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Technical Specification for Desulfurization Catalyst

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G.I.S.D.Co.

contractor:

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1. General Description

The reducing gas used in the Midrex process Reduction Furnace is produced by recirculating a major portion of the top gas taken from the Furnace exhaust. This gas is first cleaned by the top gas scrubber and is then compressed, mixed (with natural gas), and passed on through catalyst-filled tubes. These tubes are heated in a refractory-lined box called the Reformer.

Reforming causes an approximate 30% increase in gas volume. In reduction processes that utilize natural gas, the CO and H_2 needed for reduction are produced by reforming natural gas with steam (H_2O vapor) and CO_2 at elevated temperatures. Natural gas is principally CH_4 (methane). The following are the basic reforming reactions, each of which requires considerable heat and results in a volumetric expansion:

$$CH_4 + H_2O \text{-->} CO + 3H$$

$$CH_4 + CO_2 \text{-->} 2CO + 2H_2$$

Equilibrium considerations prevent the above reactions from going to completion. Also, there must always be some excess of H_2O and/or CO_2 in the mixture being reformed to avoid carbon deposition problems in the reformer tubes. This results in some residual H_2O plus CO_2 in the hot reformed gas. Stoichiometric reforming can achieve over 90% CO and H_2 in the hot reformed gas.

To have designed efficiency of the reformer catalyst H_2S in feed stock entering to the reformer should be less than 3 ppm. The hot feed gas which is mixture of process gas and natural gas will enter DS unit. The DS unit should be designed in such a way to have minimum pressure drop and will have provision for 100 % partial bypass to control H_2S at DS unit outlet.

1.1 <u>Roll of sulfur on catalyst performance:</u>

Sulphur compounds in any form are a temporary poison to reforming catalysts. Sulphur compounds are present in most natural gases and iron oxides so they are a concern in direct reduction plants. Halogens are also temporary poison, but they are less common in DR plants. A temporary poison is one that reduces the activity of the catalyst only when the poison is present. The catalyst activity returns to its original value once the poison is removed from the feed gas stream.

About 1-3 ppmv sulphur is desirable in the feed gas to a Midrex reformer to retard the Boudouard carbon forming reaction.

There are two sources of sulphur in a Midrex reformer: the natural gas and the process gas. As we know sulphur compounds in natural gas can occur naturally or may be added to odorize the gas. Sulphur compounds in the iron oxides can be released into the reducing gas stream in the shaft furnace. Selecting iron oxides that are low in sulphur release during reduction can reduce the sulphur content of the process gas.

1.2 <u>Effect of catalyst poisons on catalyst performance:</u>

A catalyst poison is any substance that reduces the activity of the catalyst. While sulphur is the most common poison encountered in reforming, there are many other possible poisons same as Chlorine or any other halogen in any gaseous compound, Zink, Lead or other metal vapours. The plant operator should be aware of the potential poisons and should be take care to avoid contaminating the catalyst with any poison. Catalyst poisoning is most likely to occur during the loading of catalyst into the reformer or from trace amounts of a poison in the reformer feed stock. Poisons may be a temporary poison like sulphur or may be a permanent poison that will continue to reduce the catalyst activity even after the source of the poison is removed.

In actual practice, catalyst poisoning of a Midrex reformer by anything other than sulphur is very rare.

2. Site condition

2.1 Plant location

The site is located in Sirjan city in Kerman province of Iran, near the Gol e Gohar iron ore site (60th Km of Sirjan to Shiraz road).

2.2 Meteorological

Average max. dry bulb temperature:	25.2 ^{o}C
Average min. dry bulb temperature:	9.3 ^{o}C
Average max. Relative humidity:	at 6:30 AM – 54 %
Average min. Relative humidity:	at 2:30 PM – 21
Maximum precipitation per day:	58 mm
Average precipitation per year:	141.5 mm
Maximum absolute temperature:	42 ^{o}C for design 50 ^{o}C considered
Minimum absolute temperature:	-14.8 ^{o}C
Prevailing wind direction:	South to North
Atmospheric pressure:	831.4 mbar
Wet bulb design temperature (worse condition)	25°C

3. Technical specifications

· Catalyst type	ZnO
· Number of Vessels	Two
· ZnO Desulphurisation Catalyst	150 ton

4. Feed gas condition

4.1 Feed gas flow:

- Nominal Flow Rate — 248,770 NCMH
- Max. Flow Rate — 269,257 NCMH

4.2 Feed gas pressure:

- Pressure — 1.94 Bar G
- Max. operating pressure — 2.433 Bar G

4.3 Feed gas temperature:

- Temperature — 340 °C
- Max. operating temperature — 400 °C

4.4 Inlet Feed gas analysis:

- CO	18.38
- CO_2	13.69
- H_2	32.32
- H_2O	14.08
- N_2	3.92
- CH_4	16.67
- C_2H_6	0.53
- C_3H_8	0.22
- C_4H_{10}	0.12
- C_5+	0.08
- O_2	0.00
- H_2S	Max.20 ppm

According to above mentioned analysis for feed gas zinc oxide catalyst shall be able to restrict H_2S quantity less than 3 ppm.

5. <u>Specification of desulfurization vessels</u>

We have considered 2 vessels for DR plant. The proposed details for each vessel are as follows:

Diameter of vessel:	5950 mm
Height of catalyst in the vessel:	2687 mm

6. <u>Product Specification</u>

6.1 Specification of ZnO Desulphurization catalyst

-Description	Desulfurization catalyst
- Application	removal of sulphur from hydrocarbon process gas
-Form	Extrusions
- Size	5 mm dia ± 0.2 mm(90% aliquot L/D 1:1 to 3:1)
- Bulk Density	1.3± 0.05 (Kg/L)
- Crush strength	>7 (Min. Avg. side crush load in Kg)
- Pore Volume	0.22± 0.03 (cm^3/g)
- Surface area	25±5 (m^2/g)
- Chemical Analysis	

- %ZnO — ≥90%
- Balance — proprietary binders
- S pick-up — up to 30% @ operating temperature > 350 ^oC

6.2 Specification of ceramic balls bed support

NOM SIZE(Inches)	RANGE DIAMETER(mm)	BULK DENSITY(Kg/L)	CRUSHING LOAD MIN(Kg)
2	50-55	1.35± 0.1	2000
3/4	17-21	1.4± 0.1	430

- **Chemical Composition**

Al_2O_3+ SiO_2	95% Min
SiO_2	65-75 %
Al_2O_3	23-28 %
Fe_2O_3+TiO_2	1.2 % Max
MgO+CaO	1.5 % Max
Na_2O+ K_2O	3.5 % Max
Fe(leachable)	< 0.1 %

- **Physical Properties**

ATTRITION LOSS	<0.05%
WATER ABSORPTION	0.1-2.0 wt%
MAX. APPLICATION TEMP	1000 degree C
SPHERICTY	<1.2

7. <u>Handling and Storage</u>

Protect from physical damage. Store in a cool, dry, ventilated area away from sources of heat, moisture and incompatibilities.