REINHOLD ENVIRONMENTAL ®

2025 Reinhold/PCUG Round Table Presentation

Hosted by AEP and Buckeye Power

in The Hilton Columbus Polaris Hotel, Columbus, OH

on June 23-24, 2025

2025 REINHOLD / PCUG CONFERENCE

Catalyst Purchasing: Insights for Preparing RFQs/ Specifications, and Evaluating Bids

W.S. Hinton & Associates
Research and Consulting Engineers

W. Scott Hinton, Ph.D., P.E.
W.S. Hinton & Assoc.
Mobile: 850-261-5239
shinton@wshinton.com

OVERVIEW

1. How to specify catalyst and put together an effective RFQ

2. How to evaluate bids from a technical perspective

TECHNICAL SPECIFICATIONS

Can't I just use the old purchasing spec? NO!!!

1. Very old/original specs were designed for a different purpose from single-layer catalyst purchases; based on an un-built, un-operated hypothetical SCR. They were most likely SCR performance specs and had wide guarantees. They are very likely not current or applicable to the current purchasing needs.

2. Even updated specs were based on unit operations at that time (hopefully) and still may not be applicable.

BOTTOM LINE – THINGS CHANGE !

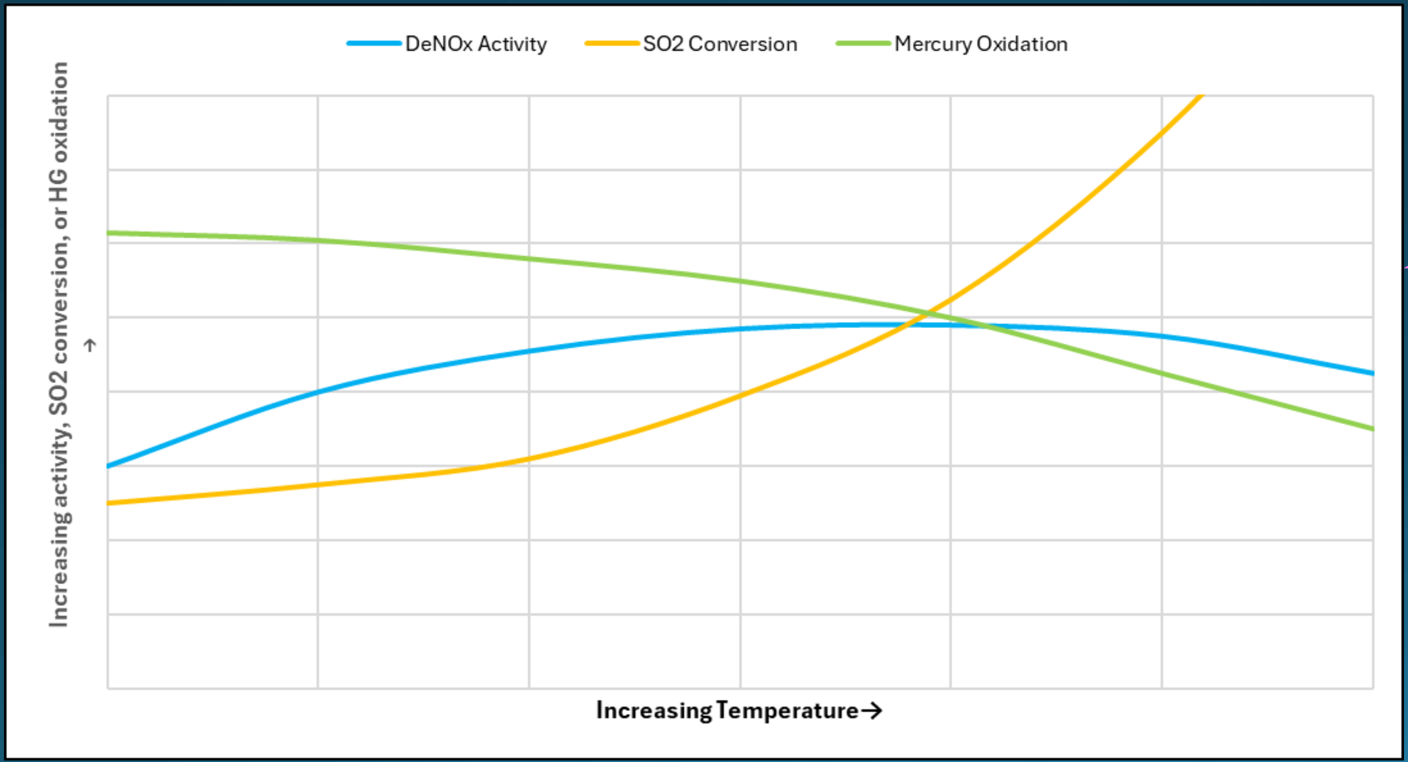
Unit operating parameters have differing importance according to purpose

Parameter	Original SCR Design Specification	Catalyst Layer Specification	Catalyst Management
Fuel Type	Very Important - wide range may be included in design	major changes such as PRB/EB fuel switch will affect specification	catalyst selection may be impacted if major change
Fuel Poisons	Very important	significant changes may affect guaranteed life	significant change will affect deactivation rate
Ash Composition and Loading	Very Important	significant changes may impact geometry selection	catalyst selection and plugging rate may be impacted if major change
Fuel Sulfur	Very Important	significant change may impact desired SO2 conversion	catalyst selection may be impacted if major change
Flow Rates	Very Important	Ballpark just to double-check velocities	Very Important - affects actual RXR potential
Inlet and Outlet NOx	Very Important	Not important other than to develop minimum temperature guidance	Very Important - affects Pmin
Distributions	Very Important	Not important, may be some limits associated with guarantees	Very Important - affects Pmin
Temperature	Very Important	Very Important	Very Important (may need to adjust lab data)

Why getting the specification right matters

SCR catalyst designs are a balance between performance characteristics, most notably deNOx, SO_2 conversion, and mercury oxidation. Flow rate and ash loading affects geometry selection and erosion. Overall SCR design affects the ammonia and NOx, which in turn affect minimum operating temperature.

If nothing else, get the temperature right! It affects all the performance parameters, and you won't be getting what you think you're getting if temperature is off.

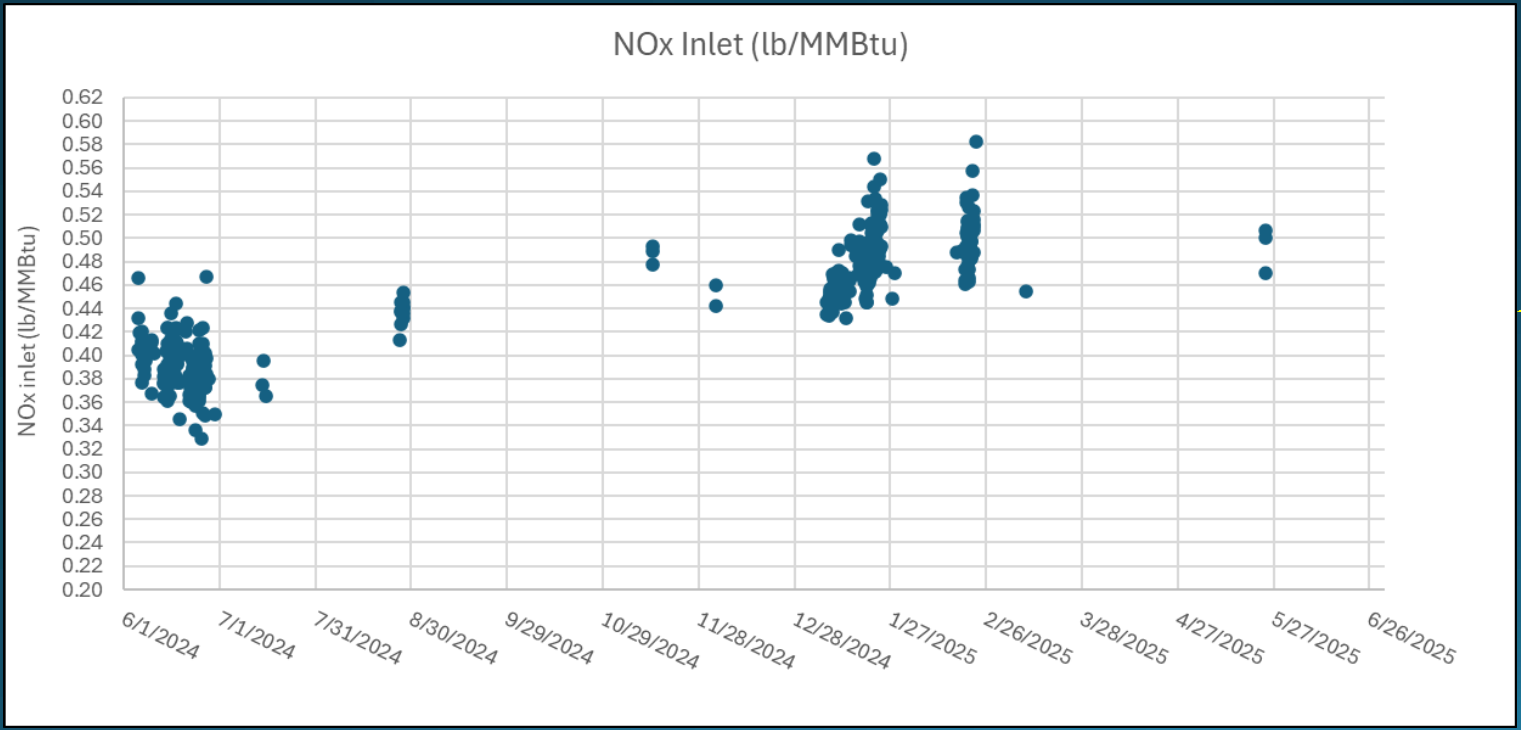


Conceptual example – do not use to make corrections!

Evaluate your recent operating data to get up-to-date design conditions

- Primary filter: High load, usually within a few % of reasonable max load, for last year. For example, take data within 3% of normal full load for last year (hourly average data). Look for about 100 data points to get good average.

- Secondary filter: Remove extraneous data from primary data set and average (maybe). Plots help to show variability and to make logical decisions about what values to use.



This plot shows an example of a variable parameter where an average is not appropriate – need to make informed decision about what value to use.

Data sheets can provide one-stop shop for specifications and responses, and streamline the RFQ by using a boilerplate document.

Inquiry:	Yellow highlighted fields shall be filled in by Catalyst Supplier

SCR Catalyst Performance & Descriptive Fill-in Data Tables for a Catalyst Layer

Plant Name and Unit Number		Supplier Name
Location (State)		Catalyst Geometry
Proposal Case (Base or Option Number or Conformed)		General Formulation

			Parameter	Units	Average Full Load (design case)
1			**Design Data**		
1	.	1	Load (gross)	MW	
1	.	2	Fuel consumption	tons/hr (wet, as-burned)	
1	.	3	Heat input	MMBtu/hr	
1	.	4	Flue gas flow rate	m^3/min (actual temp., 1 atm., wet)	
				m^3/hr (actual temp., 1 atm., wet)	0
				Nm^3/hr (0 ^oC, 1 atm, wet)	0
				lb/hr	
1	.	5	Flue gas temperature	^oF	
1	.	6	Flue gas pressure (SCR)	inches w.c.	
1	.	7	Site Elevation	feet	
			Flue Gas Composition		
1	.	1	CO_2	vol% dry @ 3% O_2	0.0
				vol% wet @ actual O_2	
1	.	2	H_2O	vol% wet @ actual O_2	
1	.	3	O_2	vol% dry	
				vol% wet	0.0
1	.	4	SO_2	ppmvd @ 3% O_2	0
				ppmvw @ actual O_2	
1	.	5	SO_3 (RXR inlet)	ppmvd @ 3% O_2	0
				ppmvw @ actual O_2	
1	.	6	NOx inlet (RXR inlet)	ppmvd @ 3% O_2	0
				ppmvw @ actual O_2	
1	.	7	NO_2/NOx Ratio (RXR inlet)	%	
1	.	8	NOx outlet (RXR outlet)	ppmvd @ 3% O_2	0
				ppmvw @ actual O_2	
1	.	9	NH_3 Slip (max., RXR outlet)	ppmvd @ 3% O_2	
1	.	10	Particulate	mg/Nm^3 (dry, 0 ^oC, 3% O_2, 1 atm.)	0
				mg/m^3 (actual conditions, 1 atm.)	
1	.	11	Mercury	Hg^T (µg/Nm^3, dry, 0^oC, actual O_2, 1 atm.)	
				Hg^0 (µg/Nm^3, dry, 0 ^oC, actual O_2, 1 atm.)	
				Hg^{2+} (µg/Nm^3, dry, 0^oC, actual O_2, 1 atm.)	
1	.	12	HCl	ppmvd @ 3% O_2	0.0
				ppmvw @ actual O_2	
	.		***Fuel***		
1	.	13	Average heating value	Btu/lb (HHV, dry basis)	
1	.	14	Average fuel moisture content	% by wt (as-burned)	
1	.	15	Average mercury content	ppm by wt (dry basis)	
1	.	16	Average chlorine content	ppm by wt (dry basis)	
2			**Reactor Vessel Data**		
2	.	1	Reactor Position in Flue Gas Train		
2	.	2	Number of SCR Reactors Per Unit		
2	.	3	Reactor Internal Dimensions	(ft inch) x (ft inch)	
2	.	4	Reactor Cross Sectional Area	m^2	
2	.	5	Number of Possible Layers in Reactor		
2	.	6	Location of Layer in Reactor		
2	.	7	Module arrangement		
2	.	8	Module length x width	m x m	
2	.	9	Module max. allowable height	m	
2	.	10	Max. allowable module weight	kg	
2	.	11	Method of catalyst cleaning		
2	.	12	Reducing agent		
			Operating Velocity Conditions		
2	.	13	Actual Superficial Reactor Gas Velocity	m/s	#DIV/0!
2	.	14	Actual Gas Velocity at Catalyst Face	m/s	
2	.	15	Actual Gas Velocity in Catalyst Channels	m/s	

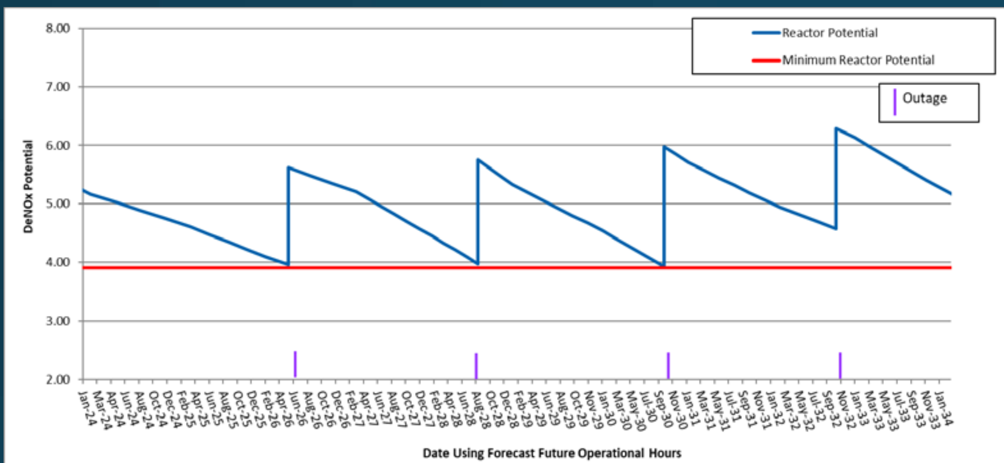
			Parameter	Units	
2			**Reactor Vessel Data**		
2	.	1	Reactor Position in Flue Gas Train		
2	.	2	Number of SCR Reactors Per Unit		
2	.	3	Reactor Internal Dimensions	(ft inch) x (ft inch)	
2	.	4	Reactor Cross Sectional Area	m^2	
2	.	5	Number of Possible Layers in Reactor		
2	.	6	Location of Layer in Reactor		
2	.	7	Module arrangement		
2	.	8	Module length x width	m x m	
2	.	9	Module max. allowable height	m	
2	.	10	Max. allowable module weight	kg	
2	.	11	Method of catalyst cleaning		
2	.	12	Reducing agent		
			Operating Velocity Conditions		
2	.	13	Actual Superficial Reactor Gas Velocity	m/s	#DIV/0!
2	.	14	Actual Gas Velocity at Catalyst Face	m/s	
2	.	15	Actual Gas Velocity in Catalyst Channels	m/s	

			Parameter	Units	
3			**Catalyst**		
3	.	1	Type		
3	.	2	Manufacturer		
3	.	3	Composition (active constituents)		
3	.	6	Pitch	mm	
3	.	7	Wall Thickness	mm	
3	.	8	Hydraulic Diameter of Channels	mm	
3	.	9	Void Fraction	%	
3	.	10	Specific Surface Area	m^2/m^3	
3	.	11	Catalyst Density	kg/m^3	
3	.	12	Proposed Catalyst Volume per Unit Layer	m^3	
3	.	13	Proposed Catalyst Volume per Reactor Layer	m^3	#DIV/0!
3	.	14	Area Velocity per Individual Layer	Nm^3/h (0 ^oC, 1 atm, wet) / m^2	
3	.	15	Space Velocity per Individual Layer	Nm^3/h (0 ^oC, 1 atm, wet) / m^3	
3	.	16	Catalyst Module Length (x-dimension)	mm	
3	.	17	Catalyst Module Width (y-dimension)	mm	
3	.	18	Catalyst Module Height (z-dimension)	mm	
3	.	19	Catalyst Module Weight	kg	
3	.	20	Catalyst Volume per Module	m^3	
3	.	21	Number of modules furnished		
3	.	22	Proposed Catalyst Element Height per Layer	mm	
3	.	23	Maximum Possible Element Height per Layer	mm	
3	.	24	Plate width	mm	
3	.	25	Number of elements / plates per module		
3	.	26	Maximum Operating Temperature	^oF	
3	.	27	Minimum Continuous Operating Temperature	^oF	
3	.	28	Minimum Ammonia Injection Temperature	^oF	
3	.	29	Recovery Temperature	^oF	
3	.	30	Maximum Rate of Temperature Change	^oF/minute	
3	.	31	Module heat capacity	kJ/kg/^oC	
3	.	32	Module Screen Pitch	mm x mm	
3	.	33	Module Screen Wire Diameter	mm	
3	.	34	Module Screen Clear Opening	mm x mm	
3	.	35	Module Screen Material		
			Performance Guarantees		
3	.	36	Fresh Catalyst Activity Constant (K_0)	m/h at STP (0 ^oC, 1 atm)	
3	.	37	Catalyst Activity Constant (K) at 16,000 hours	m/h at STP (0 ^oC, 1 atm)	
3	.	38	Catalyst Activity Constant (K) at 32,000 hours	m/h at STP (0 ^oC, 1 atm)	
3	.	39	Catalyst Activity Constant (K) at 64,000 hours	m/h at STP (0 ^oC, 1 atm)	
3	.	40	Max. SO_2 to SO_3 Oxidation Rate	%/layer	
3	.	41	Draft Loss	inches w.c.	
3	.	42	Catalyst Life	hours	
3	.	43	Mechanical Service Life	hours	
3	.	44	Max. plugging of catalyst	% of open channel area	
3	.	45	Min. Mercury oxidation (fresh catalyst)	% of Hg^o in gas at inlet	
3	.	46	Min. Mercury oxidation (after 16,000 hours)	% of Hg^o in gas at inlet	
4			**Laboratory Testing Conditions**		
4	.	1	Operating temperature	°F	0
				°C	-18
4	.	2	Nominal sample cross section mm x mm	mm x mm	150 x 150
4	.	3	Factor for real linear velocity (low load, pluggage,...)		1
4	.	4	Linear velocity m/s (gas velocity inside catalyst channels)	actual m/s	
4	.	5	NOx inlet	ppm wet, actual O_2	0
4	.	6		ppm dry, 3% O_2	0
4	.	7	SO_2 inlet	ppm dry, actual O_2	0
4	.	8		ppm dry, actual O_2	0
4	.	9	O_2 inlet	% by vol. wet	0.0
4	.	10		% by vol. dry	0.0
4	.	11	H_2O inlet	% by vol. actual O_2	0.0
4	.	12	NH_3/NOx ratio for activity test		1.00 - 1.02
4	.	13	NH_3 /NOx ratio for SO_2 oxidation test		0.0

Give the suppliers general guidance - tell the suppliers what matters to you!

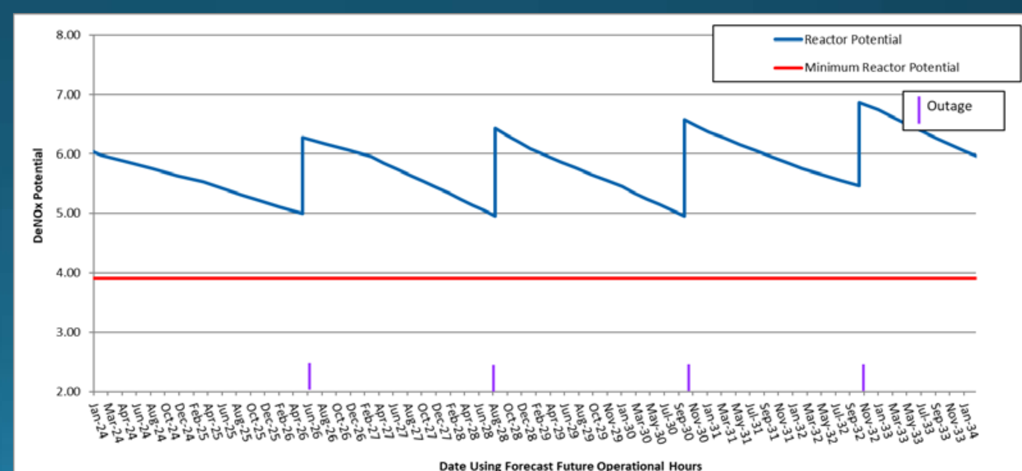
Specifics like maximizing potential, minimizing SO_2 conversion, or plugging concerns can help you get the best offering for your particular application.

- If you have past experience with geometries that work well – tell them!
- Ask for options!



In this example there is no margin in deNOx potential, would look to maximize potential. Probably want to use max. SO_2 conversion that is tolerable, max volume/height, etc., along with minimum pitch that will work (be careful about reducing pitch!)

In this example there is plenty of margin in deNOx potential, would look to trade off some potential with lower SO_2 conversion, higher mercury oxidation, larger pitch, less volume, etc. Try to skip an outage?



EVALUATING BIDS

1. Verify that bids conform to specs
2. Get everyone on a comparable technical footing
3 Apply price factors as appropriate
4. Select based on perceived cost/value and T&C's

TRAIN WRECK BID COMPARISON

Parameter	Supplier A	Supplier B	Suppplier C
Pitch	**5.9 HC**	**6.7 HC**	**5.7 Plate**
Length (mm)	**1,295**	**1,270**	**2x500**
SSA (m^2/m^3)	580	511	505
Number of RXRs	2	2	2
Cat. Vol. Per RXR (m^3)	**151**	**145**	**117**
Total Cat. Vol. (m^3)	**302**	**290**	**233**
Total SA (m^2)	**175,217**	**148,190**	**117,833**
Ko (m/hr)	42.0	37.0	35.0
SO2 Conversion	<0.5%	<0.35%	<0.20%
AV	**12.2**	**14.5**	**18.2**
Po	**3.43**	**2.55**	**1.92**
Total Price	$1,799,712	$2,050,210	$1,650,251
Price/P	$524,889	$802,539	$858,821

Note: totally fictitious example to make point

Goal should be to get 3 good bids on a similar technical basis that is optimal.

Don't be shy about asking for additional options. Give everyone the same chance.

ROUND 2: Apples-to-applies comparison (relatively) with revised bid option.

Parameter	Supplier A		Supplier B		Supplier C	
Option	Base	Option A	Base	Option A	Base	Option A
Pitch	**5.9 HC**	**6.1 HC**	**6.7 HC**	**6.1 HC**	**5.7 Plate**	**5.7 Plate**
Length (mm)	**1,295**	**1,200**	**1,270**	**1,200**	**2x500**	**2x600**
SSA (m^2/m^3)	580	540	511	555	505	505
Number of RXRs	2	2	2	2	2	2
Cat. Vol. Per RXR (m^3)	**151**	**140**	**145**	**140**	**117**	**140**
Total Cat. Vol. (m^3)	**302**	**280**	**290**	**280**	**233**	**280**
Total SA (m^2)	**175,217**	**151,200**	**148,190**	**155,400**	**117,833**	**141,400**
Ko (m/hr)	42.0	32.0	37.0	34.0	35.0	35.0
SO2 Conversion	<0.5%	<0.20%	<0.35%	<0.25%	<0.20%	<0.20%
AV	**12.2**	**14.2**	**14.5**	**13.8**	**18.2**	**15.2**
Po	**3.43**	**2.25**	**2.55**	**2.46**	**1.92**	**2.31**
Total Price	$1,799,712	$1,709,050	$2,050,210	$1,800,005	$1,650,251	$1,805,652
Price/P	$524,889	$758,126	$802,539	$731,194	$858,821	$783,078

Note: totally fictitious example to make point

Price/Value adjustments and other considerations

1. Make sure bids are adjusted for any add-ons such as screens, seals, catalyst sample holders, etc.

2. Include any shipping/storage cost considerations

2. Applying a $ value to pressure drop differences may be relatively easy, that is usually the most quantifiable parameter

3. Additional cost considerations for SO_2 conversion and mercury oxidation might be appropriate

Good to keep in mind the idea of commercial margin – differences in guarantees do not necessarily reflect differences in actual performance

Verifying Guarantees

1. Beginning of life guarantee: Independent lab testing for verification of Ko and SO_2 conversion. This provides actual, not guaranteed, Ko for catalyst management.

2. End-of-life guarantee: Good to check Ko and SO_2 conversion at end of guaranteed life. When catalyst is removed, an actual end-of-life (which will probably be longer than the guaranteed life) activity measurement is valuable so that a complete historical deactivation history is known which serves to predict future deactivation for future layers.

CONCLUSIONS

Specify Correctly: You are spending a large amount of money on catalyst – it is extremely worthwhile to make sure you are getting what serves you best.

Get Apples-to-Apples Bids: Work to get multiple offerings that are technically acceptable, such that you aren't forced into what is effectively a sole-source purchase.

Confirm Guarantees: It is worthwhile to spend a small amount of money on a large purchase to confirm that you received what you paid for.

Exchange Information: Having open discussions with suppliers will help to ensure that you get the best offering for your job – there is no advantage in holding information close to the chest.

Questions?