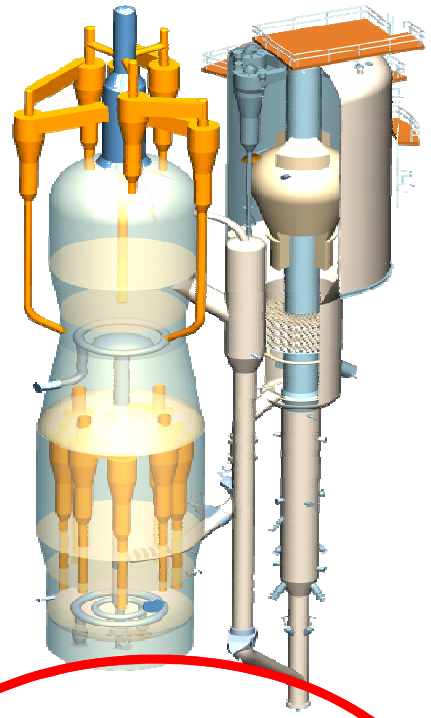
Process Technologies

1. Receiving Catalyst into the Refinery

2. Maintaining onsite

3. Adding to FCC



4. Receiving into

5. Maintaining onsite

6. Adding to FCC

7. Withdrawing from FCC

Existing Catalyst Withdrawal Systems

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Process Technologies

- Most existing FCC Catalyst Withdrawal Systems are very basic:
  - Manual control by gate valve, with manual carrier air adjustment
  - High temperature and poor velocity control results in high erosion rates of valves and lines.
  - Frequent maintenance required, risk of hot catalyst spills
- Infrequent withdrawals result in large, sudden changes in regenerator catalyst bed level
  - Can have a significant impact on unit operation and flue gas emissions
- Withdrawals normally done at night – maybe for a reason…?

Solution: INTERCAT$_{JM}$ Design Overcomes Drawbacks

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- Erosion of throttling valve for controlling withdrawal rate is completely eliminated
  - Pressure balance design allows the use of a simple on/off Everlasting valve
- Eliminates large changes in Regenerator bed level
  - Withdrawal is continuous, so bed level can be kept constant
- Eliminates high velocities in withdrawal piping
  - Line velocity tightly controlled at 10-20 ft/sec for minimal erosion
- Forced air cooling prevents high temperature catalyst from damaging road tankers
  - Withdrawn catalyst is cooled before being transferred to storage

Skid Mounted Design for Simple Installation

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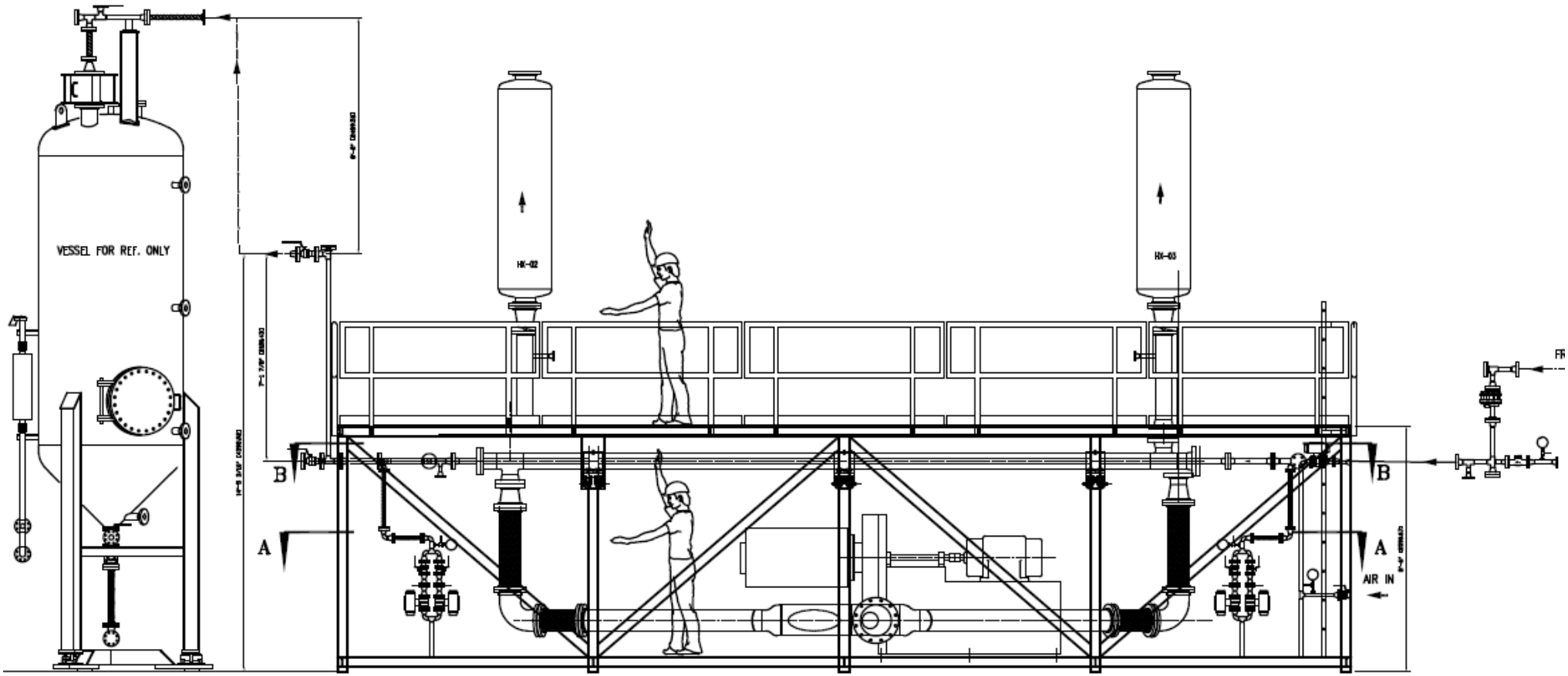

- Capacity up to 32 tons/day, first system being installed 2H 2013

8. Shipping & Disposal of Spent Catalyst

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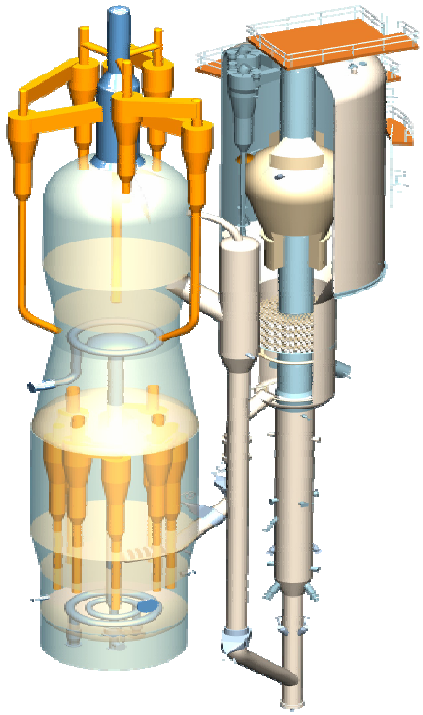
Process Technologies

1. Receiving Catalyst into the Refinery

2. Maintaining onsite

3. Adding to FCC



4. Receiving into

5. Maintaining onsite

6. Adding to FCC

7. Withdrawing

8. Shipping & Disposal

Solution:
Truck Filling & Dust Control

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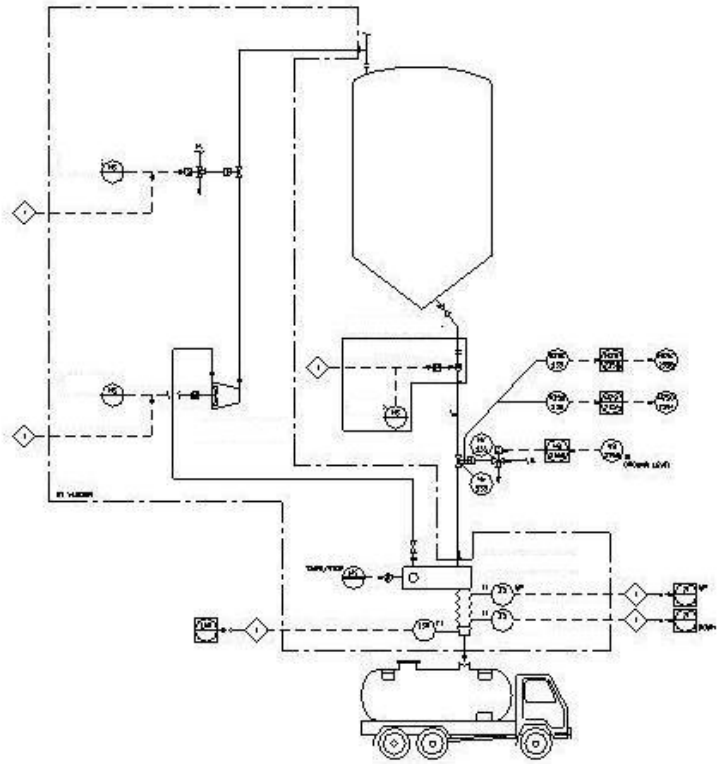
Process Technologies

- Spent catalyst needs to be loaded into trucks or sea containers for disposal
- Johnson Matthey supplies equipment to enable this to be done in a safe, controlled, and environmentally friendly manner



Summary – Where Johnson Matthey Can Help You

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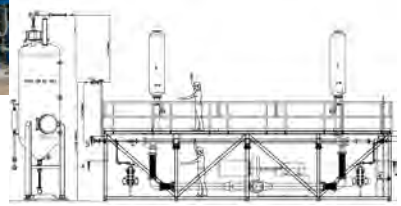
Catalyst

Receiving into Refinery

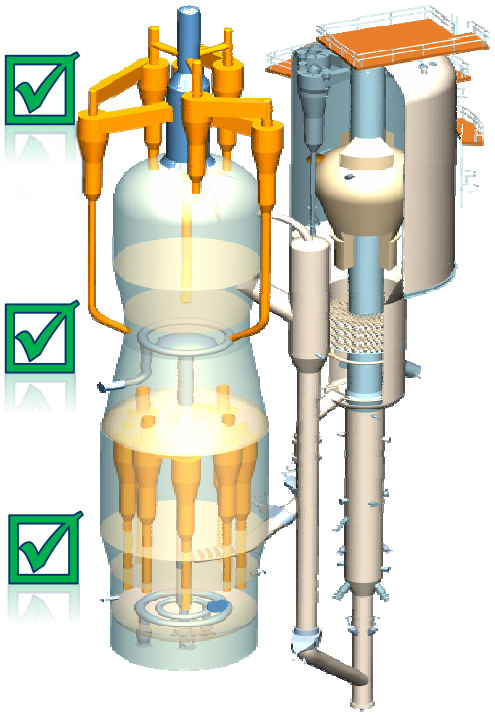
Maintaining onsite inventory

Adding to FCC



Withdrawing from FCC

Shipping & Disposal



Additives

Receiving into Refinery

Maintaining onsite inventory

Adding to FCC

And Finally – Dust Control – Sintered Metal Filters

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Process Technologies

- The same filters that are used on INTERCAT$_{JM}$'s addition systems are now available for use on refinery catalyst hoppers
- The zero emissions solution – low maintenance, and a long life

Summary – Complete Technical Solutions

Johnson Matthey
Process Technologies

- The increased catalyst handling that accompanies revamping of FCC and RFCC units can lead to significant operational challenges
- Managing FCC catalyst through its whole lifecycle can improve profitability, safety and environmental performance
- Johnson Matthey's Catalyst Management expertise is well known in the Industry
  - Fresh catalyst unloading
  - Onsite storage solutions
  - Catalyst and additive addition systems
  - Catalyst withdrawal systems
  - Spent catalyst handling
  - Hopper dust filtration systems
- Refiners can call upon Johnson Matthey wide experience to help solve any FCC catalyst handling problems