		PROJECT	Standby SRU & Additional Tanks IOCL Paradip Refinery		
JOB SPECIFICATION FOR CATALYST / PACKINGS LOADING		CLIENT	INDIAN OIL CORPORATION LIMITED		
Project No. 080557C001		Document No. 080557C-000-JSC-0093-014		Rev. No. 0	Page 1 of 18

JOB SPECIFICATION FOR CATALYST / PACKINGS LOADING

0	04/12/2019	ISSUED FOR IMPLEMENTATION	KMK	TNVS	TNVS	JMC
REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED	AUTHORIZED

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1. Introduction:

INDIAN OIL CORPORATION LIMITED (IOCL) has awarded Fax of Acceptance (FOA) dated 29th August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India.

2. Definitions & Abbreviations

Abbreviation	Definition /Expanded form
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages.
EPCM	Engineering, Procurement & Construction Management Services.
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them.
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related
SRU	Sulphur Recovery Unit

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3. General

This section contains information on the special procedure required for catalyst loading. The scope of this document is to give outlines of activities for catalyst loading. For specific conditions and methods of loading, the vendor's documents shall be referred.

4. Reference Documents

- 1.1 Licensor /Catalyst vendor documents
- 1.2 Piping and Instrumentation Drawings
- 1.3 Vessel data sheets
- 1.4 MSDS for catalysts



5. Catalyst Loading Planning & Preparation

Loading catalysts of the reactor(s) is normally the last item attended due to the sensitivity of the catalysts.

- Installation and inspection of the bottom internals
- Installation and inspection of the vapor/liquid distribution tray, quench internals, quench piping, thermos-wells, catalyst support stool or catalyst support grids

5.1 Preliminary Checking

- Check that the refractory lining height is homogeneous along the entire length and width of the reactors;
- Check that grating and mesh screens are properly installed on the catalytic bed support (layers order in accordance with the drawings);
- Open the top manhole. Aerate and check that the atmosphere inside the reactor is suitable for entering (21% O₂), and the reactor is free from any water and rust. Respect the refinery vessel entry permit system at all times. Supply air hose connections to reactor top as necessary;
- Make sure that the catalyst and inert balls drums are gathered in a sheltered place, close to the relevant reactor;
- Check that all the internal parts to be installed during loading are available. Check their conformity to the drawings and the quality of the materials;
- All the reactor internals are made of parts which can be dismantled to allow passage through the manhole. Their assembly has already been checked;
- Check the quality of the alumina balls and the ceramic balls. If they are broken, they must be sorted and fines removed;
- Ensure that all the necessary safety and personnel protection equipment is available (gloves, dust

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masks, respirators, safety harness, etc) as well as means of communication (walky-talkies);

- Before loading, the catalyst drums must be stored in a safe place and protected from rain.



5.2 Recommendations

- To avoid catalyst attrition- do not roll drums of catalysts;
- Catalyst must be loaded carefully to minimize free fall. Maximum permissible free fall height is 1 meter. Do not walk directly on catalyst. Use wood boards;
- In case of heavy rains, stop loading. If prolonged rainy weather is forecast, provision for a weatherproof cover must be made. If loading operations are not to continue for an extended period, the inlet flanges must be covered in a weather tight fashion whilst unattended;
- Working in a dusty catalyst atmosphere is not physically harmful, provided that dust masks are worn;
- Make sure that no foreign material is left in the reactor (pieces of sleeve, walking boards, tools, etc...);
- Temporarily protect all reactor outlets to avoid plugging by catalysts fines or residues.

5.3 Special Loading Device

The equipment includes:

- A stationary hopper to be built on site (see Figure 5 & 6). The stationary hopper is fitted with a slide valve. The hopper legs should be long enough to allow access into the reactor (whenever possible);
- Flexible sleeves (adequate length, 150 mm diameter);
- A mobile hopper containing about 3 drums of catalyst (see Figure – Detail 2);
- A lifting device to lift the mobile hopper from the ground level. This lifting device could be either a crane or a system of winches (see Figure 5);
- At ground level, a temporary platform should be erected at the level of the truck used to transfer the catalyst drums from storage to the reactor site. The drums will be transferred from the truck to the platform, opened and poured in the mobile hopper. Empty drums should be stored on site or immediately returned to storage facilities;
- On top of the reactors, a temporary platform should be installed, to allow the operation of the mobile hopper slide valve during loading;
- Tooling, lighting facilities, dust masks, respirators, safety harnesses, should be also prepared. It is particularly recommended that personnel involved in handling and loading of the catalyst be properly clothed, e.g. long-sleeved shirts, gloves and safety glasses. Furthermore, self-contained breathing apparatus (SCBA) shall be used by any person who must handle the catalyst or enter a closed area containing the catalyst, e.g. inside the reactor;

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- A vacuum cleaner should be available to eliminate dust and catalyst fines inside the reactor;
- Bottles should be available to take samples of the catalyst during loading;
- To protect catalyst from rain, temporary shelters should be installed on top of reactors and ground level platform.

5.4 Internal Inspection

Inspection of Reactor Internals and Cleanliness Prior To Loading Reactor Cleanliness:

Prior to loading of catalyst or support, care should be taken to make sure any water, dust, or old catalyst is removed from the reactor. Loading contractors can usually provide video inspection in the case that the reactor is kept under an inert environment.

- Special attention should be given to the outlet screens of the reactor and inter- reactor beds. Chips of catalyst should be removed from outlet screens. The outlet screens should be 100% clean. This is easily accomplished with a wire brush. Replace screen covers, if necessary.
- Coke or clumps of catalyst should be removed from all vessel walls and internals.
- Quench section nozzles should be verified to not be plugged.

Special attention is required during the re-assembly of reactor internals to ensure that proper liquid distribution occurs and to prevent catalyst migration.

- Distributors trays should be verified to be level. The tray should be leveled within .1-.3% of the reactor diameter or 6 mm (1/4 in), whichever is smaller. This is only a general guideline. Check with your distributor manufacturer for specific recommendations.
- Inspect all reactor outlet screens for bent or distorted wires. Make appropriate repairs as required.
- If the reactor has an outlet screen (sometimes referred to as an "elephant stool"), make sure that it fits snugly in the outlet nozzle of the reactor. Make sure the gap that exists where the outlet screen fits into the outlet nozzle of the reactor is sealed or is at least 3 times smaller than the support material that will be used in the bottom of the reactor.
- Ensure that all gaskets and ceramic fiber have been installed so that the distributor tray is completely sealed. Flow distribution problems can result from a tray that has not been properly sealed. Special attention should be given to the areas where thermowells and dump tubes penetrate the distribution tray. Also inspect the outer diameter of the distribution tray and seal with ceramic fiber if gaps exist.
- Inspect the same areas as mentioned in 4 on interbed outlet screens to prevent catalyst migration. Catalyst migration will cause significant damage to the distribution tray below.
- Quench sections should be inspected for levelness. The level should be within normal fabrication practice.

5.5 Loading of The Reactor Outlet Support

Figure 1 and 2 show Typical sample loading diagrams for loading support in the bottom of a reactor with an outlet screen and an inter-bed outlet screen.



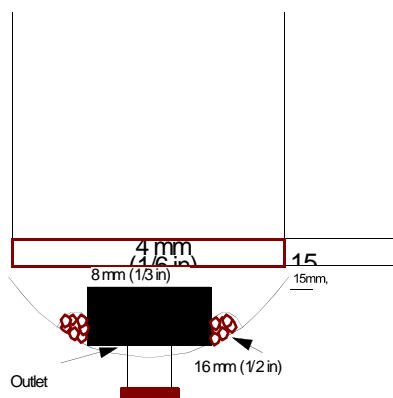
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Figure 1



In Figure 1, the outlet screen ("elephant stool") is typically designed with a sleeve that fits into the outlet nozzle of the reactor. It is very important that the outlet screen fits "tight"(ie, there is not a large gap between the screen sleeve and the outlet nozzle). A quick test for this is to try to move the outlet screen while it is in place. Any movement signifies that the outlet screen sleeve needs to be properly sealed. Attention to the bottom edge of the outlet screen where it meets the bottom head of the reactor needs to be part of the reactor internal inspection. Large gaps between the base of the outlet screen and reactor head (>3mm,1/8in) should be sealed with ceramic fibre. This area should be sealed with >16 mm (1/2 in) ceramic spheres to prevent catalyst migration under the outlet screen.

Figure 2

4 mm (1/6 in)	1
8 mm (1/3 in)	1

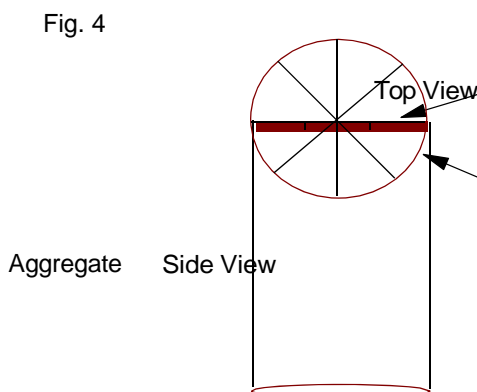
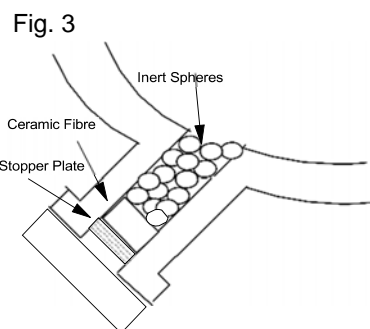
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In Figure 1 and 2, support media (Active or Inert) is used as the attrition and crush strength of these materials resist breakage and fines generation which can plug the outlet screen. In processing services where maximum activity is required, active support spheres are loaded above the top of the outlet screens. This recommendation holds unless the slot spacing of the outlet screen is greater than. If the slot space is greater than 2.5 mm, spheres that are 3 times larger than the slot space of the outlet screens. This rule of thumb prevents broken pieces from the large support from being able to pass through the screen. For Figure 1 and 2, the next layer should be less than 3.5 times smaller to prevent migration of the smaller material above. Refer to vendor/ supplier instructions for good performance of the catalyst.

The material used as support material should possess an Attrition Index* greater than 95 % and a bulk crush strength greater than the maximum expected pressure drop + the weight of catalyst above. The reactor unloading nozzles should be filled with inert material to minimize coking and to prevent potential reactive areas with no flow. A layer of ceramic fibre should be placed at the bottom of each unloading nozzle above the stopping plate to ease the removal of the plate. Refer to Figure 3.



The support material is generally sock or bucket loaded by a loading technician who is stationed inside the reactor. Care should be taken to ensure that support does not free fall more than 60 cm (2 ft) to prevent breakage. Ensure that dust and chips in the bottom of the original containers are not loaded into the reactor when transferring support material to the reactor.

For reactors with multiple beds, which use "dump tubes" to allow dumping of all beds without entry, fine aggregate is typically loaded into the tubes. This material is installed to prevent liquid bypassing of the interbed distributor, but allows the catalyst to free flow through the tube when the reactor catalyst is unloaded.



5.6 Main Catalyst Bed Loading and Techniques

Now that the support has been loaded into the reactor, catalyst loading by "sock" loading methods can

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commence. Generally, sock loading should be performed until the catalyst is out of the bottom head of the reactor. Catalyst should be graded in decreasing sizes using a ratio of 2-3 until the main bed catalyst size is reached.

The reactor loading can start when all loading devices are installed:

- Check the catalyst support grid, chiefly to remove dusts fines, if any.
- Build-up the bottom layer of alumina balls or inert ceramic balls on the support grid. Level carefully.
- Install the thermowells. Check their location and length.
- On the reactor wall, mark with chalk the upper level of catalyst, at the required height above the alumina balls or inert ceramic balls.
- Install the stationary hopper on top of the reactor. Fasten the loading sleeve.
- Start loading the catalyst bed with catalyst. Fill the reactor with catalyst up to the chalk mark on the reactor wall and level carefully.
- Check the gap between the top level of the catalyst bed and the tangent line.
- Install the inlet distributor.
- After a final inspection, close the manholes.

General Guidelines for "sock" loading methods.

- Due to the hygroscopic nature of catalyst in the oxide state, it is not recommended to load in damp conditions. Damp conditions include rain, mist, or very high humidity. The catalyst must be kept protected from the rain. In conditions of mist or high humidity, it would be considered too damp if the inside wall of the reactor is "sweating". Catalyst bags should be kept sealed until actual catalyst loading is occurring. The issue with moisture is that vaporization of water during initial startup could result in catalyst damage. Also, excessive moisture may interfere with the sulfiding process during startup.
- Care should be taken when standing on the catalyst bed. Snow shoes or boards are typically used to distribute the weight of the loading technician.
- A vacuum system should be used, when loading catalyst, to remove dust from the reactor. Dust and fines will impact the start of run pressure drop.
- Catalyst bed level should be measured every 4 ft. Acceptable bed level is determined by the following equation $\pm 0.15 \times \text{bed diameter}$. This number is based on industrial experience with various dense loading methods and acceptable flow distribution after startup. If the bed does not meet these level requirements, the bed should be manually leveled. Do not use a rake unless the prongs of the rake have been sealed with duct tape. This will prevent catalyst breakage.
- It is critical to ensure that the interface of different catalyst types and sizes meet the level criteria. It is recommended to have the loading technician visually verify the level of the bed at the interface. The outlet perimeter of the bed should be carefully inspected and leveled as needed to provide a level surface at the interface.

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- Catalyst bed density should be measured every 4 ft. This will help to identify problems with the loading method. The loading personnel should record the loading densities on a loading report. This information will aid in the troubleshooting process if problems are identified after startup.
- Records of apparent dust, problems with loading equipment, etc. need to be very carefully documented.
- Shift change of loading personnel is when problems may occur. It is important to ensure that a proper turnover occurs between each shift and that some amount of redundant coverage is provided for at least one hour during shift change.
- Dust removal equipment should be operating when catalyst is being loaded as excess dust will reduce the void fraction in the catalyst bed and cause higher SOR pressure drop. Catalyst air blowing Proceed to air blowing using Main Blowers after catalyst loading to eliminate all possible catalyst fines and dusts. A vacuum cleaner can be used

5.7 Specific Guidelines for Sock Loading

Sock loading is usually only recommended for vapor phase units, units with hydraulic limitations and chronic fouling, units loading spherical catalyst, and top beds using hollow cylinders or other high void shapes. However, several refiners will dense load even in these cases. The main reason being that sock loading involves having personnel in the reactor during loading. Catalyst slumping of as much as 10% may occur during operation of a sock loaded catalyst bed.

Vapor Phase Units:



In the case of vapor phase units (naphtha/kerosene), dense loading is usually not justified due to small incentives for increasing the total pounds of catalyst in the reactor. In addition, maldistribution is less of a concern in a vapor phase operation. The net result of sock loading a vapor phase reactor is usually a faster loading time, more pressure drop tolerance, due to the higher void fraction, and a lower start of run pressure drop.

Spherical Catalyst:

There is usually no activity benefit from dense loading spherical catalyst. There have been cases where dense loading has been performed on spherical catalyst with perceived benefits of increased loading density. This may be explained by non-uniform spherical shape and variations in actual density verses expected density. However, it is generally an accepted practice to sock load spherical catalyst unless safety or other factors are issues.

If the sock loading method is performed, the following additional guidelines are provided.

- Use at least a 15 cm (6 in) diameter sock to provide an acceptable loading rate. Typical loading rates will range from 4-9 m³/hr. (140-300 ft³/hr.). The loading rate is dependent on distance from catalyst hopper to the bed, with the lower beds requiring more time.
- A loading technician should operate the sock from inside the reactor. Proper personnel protection equipment should be used for the person inside the reactor.
- The technician should move the sock in a circular pattern as the catalyst is unloaded from the sock. When this method is used, raking and leveling of the catalyst bed is not required.
- The sock should be kept within 30 cm (1 ft) of the catalyst surface to minimize dust and freefall of the catalyst. The sock should be cut at regular intervals as the catalyst bed level rises. This will be

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dependent on the diameter of the reactor.

Table 3- Typical Loading Density and Void Fraction for Catalysts

Catalyst	Diameter mm, (in)	Sock Loaded Density g/cc, (lb/ft ³)	Void Percent Sock Loaded
Catalyst 1	2.5	0.64 (40)	49
Catalyst 2	1.3	0.56 (35)	49

5.9 Top Bed Grading



A graded top bed in a reactor is usually recommended in order to improve flow distribution and improve fouling tolerance (especially in the lead reactor). The use of high void active and inert support is a common industry practice when it comes to top bed grading. The shape of commercially available top bed catalysts and supports (Hollow Cylinders, Spheres, etc.) provide for improved flow distribution by improving radial flow throughout the catalyst bed.

When these large void catalysts and support are properly installed, significant increases in fouling tolerance will result due to the ability to accumulate a larger volume of particulates between catalyst particles. See Table 4 for a comparison of void of different shapes. Contact sales representative for recommendations on top bed grading.

Table 4 - Void Volume of Shaped Materials

Top Bed Catalyst Shape		Void Percent – Sock Loaded
Medallion		65 - 70 %
Hollow Cylinder	8 mm, 6.4 mm, 4.8mm	50 – 60 %
TriLobe Shape	2.5 mm	40 – 45%
Sphere	8 mm, 4mm	30 – 35%

- Contact vendor's Sales Representative for specific recommendations on top bed grading. Top beds can be customized to provide the optimum fouling tolerance for specific fouling problems.
- Graded top beds should only be loaded by sock loading methods to prevent significant breakage and to provide the maximum void.
- The top layer of support should be loaded within 15-30 cm (6-12 in) of the distributor. It is usually not recommended to load right up to the bottom of the distributor as flow maldistribution may occur.
- Each layer of top bed catalyst and support should be carefully leveled prior to placing the next layer on top.
- When beginning to load a new layer in the top bed, the catalyst should be discharged very slowly from the sock to prevent significant disturbance to the level of the bed. Do this until at least a 8 cm (3 in) layer of material completely covers the previous layer.

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5.10 Packing Loading

“Dry” loading is the easiest way for loading but the “wet” loading procedure is also acceptable, we suggest the use of a hopper equipped with a flexible loading sleeve which can be introduced through the top of each part of the flanged column.

5.11 Height of Packing Above A Support Plate

Too frequently, the height of packing above the support plate has been determined solely on the load-bearing capacity of the support plate (which has adequate structural strength to support both the weight of the packing and the liquid hold-up in the bed). The height of the packed bed shall be determined based on tower performance.

5.12 Preliminary Checking

- Before loading, the random packing must be stored in a safe place and protected from rain.
- Open the Column Manholes. Aerate and check that the atmosphere inside the column is suitable for entering (21% O₂). Respect the refinery vessel entry permit system at all times. Supply air hose connections to column top as necessary;
- Make sure that the random packing drums are gathered in a sheltered place, close to the relevant column;
- Check that all the internal parts to be installed during loading are available. Check their conformity to the drawings and the quality of the materials;
- All the column internals are made of parts which can be dismantled in order to allow passage through the flanges. Their assembly has already been checked;
- Ensure that all the necessary safety and personnel protection equipment is available (gloves, dust masks, respirators, safety harness, etc) as well as means of communication (walky-talkies).



5.13 Methods of Packing A Tower

The packing in a tower is either stacked or dumped depending on the size and nature of the packing. Saddles, both Intalox and Berl Saddles, are always dumped. Rings (Raschig, Lessing and Pall Rings) are likewise dumped in the size up to and including 3 in. Larger sizes are normally stacked. Cross-partition rings may be dumped or stacked. Spiral rings are normally stacked.

5.14 Dumped Packing Procedure (FIG. 8)

Packing the Tower “Dry”. Build a trip bucket or preferably a trip frame that will handle one carton of packing at a time; the cartons should be lowered to a point not over 0.6 m above the surface of the bed and then dumped slowly by means of a tripping rope. The packing should be dumped at random spots in a large tower rather than attempting to form either upright or inverted cones. If the packing is installed through manholes care must be taken to prevent a stratifying in layers on an inclined plane which would contribute to misdistribution.

Keep the Support Plate Open. Large towers usually carry their packing on Beam-Type supports here

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the open area will range from 50% to not over 75%. If saddles are dumped directly on these beams they tend to reduce this open area too much and cause localized flooding in the tower. We recommend that the beams be placed on six inch centers with six-inch Cross-Partition Rings stacked on time with an "R" (square) setting. Over the six-inch Rings should be stacked four-inch Cross-Partition Rings on an "M" (diamond) setting. Then the saddles are used then either four-inch Cross-Partition or Single-Spiral Rings may be used just below the dumped saddles. These stacked rings should be set tight and wedged in place with shims so they cannot shift around.

Hold down the Packing. If the tower is to operate in the loading range or may be subject to bumping, it is important that a hold-down plate be installed over the top of the packing to prevent it from milling around.

5.15 Final Inspection of The Distributor

After the reactor has been completely loaded, careful installation of the distributor tray should be carried out.

Use the following checklist during the final inspection.

1. All debris and catalyst has been removed from the tray deck.	
2. The outer diameter of the distribution tray is completely sealed by gasket material.	
3. All tray sections are sealed by gasket material.	
4. Any gaps around the thermowells or dump tubes have been completely sealed.	
5. The tray level still meets guidelines provided in the "inspection of reactor internals".	
6. All tray sections are in tight (e.g. they don't rattle when you hit them with a hammer).	
7. The inlet pipe has been completely cleaned of debris to prevent depositing the debris on the tray when the inlet pipe is installed.	



6. MAINTAINING A PROPER ENVIRONMENT PRIOR TO STARTUP

After the reactor has been loaded, it is recommended to install the inlet pipe spool as soon as possible. If this is not possible, the inlet manway needs to be sealed to prevent any additional moisture from entering the reactor. After the inlet pipe spool is installed, the reactor should be purged with nitrogen to remove as much moisture and oxygen from the reactor. After this is complete, maintain a nitrogen environment over the catalyst.

This simple procedure allows you to predict sock and dense loaded densities.

7. SOCK LOAD SIMULATION

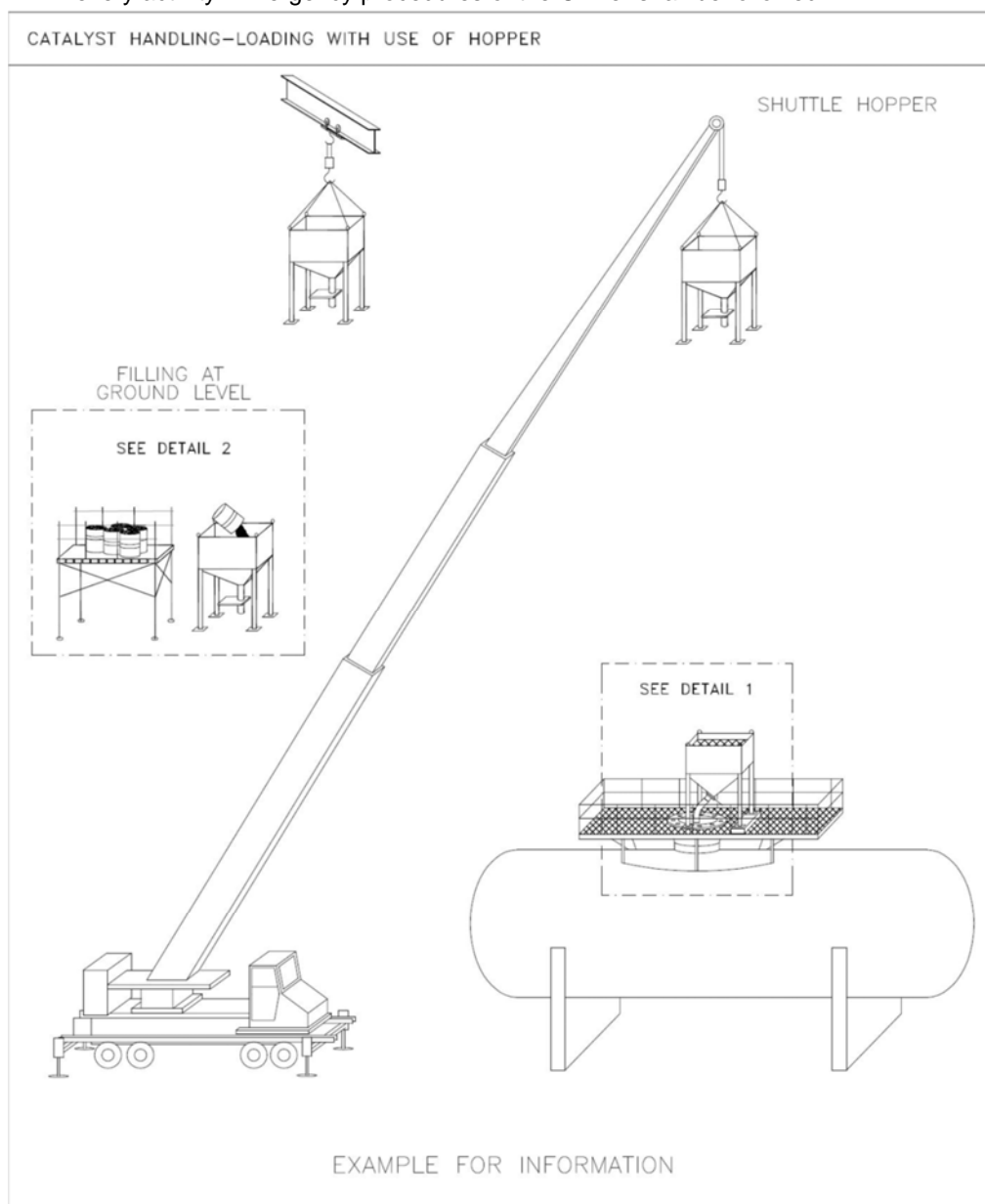
- Perform the dense load procedure described above.
- Place a cloth over the end of the graduated cylinder and turn the cylinder over 3 times.
- Measure the new volume and calculate the density.
- This is the approximate sock loaded density.

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8. HEALTH, SAFETY AND ENVIRONMENTAL PRECAUTIONS

Full attention to these hazards and to appropriate health, safety, and precautionary information is essential. Before handling, testing, or using the catalyst, a Material Safety Data Sheet must be obtained by contacting a Catalyst Sales Representative. A job safety analysis and Job safety task instructions shall be prepared and used for the activity.

Proper PPEs, safety equipment and supervision is essential to safe loading of catalysts. Loading areas and vehicle moving areas shall be properly barricaded. Valid work permit system shall be followed for every activity. Emergency procedures of the Owner shall be followed.





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Figure 5: Catalyst loading with Hopper

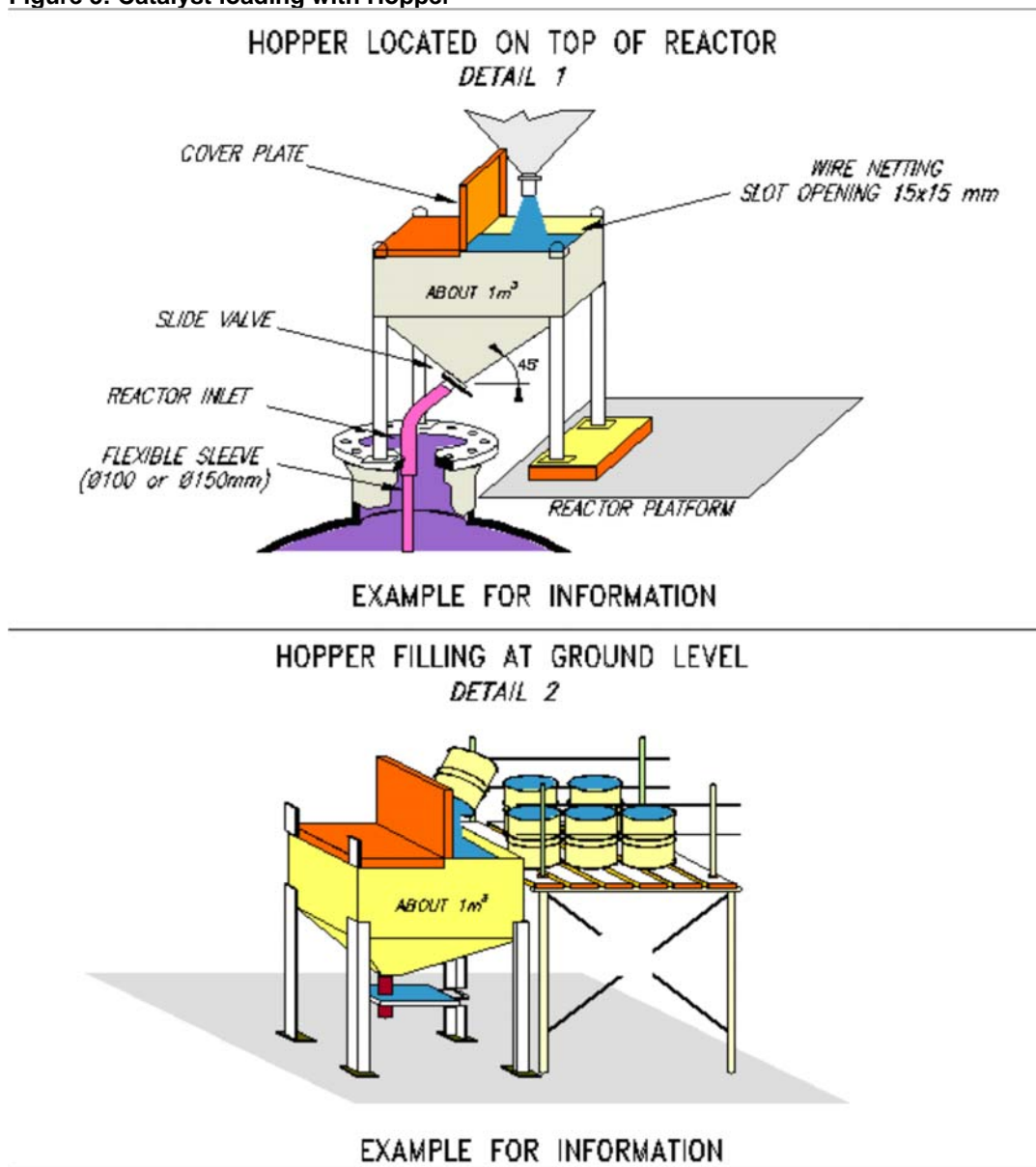




Figure 6: Hopper Arrangement

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NOTES :

- 1) FLEXIBLE SLEEVE WITH BE SLIP ON THE FIXED SLEEVE.

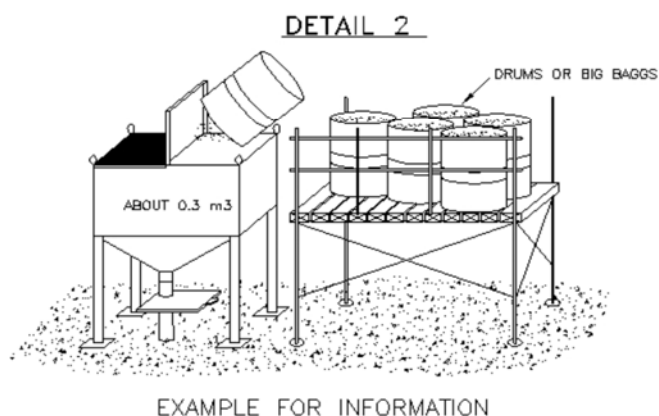
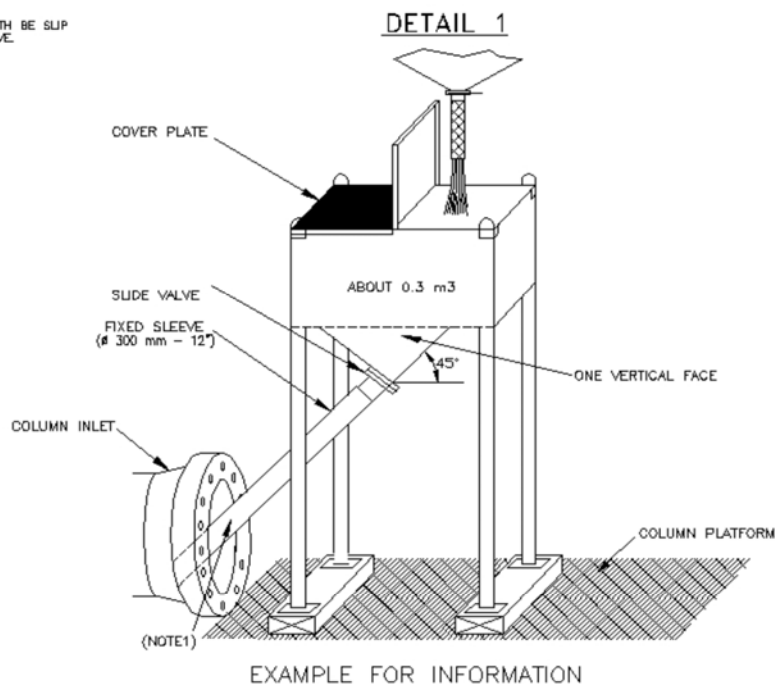




Fig. 7 PACKING LOADING DETAILS

		PROJECT	Standby SRU & Additional Tanks	
		CLIENT	INDIAN OIL CORPORATION LIMITED	
JOB SPECIFICATION FOR CATALYST / PACKINGS LOADING	Project No. 080557C001	Document No. 080557C-000-JSC-0093-014	Rev. No. 0	Page 17 of 18

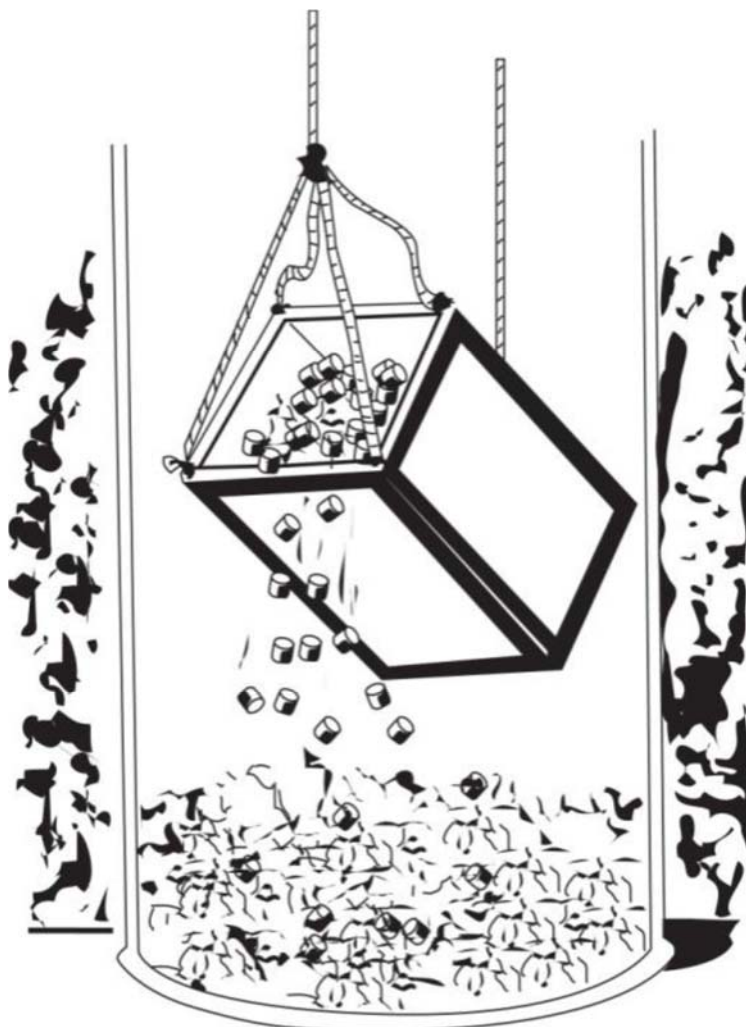




Fig. 8 DUMPED LOADING DETAILS

		PROJECT	Standby SRU & Additional Tanks		
		CLIENT	INDIAN OIL CORPORATION LIMITED		
JOB SPECIFICATION FOR CATALYST / PACKINGS LOADING	Project No. 080557C001	Document No. 080557C-000-JSC-0093-014		Rev. No. 0	Page 18 of 18

TYPICAL LOG SHEET FOR CATALYST/ PACKING LOADING.

Item Number and Name ----- -----	Catalyst/ packing Type	Loadin g Method	Catalyst / packing Volume (m3)
Bed 1		SOCK	
		SOCK	
		SOCK	
		SOCK	
		SOCK	
		SOCK	
Bed 2		SOCK	
		SOCK	
		SOCK	
Total Catalyst			
Total Catalyst/ PACKING			XXXXX